Northeast Regional Conservation Synthesis for 2025 State Wildlife Action Plans

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Northeast Fish and Wildlife Diversity Technical Committee, Northeast Association of Fish and Wildlife Agencies

By

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LAND ACKNOWLEDGEMENT

We acknowledge the Indigenous people of the Northeast. We acknowledge that the focal area of this effort spans the homeland of many tribes. It is with deep gratitude and appreciation that we seek to conserve the species and natural systems that continue to be nurtured by the original stewards and their descendants, whose relationship with these lands is unbroken. We recognize the losses inflicted on these original inhabitants and on the land itself, and we seek to contribute to the conservation and restoration of these lands and waters. We recognize that Indigenous Knowledge is unique and specific to a Tribe or Indigenous people, and Traditional Ecological Knowledge is invaluable to fish and wildlife conservation in the Northeast.

EXECUTIVE SUMMARY

This 2023 Northeast Regional Conservation Synthesis updates the original 2013 synthesis for State Wildlife Action Plans (Terwilliger Consulting Inc. [TCI] and the Northeast Fish and Wildlife Diversity Technical Committee [NEFWDTC] 2013). Its purpose is to support the 2025 State Wildlife Action Plan (SWAP) revisions. In addition, many associated resources are available on the www.northeastwildlifediversity.org website to support the SWAP ten-year revision cycle.

For more than fifty years, 14 fish and wildlife agencies in the Northeast United States (the Virginias to Maine) have worked together through the Northeast Association of Fish & Wildlife Agencies (NEAFWA) to conserve the region's fish, wildlife, and habitats in the greatest need of conservation. This document summarizes the strategic approach to regional conservation planning and implementation developed and applied collaboratively by NEAFWA's NEFWDTC and its key partners.

The Northeast states created a common lexicon and data framework to address the SWAP Elements. This includes:

- Regional species prioritization via Regional Species of Greatest Conservation Need (RSGCN)

- Development of shared terrestrial and aquatic habitat classifications
- Habitat condition assessments and maps
- Identification of priority regional threats
- A set of overarching actions, including assessments and monitoring of species and their habitats

Over the past decade, conservation efforts continued to address priority RSGCN and their habitats. These range from xeric woodland pollinators to rare wetland turtles and butterflies to freshwater mussels and stoneflies. It highlights how the states apply this regional conservation planning framework across boundaries to preempt federal listing under the Endangered Species Act by collaboratively implementing coordinated on-the-ground conservation.

NOTABLE ADVANCEMENTS AND INFORMATION SINCE THE 2013 SYNTHESIS

The 2013 regional conservation synthesis summarized regional conservation actions taken since 2007 through the Regional Conservation Needs (RCN), Competitive State Wildlife Grants (CSWG), and Landscape Conservation Cooperative (LCC) programs (TCI and NEFWDTC 2013). In 2017, the Regional SWAP Synthesis provided a collective summary of the conservation priorities and actions identified in the fourteen 2015 Northeast SWAPs, highlighting regional themes and priorities (TCI and NEFWDTC 2017).

This 2023 Regional Conservation Synthesis updates the inventory of RCN projects supported by NEFWDTC and CSWG projects undertaken in the Northeast region over the past decade. The LCC programs have been discontinued, so no projects were included from this program. Instead, the synthesis of existing regional conservation actions is now updated to include regional efforts of the Science Applications (SA) program of the United States Fish and Wildlife Service (USFWS), which address landscape-scale and priority species conservation.

Over the past decade, these key tools and projects were developed to support NEAFWA's NEFWDTC and SWAPs:

- Northeast SWAP Database, version 3.0 TCI and NEFWDTC 2020)
- Northeast SWAP Synthesis (TCI and NEFWDTC 2017)
- Northeast RSGCN list updates (TCI and NEFWDTC 2013, 2018, 2023)
- RSGCN Limiting Factors Report (TCI and NEFWDTC 2020)
- Northeast RSGCN Database, version 1.0 (TCI and NEFWDTC 2023)

- Northeast Lexicon (Crisfield and NEFWCTC 2013, 2022)
- Northeast Habitat Status and Condition Assessments (Anderson et al. 2011, 2013, 2016, 2023)
- Northeast Regional Conservation Synthesis (TCI and NEFWDTC 2013, 2023)
- Northeast Climate Change Synthesis for 2025 SWAP Revisions (Staudinger et al. 2015, 2023)
- NEFWDTC website update (2023)
- 70+ new RCN, CSWG, and SA conservation projects on RSGCN and their habitats.

This document synthesizes over two thousand programs, projects, plans, resource documents, and tools to provide guidance and information that states can incorporate into their Wildlife Action Plans and beyond. Many of these were developed through NEAFWA's NEFWDTC and its RCN Grant Program as a diverse set of regional tools and best practices for addressing the key landscape and watershed-scale wildlife conservation needs of the Northeast, as prioritized by the states and their partners. Since 2007, the RCN Grant Program, with all states contributing SWG funds to this common effort, continues to provide regionally consistent information and tools. Individual states can use this to meet their SWAP wildlife and habitat conservation goals in the context of a regional planning and implementation framework.

DOCUMENT STRUCTURE

This document follows the order of the required State Wildlife Action Plan Essential Eight Elements, reflecting the steps of the conservation planning framework. *Chapter 1* presents the Regional Species of Greatest Conservation Need. *Chapter 2* presents information on their key regional habitats. *Chapter 3* synthesizes the key regional threats, and *Chapter 4* lists the regional conservation actions that address these threats. *Chapter 5* describes the regional monitoring framework, protocols, and examples. *Chapter 6* describes the SWAP review process and guidance. Finally, *Chapters 7* and *8* highlight the regional coordination, review process, and partnerships that continue to support exemplary collaboration and public engagement across the Northeast states.

REGIONAL PRIORITY SPECIES: REGIONAL SPECIES OF GREATEST CONSERVATION NEED

This 2023 Regional Conservation Synthesis update includes the fourth revision of the RSGCN list developed by NEAFWA's NEFWDTC. The original list was published in 1999 (Therres 1999) and updated by TCI and NEFWDTC in 2013, 2018, and 2023. The list is developed using two main criteria: regional stewardship responsibility (proportion of the species range that occurs in the Northeast region) and conservation concern status (imperilment). It focuses action on current high-priority Northeast species as identified by the NEFWDTC for 2025 SWAP development and conservation planning and implementation by state fish and wildlife agencies and their partners in hopes of preempting state and federal listing.

This 2023 RSGCN list revision identifies 382 Regional Species of Greatest Conservation Need. By using updated methods and selection criteria, 17,916 Northeast species were prescreened. More than 200 experts then provided information on 7,270 mammals, birds, reptiles, amphibians, fish (marine, diadromous, and freshwater), crayfish, freshwater mussels, marine invertebrates, terrestrial snails, Odonata (dragonflies and damselflies), Hymenoptera (bumble and solitary bees), Lepidoptera (butterflies, skippers, and moths), stoneflies, mayflies, fireflies, tiger beetles, caddisflies, and fairy, clam, and tadpole shrimp.

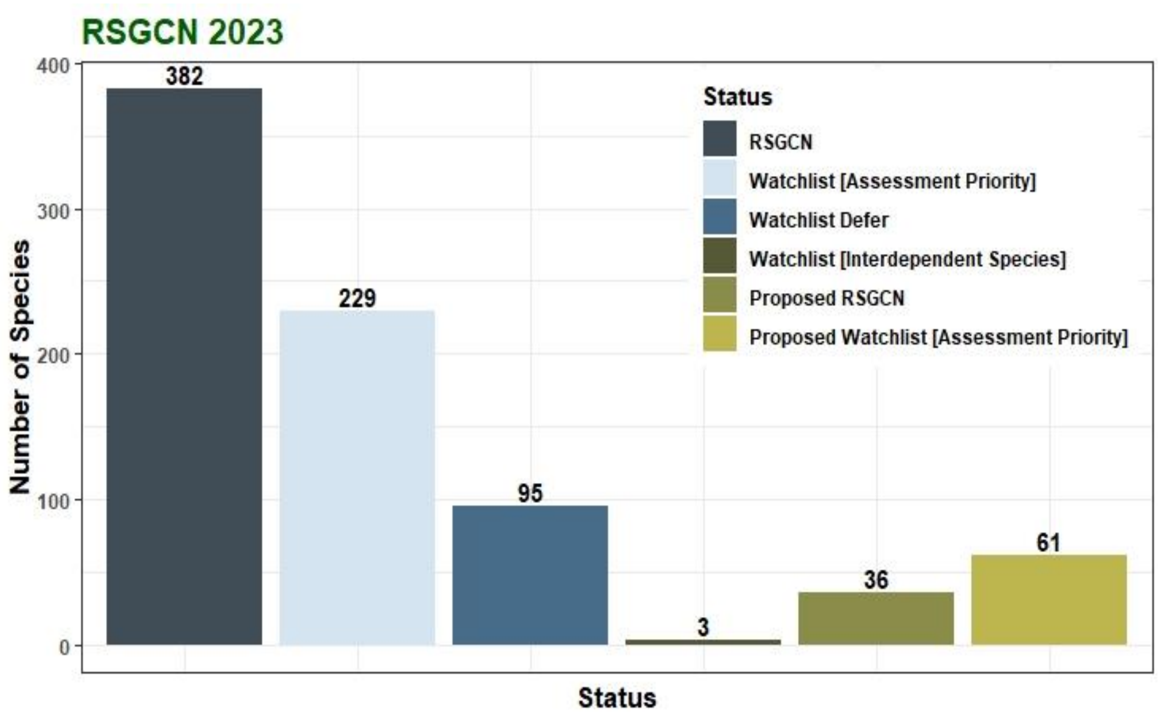

Figure ES 1 The number of Northeast species in each RSGCN category.

RSGCN and Watchlist categories total 806 species, with 47% (382) of those meeting the criteria for RSGCN status (Figure ES 1). The two "proposed" categories (Proposed RSGCN and Proposed RSGCN Watchlist Assessment Priority) represent 12% (97) of the entire list and are not currently identified as SGCN in any Northeast SWAP. However, because they meet the other RSGCN criteria, and/or their taxonomy is new or updated, including them here informs the upcoming 2025 SWAP SGCN selection as species with regional concern. The new RSGCN Watchlist Assessment Priority category contains 28% (229) of listed species highlighting those with data deficiencies, taxonomic uncertainties, or variable trends within the region. Three interdependent species met RSGCN Watchlist Interdependent Species criteria, and 95 additional species are deferred to other regions for primary stewardship in their core range. Of the 382 SGCN that met the regional responsibility and conservation concern criteria for RSGCN, Lepidoptera (Butterflies, Skippers, and Moths) is the largest taxonomic group of RSGCN, followed closely by freshwater fish. Invertebrates comprise 56% of the RSGCN, while the remaining 44% are vertebrates. This list will evolve as additional information emerges, especially for invertebrates (see *Chapter 1*).

REGIONAL PRIORITY HABITATS: REGIONAL SPECIES OF GREATEST CONSERVATION NEED

The 2022 Northeast Lexicon (Crisfield and NEFWDTC 2022) lists the 24 habitat types used in the RSGCN Database, updated with new classification systems for aquatic habitats (i.e., rivers, streams, lakes, ponds, and marine areas). These 24 habitat types allow synthesis of the finer scale Key Habitats from the 14 Northeast 2015 SWAPs for SGCN and regional analysis and application to RSGCN and Watchlist species (Figure ES 2). Available information on each of these Northeast habitat types is synthesized, including:

a. The associated RSGCN and Watchlist species
b. Current information on habitat availability and condition
c. Threats
d. Relevant national and regional management plans
e. Available best management practices
f. Additional information and research needs

In addition, information on partner programs and initiatives and citizen science projects that engage the public in conserving each habitat are summarized (see *Chapter 2*).

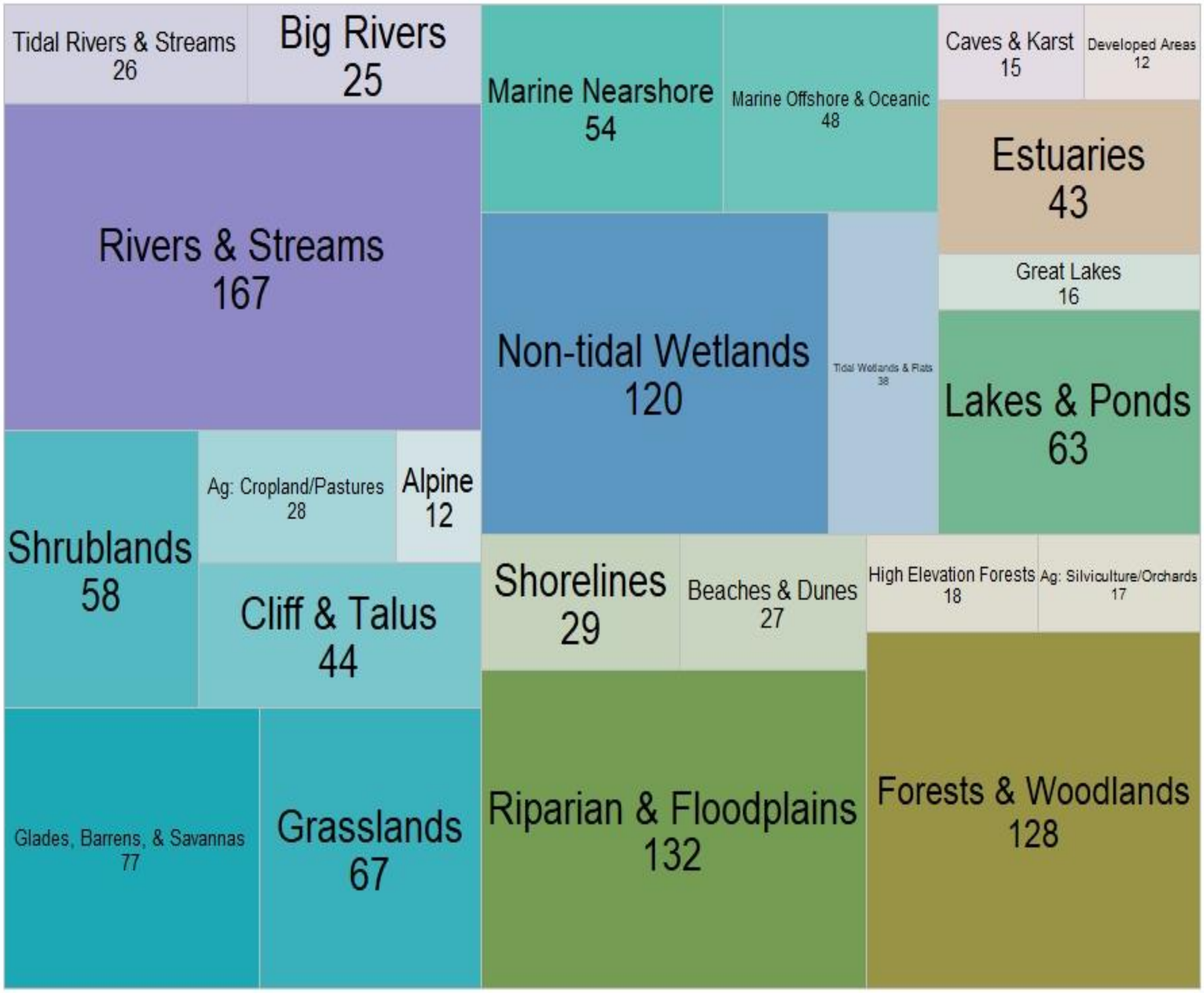

Figure ES 2 Number of RSGCN associated with the 24 Northeast habitats. Rivers and Streams, Riparian and Floodplains, Forests and Woodlands, and Nontidal Wetlands support the most RSGCN in the Northeast.

KEY THREATS IMPACTING THE RSGCN AND THEIR HABITATS IN THE NORTHEAST

Following the development of the 2015 SWAPs, the 2017 SWAP Synthesis report analyzed threats to both species and habitats identified in the 14 SWAPs (TCI and NEFWDTC 2017). Regional working groups reviewed and prioritized this analysis further. As a result, the top threats to SGCN and their Key Habitats identified in the 2005 and 2015 SWAPs are the same threats identified for the 2023 RSGCN (with slight changes in rank order). The top threats to Northeast RSGCN are pollution, climate change, invasive species and disease, biological resource use, modification of natural systems, and development (Figure ES 3).

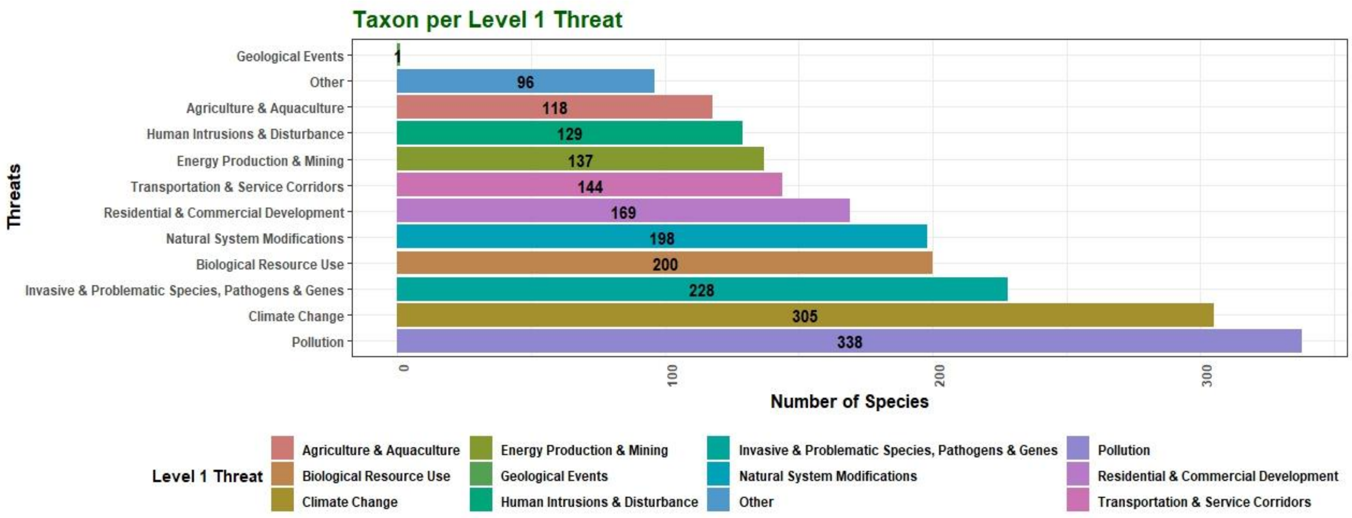

Figure ES 3 Regional threats identified in the SWAP and RSGCN process for RSGCN and Proposed RSGCN taxa (416 total species). Numbers indicate species threatened by each threat category. For an explanation of RSGCN species and categories see *Chapter 1*, for threat details see *Chapter 3* and *Supplemental Information 3*.

The regional threats classification system is consistent with the Conservation Measures Partnership (CMP) Direct Threats Classification System version 2.0 and International Union for Conservation of Nature (IUCN) updated Direct Threats Classification System, version 3.2, and advanced by Lamarre et al. in 2021. This regional classification system includes an actionable level of detail with modifications for the Northeast incorporated by TCI (*Chapter 3*). In addition, the 2022 Northeast Lexicon cites the framework as the regional threat classification scheme for the 2025 SWAPs in the Northeast.

REGIONAL PRIORITY CONSERVATION ACTIONS TO ADDRESS KEY THREATS TO RSGCN AND KEY HABITATS

The fourteen 2015 SWAPs identified and prioritized conservation actions for each state in the region. Those state-specific actions served as a solid framework for developing a set of priority actions to address top regional threats to priority species and their key habitats at the landscape, watershed, and seascape levels across the Northeast as recommended by the Landscape Conservation Report (AFWA 2021). Information was compiled from the 2015 SWAPs, the RCN program, other key regional partners, and data sources available since the 2015 SWAPs. NEFWDTC's Technical Services project used the Northeast SWAP Database to analyze and synthesize this information in its 2017 SWAP Synthesis (TCI and NEFWDTC 2017). With additional input from its Taxonomic Teams, SWAP Coordinators, and Threat Working Groups, the NEFWDTC developed seven overarching regional conservation action themes (Figure ES 4). These broad regional actions call for developing and providing information on the Northeast conservation priorities (SWAP Elements 1 and 2), addressing the top regional threats to these priority species and habitats (SWAP Element 3), and then for evaluation of those actions (SWAP Elements 4 and 5) to deliver the most effective conservation efforts across the region (SWAP Elements 7 and 8).

These priority regional actions are:

1. *Develop deliver science-based information and tools to conserve RSGCN and key habitats in the Northeast.*
2. *Conserve Northeast RSGCN and their habitats from habitat loss and degradation by addressing development, natural ecosystem modifications, and biological resource use.*
3. *Protect native species and habitats from the introduction and spread of disease and invasive species in the Northeast.*
4. *Conserve aquatic habitats by addressing pollution and aquatic connectivity in Northeast waters.*
5. *Address climate change impacts to Northeast RSGCN and their habitats.*
6. *Coordinate inclusively across state boundaries to maximize efficiency and effectiveness of fish and wildlife diversity conservation in the Northeast.*
7. *Develop and implement effective regional scale monitoring to inform adaptive management of regional priorities and conservation in the Northeast.*

Figure ES 4 Regional priority actions.

In 2016, the Conservation Measures Partnership (CMP) released the **Conservation Actions Classification, version 2.0**, which allows conservation actions to be classified and categorized in a hierarchical system (https://conservationstandards.org). The updated Northeast SWAP Database and the Northeast RSGCN Database are structured to incorporate species and habitat conservation actions for RSGCN and Watchlist species with Northeast-specific modifications.

The 70+ new NEAFWA RCN, USFWS CSWG, and SA At-Risk Species projects that address regional priority conservation targets are summarized and linked to the action and threat they address (see *Chapter 4*).

MONITORING AND REVISION FOR ADAPTIVE MANAGEMENT OF REGIONAL PRIORITIES

New information and resources for inventorying and monitoring species (Element 1), habitats (Element 2), and threats (Element 3) have become available in the past decade. The updated Northeast RSGCN Database includes information on the availability of standardized monitoring protocols for RSGCN and Watchlist species. New regional monitoring networks developed over the period are described in *Chapter 5* of this document. Programs and projects that monitor the availability and condition of habitats are in *Chapter 2*. Monitoring programs for threats related to habitat conditions are described in *Chapter 2*. *Chapter 3* focuses on monitoring threats (e.g., invasive species, disease), and *Chapter 5* focuses on regional monitoring efforts that address threats to multiple species, taxa, and/or habitats.

The RCN project, **Monitoring the Conservation of Fish and Wildlife in the Northeast: A Report on the Monitoring and Performance Reporting Framework for the Northeast Association of Fish and Wildlife Agencies,** provides a regional monitoring framework based on the status of SGCN and their habitats and the effectiveness of conservation projects implemented as part of SWAPs and the State Wildlife Grants program. The monitoring framework includes eight conservation targets: forests, freshwater streams and river systems, freshwater wetlands, migratory species, lakes and ponds, managed grasslands and shrublands, regionally significant SGCN, and unique habitats in the Northeast. Specific indicators and stressors are identified for monitoring to assess these conservation targets. RCN funded the original **Conservation Status of Fish, Wildlife, and Natural Habitats in the Northeast Landscape: Implementation of the Northeast Monitoring Framework** in 2011 (Anderson and Olivero Sheldon 2011) and its 2023 revision (Anderson et al. 2023; see *Chapters 5 and 6*).

STAKEHOLDER AND PUBLIC PARTICIPATION

Many partners, stakeholders, and the public participate in fish and wildlife conservation across the Northeast. *Chapter 1* of this Regional Conservation Synthesis provides information on conservation partners and their programs, projects, and initiatives that address the needs of RSGCN and Watchlist species. *Chapter 2* addresses stakeholder and public participation related to the 24 habitats that support RSGCN and Watchlist species. *Chapter 7* summarizes landscape and seascape-level conservation partnerships that address the Northeast's multiple taxonomic groups and/or habitats. This synthesis of conservation partners and their ongoing regional efforts presents opportunities to enhance collaboration, leverage resources, and synergize conservation efforts across Northeast lands and waters. Finally, *Chapter 8* summarizes available information on best practices for education and outreach activities, citizen science, and diversity, equity, justice, and inclusion initiatives. All these resources can enhance public engagement and contributions to SWAP development and implementation, addressing required Element 8 (see *Chapters 7* and *8*).

The 2023 NEFWDTC website update (www.northeastwildlifediversity.org) allows for web-enabling this Regional Conservation Synthesis, the updated Northeast RSGCN Database, and associated communication tools and products. These tools and resources will be searchable with filters to provide detailed information for specific targets, purposes, or users. In addition, by linking with other NEFWDTC programs, such as the RCN Grants Program, regional information will be integrated into a centralized online platform available to the states, conservation partners, and the public.

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INTRODUCTION

GUIDE TO THIS DOCUMENT

As mandated by Congress, each State Wildlife Action Plan must address eight Essential Elements. This document follows that same structure, but on a regional scale, in sequential chapters as follows:

Chapter 1 addresses SWAP Element 1: Species and summarizes the status of Regional Species of Greatest Conservation Need (RSGCN) and Watchlist species region wide. These 806 species are indicative of the diversity and overall health of wildlife in the Northeast region. The RSGCN list, organized into 20 taxonomic groups, is updated every five years to include new information on the status of select species in the region and for additional taxonomic groups, particularly invertebrates. This Chapter incorporates these updates, which are essential for addressing Element 1 at the regional level.

Chapter 2 addresses SWAP Element 2: Key Habitats and summarizes the regional extent and condition of habitats and community types essential to the conservation of Northeast RSGCN and Watchlist species. This Chapter also highlights the regional terrestrial and aquatic habitat classification systems, maps, guides, and assessments for use in the revisions of State Wildlife Action Plans. It describes 24 coarse habitat types used in the Northeast Lexicon and RSGCN Database. A synthesis of the available information on these habitat types, including lists of RSGCN and Watchlist species associated with each; current information on the habitat's availability and condition; threats; relevant national and regional management plans conservation partners; available best management practices; and habitat-specific information and research needs are provided. Additional information on the availability and the condition of Northeast habitats was developed in coordination with the Northeast Habitat Condition Assessment, a concurrent RCN project (Anderson et al. 2023).

Chapter 3 addresses SWAP Element 3: Threats and summarizes the issues and problems identified in the 14 Northeast SWAPs that may adversely affect RSGCN or their habitats. It also describes the priority research and survey efforts needed to support restoration and improved conservation of these species and habitats. Following the development of the 2015 SWAPs, the *Northeast State Wildlife Action Plan Synthesis: Regional Conservation Priorities* report synthesized the threats to both species and habitats identified in the 14 individual SWAPs (TCI and NEFWDTC 2017). The Conservation Measures Partnership (CMP) and the International Union for Conservation of Nature (IUCN) have developed several threat classification systems, which were advanced by Lamarre et al. (2021) for use in Quebec. This classification system is consistent with the older classification systems and was modified to include relevant threats for the Northeast (see *Supplemental Information 3*).

Chapter 4 addresses Element 4: Conservation Actions and summarizes how regional priority conservation actions identified by the 2017 SWAP Synthesis are being implemented by RCN, USFWS SA, and CSWG partner projects throughout the region. This Chapter lists seven priority regional conservation actions grounded in the common themes and priorities of the 2015 Northeast SWAPs (TCI and NEFWDTC 2017) and further prioritized by the NEFWDTC and its SWAP Coordinators, Threat Working Groups, and taxonomic teams. *Appendix 4A* updates the inventory of RCN projects supported by the NEFWDTC and the Competitive State Wildlife Grant and Science Applications projects undertaken in the Northeast region over the past decade. Supplemental Information 4 provides the action classification system, and *Appendix 4B* provides a matrix summary of priority actions identified in the 2017 SWAP synthesis to address each key threat.

Chapter 5 addresses Element 5: Inventory and Monitoring and summarizes the Northeast Monitoring and Performance Reporting Framework (NEAFWA 2008), monitoring protocols, and plans identified in RCN and CSWG project reports. The focus is on monitoring RSGCN and their habitats, monitoring the effectiveness of the conservation actions summarized in *Chapter 4*, and adapting these conservation actions in response to new information or changing conditions. This Chapter also provides further information and resources for inventorying and monitoring species (Element 1), habitats (Element 2), threats (Element 3), and Actions (Element 4). In addition, Supplementary Information 5 and *Chapter 4* include newly standardized monitoring protocols for RSGCN and Watchlist species and links to regional monitoring networks developed over the past decade.

Chapter 6 addresses Element 6: Review and summarizes regional coordination and processes for reviewing the plan at intervals not to exceed ten years. It addresses Element 6 and provides the key SWAP guidance and the required review/update schedules. It also includes concise summaries of the advancements since the previous regional conservation synthesis (TCI and NEFWDTC 2013) contained in the other chapters of this 2023 Regional Conservation Synthesis and key guidance resources.

Chapter 7 addresses Element 7: Partners and summarizes landscape and seascape-level conservation partnerships in the Northeast, including federal, state, and local agencies, Native American Tribes, and other non-governmental and non-tribal entities that either manage significant land and water areas within the region or administer programs that significantly affect the conservation of identified species and habitats. This Chapter also provides information on conservation partners and their programs, projects, and initiatives that address the needs of RSGCN and Watchlist species and their 24 habitats, suggesting opportunities to enhance collaboration, leverage resources, and synergize conservation efforts.

Chapter 8 addresses Element 8: Public Engagement and summarizes advancements in social science relevant to the conservation of regional priority species and habitats, public outreach and education, and citizen science programs. *Chapter 8* also summarizes available information on best practices for education and outreach activities and diversity, equity, justice, and inclusion initiatives. Key citizen science projects and programs that are currently contributing to the conservation of RSGCN and Watchlist species and their habitats in the Northeast are included in *Chapter 1* (species or taxa-based), *Chapter 2* (habitat-based), and *Chapter 8* (multi-taxa and/or habitat).

Appendices for this and all Regional Conservation Synthesis chapters can be found together in the appendices document so the reader can open the chapters and appendices side-by-side if desired. Appendices include Acronyms, RSGCN Methods, Crosswalk of SWAP Key Habitats with the 24 habitats, Crosswalk of DSLland Formations and Ecosystems with the 24 habitats, List of NEAFWA RCN and USFWS (CSWG, SA) projects, and the Action matrix from 2017 SWAP Synthesis.

Supplemental Information for this and all Synthesis Chapters can be found in the Supplemental Information Excel file. It contains data tables better represented in a data file for ease of use including tables of all RSGCN categories, state breakdown of RSGCN species, lists of RSGCN and Watchlist species associated with each of the 24 habitats, the threats classification system, with TCI customization of the Quebec system (Lamarre et al. 2021), IUCN/CMP Actions classification system, and standardized monitoring protocols for species.

NEED AND PURPOSE

This document is intended to inform State Wildlife Action Plan revisions and conservation efforts at any scale in the Northeast. It is available for use by local, state, regional, and national conservation entities. It represents another milestone in the long-term relationship between NEAFWA's Fish and Wildlife Diversity Technical Committee and its partners, one that continues to produce a strategic series of information, tools, and networks for the effective conservation of regional priority species and habitats as well as a framework for regional planning, partnerships, and alliances.

As states revise their Wildlife Action Plans for 2025, there is a need to synthesize this regional information in a way that is most useful and applicable to their own needs, as well as to the needs of partners in their planning processes. Therefore, states can use this document to address the regional context (as an appendix or by reference) and individual sections to address each required element for State Wildlife Action Plans.

The four goals and six primary objectives for developing this Regional Conservation Synthesis are described below.

UPDATED GOALS

1) Inform SWAP revisions by providing regional context, synthesized information, and priorities to support states in their Wildlife Action Plan development and implementation.
2) Inform conservation planning at many scales in the Northeast.
3) Raise the awareness and use of these shared regional priorities in the Northeast.
4) Highlight the defining ecological features and resources of the Northeast.

UPDATED OBJECTIVES

1) Identify opportunities for coordinated conservation activities across a regional landscape,
2) Identify regional conservation priority species, habitats, threats, and conservation actions for state fish and wildlife agencies and their partners.
3) In a regional context, provide information about species, habitats, threats, stressors, and conservation activities.
4) Compile and organize existing regional information and best management practices for species, habitats, threats and stressors, conservation actions, monitoring and evaluation programs, and consistent metrics and reporting tools to evaluate conservation effectiveness consistent with the order and content of SWAP Elements
5) Facilitate consistency through the use of the Northeast Regional Lexicon and standard taxonomies.
6) Advance conservation adoption through clear identification and communication of a set of shared conservation priorities relevant to the Northeast region, supporting SWAP revisions and facilitate the development of regional and state-level partnerships.

PROVIDE REGIONAL CONTEXT AND OPPORTUNITIES FOR COORDINATED CONSERVATION

Many conservation issues are broader than any one state or jurisdiction. For example, restoring the rare wetland turtles, butterflies, Brook Floater (*Alasmidonta varicosa*), other freshwater mussels, or xeric pine barren pollinator habitat requires collaboration among many states to achieve a stable population. Similarly, coordinated conservation activities addressing water quality, disease and invasive species, climate change, and habitat connectivity is most effective when implemented in a coordinated, consistent approach across multiple state jurisdictions. This document encourages each state fish and wildlife agency to identify opportunities for collaborative action across a regional landscape, to take advantage of economies of scale, and to ensure that vulnerable species or habitats are not overlooked. It also provides basic background information about the region as a whole—its special habitats, species, and human impacts. This regional perspective is essential for understanding the dynamics of fish and wildlife conservation as practiced in the Northeast states.

PROVIDE REGIONAL CONSERVATION PRIORITIES

The information contained in this document will help state fish and wildlife agencies and their partners address the most pressing conservation issues through a collaborative, regional approach involving the states, USFWS, and the many Northeast conservation partners. The SWAP Elements align with the NEFWDTC charges, RCN projects designed to address the priorities identified, and the Northeast Monitoring and Performance Reporting Framework (NEAFWA 2008), all of which reflect the structure of this document. Accordingly, this Regional Conservation Synthesis serves as a compendium of information for states and their public and private partners. It also emphasizes the importance of coordinating conservation activities and economies of scale for regional planning.

HIGHLIGHT WHAT IS IMPORTANT AND DEFINING ABOUT THE NORTHEAST REGION

This document brings attention to the special ecological features of the Northeast states, including the region's numerous endemic species and globally rare communities, its biodiversity hotspots (from high-elevation forests, barrens and grasslands, to the wetlands and coastal bays and marshes of the Atlantic), and its diversity of species that are now of conservation concern. It also places information about threats, stressors, and conservation activities into a regional context and provides further support for collaborative conservation efforts across state lines.

SYNTHESIZE AND ORGANIZE EXISTING INFORMATION

One of the most valuable aspects of this document is its organization and presentation of a decade of existing regional information about species, habitats, threats and stressors, conservation actions, and monitoring and evaluation programs of either regional interest or regional concern. Although a wealth of information about these topics is contained in most states' Wildlife Action Plans, this document brings together and organizes the state-specific information at a regional scale, thus making it easier for groups of states to develop multi-jurisdictional conservation strategies and approaches.

ASSIST WITH CONSERVATION ADOPTION

By clearly identifying a set of shared conservation priorities relevant to the entire Northeast region, this document supports the efforts of individual states and their partners to adopt and incorporate regional conservation priorities into future iterations of their Wildlife Action Plans. It also helps to facilitate the development of regional and state-level partnerships. Identifying shared regional conservation priorities may also make it easier to obtain buy-in and support for the Wildlife Action Plans from the private sector as well as public entities, including non-governmental organizations and various municipal and federal agencies. These regional priorities will also provide states with the support they need to justify committing limited resources to regional as well as state-specific conservation efforts.

FACILITATE CONSISTENCY

This document summarizes and incorporates the Northeast regional lexicon, using standard terminology for the eight required elements. It follows standard taxonomies for species recommended as national Best Practices (AFWA 2012, 2021, 2022a), b) and developed by the Integrated Taxonomic Information System (ITIS) and NatureServe. It also applies standard habitat classifications (Crisfield and NEFWDTC 2022, Gawler 2008, Olivero and Anderson 2008, Anderson et al. 2023) as well as standard taxonomies for threats, stressors, and conservation actions developed by the International Union for the Conservation of Nature and the Conservation Measures Partnership (CMP 2020, Lamarre et al. 2021). By using standard definitions and classifications, the ability of Northeast states to communicate and collaborate effectively across jurisdictional boundaries is greatly enhanced.

New national and regional guidance is available for 2025 SWAPs. In 2012, the Association of Fish and Wildlife Agencies "Teaming with Wildlife" Committee issued *Best Practices for State Wildlife Action Plans: Voluntary Guidance for States for Revision and Implementation* (AFWA 2012). These best practices include guidance on all eight SWAP elements, from classification standards and systems to assessing conservation status. AFWA is updating this guidance for the 2025 SWAPs (AFWA *in prep*). In August 2022 AFWA provided guidance on adding plants to the SWAPs as

Species of Greatest Conservation Need, using the minor revision process (AFWA 2022a).

In December 2017, the USFWS and AFWA issued a joint memorandum with updated guidance for reviewing and revising State Wildlife Action Plans (USFWS and AFWA 2017). The guidance provides detailed information regarding procedures for comprehensive, major, and minor SWAP revisions. The roles of Regional Review Teams are outlined, and examples of comprehensive, major, and minor revisions are provided.

In late 2022 AFWA issued a 2nd edition of **Voluntary Guidance for States to Incorporate Climate Adaptation in State Wildlife Action Plans and Other Management Plans**, updating guidance from 2009. The updated guidance includes "principles and tools that can be used to plan for and implement climate change adaptation, voluntary guidance for incorporating climate change into the existing required elements of SWAPs, and case studies to demonstrate adaptation strategies deployed by states in their management efforts" (AFWA 2022b, p. 4).

BACKGROUND

State fish and wildlife agencies in the Northeast United States have worked collaboratively on wildlife conservation priorities for over half a century. By the 1980s, state wildlife diversity managers coordinated to develop a regional list of priority species—now called the Regional Species of Greatest Conservation Need—and to identify regional conservation needs. These projects have been designed through a collaborative regional prioritization process to address important conservation needs and recently, to help with the revision of Wildlife Action Plans for the Northeast states. This document synthesizes the suite of regional projects initiated by NEAFWA's Fish and Wildlife Diversity Technical Committee and its key partners that address identified regional priorities.

Originally drafted at the request of Congress to enable eligibility for funding through the State Wildlife Grants Program, the first Wildlife Action Plans were successfully completed by wildlife management agencies in each of the 56 US states and territories in 2005. Together, the 14 Northeast plans represent a detailed blueprint for wildlife conservation across the Northeast United States. Each plan identifies a set of species of greatest conservation need, priority wildlife habitats for conservation, threats and stressors, recommended conservation actions, partnership and outreach opportunities, and methods for monitoring and evaluation specific to the individual state's needs. Although each of the plans is based on a common set of elements, the individual state wildlife agencies were given considerable latitude by Congress and the US Fish and Wildlife Service to customize their plans to fit the particular conservation needs of their respective states. While the ability to develop customized plans provides obvious benefits, one important drawback is the inherent difficulty of comparing and planning across states.

Recognizing this need to identify major conservation issues that extend across state lines to larger landscape or regional scales, NEAFWA held meetings in 2006 and 2011 to begin developing and implementing the plans at a regional level. As a result of these initial meetings, the Northeast states, working with the US Fish and Wildlife Service and Wildlife Management Institute (WMI), began pooling a portion (4%) of their State Wildlife Grant funds program allocation to develop a grant program that would specifically address regional conservation needs. Since then, the Regional Conservation Need Grant program has supported the development of almost 100 key regional tools (see *Appendix 4A* for the complete list) and contributed significant yearly funding towards regional conservation needs. These steps toward creating a regional culture of cooperation have also enabled states to pool and leverage their individual resources for wildlife conservation to address issues of common interest region wide.

IDENTIFYING PRIORITIES FOR REGIONAL CONSERVATION

The development of coordinated regional species lists began in the 1980s (French and Pence 2000). It led to the publication of the first region-wide list of species in need of conservation (Therres 1999) and in subsequent species accounts (TCI 2001). Hunt (2005) adapted the methodology to rank fish and wildlife species as SGCN in the New Hampshire Wildlife Action Plan. This methodology was applied region-wide by the Northeast Partners in Reptile and Amphibian Conservation (NEPARC) to identify high-priority members of the Northeast herpetofauna. This priority-setting process continues to evolve, and four revisions later, the 2023 list now includes several advancements (see *Chapter 1* and *Appendix 1A*).

Similar standard classification and prioritization systems were developed for habitats, threats, and actions, enabling an unprecedented compilation of all 14 State Wildlife Action Plans in the Northeast Region. This collaboration led to a coordinated revision of the 2015 SWAPs, with Northeast states utilizing a common framework, guidance, and terminology from the Northeast Lexicon (Crisfield and NEFWDTC 2013 and 2022) and the Northeast SWAP Database (TCI and NEFWDTC 2020, version 3.0). This enabled the compilation of information on RSGCN, their habitats, and the threats they face (TCI and NEFWDTC 2013, 2015, 2017, 2020, 2023). The RCN program funded projects to develop a consistent habitat classification framework and condition assessment (Anderson et al. 2023). Similarly, consistent threat and action classification systems were used to characterize SWAP threats and actions (CMP 2020 and LaMarre et al. 2021); and these, in turn, enabled compilation and comparison across all 14 Northeast SWAPs.

The goal was to determine priority RSGCN and their habitats, common threats, and to identify actions that could be implemented through regional collaboration and coordination. The compilation, analysis and development of a Regional SWAP Synthesis (TCI and NEFWDTC 2017) summarized the threats to RSGCN and their habitats as well as regional conservation priority actions with recommendations for collaborative regional action. The resulting regional priorities outlined in the 2017 SWAP Synthesis were further prioritized and refined by NEFWDTC's taxonomic teams and Regional Threat Working Groups to identify top threats and actions, region wide. This Regional Conservation Synthesis presents those collaboratively developed regional priorities as well as the hundreds of projects developed and funded to address these priority needs through the RCN and other programs.

In 2018, AFWA adopted a landscape conservation resolution. In 2020, the AFWA President's Task Force on Shared Science and Landscape Conservation Priorities recommended convening a new working group to develop recommendations on how SWAPs could become even more effective at improving range-wide conservation of SGCN by leading or contributing to national and/or regional landscape conservation priorities. The AFWA SWAP and Landscape Conservation Working Group subsequently prepared the *Leading At-risk Fish and Wildlife Conservation: A Framework to Enhance Landscape-Scale and Cross-Boundary Conservation through Coordinated State Wildlife Action Plans* report in 2021 (AFWA 2021). This report summarizes five Guiding Principles, each with specific Recommended Actions, associated outcomes, and a recommended implementation framework. In addition, a NEAFWA Landscape Committee was established in 2022 to guide the implementation of this report in the Northeast. The NEFWDTC and its SWAP Coordinator subcommittee contribute to this effort monthly as they work together to identify and prioritize projects that facilitate even more robust and strategic collaboration while the 2025 SWAP revisions are being developed. Each of the Chapters of this Regional Conservation Synthesis addresses multiple Recommended Actions, implementing the first four of the five Guiding Principles, and this Regional Conservation Synthesis implements at least 11 of the AFWA Recommended Actions (see *Chapters 4* and *7*).

Several recent grant projects were prioritized and funded to accomplish this in 2022-2023. The **Updating Three Foundational Tools for the 2025 State Wildlife Action Plan Revisions** project funded the development and production of the Northeast Lexicon (Crisfield and NEFWDTC 2022), this Northeast Regional Conservation Synthesis (TCI and NEFWDTC 2023), and the Northeast Habitat Condition Assessment (Anderson et al. 2023). NEFWDTC's SWAP Coordinators subcommittee also secured Wildlife and Sport Fisheries (WSFR) CSWG funding to upgrade and modernize the Northeast SWAP Database. These projects facilitate coordination and provide the 14 Northeast SWAPs with a common terminology, data framework, and a portal to enter and analyze consistent SWAP data. Significant progress enhancing SWAP coordination for the 2025 revisions continues through the work of NEFWDTC and its SWAP Coordinators subcommittee. This legacy of collaboration includes monthly coordination between the 14 states and the RSGCN and RCN prioritization and planning processes. The latter shapes the NEFWDTC's ability to respond to its regional charges through technical services and RCN projects that focus action on the Northeastern highest priority land, water, and seascapes. RCN and key partner projects (see Table 4.1.1 and *Appendix 4A*) enable the states to collaboratively address these emerging and current priorities through mutual investment and consistent, more effective regional implementation.

The regional collaboration and conservation partnerships described in this document can be traced to the creation of the RCN Grant Program. Since 2007, the NEAFWA members (thirteen states and the District of Columbia) have each contributed 4% of their annual federal State Wildlife Grants Program funding to support projects of regional conservation interest. Since its inception, the RCN program has awarded more than $4.7 million to address regional fish and wildlife management challenges and high-priority conservation initiatives. Partners matched these awards for total conservation funding of more than $4 million between 2007 and 2023. Many of the funded projects have produced results that were used as the foundation for successful grant proposals to implement recommendations or further study the species, habitat, or threats identified both in the individual SWAPs and through previous regional syntheses.

In the years ahead, this grant program will continue to support innovative approaches that address conservation priorities across the Northeast states. The RCN Grant Program thus represents a significant regional conservation collaboration success story and serves as a model for the nation, one that is expected to continue as long as the Northeast states provide financial support. In addition, funding is also available for regional collaboration through the competitive portion of the SWG Program administered by the USFWS. This grant program has funded almost 40 projects since 2008 for a total of $18 million with partners matching more than $8 million.

Funding priorities for the Northeast RCN Grant Program continue to evolve and many of the projects funded to date are summarized in this document. The program itself practices adaptive management, refining priorities and selecting topics for funding in response to urgent emerging wildlife needs, while simultaneously addressing longstanding regional conservation concerns and keeping common species common. Specific project priorities addressed during each RCN grant cycle are available at the website, http://www.northeastwildlifediversity.org.

INTENDED AUDIENCES AND USES

This document is a product of the RCN Grant Program (RCN 2- Project GSA-00029) and is intended to serve as a resource for fish and wildlife agencies and their conservation partners during their comprehensive review and revision of Wildlife Action Plans. It is also a resource for other conservation agencies, organizations, and individuals in the Northeast. It further provides a regional conservation context in which each of the Northeast states participates and should therefore be incorporated into local, state, and regional planning efforts.

States are encouraged to use part or all of the text of this document in their Wildlife Action Plan revisions to address the regional context of state-specific concerns. State wildlife agencies and their partners are welcome to copy or reproduce any of the material contained in this document or to incorporate it by reference in their Wildlife Action Plan. They are also welcome and encouraged to use the entire document providing regional context for their Action Plan; or to include or incorporate it as an appendix or by reference (TCI and NEFWDTC 2023).

FURTHER INFORMATION

The NEFWDTC website update (www.northeastwildlifediversity.org) in 2023 allows for web-enabling this Regional Conservation Synthesis, the updated Northeast RSGCN Database, and associated communication tools and products. These tools and resources will be searchable with filters to provide detailed information for specific targets, purposes, or users. In addition, by linking with other NEFWDTC programs, such as the RCN Grants Program, regional information will be integrated into a centralized online platform available to the states, conservation partners, and the public.

Northeast SWAP Website links:

- Connecticut
- D.C.
- Delaware
- Maine
- Maryland
- Massachusetts
- New Hampshire
- New Jersey
- New York
- Pennsylvania - Fish

- Pennsylvania - Game
- Rhode Island
- Vermont
- Virginia
- West Virginia

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CHAPTER 1: REGIONAL SPECIES OF GREATEST CONSERVATION NEED IN THE NORTHEAST

SWAP Element 1

Information on the distribution and abundance of species of wildlife, including low and declining populations, as the State fish and wildlife agency deems appropriate that are indicative of the diversity and health of the State's wildlife.

A. The Strategy indicates sources of information (e.g., literature, databases, agencies, individuals) on wildlife abundance and distribution consulted during the planning process.
B. The Strategy includes information about both abundance and distribution for species in all major groups to the extent that data are available. There are plans for acquiring information about species for which adequate abundance and/or distribution information is unavailable.
C. The Strategy identifies low and declining populations to the extent data are available.
D. All major wildlife groups have been considered or an explanation is provided as to why they were not (e.g., including reference to implemented marine fisheries management plans). The State may indicate whether these groups are to be included in a future Strategy revision.
E. The Strategy describes the process used to select the species in greatest need of conservation. The quantity of information in the Strategy is determined by the State with input from its partners, based on what is available to the State.

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HOW TO USE THIS CHAPTER:

Chapter 1 provides a summary of the overall region, methods, and approach to developing the RSGCN list and presents a summary of the new 2023 list and all the taxonomic groups.

- Section 1.1 describes the purpose and need for RSGCN.
- Section 1.2 discusses the method updates and RSGCN process.
- Section 1.3 describes the RSGCN 2023, each of the 20 taxonomic groups broken-down by SGCN, RSGCN, conservation highlights, RSGCN categories, each with habitats and threats per taxa, and regional conservation work by partners (if applicable).
    - Each RSGCN and Proposed RSGCN were assigned to all suitable habitats and threats, meaning each species, population, or entity can have more than one habitat or threat and are summarized as such. More detailed information on habitats and threats can be found in *Chapter 2* and *Chapter 3*, respectively.
- Section 1.4 of *Chapter 1* has available links to taxon partners, *Chapter 7* describes partners in greater detail.
- This Chapter ends, Section 1.5, with an overall discussion of the RSGCN list and categories, process advancements, and recommendations.
- Appendices for this and all chapters can be found in the Appendices PDF, separate from the chapters. *Chapter 1 Appendix 1A* covers the methods of the RSGCN process in more detail.
- Supplemental Information, such as full species lists for all RSGCN categories and the state breakdown of RSGCN per state, can be found in the Excel workbook with *Supplemental Information 1A-1E* for *Chapter 1*.

1.0 REGIONAL OVERVIEW

1.1 PURPOSE AND BACKGROUND OF IDENTIFYING REGIONAL SPECIES OF GREATEST CONSERVATION NEED

The states of the Northeast region and the District of Columbia have collaborated to prioritize Regional Species of Greatest Conservation Need (RSGCN) for shared conservation and management since 1999. This regional effort aims to maintain a non-regulatory list of RSGCN to provide focus, resources, and collaboration to conserve these species of mutual conservation concern (and their habitats) for current and future generations in the Northeast[1].

Northeast RSGCN species for which the region has stewardship responsibility due to high conservation concerns and/or populations centralized within the Northeast Region. The list includes 20 vertebrate and invertebrate taxa groups of Species of Greatest Conservation Need (SGCN) from State Wildlife Action Plans (SWAPs) in the Northeast Association of Fish and Wildlife Agencies (NEAFWA) planning geography (Maine to Virginia, including the District of Columbia). The list promotes focused action on high-priority Northeast species by the Northeast Fish and Wildlife Diversity Technical Committee (NEFWDTC) in developing SWAPS and conservation planning and implementation by state fish and wildlife agencies and their partners.

NEAFWA's NEFWDTC updates the Regional Species of Greatest Conservation Need list every five years using the following criteria: Regional stewardship responsibility (proportion of the species range in the Northeast region) and Conservation concern status (imperilment). To meet these objectives and fulfill the purposes and goals of RSGCN, the five-year update during 2021-2023 has undergone significant updates in methodology. This report outlines those updates and summarizes the results leading toward greater regional conservation efforts in the Northeast. This 2023 update is the 4th revision of the Regional Species of Greatest Conservation Need List developed by the Northeast Fish and Wildlife Diversity Technical Committee of the Northeast Association of Fish and Wildlife Agencies. The original list was published in 1999 (Therres 1999), and sequential updates in 2013 and 2018 followed (Terwilliger Consulting Inc. 2013, 2018).

RSGCN provides an effective, collaborative conservation focus, which facilitates regional watershed and landscape approaches for fish and wildlife diversity conservation in the Northeast. The current RSGCN list and supportive information on status updates demonstrate how the Northeast continues to lead the RSGCN concept nationally by implementing NEAFWA's conservation planning model through its Regional

Conservation Needs Program and committee charges. This effort informs all Northeast state fish and wildlife agencies, their SWAPs, and partners about these priority species, habitats, threats, and actions. The NEFWDTC then develops and implements research, surveys and monitoring, and conservation on the ground through the Regional Conservation Needs (RCN) program to fund conservation at the regional scale. Additional information can be found in the Northeast RSGCN Database (Terwilliger Consulting Inc. and Northeast Fish and Wildlife Diversity Technical Committee 2023).

To meet these objectives and fulfill the purposes and goals of RSGCN, the 2021-2023 update has undergone significant changes in methodology. The method advancements have come from numerous iterations of this process across multiple regions (Terwilliger Consulting Inc. 2019, 2021), including greater consistency between regions and adding a "Proposed" category to include non-SGCN species. This report outlines these changes and summarizes the results leading towards greater regional conservation efforts and actions herein.

This 4th revision of the RSGCN list resulted in 382 RSGCN. Again, updated method and selection criteria were used to prescreen and evaluate all species known to occur in the NEAFWA region (Table 1.1.1). The update resulted in 17,916 species with predicted ranks across 20 taxonomic groups for which data and expertise existed, then reviewed by experts from the 13 states and the District of Columbia. Almost 200 experts provided knowledge on mammals, birds, reptiles, amphibians, fish (marine, diadromous, and freshwater), crayfish, freshwater mussels, marine invertebrates, terrestrial snails, Odonata (dragonflies and damselflies), Hymenoptera (bumble and solitary bees), Lepidoptera (butterflies, skippers, and moths), fireflies, tiger beetles, mayflies, stoneflies, caddisflies, and fairy, clam, and tadpole shrimp.

Table 1.1.1 Summary of biodiversity across taxonomic groups in the Northeast; includes the 20 taxonomic groups assessed for the RSGCN, showing the number of species from each group and the number of SGCN from each group within the Northeast.

Taxonomic Groups	*Northeast Species*	*Species of Greatest Concern*
Birds	426	284
Mammals	183	107
Amphibians	111	88
Reptiles	115	84
Fish – Fresh	335	213
Fish – Diadromous	28	14
Fish – Marine	661	102
Terrestrial Snails	268	182
Freshwater Bivalves	150	106
Crayfish	78	26

Fairy, Clam, & Tadpole Shrimp	18	5
Dragonflies and Damselflies	255	205
Butterflies and Skippers	224	134
Moths	2422	364
Tiger Beetles	40	35
Fireflies	43	13
Caddisflies	565	40
Mayflies	281	62
Stoneflies	253	67
Bumble Bees	23	17
Solitary Bees	399	131
Marine Invertebrates	465	95
Plants	6084	1785
Other species	4490	632
Total	17916	4788

The goal of the RSGCN list is to secure and restore Regional Species of Greatest Conservation Need (and their habitats) across the region's lands and waters through strategic, collaborative action. This goal is accomplished by maintaining a non-regulatory list of RSGCN to provide focus, resources, and collaboration to conserve these species of mutual conservation concern (and their habitats) for current and future generations in the Northeast. It creates a recognizable regional stewardship responsibility, implements proactive measures to prevent further declines of common species with conservation concerns, and prioritizes imperiled species. The RCN program spotlights species with population or habitat declines or emerging issues for collective conservation actions, fills data gaps, and enhances knowledge of a species' range-wide distribution, imperilment status, threats, and needed actions.

1.2 REGIONAL SPECIES OF GREATEST CONSERVATION NEED (RSGCN) METHODS

1.2.1 DEVELOPMENT OF RSGCN PROCESS IN THE NORTHEAST

HISTORY OF RSGCN METHOD

1980s: Since the 1980s, states have shared lists of species of concern and information about the species to support each other's efforts to protect them.

1999: The NEFWDTC evaluated 106 species and suggested 26 warranted federal listing consideration based on four factors:

- *Risk:* declining populations or high risk of disappearing from the Northeast
- *Data:* lack of data with suspicion of the danger of disappearing from the region

- *Area:* the Northeast comprises a significant portion of the species' global range.
- *Special Cases:* e.g., collecting pressure, taxonomic uncertainty, intensive management needed, etc.

2010: The Northeast Partners in Amphibian and Reptile Conservation (NEPARC) developed a prioritization method based on the State Wildlife Action Plan Species of Greatest Conservation Need and species' ranges.

- *Conservation Need*: the percent of states in the Northeast that identified the species as SGCN in 2005 SWAPs.
- *Regional Responsibility*: the portion of the species' North American range in the Northeast (estimated by taxa experts)

2013: The NEFWDTC worked with the North Atlantic Landscape Conservation Cooperative (LCC) to extend the NEPARC method to all taxa and update the RSGCN list.

2018: State Wildlife Action Plans, revised in 2015, provided the most recent review of Species of Greatest Conservation Need. The NEFWDTC updated the RSGCN list with three objectives:

- *Regional Species of Greatest Conservation Need:* to rank the most imperiled species that our region has responsibility for protecting.
- *Data Deficient:* to identify understudied taxa with potential conservation concern.
- *Stronghold Species:* to identify species that are imperiled outside the Northeast region but have relatively healthy populations in the Northeast.

1.2.2 APPROACH FOR SELECTING RSGCN 2023

Phase 1 of updating the RSGCN list involves the evaluation and refinement of the method. This revision benefits from both the Southeast (Rice et al. 2019) and Midwest (Terwilliger et al. 2021) applications of the original Northeast process (1990-2018), just as the other regions have benefited from the iterations in the Northeast. Each application has resulted in advancements in thinking and data processing efficiencies available to the Northeast for this current list update process.

TCI assembled and coordinated an RSGCN Method Team to refine and update the method. An Invertebrate Overview Team was formed to determine which new taxonomic groups could be added for evaluation. These teams comprised NEFWDTC, SWAP Coordinators, or Taxonomic Team members who worked on previous RSGCN list updates and several new state representatives. TCI reported progress to the NEFWDTC monthly. A survey was sent to states for input in improving the method.

Appendix 1A depicts the RSGCN selection criteria, filters, and processes used in the 2023 update. Differences and advancements are listed that compare the original

Northeast and updated methods. Taxonomic experts estimated regional responsibility and determined conservation needs based on biological population status and trend assessments.

Phase 2 of the RSGCN selection process focused on compiling and reviewing data from the 14 NEAFWA SWAPs and other sources to categorize candidate RSGCN based on agreed-upon criteria (*Appendix 1A*). TCI pre-screened the available data and prepared draft taxa lists for taxonomic team review. Once quality assurance and quality control (QA/QC) was complete, TCI applied the selection criteria to produce a species list in four categories: Likely RSGCN, Maybe RSGCN, Not Likely RSGCN, and Unknown RSGCN. This prescreening effort helped to organize and prepare the data for more efficient review by taxa experts.

Phase 3 included assembling an updated list of regional taxonomic experts. TCI coordinated the participation of almost 200 taxonomic experts from all 20 taxa groups to participate in the RSGCN selection process using the compiled and analyzed data. TCI facilitated the taxa teams' reviews for RSGCN selection. Each state selected a representative to serve on the review team for each taxonomic group. Every effort was made to include biologists with field experience covering the entire region, especially for invertebrate groups. TCI facilitated three rounds of webinars for selecting RSGCN by each taxa team and to capture and confirm species status information as well as habitat, limiting factors, threats, and actions for all species possible during this period.

The 2023 methodological advancements, informed by the RSGCN projects in the Southeast and Midwest, include new categories to more comprehensively capture species' conservation needs (see *Appendix 1A*). Three Watchlist categories were added, consistent with the Midwest RSGCN list: Watchlist [Assessment Priority], Watchlist [Interdependent Species], and Watchlist [Defer to an adjacent region]. The Watchlist [Assessment Priority] species category updates the previous Data Deficient classification. The new Watchlist [Interdependent Species] allows for including species on which an RSGCN depends but does not meet selection criteria to be independently identified as RSGCN. The new Watchlist [Defer to an adjacent region] allows RSGCN of low regional responsibility (i.e., less than 25%) but of conservation concern in the Northeast to be deferred to adjacent regions that now have their RSGCN lists. All fish and wildlife species known to occur in the Northeast were pre-screened for potential identification as RSGCN or Watchlist species. Species not currently identified in a Northeast SWAP as an SGCN but that the taxa teams identified as meeting selection criteria are now recognized as Proposed RSGCN or Proposed Watchlist species until a SWAP identifies them as SGCN.

The draft list was compiled and sent for review to the taxa teams, NEFWDTC, and NEAFWA. With the updated and expanded RSGCN list for the Northeast, the Northeast RSGCN Database was developed (Terwilliger Consulting Inc., and Northeast Fish and Wildlife Diversity Technical Committee. 2023). The updated Northeast RSGCN Database includes more than 500 data fields on the species status, distribution, habitats, threats, limiting factors, management needs, monitoring protocols, and research needs. TCI pre-populated the database with as much publicly available information as possible from publishes sources. Taxa teams also were asked to confirm state-level data in the database for each species, including data fields on S-Ranks, state listing status, whether the species is an SGCN in their state, and whether the species occurs in their state.

Phase 4 of the project finalized the RSGCN list, their habitats, and their limiting factors following the additional coordination with the taxa teams and NEFWDTC before submission to the NEAFWA Administrators and Directors for final approval. Analysis and supportive data with QA/QC, research, and reporting of the results completed the process. The data collected and managed during the RSGCN process represent a living database with multiple tables structured for the NEFWDTC to inform conservation actions regionally across NEAFWA. TCI evaluated options for products and platforms to maximize the utility and accessibility of the RSGCN list and its associated data, presenting them for consideration by the NEFWDTC in September 2022.

1.2.3 KEY DIFFERENCES/ADVANCEMENTS FOR THE 2023 RSGCN UPDATE:

- The pre-screening process begins with all species in the Northeast, not just SGCN.
- **Regional Responsibility**, the proportion of the species' North American or North Atlantic range overlapping the NEAFWA region (including the Canadian Provinces of Ontario, Quebec, New Brunswick, Nova Scotia, Newfoundland, Labrador, and Prince Edward Island), calculations were refined.
- **Concern Level**, which indicates the level of conservation status and needs in the region, are Very High, High, and Moderate.
- The formalization of **Regional Responsibility Overriding Factors (ROF)** and **Concern Overriding Factors (COF)**. The taxa teams identified ROF and COF to document the reasons for placing a species as RSGCN to clarify RSGCN status when it does not otherwise meet the Regional Responsibility or Concern selection criteria.
- Regional Responsibility Overriding Factors include:
    - ***Core Population***: Species found over a very large geographic area, but the strongest populations are in the NEAFWA region.

- *Climate Change Range Shift*: Species where predicted range shifts due to climate change would make the species a higher regional responsibility in the future.
- *Migratory Species*: Species where the overall geographic range does not meet the 50% threshold for regional responsibility, but specific seasonal ranges do. Migratory species may be included as RSGCN if:
  - ⩾ 50% of the breeding range occurs in the Northeast (the NEAFWA region, including Canadian Provinces)
  - ⩾ 50% of the migratory stopover habitat occurs in the Northeast
  - ⩾ 50% of the wintering habitat occurs in the Northeast
- *Highly Imperiled*: The species is highly imperiled throughout its range and is of high conservation concern in every region in which it occurs.
- *Disjunct Population:* Species has a disjunct population that may contribute to genetic diversity or the three R's (resiliency, redundancy, or representation) when conducting species status assessments.
- *Stewardship Priority:* The region has a significant stewardship responsibility for managing, restoring, or recovering the species.

- Concern Overriding Factors include:
  - *Emerging:* Species where conservation statuses are likely to change quickly due to a new or widespread threat, such as disease or a shift in market forces driving harvest or collection.
  - *Climate Vulnerability*: Species where Concern Levels are expected to increase in the coming decades due to climate change.
  - *Keystone Species*: Species that many other species rely on for their sustained presence.
  - *Stronghold Species*: Species for which the Northeast supports the strongest populations and are imperiled outside of the region.
  - *Genetic Distinctiveness*: Species or other taxonomic levels with unique genetics, such as isolated populations, DPS, subspecies, uncertain taxonomy, etc.
  - *Cultural Values*: Species with historical significance or strong values to Indigenous peoples may be included as RSGCN in recognition of the importance of maintaining secure populations.
- Vertebrate and invertebrate taxa are screened with the same selection criteria.
- The Federal listing status criteria have expanded to include Candidate species and Endangered, Threatened, or Proposed.
- The S-Rank filter is now a regional average of all the states with an S-Rank for that species. However, an average regional S-Rank of less than S2 remains a filter.

- A new filter of State Protected Status is now included for species prescreened as Maybe RSGCN.
- In the 2017/18 review, species that were included based on established taxonomic-specific assessments have been formalized in the ROF (all) and COF (all).
- An RSGCN Watchlist was added for species that are of concern to the taxa teams but for which:
    - The species are data deficient, have uncertain taxonomy, or are showing varying trends in different parts of the region, prioritizing them for additional survey or research efforts = **Watchlist [Assessment Priority]**
    - The species is interdependent with an RSGCN but does not qualify as RSGCN on its own = **Watchlist [Interdependent Species]**
    - The region has low regional responsibility but high concern = **Watchlist [Deferral to adjacent region]**
- Species not currently identified as SGCN by at least one state in the region may now be considered **Proposed RSGCN** or **Proposed Watchlist** species.

Taxa teams remain the definitive authority on reviewing, confirming, or revising prescreened RSGCN recommendations, identifying Overriding Factor(s), determining RSGCN Concern Levels and Regional Responsibility, and recommending species for the Watchlist. Terwilliger Consulting Inc. coordinates their review and consensus process as part of the RCN Technical Services RCN project to the NEFWDTC. For more information on the methods and selection process, see *Appendix 1A*.

1.3 RSGCN 2023

Of 17,916 Northeast species, 7,270 were evaluated and prescreened using the NEAFWA RSGCN selection criteria and fell within the 20 Taxonomic Teams. The 2015 State Wildlife Action Plans list almost 27% (4,788 species) of these species as SGCN in the Northeast (Table 1.3.1). Of these SGCN, approximately 693 invertebrates from other taxonomic groups and 230 plants were beyond the scope of this assessment due to data deficiency, lack of current expertise across the entire taxon regionally, or scope of jurisdiction. Species that regularly occur in the region are included, and many invertebrate taxa are under review and therefore omitted from this analysis. The invertebrate list is incomplete, but because the RSGCN process continues to evaluate them, an increase from only two major invertebrate groups reviewed for 2018 increased to 13 invertebrate taxonomic groups through the 2023 RSGCN process and included in this analysis. Twenty Taxonomic Teams identified 382 RSGCN, 37 Proposed RSGCN (*Supplemental Information 1A*), 229 Watchlist Assessment Priority, and 62 Proposed Watchlist Assessment Priority (*Supplemental Information 1B*). Results are presented by category below in this order. Of the total Northeast species considered for the RSGCN list, 5% warranted regional conservation needs and were assigned to one of the RSGCN list categories (Figure 1.3.1, Table 1.3.1). The large number of species included in these lists reflects the magnitude of the threats facing fish and wildlife species in the Northeast, as well as the commendable efforts of the individual Northeast states to ensure that their State Wildlife Action Plans were comprehensive in their coverage of species in major taxonomic groups.

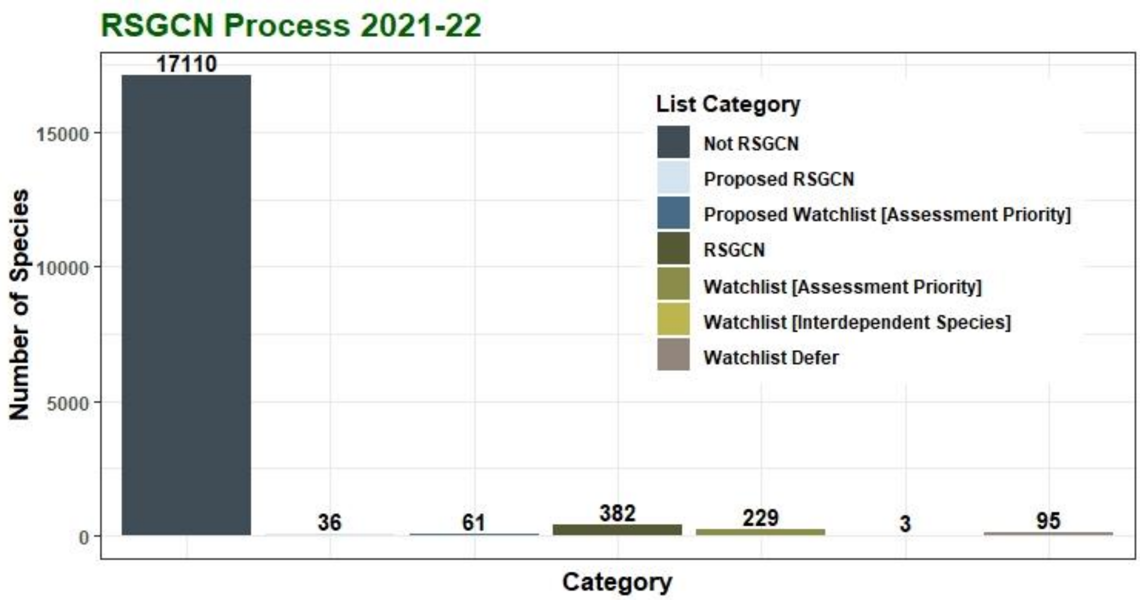


Figure 1.3.1 Number of Northeast species (17,916 total species) evaluated; includes the 20 taxonomic groups assessed for the 2023 RSGCN update.

The percentage of vertebrate species identified as SGCN in one or more of the Northeast State Wildlife Action Plans approaches 48% of the total number of vertebrate species in the Northeast (Table 1.3.1). For Invertebrates, Northeast states identified 39% of invertebrate species as SGCN in State Wildlife Action Plans. Major taxonomic groups with the highest percentage of RSGCN in the Northeast include Freshwater Fish (12%), Birds (9%), and Terrestrial Snails (7%). Of the 806 total RSGCN analyzed in Table 1.3.1, approximately 53% have high Regional Responsibility (>50% of their range occurs in the Northeast), and 50% have High or Very High regional concern.

Table 1.3.1 Number of total Northeast species, SGCN, and RSGCN (with categories); includes the 20 taxonomic groups assessed for the RSGCN.

	Northeast Species	*SGCN*	*RSGCN (incl. Proposed)*	*Assessment Priority (incl. Proposed)*	*Defer*	*Interdependent*	*All RSGCN/WL Categories*
Birds	426	284	28	30	12	0	70

Mammals	183	107	29	15	5	0	49
Amphibians	111	88	22	6	2	0	30
Reptiles	115	84	16	8	1	0	25
Fish – Fresh	335	213	47	34	16	0	97
Fish – Diadromous	28	14	9	2	0	0	11
Fish – Marine	661	102	27	12	3	2	44
Terrestrial Snails	268	182	32	24	4	0	60
Freshwater Bivalves	150	106	21	2	13	0	36
Crayfish	78	26	12	17	0	0	29
Fairy, Clam, & Tadpole Shrimp	18	5	3	2	0	0	5
Dragonflies and Damselflies	255	205	22	20	7	0	49
Butterflies and Skippers	224	134	26	12	5	0	43
Moths	2422	364	29	32	6	0	67
Tiger Beetles	40	35	8	4	1	0	13
Fireflies	43	13	13	6	0	0	19
Caddisflies	565	40	15	9	1	0	25
Mayflies	281	62	16	20	9	0	45
Stoneflies	253	67	31	2	0	0	33
Bumble Bees	23	17	3	3	4	0	10
Solitary Bees	399	131	5	21	6	1	33
Marine Invertebrates	465	95	4	9	0	0	13
Plants	6084	1785	n/a	n/a	n/a	n/a	n/a
Other species	4490	632	n/a	n/a	n/a	n/a	n/a
Total	17916	4788	418	290	95	3	806

RSGCN status categories total 806 species, with 47% (382) of those meeting the criteria for RSGCN or Watchlist status (Figure 1.3.2). The two Proposed categories represent 12% (97) of the 806 species not currently listed as SGCN in any Northeast SWAP. However, because they meet the other RSGCN or Watchlist criteria and often contain species whose taxonomy is new or updated, they will help inform the upcoming 2025 SWAP SGCN selection as species with regional concern. For example, the new RSGCN Watchlist [Assessment Priority] category contains 28% (229) of listed species highlighting species with data deficiencies, taxonomic uncertainties, or variable trends within the region. Three meet RSGCN Watchlist [Interdependent Species] criteria (*Supplemental Information 1C*), and 95 additional species are deferred to other regions for primary stewardship in the core of their range (*Supplemental Information 1D*).

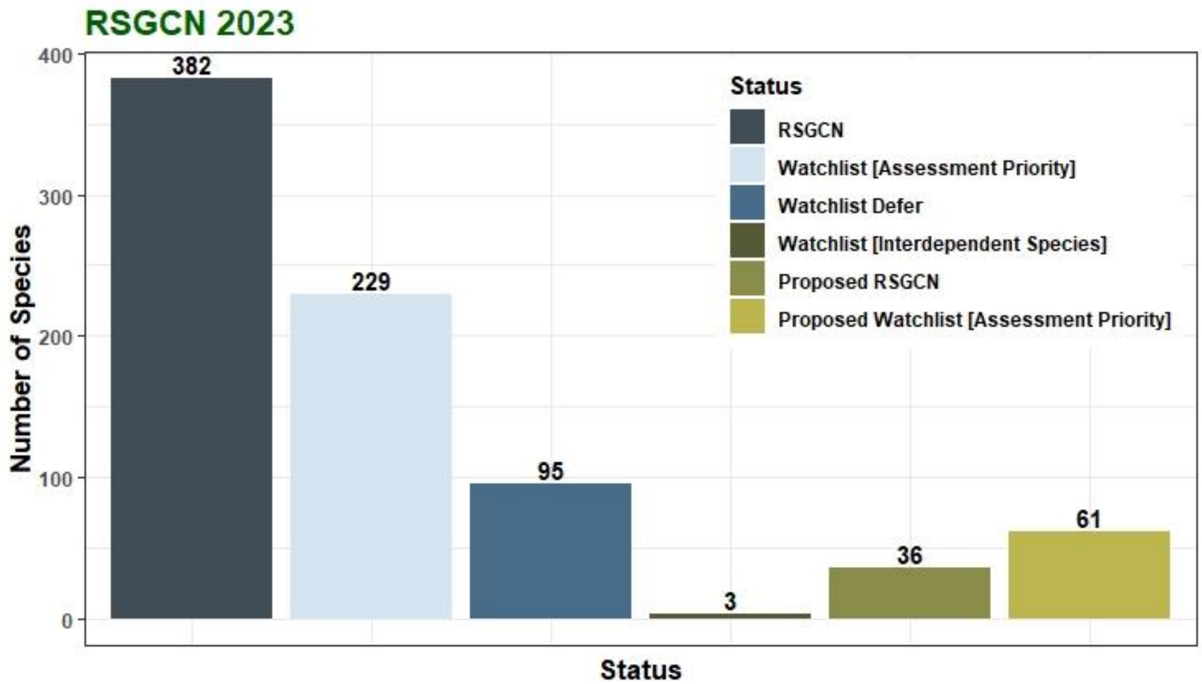


Figure 1.3.2 Number of species (806) in each 2023 RSGCN category.

RSGCN CATEGORIES: 382 RSGCN AND 36 PROPOSED RSGCN

RSGCN

382 SGCN met the regional responsibility and conservation concern criteria for RSGCN (Figure 1.3.2*; Supplemental Information 1A*). Lepidoptera (Butterflies, Skippers, and Moths) represents the largest taxonomic group of RSGCN evaluated, followed closely by freshwater fish (Figure 1.3.3). 56% of RSGCN are invertebrates (Figure 1.3.3, green), while the remaining 44% are vertebrates (Figure 1.3.3, purple).

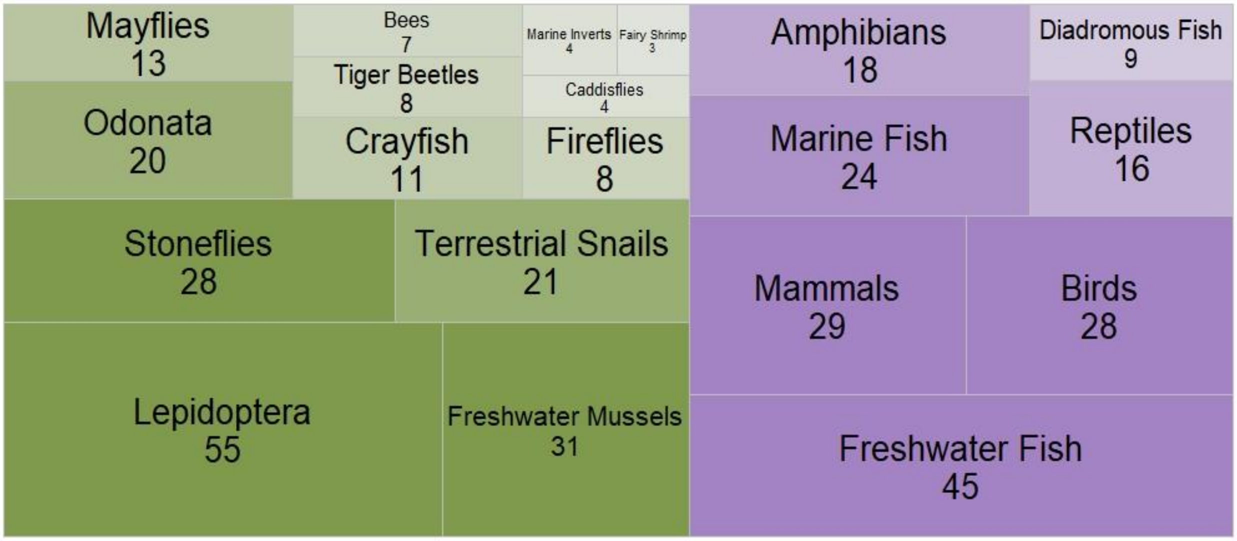


Figure 1.3.3 Number of RSGCN (382) by taxa, in each of the 20 taxa evaluated in the Northeast RSGCN list update.

PROPOSED RSGCN

Thirty-six (36) species met the regional responsibility and conservation concern criteria for RSGCN (not yet listed as SGCN in any Northeast SWAP). This Proposed RSGCN category often contains newly described species, those with recent taxonomy changes since the 2015 SWAPs, or taxonomic groups not comprehensively reviewed in all SWAPs (Figure 1.3.4). Caddisflies are the largest taxonomic group of Proposed RSGCN, outweighing all the vertebrates. Fireflies and amphibians are the next largest, with the other taxa groups containing a few species at most (Figure 1.3.4). Seventy-five percent of Proposed RSGCN are invertebrates (Figure 1.3.4, green), while the remaining 25% are vertebrates (Figure 1.3.4, purple).

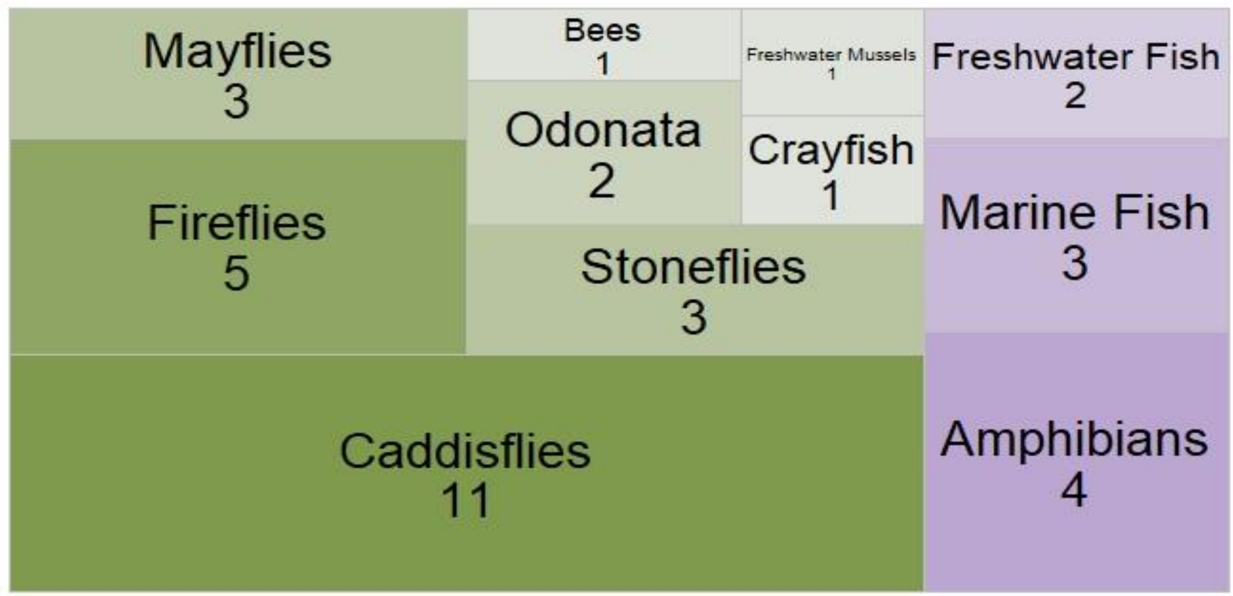


Figure 1.3.4 Number of Proposed RSGCN (36) by taxa (20 total taxa evaluated in the Northeast RSGCN update).

CONCERN LEVEL RESULT HIGHLIGHTS

RSGCN were categorized by Very High, High, and Moderate conservation Concern Levels (*Supplemental Information 1A*). **Of the 382 RSGCN, 37% are Very High** (121) regional concern by taxa team experts. Freshwater mussels and freshwater fish were assigned the most species (18 and 16 respectively) as Very High concern (Figure 1.3.5). **High** concern contained the most RSGCN with 44% (167), and species and Lepidoptera listed the greatest number of species (29, Figure 1.3.5). **Moderate** conservation concern contains the remaining 25% (94) of RSGCN (Figure 1.3.5).

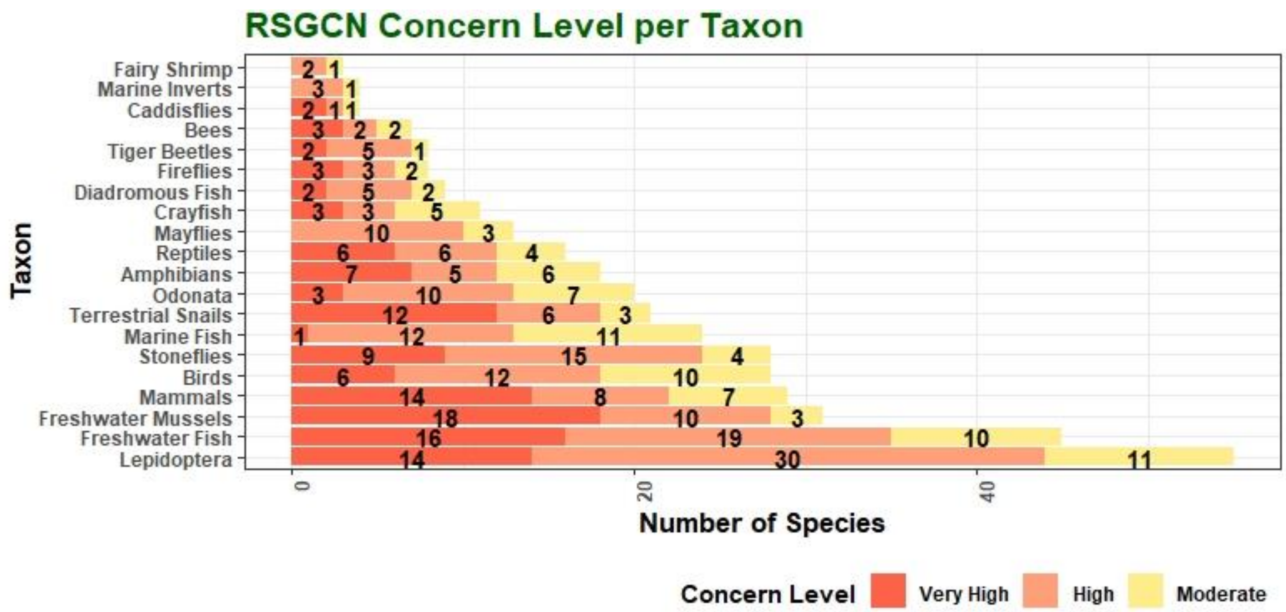


Figure 1.3.5 Number of RSGCN by conservation Concern Level in each taxon.

The percent of species listed in each Concern Level group within each taxon varies across taxa. For example, Marine Fish and Crayfish list the highest percentage of species as Moderate concern. At the same time, Terrestrial Snails and Freshwater Mussels are assigned the highest percentage of species at the Very High Concern Level within their taxa (Figure 1.3.6).

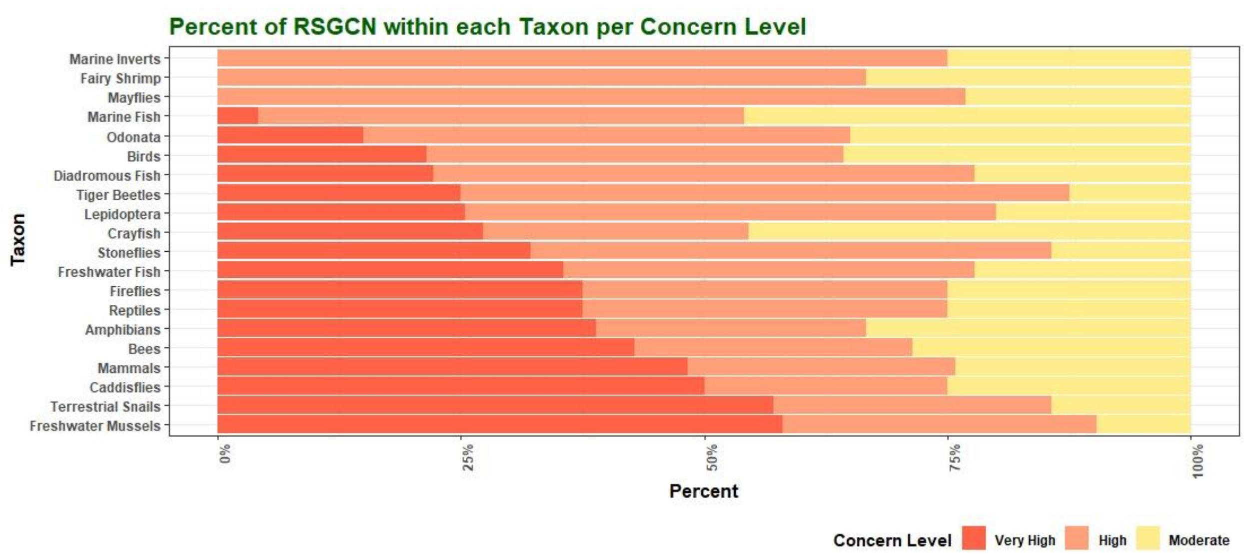


Figure 1.3.6 Percent of Concern Level status within each Northeast RSGCN taxon.

REGIONAL RESPONSIBILITY RESULTS HIGHLIGHTS

Regional responsibility varies across RSGCN taxa groups. Nine of the 20 taxa groups contain all categories of regional responsibility (Figure 1.3.7, Figure 1.3.8). Sixteen of 20 taxa groups include endemic species. For example, Stoneflies list 16 species as endemic, Terrestrial Snails list 15, and Freshwater Fish list 15 (Figure 1.3.7).

REGIONAL RESPONSIBILITY AND NORTHEAST ENDEMIC SPECIES

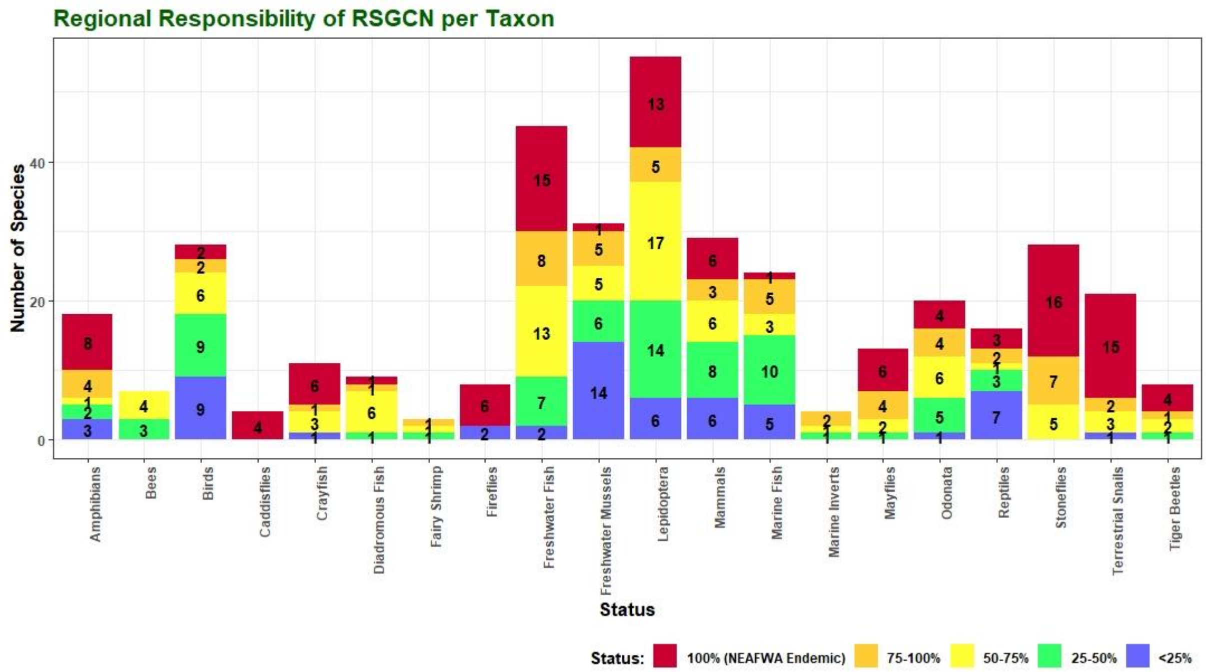


Figure 1.3.7 Regional responsibility levels of RSGCN by taxa. Endemic species are shown in red.

Six taxa (Caddisflies, Crayfish, Fireflies, Stoneflies, Terrestrial Snails, and Tiger Beetles) list 50% or more of their RSGCN as endemic to the NEAFWA region (Figure 1.3.8). In addition, there are four taxonomic groups, mostly migratory, with disproportionately high proportions of RSGCN species below 50% Regional Responsibility that required identification of Regional Responsibility Overriding Factor(s) (Birds=18, Freshwater Mussels =20, Marine Fish =15, Reptiles =10; Figure 1.8). Overriding factors within each taxonomic group allow for the inclusion of low Regional Responsibility species as RSGCN, including:

- **Birds**: Highly Imperiled (9), Stewardship Priority (8), Core Population (6), Migratory Species (5).
- **Freshwater Mussels**: Highly Imperiled (16), Core Population (7), Stewardship Priority (4).
- **Marine Fish**: Migratory Species (11).
- **Reptiles**: Highly Imperiled (7), Migratory Species (4), Disjunct (3).

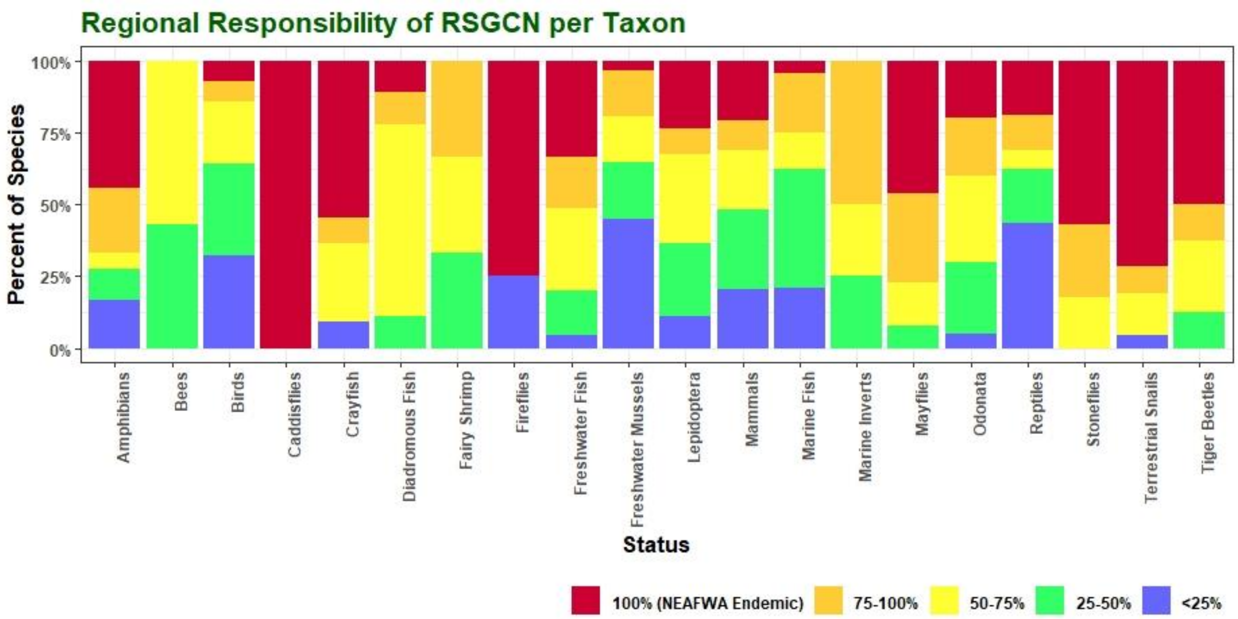


Figure 1.3.8 Percent Regional Responsibility for RSGCN by taxa. Endemics in red.

NEAFWA ENDEMIC RSGCN

There are 109 endemic RSGCN in the Northeast representing 16 of the 20 taxa groups. Of those, 49 RSGCN species have a Very High Concern Level (Figure 1.3.9). Eighteen of these Very High concern RSGCN endemics occur in more than one state within the region, while 30 species are single-state endemics. Virginia has the highest number of single-state endemics.

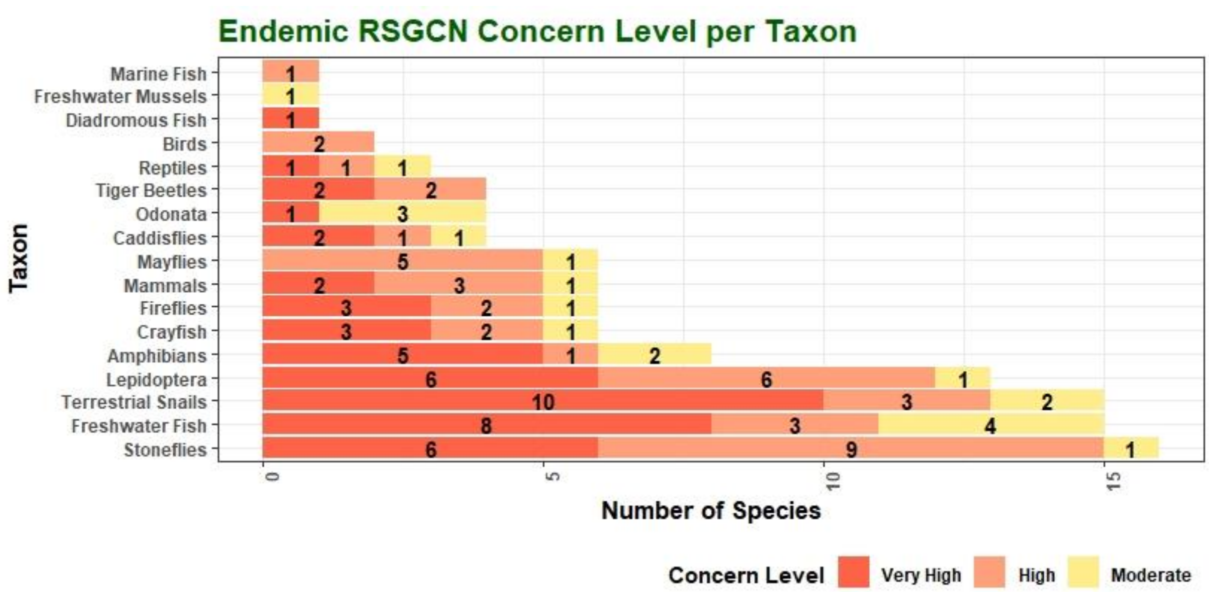


Figure 1.3.9 Number of endemic RSGCN by taxa with Concern Levels in the Northeast.

DATA GAP ANALYSIS HIGHLIGHTS

The available information on life history, habitat, vulnerability, and threats in the Northeast RSGCN Database varied widely across 20 different RSGCN taxa (Terwilliger Consulting Inc. and Northeast Fish and Wildlife Diversity Technical Committee 2023). A pre-population effort using publicly available information (before taxa team review and confirmation) resulted in substantive data on seasonal activity and habitat associations for inclusion in the database. At least one habitat group and one habitat type were associated with nearly all but a few species. The database contains much less data for invertebrate groups than vertebrates, reflecting the lack of information found or available for these less-studied taxa. The analysis indicated that more data gaps exist for species behavior, ecology, threats, monitoring and research needs, and data fields (Figure 1.3.10). The gap analysis currently represents data in the database, not the scientific literature available, but the trend is similar. A full literature search on the Web of Science on all the RSGCN species showed comparative results. Additional strategic data gaps can continue to be filled, and NEFWDTC priorities and recommendations will be implemented as part of the Technical Services RCN 3.0 project. A Technical Services RCN 2.0 project supplemented filling database gaps for priority taxa. This additional work added significant data to the RSGCN Database by focusing on data-deficient species, targeting Hymenoptera (Bumble and Solitary Bees) and Lepidoptera (Butterflies, Skippers, and Moths, Figure).

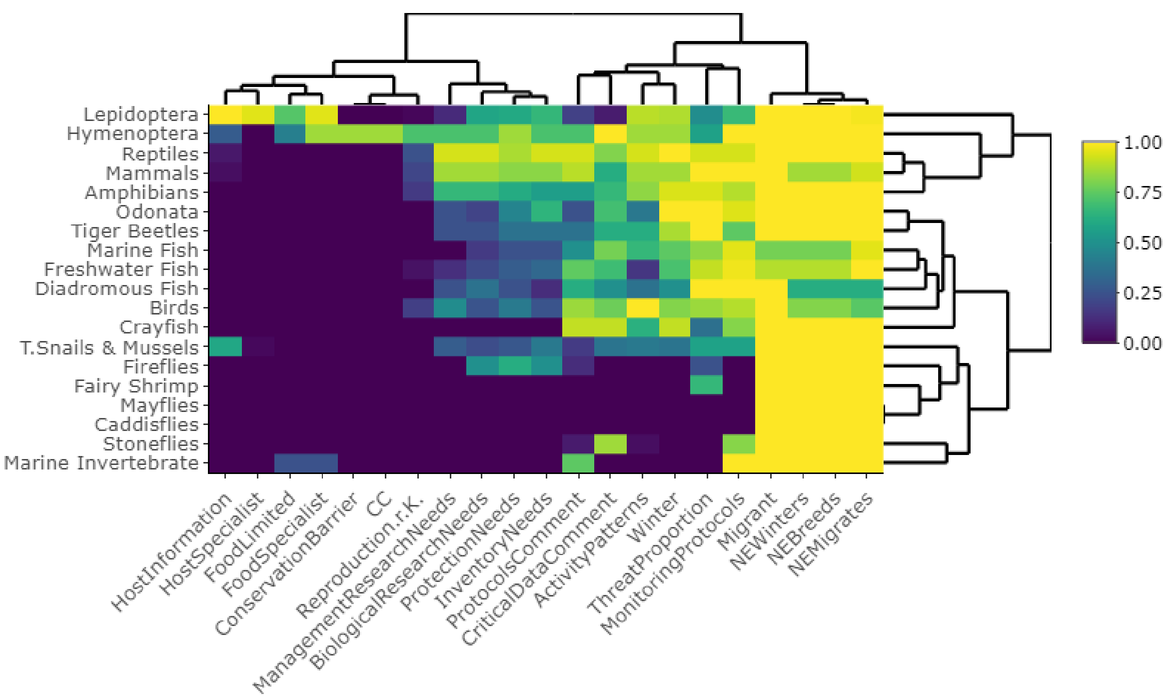


Figure 1.3.10 Proportion (1 = 100% of data known, 0 = 0% data known) of data categories by taxa in the RSGCN Database shown from least known to most known (left to right), highlighting data gaps. Branches on the top and left show similarities between known information.

STATE AND REGIONAL OPPORTUNITIES

States can use shared geographic responsibility to set priorities for RSGCN conservation across the Northeast. Conservation corridors and multi-state habitat protection can expand regional efforts. Virginia supports the highest number of RSGCN of any state, partially due to the number of endemics in the state, its diverse habitats, and its geographic location between the Northeast and Southeast regions. Exploring the number of RSGCN by state area shows opportunities for collaboration where states with the smaller spatial area still have large numbers of RSGCN (Figure 1.3.11). As climate impacts increase, RSGCN considerations help inform a regional approach to climate adaptation strategies as species ranges and habitats shift.

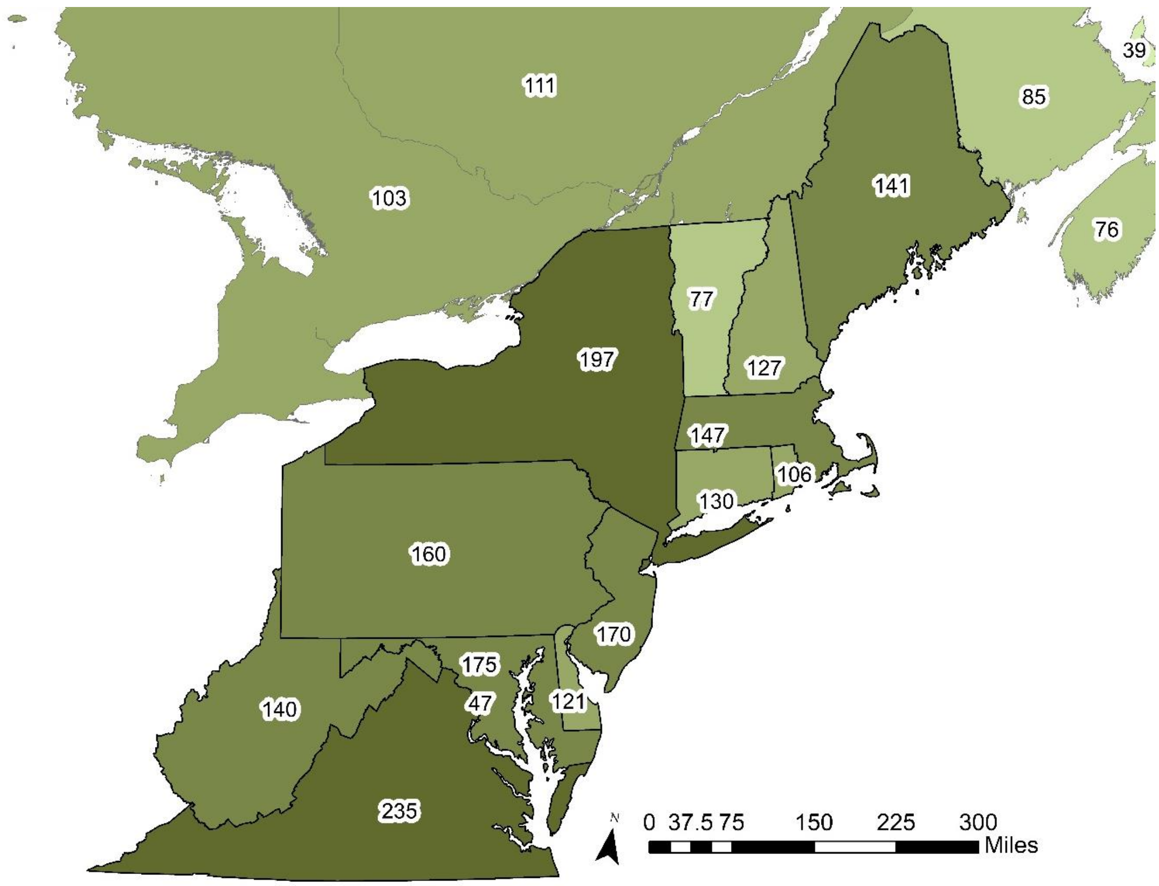


Figure 1.3.11 Map showing NEAFWA States with the number of RSGCN species occurring in each state; darker colors indicate more RSGCN species per state, while lighter colors represent fewer RSGCN species. See *Supplemental Information 1E* for state breakdowns of all RSGCN categories.

2023 RSGCN CHANGES AND OPPORTUNITIES

This fourth iteration of the RSGCN list included more species than the 2013 and 2018 lists. (Figure1.3.12). In 2013, almost 350 species within only nine taxonomic groups met RSGCN qualifications for regional conservation concerns. By 2018 358 species within 14 taxonomic groups were placed on the RSGCN list (Figure1.3.12). This 2023 RSGCN list contains 382 species from 20 taxonomic groups (Figure1.3.12). The increase in RSGCN species reflects the refinement of the process explained in Section 1.2.2 and *Appendix 1A*, especially the inclusion of additional taxonomic groups and the inclusion of non-SGCN species as proposed. Including more taxa groups was possible as additional expertise and data are available in each RSGCN list revision and update. Improvements to the process including improved standardized pre-screening efforts, can also explain changes within taxa groups totals.

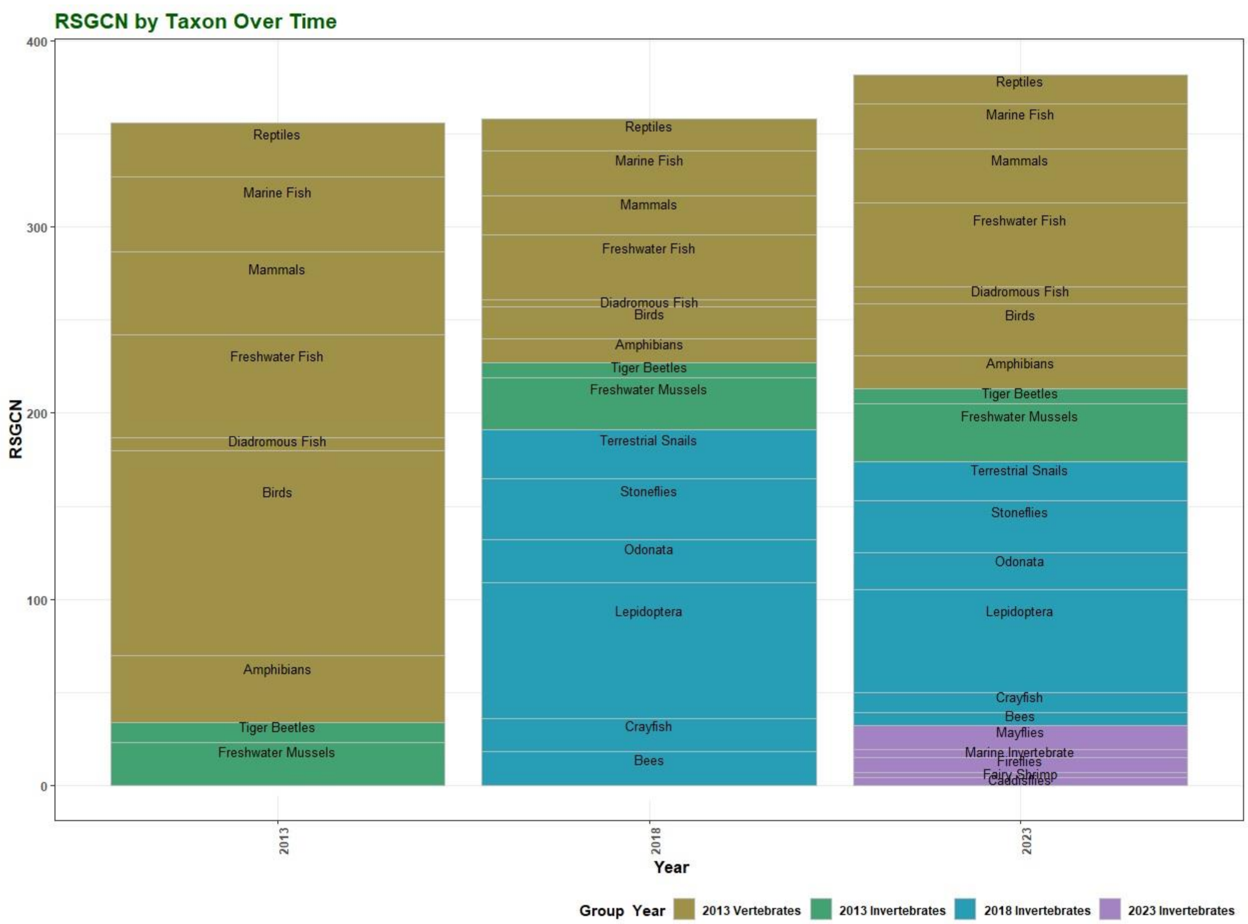


Figure1.3.12 Comparison of the number of RSGCN in the 2013, 2018, and 2023 list revisions by taxa.

The status of some RSGCN changed while remaining on the list (Figure 1.3.13). More than half of the RSGCN did not change status with this five-year update, but 39 RSGCN had a conservation concern decrease, while 22 had a concern increase. In addition, 126 RSGCN species were added to the list; the remaining additions reflect the new categories (Figure 1.3.13). The three fish taxa groups (diadromous, freshwater, and marine) showed the most increase (30%), but proportionally that increase is lower than other taxon groups. Ephemeroptera (Mayflies), Trichoptera (Caddisflies), Fireflies, Marine Invertebrates, and Fairy, Clam, and Tadpole Shrimp are newly added invertebrate taxonomic groups and do not show concern increases or decreases. Stonefly RSGCN were not updated in 2023 and are pending the ongoing RCN 3.0 project results. Sixty-four former RSGCN taxa from 2018 had status changes from RSGCN to conduct a regional assessment of the taxonomic group Watchlist species.

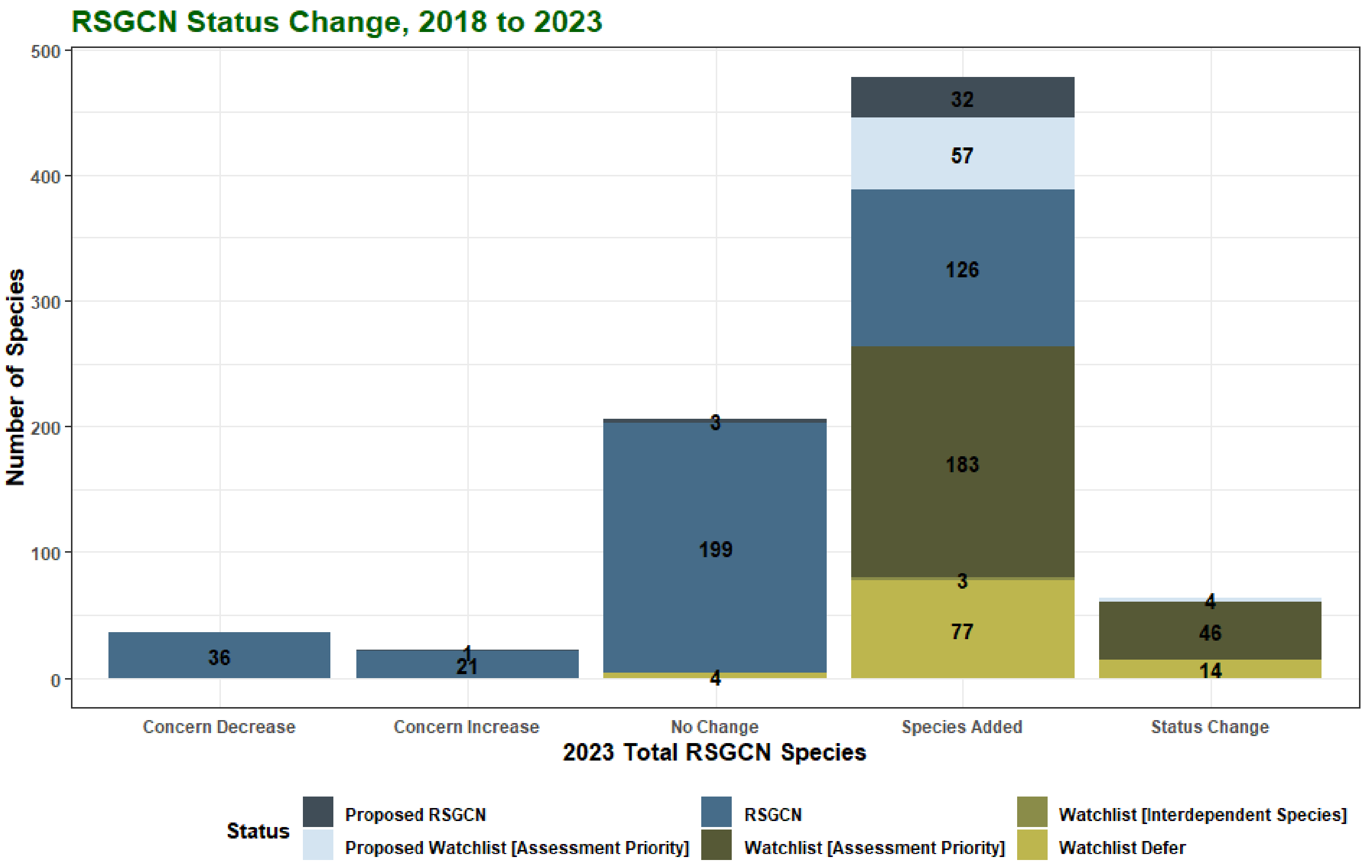


Figure 1.3.13 Status changes between the 2018 and the 2023 RSGCN lists grouped by the 2023 RSGCN category.

ADDITIONAL SPECIES CONSIDERED – NEW RSGCN WATCHLISTS

RSGCN WATCHLIST [ASSESSMENT PRIORITY]

229 species were identified as RSGCN Watchlist [Assessment Priority] (Figure 1.3.14)**.** Just under half (43%) of the RSGCN Watchlist [Assessment Priority] species are vertebrates, with the remaining 57% representing invertebrates. Twenty-five Watchlist [Assessment Priority] species are endemic to the NEAFWA region. This category, new to the Northeast region, incorporates RSGCN, previously identified as Data Deficient in 2018, which remain priorities for regional surveying efforts. In some cases, the taxa teams identified regional differences in species status and trends. Other species were data deficient, but enough concern or known declines were noted to warrant inclusion as a Watchlist species. Current taxonomic uncertainties or reclassifications were ongoing for other species, which precluded taxa experts' ability to assess the status or distribution of these taxa. These species should be a priority for assessment efforts to collect additional data to document status, trends, and threats across the region.

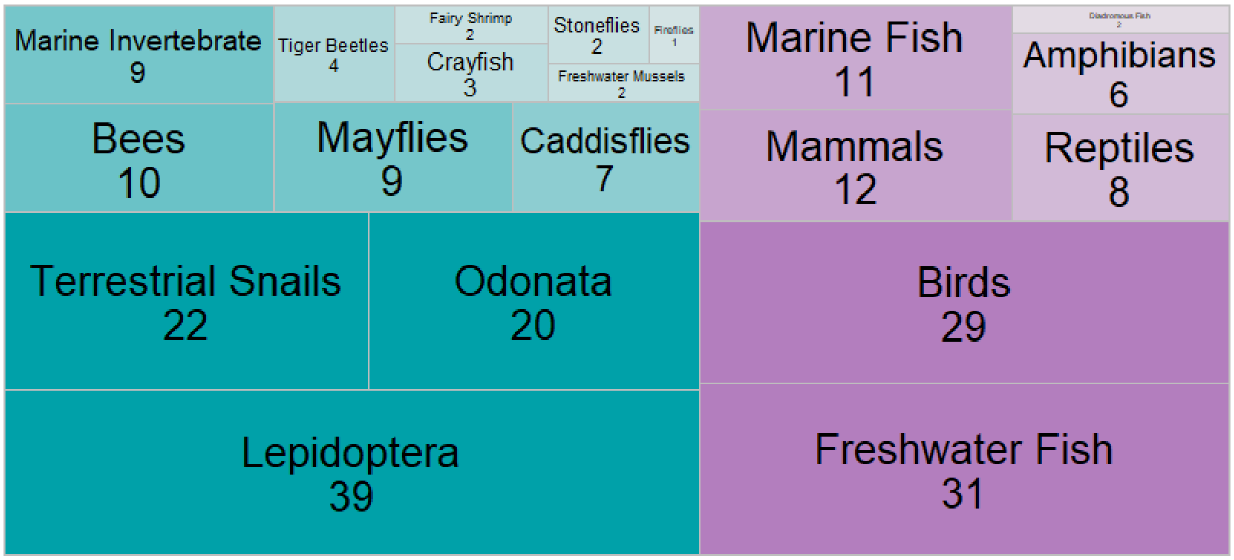


Figure 1.3.14 Number of 2023 RSGCN Watchlist Assessment Priority species by taxa.

PROPOSED RSGCN WATCHLIST [ASSESSMENT PRIORITY]

62 species were identified as Proposed RSGCN Watchlist [Assessment Priority] (Figure 1.3.15). Vertebrates represent less than a quarter (13%) of the Proposed RSGCN Watchlist [Assessment Priority] species. Invertebrates comprise the majority of Proposed RSGCN Watchlist [Assessment Priority] species at 54 (87%), with over half being Lepidoptera. Vertebrate taxa are better vetted as SGCN than invertebrates leading to the discrepancy; only 159 invertebrates are SGCN in seven or more (>50%) states across the Northeast. This category greatly informs coordinated regional inclusivity of invertebrates when updating the 2025 SGCN lists.

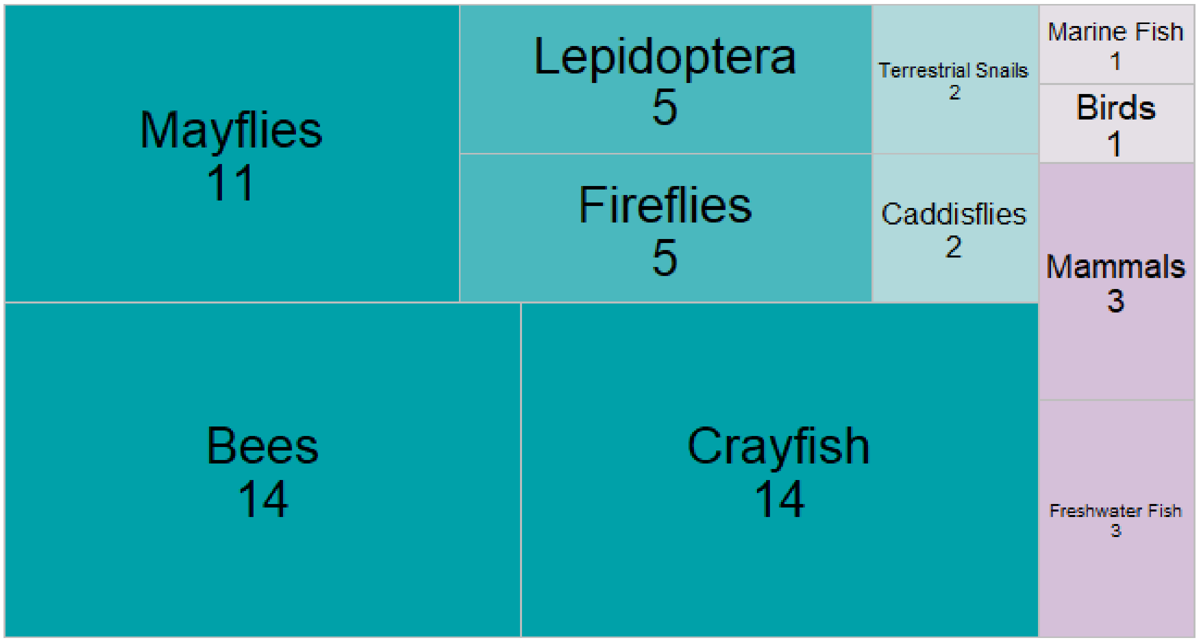


Figure 1.3.15 Number of 2023 Proposed RSGCN Watchlist Assessment Priority by taxa.

RSGCN WATCHLIST [INTERDEPENDENT SPECIES]

Two marine fish and one solitary bee are **Watchlist [Interdependent Species]** in the Northeast, meaning they are interdependent with another RSGCN but do not meet the criteria for RSGCN status on their own. *Ammodytes americanus* (American Sand Lance), *Ammodytes dubius* (Northern Sand Lance), and Melitta melittoides occur in six, three, and two states within the Northeast. Both sand lance species are considered important forage species for many marine species and several RSGCN, including the Northern Right Whale (*Eubalaena glacialis*) and at least 15 other species. The melittid bee is interdependent with a Watchlist Assessment Priority cuckoo bee species, *Nomada rodecki*. It was considered by the taxa team as an important parasitic species to highlight for conservation and can be used to umbrella additional similarly threatened bee species.

RSGCN WATCHLIST [DEFERRAL TO ADJACENT REGION(S)]

Ninety-five (95) species were of enough concern to the taxa experts to warrant conservation need but occurred only on the periphery of the Northeast region and therefore deferred to the adjacent region(s) for primary stewardship and conservation (Figure 1.3.16). This means that Northeast states where each occurs will continue their conservation efforts but signifies that the Northeast acknowledges that its actions do not affect the majority of the species range and population status. Six deferral categories span four Association of Fish and Wildlife Agencies (AFWA) regions, with some combined (Figure 1.3.17). Most RSGCN Watchlist [Deferral] species were deferred to the

Southeast due to the overlap in species ranges in Virginia and West Virginia. The Midwest deferrals represent the second largest number of species, followed by deferrals to Canada and the West (Figure 1.3.17).

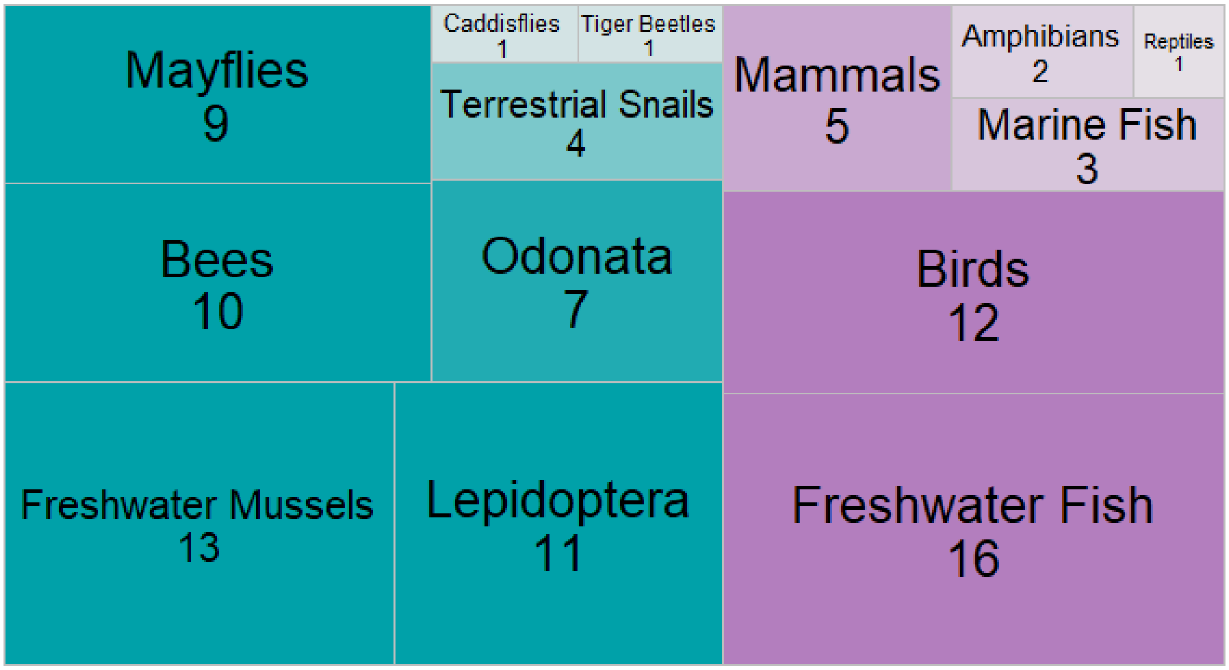


Figure 1.3.16 The number of Watchlist [Deferral] species by taxa.

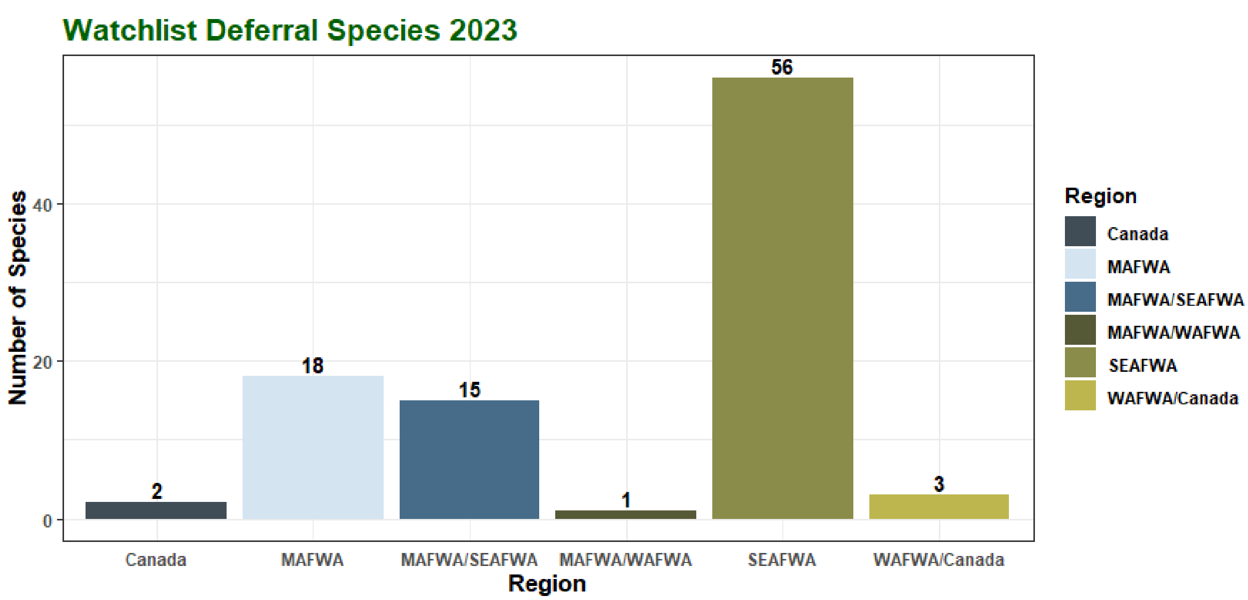


Figure 1.3.17 Regions with RSGCN Watchlist [Deferral] species from the Northeast.

1.3.1 AMPHIBIANS

Of the 111 amphibians (Class Amphibia) in the NEAFWA regional footprint. Of the total number of amphibians occurring in the Northeast US, 89 were listed as SGCN in at least one of the fourteen 2015 Northeast SWAPS. Of these 89 species listed as SGCN in Northeast SWAPs, 18 Amphibians met the criteria for RSGCN, including three anurans and 15 salamanders (Table 1.3.2). An additional four non-SGCN species met the criteria for Proposed RSGCN, six Watchlist [Assessment Priority], and two Watchlist [Deferrals]. Therefore, no amphibian species from the 2018 RSGCN list have been removed from the 2023 list. However, two subspecies, *Cryptobranchus alleganiensis alleganiensis* and *Pseudotriton montanus montanus* are now listed at the nominal level instead to reflect continuing taxonomic uncertainty and changes.


Big Levels Salamander, © Will Lattea

<u>Regional Priority Concern Highlights:</u>

- Species trends differ across the region or inter-regionally: taxa populations appear to be increasing or decreasing across the region; other taxa range shifts are moving in various directions (e.g., north, south, or an elevation change).
- Climate change vulnerability and range shifts are occurring in high-elevation salamanders especially.
- Bd and chytrid continue to be a major threat.

<u>Species Information, Research & Monitoring Needs:</u>

- Taxonomic/genetic research and clarification continue for many salamanders.
- Additional need for standard protocols for research, inventory, and monitoring.
- Climate change information as an amplifier of currently known threats.

RSGCN: 18 AMPHIBIANS

The 2023 Northeast RSGCN list includes 18 species of amphibians, of which 15 are salamanders, and three are frogs. Two species, the Cheat Mountain Salamander (*Plethodon nettingi*) and Shenandoah Salamander (*Plethodon shenandoah*), are federally protected as Threatened and Endangered, respectively. Concern levels across this group of amphibians range from seven species listed as Very High concern, five species considered as High concern, with an additional six species listed as Moderate Concern Level by the regional reptile and amphibian taxonomic team (Table 1.3.2). The

West Virginia Spring Salamander (*Gyrinophilus subterraneus*), Valley and Ridge Salamander (*Plethodon hoffmani*), New Jersey Chorus Frog (*Pseudacris kalmi*), Peaks of Otter Salamander (*Plethodon hubrichti*), Cheat Mountain Salamander, Cow Knob Salamander (*Plethodon punctatus*), Shenandoah Salamander, and Shenandoah Mountain Salamander (*Plethodon virginia*) are endemic to the Northeast region. Most of these endemics are listed as very High concern.

Table 1.3.2 RSGCN Amphibians (2023).

Subtaxon	Scientific Name	Common Name	Regional Responsibility	Concern Level
Salamanders	*Plethodon hubrichti*	Peaks of Otter Salamander	100% (NEAFWA Endemic)	Very High
Salamanders	*Plethodon nettingi*	Cheat Mountain Salamander	100% (NEAFWA Endemic)	Very High
Salamanders	*Plethodon punctatus*	Cow Knob Salamander	100% (NEAFWA Endemic)	Very High
Salamanders	*Plethodon shenandoah*	Shenandoah Salamander	100% (NEAFWA Endemic)	Very High
Salamanders	*Plethodon virginia*	Shenandoah Mountain Salamander	100% (NEAFWA Endemic)	Very High
Salamanders	*Plethodon pauleyi*	Yellow-spotted Woodland Salamander	75-100%	Very High
Salamanders	*Ambystoma tigrinum*	Eastern Tiger Salamander	<25%	Very High
Salamanders	*Gyrinophilus subterraneus*	West Virginia Spring Salamander	100% (NEAFWA Endemic)	High
Frogs and Toads	*Lithobates kauffeldi*	Mid-Atlantic Coast Leopard Frog	75-100%	High
Salamanders	*Ambystoma laterale*	Blue-spotted Salamander	75-100%	High
Salamanders	*Cryptobranchus alleganiensis*	Hellbender	25-50%	High
Salamanders	*Plethodon welleri*	Weller's Salamander	<25%	High

Salamanders	*Plethodon hoffmani*	Valley and Ridge Salamander	100% (NEAFWA Endemic)	Moderate
Frogs and Toads	*Pseudacris kalmi*	New Jersey Chorus Frog	100% (NEAFWA Endemic)	Moderate
Salamanders	*Ambystoma jeffersonianum/laterale complex*	Jefferson/Blue-spotted Salamander Complex	75-100%	Moderate
Salamanders	*Desmognathus welteri*	Black Mountain Salamander	50-75%	Moderate
Salamanders	*Aneides aeneus*	Green Salamander	25-50%	Moderate
Frogs and Toads	*Dryophytes andersonii*	Pine Barrens Treefrog	<25%	Moderate

PROPOSED RSGCN: 4 AMPHIBIANS

Four species of amphibians are not currently listed in Northeast SWAPs as SGCN but were of concern to the taxa team, which concurred with their qualification for the 2023 Proposed RSGCN list. All four of these species are salamanders (Table 1.3.3). These species were recently split from other taxonomies; *Desmognnathus planiceps* from *D. fuscus, Plethod dixi* and *P. jacksoni* from *P. wherlei,* and *P. sherando* from *P. cinereus*.

Table 1.3.3 The Proposed RSGCN salamanders, all of these are found in VA.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Plethodon dixi	Dixie Cavern Salamander	100% (NEAFWA Endemic)	Very High
Plethodon jacksoni	Blacksburg Salamander	75-100%	Very High
Plethodon sherando	Big Levels Salamander	100% (NEAFWA Endemic)	Very High
Desmognathus planiceps	Flat-headed Salamander	50-75%	Moderate

OVERVIEW

RSGCN were assigned to their key habitats, with most species using more than one habitat across different life stages. Of the RSGCN and Proposed RSGCN Amphibians, approximately 73% use Forests and Woodlands, 41% use Riparian Floodplains, and 36% use both High-elevation Forests and Cliff and Talus habitats (Figure 1.3.18).

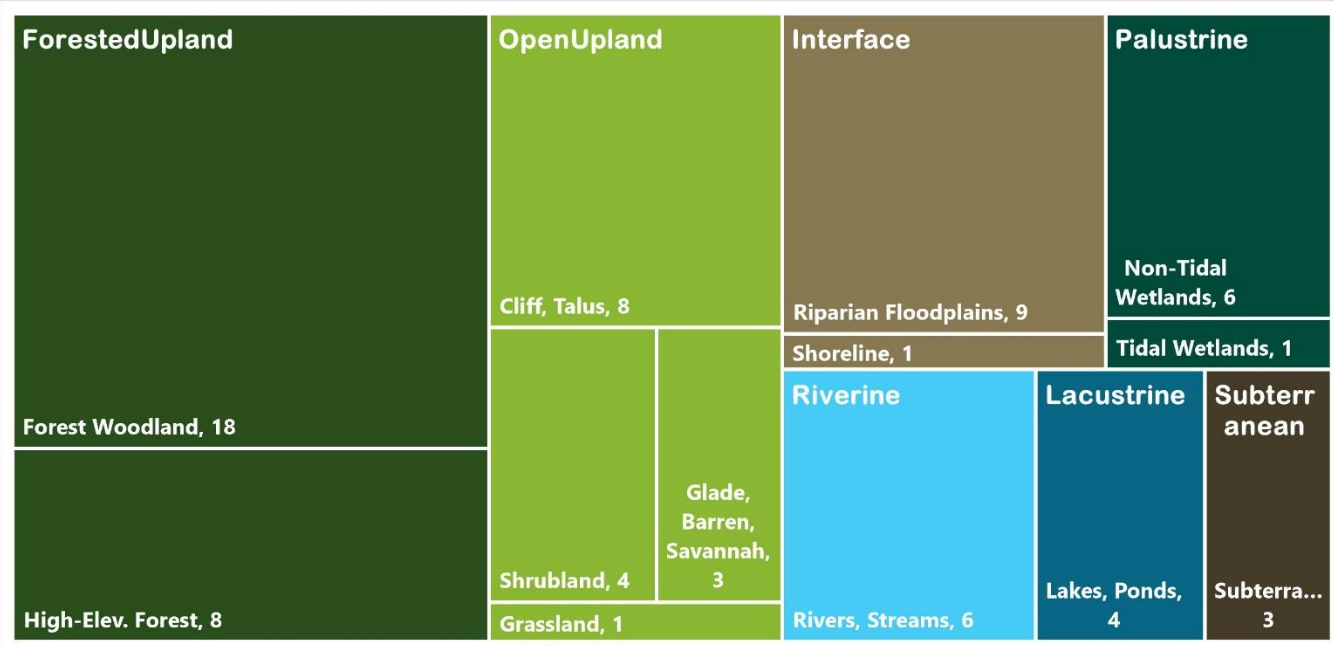


Figure 1.3.18 Number of RSGCN and Proposed RSGCN Amphibian habitat in the Northeast. Habitat group names are at the top of each color block and grouped by color; habitat type names appear at the bottom of each proportionally sized square and are colored by habitat group (see *Chapter 2* for more information on habitats).

Amphibian species in the Northeast are under threat and vulnerable to multiple threats. Threats are categorized using the modified CMP Threat Levels 1, 2, and 3 (*Supplemental Information* 3). The highest percentage of RSGCN and Proposed RSGCN Amphibians are threatened by: Biological Resource Use (91%), Climate Change (77%), and Pollution (77%; Table 1.3.4). Within the Biological Resource Use category, threats include logging and forest management. Best management practices such as the timing of cutting, canopy cover left intact, downed woody debris, and buffers around riparian zones can help alleviate these threats for amphibians (Macneil et al. 2013). Pollution, such as acid rain, herbicides and pesticides, and runoff, impact the greatest number of RSGCN and Proposed RSGCN Amphibians in the Northeast. Finally, Climate Change threats include temperature and precipitation fluctuations and droughts. The combination of these threats together impacts Amphibians and others in aquatic habitats. For example, earlier springs in the Northeast due to climate change combine to increase species exposure to pollution from road salt (Delaune et al. 2021); this is one example of how Climate change can amplify other threats such as Pollution and Transportation and service corridors.

Table 1.3.4 Level 1 threats with the number and percent of RSCGN and Proposed RSGCN Amphibian species threatened. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Biological Resource Use (Threat 5.0)	20	91%
Climate Change (Threat 11.0)	17	77%
Pollution (Threat 9.0)	17	77%
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	14	64%
Transportation & Service Corridors (Threat 4.0)	14	64%
Residential & Commercial Development (Threat 1.0)	13	59%
Agriculture & Aquaculture (Threat 2.0)	12	55%
Natural System Modifications (Threat 7.0)	10	45%
Energy Production & Mining (Threat 3.0)	8	36%
Human Intrusions & Disturbance (Threat 6.0)	7	32%
Other (Threat 12.0)	2	9%

WATCHLIST AMPHIBIANS

There are eight amphibian Watchlist species, six species that taxa teams identified as Watchlist [Assessment Priority], and two species identified for deferral to adjacent regions. Watchlist Assessment Priority species inform 2025 SWAP revisions and serve as a tool to prioritize research and monitoring needs for these taxa. Watchlist species deferred to adjacent regions also inform nationwide cross-regional collaboration and conservation communication for broader landscape conservation efforts.

WATCHLIST [ASSESSMENT PRIORITY]: 6 AMPHIBIANS

Similar to the 2023 Amphibian RSGCN list, salamanders outnumber anurans on the 2023 Watchlist [Assessment Priority] list. Taxa team experts assigned four salamander species, one toad, and one frog species as Watchlist [Assessment Priority] (Table 1.3.5). Two salamander species have a regional responsibility of 50-75%, indicating their range primarily occurs in the Northeast. The other four species have regional responsibility under 25%. Watchlist [Assessment Priority] species differ from RSGCN in that they do not have a conservation Concern Level due to a lack of information on population status, natural history, and threats. Therefore, they are aptly highlighted as needing additional assessment and data.

Table 1.3.5 Amphibian 2023 Watchlist [Assessment Priority] species.

Subtaxon	Scientific Name	Common Name	Regional Responsibility
Frogs and Toads	*Scaphiopus holbrookii*	Eastern Spadefoot	<25%
Frogs and Toads	*Lithobates pipiens*	Northern Leopard Frog	<25%

Salamanders	*Ambystoma opacum*	Marbled Salamander	<25%
Salamanders	*Ambystoma jeffersonianum*	Jefferson Salamander	50-75%
Salamanders	*Necturus maculosus*	Mudpuppy	<25%
Salamanders	*Gyrinophilus porphyriticus duryi*	Kentucky Spring Salamander	50-75%

Both the Eastern Spadefoot (*Scaphiopus holbrookii)* and Northern Leopard Frog (*Lithobates pipiens*) have reports of population declines in the Northeastern portion of their ranges. Still, the amount and reasons for the decline are largely unknown. The Amphibian taxa team concluded that more monitoring and research are needed to understand these declines at the range edges and any potential implications in the core of their range, even though their regional responsibility is below 25%.
The four Watchlist [Assessment Priority] salamander species are all SGCN in several northeastern states. The Kentucky Spring Salamander (*Gyrinophilus porphyriticus duryi*) was identified as a species lacking natural history and distribution data and would benefit from additional monitoring and research. While the other three salamander species are more widespread, disease and climate change threats are on the rise, and it is unknown how the northeastern populations will respond.

WATCHLIST [DEFER TO ADJACENT REGION]: 2 AMPHIBIANS.

The Amphibian Taxa Team identified Northern Pygmy Salamander (*Desmognathus organi*) and the Mud Salamander (*Pseudotriton montanus*) as regional conservation concern but recognized the core of their ranges fall to the south. Therefore, their primary stewardship is in the southeastern United States (Table 1.3.6). The Northern Pygmy Salamander has a narrow distribution restricted to the high-elevation forests in southern Virginia.

Table 1.3.6 2023 Watchlist [Deferral] Amphibians.

Subtaxon	Scientific Name	Common Name	Deferred Region(s)	Listed in Deferred Region(s)
Salamander	*Desmognathus organi*	Northern Pygmy Salamander	SEAFWA	RSGCN in SEAFWA
Salamander	*Pseudotriton montanus*)	Mud Salamander	SEAFWA	RSGCN in SEAFWA

REGIONAL EFFORTS IN NORTHEAST AMPHIBIAN CONSERVATION

Since the last Northeast Conservation Synthesis in 2013 (TCI and NEFWDTC 2013), considerable advancements have contributed to the knowledge and conservation of this taxa through coordinated regional efforts. The Regional Conservation Needs Program

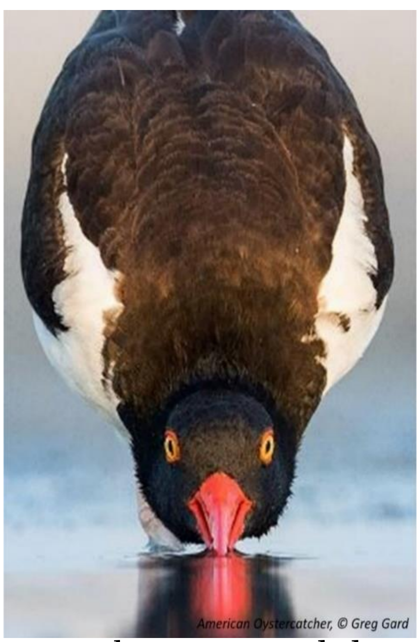
(RCN) has sponsored several projects to address priority needs identified for this taxon. For example, the Atlantic Coast Leopard Frog is a recently described cryptic species primarily associated with large coastal marshes and early successional floodplain meadows and swamps along the riparian corridors of medium-large rivers. During the summer months, fields surrounding wetlands may be used for foraging, but the extent of upland habitat use is currently unknown. Little is known about the species' ecology, and research is needed to understand conservation challenges and to inform conservation planning and management. Assessing dispersal capabilities and gene flow among populations and determining if the isolation of populations has led to inbreeding depression are important considerations. There is evidence of historic declines in the northern portion of the region. Although the species has been able to persist in highly urbanized areas in the Northeast, dense housing and urban areas are a threat. Understanding environmental tolerances (e.g., salinity, pH, etc.) is important. The Atlantic coast leopard frog is vulnerable to changing climatic conditions, especially coastal populations. Atlantic Coast Leopard Frogs occur sympatrically with northern leopard frogs, and understanding potential competitive interactions, differences in habitat use, and possible hybridization is important. The Final RCN report by Schlesinger et al. (2017) showed that in the southern portion of the northeastern region, Atlantic Coast Leopard Frogs are sympatric with southern leopard frogs, and similar work is needed to understand interactions among these two species.

The Appalachian Mountains are the global center of endemism for salamander taxa as it is considered the center for adaptive radiation for the Order Caudata (salamanders). Included on the 2023 RSGCN list are many narrowly endemic and rare species (75 to 100% regional responsibility), such as the Cheat Mountain, Cow Knob, Peaks of Otter, Shenandoah Mountain, Shenandoah, Yellow-spotted Woodland, Valley and Ridge, Blue-spotted, and West Virginia Spring Salamanders. Of these species, there are eight in the genus *Plethodon*, three species of the genus *Ambystoma,* and four others in their own genus. There is ongoing genetic work in all these genera, as potential impacts from climate change on genetically isolated high-elevation populations may be detrimental and warrant species protection.

The Hellbender (*Cryptobranchus alleganiensis*), a large aquatic salamander associated with major rivers in the eastern United States, has been identified as a high-priority species for the RCN grant program. The **Hellbender eDNA RCN Report** (2016) found positive sampled sites in New York, Pennsylvania, Maryland, and Virginia, with an unreliable detection in WV. Populations of Hellbenders have declined precipitously due to water pollution, sedimentation, and the damming and channelization of major rivers throughout the eastern United States. In addition, chytrid fungi have been responsible for reducing captive populations and are thought to be causing additional declines in the wild populations of the species. The Ozark subspecies of the hellbender, which may be elevated to full species, was added to the federal Endangered Species list in 2011. The 2018 Species Status Report predicts future range declines (USFWS 2018). Conserving the Hellbender will require integrated conservation action on the part of state, federal, and private conservation agencies, exactly the sort of partnership that can continue to be supported and fostered through the RCN Grant Program. The two RCN projects confirmed the distribution and status of Hellbenders throughout the region and provided several protocols and standard operating procedures for research, sampling, and disease prevention. NEPARC[2] and its Regional Working Groups have developed additional protocols and conservation resources for amphibians and reptiles.

1.3.2 BIRDS

426 Birds (Class Aves) inhabit the NEAFWA regional footprint. Of those, 273 were listed as SGCN in at least one of the 14 2015 Northeast SWAPs. Twenty-eight of these bird species met the criteria as RSGCN, including 12 landbirds, nine waterbirds and waterfowl, five shorebirds, one landfowl, and one raptor. Forty-two birds are listed in one of the Watchlist categories: 29 Watchlist [Assessment Priority] and 11 Watchlist [Deferrals], and one additional non-SGCN species met the criteria for Proposed Watchlist [Assessment Priority].


American Oystercatcher, © Greg Gard

<u>Regional Priority Concern Highlights:</u>

- Coastal habitat loss intensified by climate change sea level rise.
- Wind development concerns along mountain and coastal migratory routes.
- Invasive insect threats to forest birds.
- Aerial insectivore threats from insecticide spraying.
- Habitat loss threats continue on wintering grounds.
- Unidentified causes of population decline remain.
- Emerging diseases and virus increase.

<u>Species Information, Research & Monitoring Needs</u>

- A regional colonial waterbird survey is recommended.
- For one of the better-known taxa, additional coordinated survey efforts, range shift data due to climate change are needed, and wind development impacts remain unknown.

RSGCN: 28 BIRDS

Twenty-eight bird species have been identified as RSGCN in the Northeast based on conservation concern and regional responsibility status (Table 1.3.7). Of these, the NEFWDTC Bird Taxonomic Team listed six bird species as Very High concern, 12 as High concern, and ten as Moderate concern in the Northeast. Two listed entities are northeast endemics, Ipswich Sparrow (*Passerculus sandwichensis princeps*) and Coastal Plain Swamp Sparrow (*Melospiza georgiana nigrescens*), with three others having a regional responsibility greater than 75%. In addition, eight previously listed RSGCN Birds had listing revisions due to listing nominal species, subspecies, or population entities.

Table 1.3.7 2023 RSGCN Birds. Note that the Regional Responsibility listed is the overall geographic range. Northeast Regional Responsibility may differ for breeding, migration, and wintering seasons.

Subtaxon	Scientific Name	Common Name	Regional Responsibility	Concern Level
Landbirds	*Antrostomus vociferus*	Eastern Whip-poor-will	25-50%	High
Landbirds	*Passerculus sandwichensis princeps*	Ipswich Sparrow	100% (NEAFWA Endemic)	High
Landbirds	*Melospiza georgiana nigrescens*	Coastal Plain Swamp Sparrow	100% (NEAFWA Endemic)	High
Landbirds	*Catharus bicknelli*	Bicknell's Thrush	75-100%	High
Landbirds	*Setophaga cerulea*	Cerulean Warbler	<25%	High
Shorebirds	*Calidris canutus rufa*	Red Knot	<25%	High
Shorebirds	*Calidris maritima*	Purple Sandpiper	50-75%	High
Shorebirds	*Charadrius melodus*	Piping Plover (Atlantic Coast pop.)	25-50%	High
Landfowl	*Bonasa umbellus*	Ruffed Grouse	25-50%	High
Waterbirds	*Rynchops niger*	Black Skimmer	<25%	High
Waterbirds	*Sternula antillarum*	Least Tern	25-50%	High
Waterfowl	*Anas rubripes*	American Black Duck	50-75%	High
Landbirds	*Sturnella magna*	Eastern Meadowlark	<25%	Moderate
Landbirds	*Euphagus carolinus*	Rusty Blackbird	50-75%	Moderate
Landbirds	*Hylocichla mustelina*	Wood Thrush	25-50%	Moderate
Landbirds	*Vermivora cyanoptera*	Blue-winged Warbler	<25%	Moderate
Raptors	*Aquila chrysaetos*	Golden Eagle (Eastern pop.)	50-75%	Moderate
Shorebirds	*Scolopax minor*	American Woodcock	25-50%	Moderate
Waterbirds	*Haematopus palliatus*	American Oystercatcher	25-50%	Moderate
Waterbirds	*Sterna hirundo*	Common Tern	<25%	Moderate
Waterfowl	*Branta bernicla hrota*	Pale-bellied Brant	75-100%	Moderate
Waterfowl	*Histrionicus histrionicus*	Harlequin Duck (Eastern pop.)	25-50%	Moderate

Landbirds	*Lanius ludovicianus*	Loggerhead Shrike	<25%	Very High
Landbirds	*Vermivora chrysoptera*	Golden-winged Warbler (Appalachian pop.)	<25%	Very High
Landbirds	*Ammospiza caudacuta*	Saltmarsh Sparrow	50-75%	Very High
Shorebirds	*Charadrius melodus*	Piping Plover (Great Lakes pop.)	<25%	Very High
Waterbirds	*Laterallus jamaicensis jamaicensis*	Black Rail	25-50%	Very High
Waterbirds	*Sterna dougallii*	Roseate Tern	50-75%	Very High

No birds were listed as Proposed RSGCN since all birds of conservation concern are SGCN in at least one state.

OVERVIEW

Twenty-eight bird species have been identified as RSGCN in the Northeast based on conservation status and need (Table 1.3.7). Many of the 28 Bird RSGCN are emblematic of an important and vulnerable Northeast habitat, including coastal beaches, coastal islands, salt marshes, early successional habitats, and unfragmented forests (Figure 1.3.19).

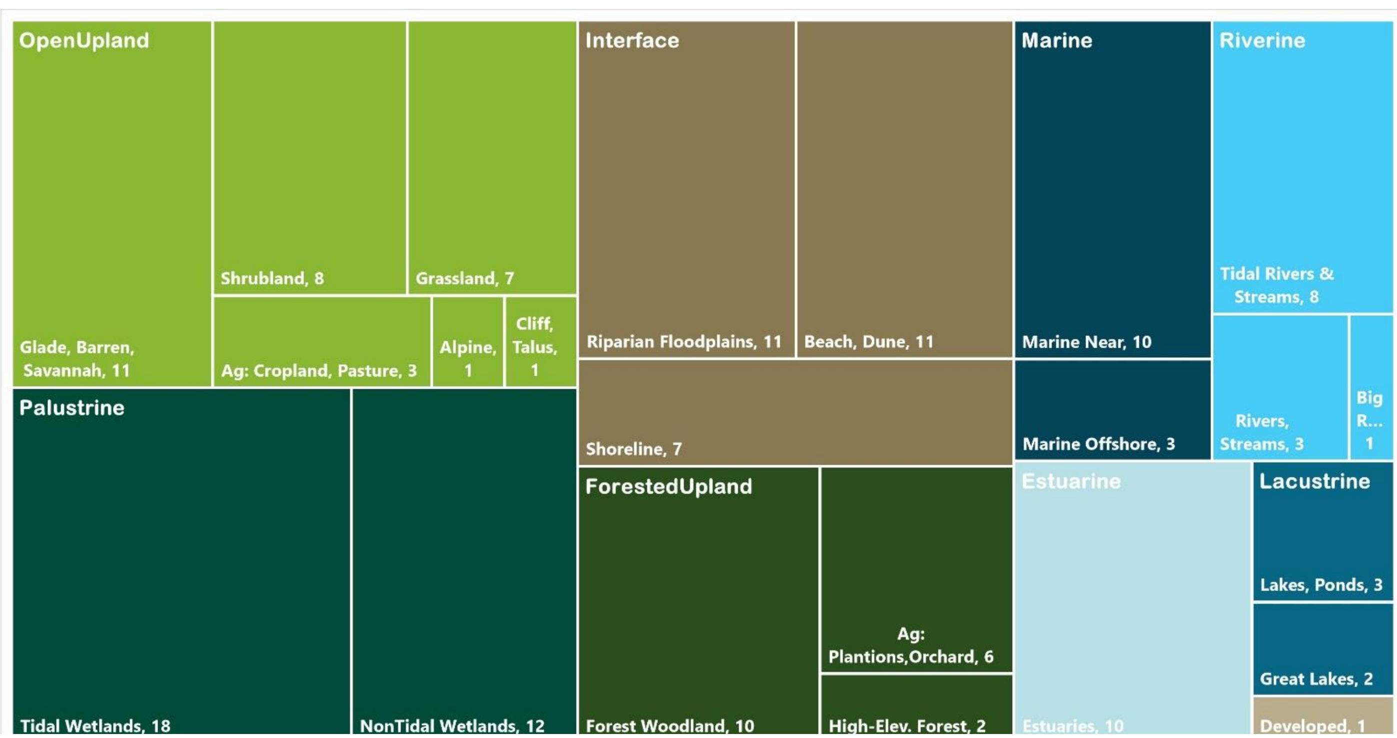


Figure 1.3.19 Number of 2023 RSGCN Birds associated with each habitat group and type. Species may be associated with multiple habitat types. Greater than 50% of RSGCN bird habitat in the Northeast are in Open uplands, Palustrine, and Interface habitat groups. Habitat group names are at the top of each color block and grouped by color; habitat type names appear at the bottom of each proportionally sized square and are colored by habitat group (see *Chapter 2* for more information on habitats).

Twenty-eight RSGCN birds inhabit the Northeast region's coast in salt marshes, beaches, dunes, or offshore islands. Throughout the Northeast, for centuries, human activities have heavily impacted these habitats through development, pollution, marsh filling and draining, spraying for mosquito control, and recreational use of beaches (see *Chapter 2*). In sum, these activities represent formidable threats to coastal bird species. Among these species, the Piping Plover (*Charadrius melodus*), Red Knot (*Calidris canutus rufa*), and Roseate Tern (*Sterna dougallii*) have been the subjects of considerable conservation attention in the Northeast due to their current listing under the US Endangered Species Act.

The **2022 State of the Birds** report identified seventy tipping point species. They have lost more than half of their population in the last 50 years and will lose another 50% of the remnant population within the next 50 years. Tipping point 2023 RSGCN birds include Black Rail (*Laterallus jamaicensis (jamaicensis)*), Least Tern (*Sternula antillarum*), Golden-winged Warbler (*Vermivora chrysoptera*), Saltmarsh Sparrow (*Ammospiza caudacuta*), and Bicknell's Thrush (*Catharus bicknelli*). Other species that have lost 50% of their population are stabilizing. Two RSGCN eastern forest birds, the Cerulean Warbler (*Setophaga cerulea*) and Wood Thrush (*Hylocichla mustelina*), while showing long-term population declines, have exhibited recent stabilizing in areas where regional habitat protections have been a priority (NABCI 2022).

Table 1.3.8 Level 1 threats with the number and percent of RSCGN and Proposed RSGCN Bird species threatened. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Climate Change (Threat 11.0)	**26**	**93%**
Pollution (Threat 9.0)	**26**	**93%**
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	**22**	**79%**
Residential & Commercial Development (Threat 1.0)	**22**	**79%**
Human Intrusions & Disturbance (Threat 6.0)	**21**	**75%**
Natural System Modifications (Threat 7.0)	**20**	**71%**
Energy Production & Mining (Threat 3.0)	**17**	**61%**
Agriculture & Aquaculture (Threat 2.0)	**15**	**54%**
Biological Resource Use (Threat 5.0)	**15**	**54%**
Transportation & Service Corridors (Threat 4.0)	**15**	**54%**
Other (Threat 12.0)	**12**	**43%**

Threats to RSGCN and Proposed RSGCN Birds are categorized using the modified CMP Threat Levels 1, 2, and 3 (*Supplemental Information 3*). The highest percentage of RSGCN and Proposed RSGCN Birds are threatened by Climate Change (93%) and Pollution (93%) as the top threats in the Northeast, followed by Invasive and Problematic Species, Pathogens and Genes (79%) and Residential and Commercial Development (79%) as the second highest threats (Table 1.3.8). Climate Change impacts include changes in the vegetation communities due to climate change, phenological mismatch, storms, and severe weather events. For example, climate change is responsible for the predicted extinction of the Saltmarsh Sparrow within 20-30 years (Field et al. 2017). The Northeast Climate Change Synthesis report contains more detailed patterns in range shifts, habitat use, and actions with these threats (Staudinger et al. 2015 and 2023 in prep.). Oil spills, herbicides and pesticides, and acid rain are additional threats within Pollution that impact the greatest number of RSGCN and Proposed RSGCN birds in the Northeast (Table 1.3.8). Nest predation was the top threat to ground-nesting birds (Invasive and Problematic Species, Pathogens and Genes - specifically terrestrial mammals). Finally, Residential and Commercial Development threatens Birds most due to low-density housing areas.

WATCHLIST BIRDS

In total, the Bird Taxonomic Team identified 44 bird species as Watchlist species, 30 as Watchlist [Assessment Priority], one as Proposed Watchlist [Assessment Priority], and 12 species identified for deferral to adjacent regions.

WATCHLIST [ASSESSMENT PRIORITY]: 30 BIRDS

The 30 2023 Watchlist [Assessment Priority] bird species include 13 Landbirds, four raptors, four shorebirds, one landfowl (Order Galliformes), and eight waterbird or waterfowl species (Table 1.3.9). While birds are one of the most closely monitored taxa groups, experts have flagged some species needing additional or continuous monitoring. Climate change amplifies habitat loss and degradation, while diseases and pollution continue to threaten birds at alarming rates. In addition, many birds' overall geographic regional responsibility falls below the threshold of 50%. Still, seasonal responsibility for breeding grounds, migration stopovers, and wintering grounds elevate and qualify the Northeast as key stewards in these bird conservation seasonal cycles.

Many of the Watchlist [Assessment Priority] birds have emerging threats and climate change vulnerabilities that require monitoring and research due to the steep declines across this subtaxon, as indicated in breeding bird surveys. Eight Watchlist [Assessment Priority] birds were flagged in the State of the Birds (2022) as tipping point species. Similar to the RSGCN species in this list, these Watchlist species have lost more than

50% of their population over the past six decades and are projected to lose 50% more of the remnant population: Bobolink (*Dolichonyx oryzivorus*), Chimney Swift (*Chaetura pelagica*), King Rail (*Rallus elegans*), Prairie Warbler (*Setophaga discolor*), Ruddy Turnstone (*Arenaria interpres (morinella)*), Seaside Sparrow (*Ammospiza maritima*), Semipalmated Sandpiper (*Calidris pusilla*), and Whimbrel (*Numenius phaeopus*) (NABCI 2022).

Table 1.3.9 Watchlist [Assessment Priority] Birds 2023. Note that the Regional Responsibility listed is the overall geographic range. Northeast Regional Responsibility may differ for breeding, migration, and wintering seasons.

Subtaxon	Scientific Name	Common Name	Regional Responsibility
Landbirds	*Coccyzus erythropthalmus*	Black-billed Cuckoo	<25%
Landbirds	*Chordeiles minor*	Common Nighthawk	<25%
Landbirds	*Chaetura pelagica*	Chimney Swift	<25%
Landbirds	*Empidonax minimus*	Least Flycatcher	<25%
Landbirds	*Riparia riparia*	Bank Swallow	<25%
Landbirds	*Icteria virens*	Yellow-breasted Chat	<25%
Landbirds	*Dolichonyx oryzivorus*	Bobolink	<25%
Landbirds	*Ammodramus savannarum*	Grasshopper Sparrow	<25%
Landbirds	*Ammospiza maritima*	Seaside Sparrow	25-50%
Landbirds	*Catharus fuscescens*	Veery	<25%
Landbirds	*Setophaga striata*	Blackpoll Warbler	25-50%
Landbirds	*Setophaga discolor*	Prairie Warbler	<25%
Landbirds	*Cardellina canadensis*	Canada Warbler	25-50%
Raptors	*Accipiter gentilis*	Northern Goshawk	<25%
Raptors	*Falco peregrinus (anatum)*	Peregrine Falcon	<25%
Raptors	*Falco sparverius*	American Kestrel	<25%
Raptors	*Tyto alba*	Barn Owl	<25%
Shorebirds	*Arenaria interpres (morinella)*	Ruddy Turnstone	<25%
Shorebirds	*Numenius phaeopus*	Whimbrel	<25%
Shorebirds	*Calidris pusilla*	Semipalmated Sandpiper	25-50%
Shorebirds	*Tringa semipalmata*	Willet	<25%
Landfowl	*Bonasa umbellus*	Ruffed Grouse	25-50%

Waterbirds	*Phalacrocorax carbo*	Great Cormorant	50-75%
Waterbirds	*Egretta thula*	Snowy Egret	<25%
Waterbirds	*Nycticorax nycticorax*	Black-crowned Night-Heron	<25%
Waterbirds	*Ixobrychus exilis*	Least Bittern	<25%
Waterbirds	*Plegadis falcinellus*	Glossy Ibis	25-50%
Waterbirds	*Rallus elegans*	King Rail	25-50%
Waterfowl	*Bucephala islandica*	Barrow's Goldeneye (Eastern pop.)	25-50%
Waterfowl	*Somateria mollissima (dresseri)*	Common Eider	75-100%

PROPOSED WATCHLIST [ASSESSMENT PRIORITY]: 1 BIRD

Nelson's Sparrow (*Ammospiza nelsoni subvirgatus*) is a subspecies not currently on any Northeast state SGCN list (the nominal species is listed in New Hampshire and Maine). Bird Taxonomic Team experts flagged this species for observed population declines. Because 80% of its breeding range is in Canada, more research is needed on forest conditions and dependence on wetlands. Therefore, it is a Proposed Watchlist Assessment Priority species.

WATCHLIST [DEFER TO ADJACENT REGION]: 12 BIRDS

Bird Taxonomic Team experts identified 12 Watchlist [Deferral] Birds (Table 1.3.10). Midwest deferrals include seven birds, with four listed as RSGCN in MAFWA. Seven birds were also deferred to the Southeast, four listed as RSGCN in SEAFWA. Two other species are deferred to the Western US or north to Canada. The six birds not listed in the adjacent regions are opportunities for NEAFWA and neighbors to collaborate.

Table 1.3.10 Watchlist [Deferral] Birds 2023.

Subtaxon	Scientific Name	Common Name	Deferred Region(s)	Listed in Deferred Region(s)
Shorebirds	*Bartramia longicauda*	Upland Sandpiper	MAFWA	RSGCN in MAFWA
Waterbirds	*Sterna forsteri*	Forster's Tern	MAFWA	No
Waterbirds	*Chlidonias niger*	Black Tern	MAFWA	RSGCN in MAFWA
Waterbirds	*Egretta tricolor*	Tricolored Heron	SEAFWA	No
Waterbirds	*Egretta caerulea*	Little Blue Heron	SEAFWA	RSGCN in SEAFWA
Waterbirds	*Gelochelidon nilotica*	Gull-billed Tern	SEAFWA	RSGCN in SEAFWA

Waterbirds	*Thalasseus maximus*	Royal Tern	SEAFWA	No
Landfowl	*Colinus virginianus*	Northern Bobwhite	MAFWA / SEAFWA	RSGCN in MAFWA/SEAFWA
Landbirds	*Centronyx henslowii*	Henslow's Sparrow	MAFWA / SEAFWA	RSGCN in MAFWA/SEAFWA
Landbirds	*Pooecetes gramineus*	Vesper Sparrow	MAFWA / SEAFWA	No
Landbirds	*Coccothraustes vespertinus*	Evening Grosbeak	MAFWA / WAFWA	No
Landbirds	*Contopus cooperi*	Olive-sided Flycatcher	WAFWA / Canada	No

REGIONAL EFFORTS IN NORTHEAST BIRD CONSERVATION

Piping plovers and American oystercatchers, red knots, and least terns rely on sandy beaches under constant threat across the Northeast from human development and recreational use. The USFWS published **The Red Knot Draft Recovery Plan** in 2021 (USFWS 2021). This remarkable bird nests in the high arctic, overwinters in the southernmost part of South America and feeds along the mid-Atlantic shores (especially Delaware Bay) on horseshoe crab eggs during spring migration. Conservation measures implemented for their breeding, migration, and wintering areas also benefit other shorebirds, including the willet, ruddy turnstone, semipalmated and purple sandpipers, and sanderling that inhabit the Delaware Bay and other estuaries along the Northeast coast (see *Chapter 2*).

Four RCN reports focused on shrublands and young forests (see *Chapter 2*). Two reports in this series include the Northeast conservation plan and BMP for the central Appalachian Mountains for the American Woodcock, an RSGCN species (Gilbart 2012, TWMP[3]).

Sea-level rise from climate change is an ongoing threat to the Northeast's extensive salt marsh systems, many of which are already heavily degraded from past ditching, filling, and associated coastal development. The Northeast encompasses almost the entire breeding range of the Saltmarsh Sparrow and has high responsibility for black rail, both of which nest in salt marsh habitat. And while freshwater marshes are generally better protected today than in the past, they remain far less common than they were historically and are still subject to degradation from pollution and development.

The eastern Black Rail is a secretive marsh bird and has experienced range contraction in the Northeast; more information can be found in the RCN project final report status assessment (Watts 2016).

Colonial nesting water birds represent an important guild that includes gulls, terns, skimmers, herons, and egrets. All these species had declined significantly by the early 20th century due to overharvesting. By the latter half of the century, species like terns had been displaced from many colonies by increasing gull populations. However, these populations have declined recently as landfills have closed or implemented more effective sanitation measures. Roseate terns are highly vulnerable since the bulk of the population is concentrated in a handful of colonies from New York to Maine. The Cape Cod and offshore Massachusetts islands are key staging sites for Massachusetts and New York colonies. In addition to the ongoing threat from gulls, these colonies are also subject to risks such as oil spills and sea-level rise.

The Black Duck Joint Venture, a partnership established under the North American Waterfowl Management Plan, has brought together scientists, conservationists, and hunting organizations across the species' historical range to coordinate conservation efforts, including monitoring, research, and communications. **The American Black Duck Conservation Plan** was published in 2020 with the following strategic goals: protect marsh migration corridors, develop BMPs (see *Chapter 5*), Restore tidal and non-tidal wetlands, improve wetland management, and control invasive species (Hartley & Weldon 2020, see *Chapter 2*). These efforts continue to benefit other wetland and marsh species, such as the bitterns, rails, sedge and marsh wrens, herons, egrets, grebes, and shorebirds, through conserving the freshwater marshes in the region.

Because most birds on the RSGCN list are migratory, it is increasingly important to acknowledge that many face threats outside a given state or even the Northeast as a whole. Birds are affected by habitat loss, disturbance, altered food supplies, and even direct human persecution at any stage of their annual cycle. In some cases, these threats are highest in the non-breeding season. For example, almost all Bicknell's thrushes winter on the Caribbean Island of Hispaniola, where deforestation is an important issue. If habitat conservation does not occur on this species' winter grounds, there is only so much the Northeast can do to ensure its survival.

Similarly, migratory shorebirds breed in the arctic and winter in South America and only occur in the region during stopovers. States are increasingly aware of their role in full life cycle conservation for these species, even though they do not breed in the region. The Association of Fish and Wildlife Agencies (AFWA) has provided draft wording, information, and tools that can be used to develop an international section or to integrate full lifecycle conservation into these plans to assist the states in including international conservation issues and actions within their State Wildlife Action Plans. The NECASC[4] Climate Change Synthesis will inform SWAP coordinators about RSGCN species actions, threats, risks, and responses to climate change in the Northeast. For RCN monitoring protocols specific to birds, see *Chapter 5*.

1.3.3 DIADROMOUS FISH

There are 28 Diadromous Fish (Class Actinopterygii and Class Petromyzontida (Sea Lamprey (*Petromyzon marinus*) diadromous population)) that inhabit the NEAFWA regional footprint. Of those, 11 were listed as SGCN in at least one of the 14 2015 Northeast SWAPS. Nine of these Diadromous Fish met the criteria as RSGCN. Two are listed in one of the Watchlist categories: Watchlist [Assessment Priority]. No Diadromous Fish are Watchlist [Deferrals] or Proposed Watchlist [Assessment Priority]. Two of these RSGCN are Federally listed as Endangered.


Shortnose Sturgeon, © Robert S. Michelson

<u>Regional Priority Concern Highlights:</u>

- Restoration efforts for Blueback herring do not seem to show significant improvement.
- Dams/fish passage and aquatic connectivity (roads, bridges) pose major threats as barriers to migration are primary concerns.

- Entrapment and impingement of juveniles at powerplant and municipal intakes cause issues at this life stage.

Species Information, Research & Monitoring Needs

- Life history and population surveys are needed.
- Offshore monitoring protocols exist for ~50% of RSGCN.
- Data are lacking for species and populations that move out of the Northeast range for winter.

RSGCN: 9 DIADROMOUS FISH

Nine Diadromous Fish are RSGCN in the Northeast based on conservation concerns and regional responsibility (Table 1.3.11). Two were ranked Very High concern, five were ranked High concern, and two species were Moderate concern in the Northeast. The Gulf of Maine population of Atlantic Salmon (*Salmo salar* pop. 5) is endemic to the Northeast (100% Regional Responsibility), and the native population of Rainbow Smelt (*Osmerus mordax*) has a regional responsibility of 75-100%. Other RSGCN in this group have lower regional responsibilities because they migrate out of the northeast in the winter, but conservation concern in the region helps protect the spawning grounds.

Table 1.3.11 RSGCN Diadromous Fish 2023. Note that the Regional Responsibility listed is for the overall geographic range. Northeast regional responsibility may vary for breeding, migration, and wintering seasons.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Acipenser brevirostrum	Shortnose Sturgeon	50-75%	Very High
Salmo salar pop. 5	Atlantic Salmon (Gulf of Maine)	100% NEAFWA Endemic	Very High
Anguilla rostrata	American Eel	25-50%	High
Alosa sapidissima	American Shad	50-75%	High
Alosa pseudoharengus	Alewife	50-75%	High
Osmerus mordax	Rainbow Smelt (native pop.)	75-100%	High
Acipenser oxyrinchus	Atlantic Sturgeon	50-75%	High
Alosa aestivalis	Blueback Herring	50-75%	Moderate
Alosa mediocris	Hickory Shad	50-75%	Moderate

Since all Diadromous Fish of conservation concern were listed as SGCN in at least one state, none were Proposed RSGCN.

OVERVIEW

The nine RSGCN Diadromous Fish use five habitat groups (outlined in *Chapter 2*), and within those, RSGCN Diadromous fish use nine habitat types during at least one of their life stages. One hundred Diadromous fish use estuaries, rivers and streams, and marine near-shore habitats, 89% use big rivers and tidal rivers (Figure 1.3.20). These habitats are vital for reproduction and juvenile life stages for these species.

Figure 1.3.20 Number of RSGCN Diadromous Fish associated with each habitat in the Northeast. Note that the Regional Responsibility listed is for the overall geographic range. Northeast regional responsibility may vary for breeding, migration, and wintering seasons. Habitat group names are at the top of each color block and grouped by color; habitat type names appear at the bottom of each proportionally sized square and are colored by habitat group (see *Chapter 2* for more information on habitats).

RSGCN Diadromous Fish are all (100%) threatened by Energy and Mining Production, Natural Systems Modification, and Pollution (Table 1.3.12). The top threats in these categories are Hydroelectric Dams, Water Level Management Using Dams, and Runoff, respectively. While Diadromous Fish are vulnerable to many threats, dam removal has the greatest potential to aid in conserving this taxon (Waldman & Quinn 2022).

Table 1.3.12 Level 1 threats with number and percent of RSCGN Diadromous Fish threatened by each. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Energy Production & Mining (Threat 3.0)	9	100%
Natural System Modifications (Threat 7.0)	9	100%

Pollution (Threat 9.0)	9	100%
Biological Resource Use (Threat 5.0)	8	89%
Climate Change (Threat 11.0)	8	89%
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	7	78%
Transportation & Service Corridors (Threat 4.0)	6	67%
Human Intrusions & Disturbance (Threat 6.0)	5	56%
Residential & Commercial Development (Threat 1.0)	5	56%
Agriculture & Aquaculture (Threat 2.0)	4	44%
Other (Threat 12.0)	2	22%

WATCHLIST

Diadromous Watchlist [Assessment Priority] Fish were identified for more assessment because while these fish have the same threats as the RSGCN Diadromous Fish, there are unknown threats hypothesized to be coming from poor marine ecosystem health.

WATCHLIST [ASSESSMENT PRIORITY]: 2 DIADROMOUS FISH

Taxonomic Team experts identified the Striped Bass (*Morone saxatilis*) and Diadromous populations of Sea Lamprey (*Petromyzon marinus*) as Watchlist [Assessment Priority] (Table 1.3.13). Striped bass has major spawning groups within the Northeast. Stock assessments show they are overfished. Sea Lamprey have seen numbers declining even in secure watersheds like the Connecticut River. Assessment is needed to evaluate whether marine threats contribute to continued declines.

Table 1.3.13 Watchlist [Assessment Priority] Diadromous Fish 2023.

Scientific Name	Common Name	Regional Responsibility
Morone saxatilis	Striped Bass	25-50%
Petromyzon marinus	Sea Lamprey (diadromous pop.)	50-75%

REGIONAL EFFORTS IN NORTHEAST CONSERVATION

NOAA Fisheries[5] has an **Atlantic Salmon Research Hub** with a recovery plan, data, and information. This research leads to aquatic recovery and the RCN connectivity project. The University of Maine hosts the **Diadromous Species Restoration Research Network**[6]. The focus of this group is to promote collaborative research and restoration for diadromous fish. Atlantic Salmon are co-managed by The Penobscot Indian Nation, USFWS, and Maine DMR and have developed the **Collaborative Management Strategy for the Gulf of Maine Atlantic Salmon Recovery Program**. Tagging Atlantic Salmon in Greenland, NOAA biologists help track juvenile salmon to learn more about the marine life stages. Several up-to-date sources of information can be useful to the Northeast states in developing the marine component of their Wildlife Action Plans, like the recovery plan for the Gulf of Maine Atlantic Salmon (USFWS & NMFS 2018). NOAA's National Marine Fisheries Service and the Atlantic States Marine Fisheries Commission maintain status information on species of conservation need. The Atlantic Coast Fish Habitat Partnership's[7] current plan, which presents important overview information on many of the Northeast states SGCN and RSGCN species. This plan summarizes key species, habitat, threat, and conservation action information. Recent review articles by the American Fisheries Society and USGS with information about fish declines in North America are available through Action Bioscience[8].

1.3.4 FRESHWATER FISH

335 (Class Actinopterygii and Petromyzontida) inhabit the NEAFWA regional footprint. Forty-five of these Freshwater Fish met the criteria as RSGCN. Fifty are listed in one of the Watchlist categories: 31 Watchlist [Assessment Priority], 16 Watchlist [Deferrals], and five non-SGCN species met the criteria for Proposed RSGCN and Proposed Watchlist [Assessment Priority]. Six RSGCN and two Watchlist [Deferral] Freshwater Fish are listed under the Endangered Species Act as Endangered or Threatened.

Candy Darter, © Derek Wheaton

Regional Priority Concern Highlights:

- Need for clear communication messages on issues like Brook trout and similar species across multiple states.
- Climate change impacts to freshwater habitats
- Competition with introduced / non-native species (shiners especially and stocked pops vs. natives).

Species Information, Research & Monitoring Needs

- Native populations/genetics assessments are needed for many species (e.g., those with stocked populations).
- Climate change and activity and behavioral data are needed.

RSGCN: 45 FRESHWATER FISH

Experts identified 45 Freshwater Fish as RSGCN in the Northeast based on conservation concerns and regional responsibility (Table 1.3.14). Sixteen were ranked Very High concern, 19 were ranked High concern, and ten species were classified as Moderate concern in the Northeast. Fifteen are endemic to the Northeast (100% Regional Responsibility). The other RSGCN in this group has lower regional responsibilities because they migrate out of the northeast in the winter. Still, conservation concern in the region helps protect the spawning grounds.

Table 1.3.14 2023 RSGCN Freshwater Fish in the Northeast.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Notropis bifrenatus	Bridle Shiner	75-100%	Very High
Notropis chalybaeus	Ironcolor Shiner	25-50%	Very High
Notropis semperasper	Roughhead Shiner	100% (NEAFWA Endemic)	Very High
Erimystax cahni	Slender Chub	25-50%	Very High
Cottus sp. 1	Bluestone Sculpin	100% (NEAFWA Endemic)	Very High
Cottus sp. 4	Clinch Sculpin	100% (NEAFWA Endemic)	Very High
Cottus sp. 5	Holston Sculpin	50-75%	Very High
Cottus sp. 7	Checkered Sculpin	100% (NEAFWA Endemic)	Very High
Etheostoma sellare	Maryland Darter	100% (NEAFWA Endemic)	Very High
Etheostoma osburni	Candy Darter	100% (NEAFWA Endemic)	Very High
Percina rex	Roanoke Logperch	75-100%	Very High
Etheostoma percnurum	Duskytail Darter	50-75%	Very High
Coregonus hoyi	Bloater	50-75%	Very High
Catostomus utawana	Summer Sucker	100% (NEAFWA Endemic)	Very High
Crystallaria cincotta	Diamond Darter	100% (NEAFWA Endemic)	Very High
Lepomis peltastes	Northern Sunfish	25-50%	Very High

Percina bimaculata	Chesapeake Logperch	100% (NEAFWA Endemic)	High
Ichthyomyzon fossor	Northern Brook Lamprey	25-50%	High
Ichthyomyzon greeleyi	Mountain Brook Lamprey	50-75%	High
Acipenser fulvescens	Lake Sturgeon	50-75%	High
Prosopium cylindraceum	Round Whitefish	50-75%	High
Notropis scabriceps	New River Shiner	75-100%	High
Phenacobius teretulus	Kanawha Minnow	75-100%	High
Noturus flavipinnis	Yellowfin Madtom	50-75%	High
Noturus gilberti	Orangefin Madtom	75-100%	High
Cottus baileyi	Black Sculpin	75-100%	High
Enneacanthus chaetodon	Blackbanded Sunfish	<25%	High
Etheostoma maculatum	Spotted Darter	50-75%	High
Percina notogramma	Stripeback Darter	100% (NEAFWA Endemic)	High
Percina gymnocephala	Appalachia Darter	75-100%	High
Percina macrocephala	Longhead Darter	50-75%	High
Thoburnia hamiltoni	Rustyside Sucker	75-100%	High
Aphredoderus sayanus gibbosus	Western Pirate Perch	<25%	High
Lethenteron appendix	American Brook Lamprey	25-50%	High
Salvelinus alpinus oquassa	Landlocked Arctic Char	100% (NEAFWA Endemic)	High
Margariscus margarita	Allegheny Pearl Dace	100% (NEAFWA Endemic)	Moderate
Exoglossum laurae	Tonguetied Minnow	50-75%	Moderate
Enneacanthus obesus	Banded Sunfish	50-75%	Moderate
Etheostoma fusiforme	Swamp Darter	25-50%	Moderate
Etheostoma vitreum	Glassy Darter	50-75%	Moderate
Etheostoma kanawhae	Kanawha Darter	50-75%	Moderate
Etheostoma longimanum	Longfin Darter	100% (NEAFWA Endemic)	Moderate

Etheostoma variatum	Variegate Darter	25-50%	Moderate
Percina peltata	Shield Darter	100% (NEAFWA Endemic)	Moderate
Cottus kanawhae	Kanawha Sculpin	100% (NEAFWA Endemic)	Moderate

PROPOSED RSGCN: 2 FRESHWATER FISH

Two Freshwater Fish species are not SGCN as of 2023 in the 14 Northeastern states; therefore, they are listed as Proposed RSGCN, and taxa team experts suggest looking at these species as future SGCN and RSGCN (Table 1.3.15).

Table 1.3.15 Proposed RSGCN 2023 Freshwater Fish.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Chrosomus sp. cf. saylori	Clinch Dace	75-100%	Very High
Aphredoderus sayanus sayanus	Eastern Pirate Perch	25-50%	High

OVERVIEW

RSGCN and Proposed RSGCN Freshwater Fish inhabit Lacustrine, Palustrine, and Riverine habitat groups (Figure 1.3.21, see *Chapter 2*). Rivers and Streams are home to 96% of these fish, 28% in Lakes and Ponds, and 15% in Nontidal Wetlands (Figure 1.3.21).

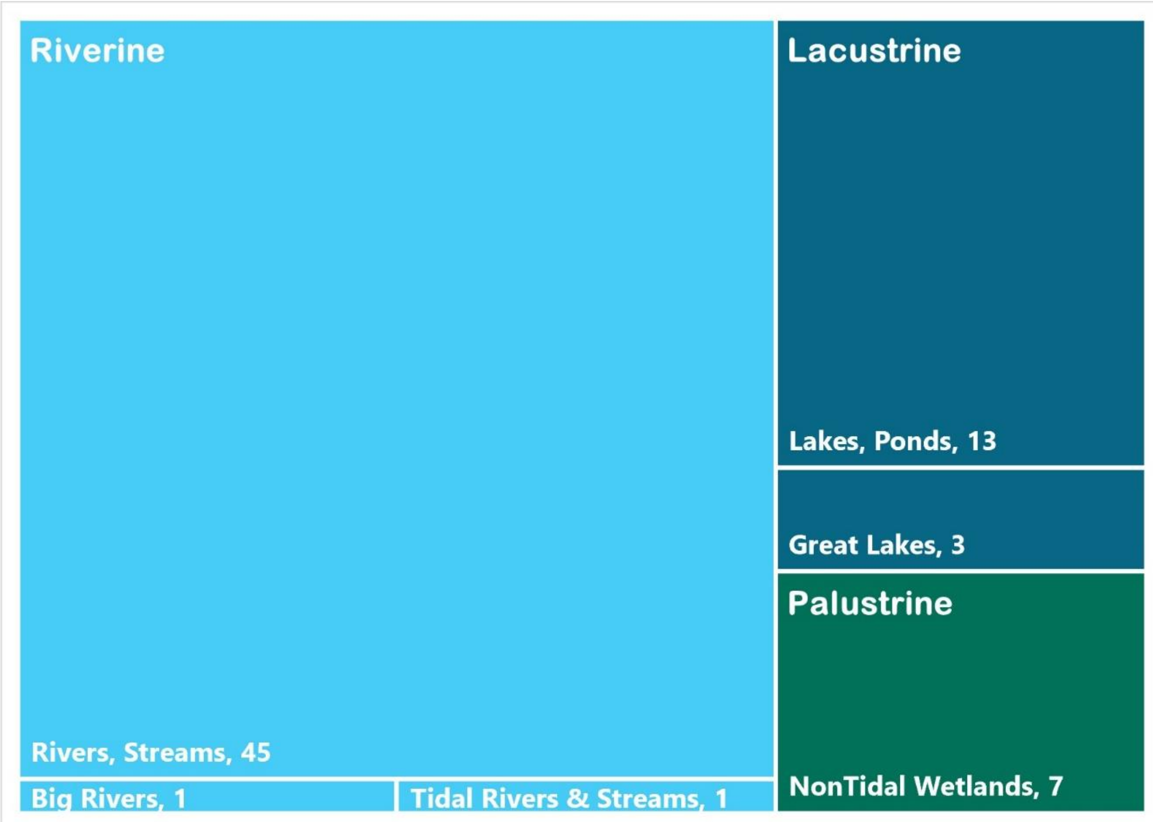


Figure 1.3.21 Number of RSGCN and Proposed RSGCN Freshwater Fish associated with each habitat in the Northeast. Species may be associated with multiple habitat types. Habitat group names are at the top of each color block and grouped by color; habitat type names appear at the bottom of each proportionally sized square and are colored by habitat group (see *Chapter 2* for more information on habitats).

Freshwater Fish (RSGCN and Proposed RSGCN) threats include Pollution (96%), Invasive and Problematic Species, Pathogens, and Genes (66%), and Climate Change (55%, Table 1.3.16). Top Pollution threats are soil erosion and sedimentation, industrial discharges, and runoff. Loss of genetic integrity, interspecific competition with a favored species, and aquatic animals also threaten Freshwater Fish. Climate Change threats to these species are due to temperature and precipitation fluctuations and gradual regime changes. In an analysis of drivers in the decline of freshwater fish, globally, invasive species, climate change, and habitat loss/degradation are the top threats. At the same time, in the US, total phosphorus, nitrogen, and riparian vegetation cover were listed as the top three threats (Brain & Prosser 2022). Additionally, Miranda et al. (2022) found that pollution from an analysis of IUCN Red-List fish species is the top threat for freshwater fishes.

Table 1.3.16 Level 1 threats with the number and percent of RSCGN and Proposed RSGCN Freshwater Fish threatened by each. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Pollution (Threat 9.0)	45	96%
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	31	66%
Climate Change (Threat 11.0)	26	55%
Natural System Modifications (Threat 7.0)	22	47%
Biological Resource Use (Threat 5.0)	18	38%
Energy Production & Mining (Threat 3.0)	12	26%
Agriculture & Aquaculture (Threat 2.0)	10	21%
Transportation & Service Corridors (Threat 4.0)	9	19%
Other (Threat 12.0)	8	17%
Human Intrusions & Disturbance (Threat 6.0)	7	15%
Residential & Commercial Development (Threat 1.0)	6	13%

WATCHLIST

Taxonomic Team experts identified 50 Freshwater Fish as Watchlist species, 31 fishes as Watchlist [Assessment Priority], three as Proposed Watchlist [Assessment Priority], and 16 species were identified for deferral to adjacent regions.

WATCHLIST [ASSESSMENT PRIORITY]: 31 FRESHWATER FISH

Taxa team experts identified 31 Freshwater Fish as Watchlist [Assessment Priority] species based on Regional Responsibility and Concern Level (Table 1.3.17). For example, the Comely Shiner (*Notropis amoenus*), which the region has 100-75% Regional Responsibility for (Table 1.3.17), was flagged by the taxa teams as needing targeted surveys. Experts have found it in the James and Rappahannock drainages but only sporadically. This species also occurs with mimic shiners; research is required to see if these fish are taking up niche space for the Comely Shiner.

Table 1.3.17 Watchlist [Assessment Priority] Freshwater Fish 2023.

Scientific Name	Common Name	Regional Responsibility
Notropis amoenus	Comely Shiner	75-100%
Notropis procne	Swallowtail Shiner	50-75%
Coregonus clupeaformis	Lake Whitefish	50-75%
Salvelinus namaycush	Lake Trout (native pop.)	50-75%
Salvelinus fontinalis	Brook Trout (wild pop.)	50-75%
Esox americanus	Redfin Pickerel	25-50%

Notropis ariommus	Popeye Shiner	25-50%
Notropis heterodon	Blackchin Shiner	25-50%
Notropis heterolepis	Blacknose Shiner	25-50%
Phenacobius mirabilis	Suckermouth Minnow	<25%
Phenacobius crassilabrum	Fatlips Minnow	<25%
Couesius plumbeus	Lake Chub	25-50%
Lythrurus lirus	Mountain Shiner	<25%
Catostomus catostomus	Longnose Sucker	25-50%
Carpiodes velifer	Highfin Carpsucker	<25%
Ictiobus cyprinellus	Bigmouth Buffalo	<25%
Lota lota	Burbot	<25%
Fundulus rathbuni	Speckled Killifish	<25%
Cottus cognatus	Slimy Sculpin	50-75%
Acantharchus pomotis	Mud Sunfish	25-50%
Ambloplites cavifrons	Roanoke Bass	50-75%
Etheostoma chlorobranchium	Greenfin Darter	<25%
Etheostoma jessiae	Blueside Darter	<25%
Etheostoma vulneratum	Wounded Darter	<25%
Percina aurantiaca	Tangerine Darter	<25%
Percina copelandi	Channel Darter	25-50%
Percina crassa	Piedmont Darter	<25%
Ammocrypta pellucida	Eastern Sand Darter	25-50%
Etheostoma denoncourti	Golden Darter	25-50%
Sander canadensis	Sauger	<25%
Etheostoma brevispinum	Carolina Fantail Darter	<25%

PROPOSED WATCHLIST [ASSESSMENT PRIORITY]: 3 FRESHWATER FISH

Three Freshwater Fish made the Proposed RSGCN category (Table 1.3.18). The Potmac Sculpin (*Cottus girardi*) is an endemic Freshwater Fish that occurs in four states (Maryland, Pennsylvania, Virginia, and West Virginia).

Table 1.3.18 Proposed Watchlist [Assessment Priority] Freshwater Fish 2023.

Scientific Name	Common Name	Regional Responsibility
Etheostoma meadiae	Bluespar Darter	50-75%
Percopsis omiscomaycus	Trout-perch	<25%
Cottus girardi	Potomac Sculpin	100% (NEAFWA Endemic)

WATCHLIST [DEFER TO ADJACENT REGION]: 16 FRESHWATER FISH

There are 16 Watchlist [Deferral] Freshwater Fish that Fish Taxonomic Team experts identified (Table 1.3.19). Eight of the taxon are deferred to the Midwest, with four fishes listed as RSGCN and one listed as Watchlist [Assessment Priority] in MAFWA. Twelve were also deferred to the Southeast; six are RSGCN in SEAFWA. No other species are deferred to the Western US or north to Canada. The eight not yet listed in the adjacent regions are opportunities for NEAFWA and neighbors to collaborate.

Table 1.3.19 2023 Freshwater Fish Watchlist [Deferral].

Scientific Name	Common Name	Deferred Region	Listed in Deferred Region
Ichthyomyzon bdellium	Ohio Lamprey	MAFWA/SEAFWA	MAFWA/ SEAFWA
Clinostomus elongatus	Redside Dace	MAFWA	MAFWA
Notropis alborus	Whitemouth Shiner	SEAFWA	SEAFWA
Cyprinella whipplei	Steelcolor Shiner	SEAFWA	No
Erimystax x-punctatus	Gravel Chub	MAFWA	Watchlist MAFWA
Erimyzon sucetta	Lake Chubsucker	MAFWA/SEAFWA	No
Cycleptus elongatus	Blue Sucker	MAFWA/SEAFWA	SEAFWA
Ameiurus brunneus	Snail Bullhead	SEAFWA	No
Fundulus catenatus	Northern Studfish	SEAFWA	No
Etheostoma cinereum	Ashy Darter	SEAFWA	No
Percina sciera	Dusky Darter	SEAFWA	No
Percina burtoni	Blotchside Logperch	SEAFWA	No
Percina maculata	Blackside Darter	MAFWA	No
Ammocrypta clara	Western Sand Darter	MAFWA/SEAFWA	MAFWA/SEAFWA
Erimonax monachus	Spotfin Chub	SEAFWA	SEAFWA
Chrosomus cumberlandensis	Blackside Dace	MAFWA	MAFWA/SEAFWA

REGIONAL EFFORTS IN NORTHEAST CONSERVATION

Several up-to-date sources of information can be useful to the Northeast states in developing the marine component of their Wildlife Action Plans. First, NOAA's National Marine Fisheries Service and the Atlantic States Marine Fisheries Commission maintain status information on species of conservation need. The Atlantic Coast Fish Habitat Partnership's recent plan[7], which presents important overview information on many of the Northeast states SGCN and RSGCN species. This plan summarizes key species, habitat, threat, and conservation action information. Finally, recent review articles by the American Fisheries Society and USGS with information about fish declines in North America can be found at Action Bioscience[8].

1.3.5 MARINE FISH

There are 661 Marine Fish (four Classes: Actinopterygii, Teleostei, Myxini, and Chondrichthyes) that inhabit the NEAFWA regional footprint in the North Atlantic. Twenty-four of these Marine Fish met the criteria as RSGCN; three are Proposed RSGCN. Sixteen are in one of the Watchlist categories: 11 Watchlist [Assessment Priority], two Watchlist [Interdependent], and three Watchlist [Deferrals], and one non-SGCN species met the criteria for Proposed Watchlist [Assessment Priority].

Regional Priority Concern Highlights:

- Climate change – range shifts, increasing temperature unknowns.
- Loss of eelgrass habitat.
- Offshore wind development.
- Fishery-independent assessments.

Species Information, Research & Monitoring Needs:

- Surveys/life history data for several skates and sharks.
- Information is needed concerning regional responsibility and seasonal activity data for migrating marine fish.

RSGCN: 24 MARINE FISH

The 2023 Northeast RSGCN list includes 24 species of marine fish. Concern levels across this group of Marine Fish range from one species, Weakfish (*Cynoscion regalis*), listed as Very High concern, to 12 species considered as High concern, with an additional 11 species listed as Moderate Concern Level (Table 1.3.20). One Marine Fish, the Atlantic Herring (*Clupea harengus*), is a NEAFWA endemic; Taxonomic Team experts agree that the stock is in decline and that this species severs several important ecological roles, such as important food source for upper trophic levels.

Table 1.3.20 Marine Fish RSGCN list 2023. Note that the Regional Responsibility listed is for the overall geographic range. Northeast regional responsibility may vary for breeding, migration, and wintering seasons.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Cynoscion regalis	Weakfish	25-50%	Very High
Rhincodon typus	Whale Shark	25-50%	High
Carcharodon carcharias	White Shark	25-50%	High
Cetorhinus maximus	Basking Shark	25-50%	High
Isurus paucus	Longfin Mako	<25%	High
Carcharhinus obscurus	Dusky Shark	<25%	High
Clupea harengus	Atlantic Herring	100% (NEAFWA Endemic)	High
Gadus morhua	Atlantic Cod	25-50%	High
Thunnus thynnus	Bluefin Tuna	<25%	High
Pseudopleuronectes americanus	Winter Flounder	75-100%	High
Dipturus laevis	Barndoor Skate	75-100%	High
Leucoraja ocellata	Winter Skate	75-100%	High
Malacoraja senta	Smooth Skate	75-100%	High
Centropristis striata	Black Sea Bass	25-50%	Moderate
Carcharias taurus	Sand Tiger	25-50%	Moderate
Lamna nasus	Porbeagle	50-75%	Moderate
Alopias vulpinus	Common Thresher Shark	25-50%	Moderate
Isurus oxyrinchus	Shortfin Mako	<25%	Moderate
Carcharhinus plumbeus	Sandbar Shark	25-50%	Moderate
Carcharhinus signatus	Night Shark	<25%	Moderate
Sphyrna zygaena	Smooth Hammerhead	50-75%	Moderate
Pomatomus saltatrix	Bluefish	25-50%	Moderate
Tautoga onitis	Tautog	75-100%	Moderate
Amblyraja radiata	Thorny Skate	50-75%	Moderate

PROPOSED RSGCN: 3 MARINE FISH

These three species of Marine Fish are not currently listed in Northeast SWAPs as SGCN but were of concern to the taxa team, which concurred with their qualification for the 2023 Proposed RSGCN list. Yellowtail Flounder (*Limanda ferruginea*) and Atlantic Halibut (*Hippoglossus hippoglossus*) have stock assessments that indicate overfishing. The White Marlin (*Kajikia albida*) has no commercial fishery but are highly migratory sportfish (Table 1.3.21).

Table 1.3.21 Proposed RSGCN Marine Fish 2023.

Scientific Name	Common Name	Regional Responsibility	Concern Final
Limanda ferruginea	Yellowtail Flounder	75-100%	Moderate
Hippoglossus hippoglossus	Atlantic Halibut	50-75%	Moderate
Kajikia albida	White Marlin	25-50%	Moderate

OVERVIEW

The 27 RSGCN and Proposed RSGCN Marine Fish can be found in four habitat groups and five habitat types (see *Chapter 2*). All (100%) of these fish use Marine Off-shore habitats, 81% use Marine Near-shore, and 56% use Estuaries. Smaller numbers of these Marine Fish use Tidal Rivers and Tidal wetlands (Figure 1.3.22).

Figure 1.3.22 Number of RSGCN and Proposed RSGCN Marine Fish associated with each habitat in the Northeast. Species may be associated with multiple habitat types. Habitat group names are at the top of each color block and grouped by color, habitat type names appear at the bottom of each proportionally sized square and colored by habitat group (see *Chapter 2* for more information on habitats).

Threatening Marine Fish are Biological Resource Use (100%), Climate Change (81%), and Pollution (59%, Table 1.3.22). Biological resource use threats include commercial fishing, recreational or subsistence fishing, and commercial harvesting. Miranda et al. (2022) found that fishing is the main threat to marine fishes. In addition, climate change is causing direct and indirect threats to marine ecosystems, including fish listed as RSGCN. Several studies have suggestions to help managers mitigate the effects of climate change and reduce it as an amplifier for other threats (Lomonico et al. 2021, Thorstad et al. 2020).

Table 1.3.22 Level 1 threats with the percent of RSCGN and Proposed RSGCN Marine Fish threatened by each. The top Level 3 threats from each Level 1 category with the percent of species threatened by each Level 3. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Biological Resource Use (Threat 5.0)	27	100%
Climate Change (Threat 11.0)	22	81%
Pollution (Threat 9.0)	16	59%
Energy Production & Mining (Threat 3.0)	15	56%
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	12	44%
Human Intrusions & Disturbance (Threat 6.0)	9	33%
Other (Threat 12.0)	7	26%
Transportation & Service Corridors (Threat 4.0)	5	19%
Agriculture & Aquaculture (Threat 2.0)	4	15%
Natural System Modifications (Threat 7.0)	1	4%
Residential & Commercial Development (Threat 1.0)	1	4%

WATCHLIST

Taxonomic Teams identified 17 Marine Fish species as Watchlist species. Eleven species as Watchlist [Assessment Priority], one species is listed as Proposed Watchlist [Assessment Priority], two species are listed as Watchlist [Interdependent], and three species were identified for deferral to adjacent regions.

WATCHLIST [ASSESSMENT PRIORITY]: 11 MARINE FISH

Taxonomic Team experts assigned 11 Marine Fish Watchlist [Assessment Priority] (Table 1.3.23). There are two species, Atlantic Torpedo (*Torpedo nobiliana*) and Atlantic Tomcod (*Microgadus tomcod*), that are Endemic to the North Atlantic and the Northeast. Seven Marine Fish Watchlist [Assessment Priority] species have greater than 50% regional responsibility, indicating their range primarily occurs in the Northeast. The Cownose Ray (*Rhinoptera bonasus*) has Regional Responsibility between 50-25%. Two more Watchlist Marine Fish have Regional Responsibility under 25%. Watchlist [Assessment Priority] species differ from RSGCN in that they do not have a conservation Concern Level due to a lack of information on population status, natural history, and threats. Therefore, they are aptly highlighted as needing additional assessment and data.

Table 1.3.23 Marine Fish Watchlist [Assessment Priority] 2023. Note that the Regional Responsibility listed is for the overall geographic range. Northeast regional responsibility may vary for breeding, migration, and wintering seasons.

Scientific Name	Common Name	Regional Responsibility
Torpedo nobiliana	Atlantic Torpedo	100% (NEAFWA Endemic)
Microgadus tomcod	Atlantic Tomcod	100% (NEAFWA Endemic)
Prionace glauca	Blue Shark	75-100%
Paralichthys oblongus	Fourspot Flounder	75-100%
Dasyatis centroura	Roughtail Stingray	50-75%
Fundulus luciae	Spotfin Killifish	50-75%
Syngnathus fuscus	Northern Pipefish	50-75%
Leucoraja garmani	Rosette Skate	50-75%
Rhinoptera bonasus	Cownose Ray	25-50%
Sphyrna lewini	Scalloped Hammerhead	<25%
Hippocampus erectus	Lined seahorse	<25%

PROPOSED WATCHLIST [ASSESSMENT PRIORITY]: 1 MARINE FISH

Golden Tilefish (*Lopholatilus chamaeleonticeps*) is a subspecies not currently on any Northeast state SGCN list. The highest abundance of Golden Tilefish occurs between Massachusetts and New Jersey. Taxonomic Team experts indicated that they are very susceptible to temperature change, leading to high climate vulnerability. The Northeast has 50-75% Regional Responsibility. This species is commercially and recreationally fished.

WATCHLIST [INTERDEPENDENT SPECIES]: 2 MARINE FISH

Watchlist [Interdependent Species] are species on which an RSGCN or Proposed RSGCN depend but which does not independently qualify as RSGCN. Taxonomic Team experts flagged both Marine Fish listed in this category as highly important migratory forage species that need more assessment due to being very data-limited (Table 1.3.24).

Table 1.3.24 2023 Watchlist [Interdependent Species] Marine Fish.

Scientific Name	Common Name	Regional Responsibility
Ammodytes americanus	American Sand Lance	75-100%
Ammodytes dubius	Northern Sand Lance	75-100%

WATCHLIST [DEFER TO ADJACENT REGION]: 3 MARINE FISH

Taxonomic Team experts deferred three Watchlist [Deferral] Marine Fish (Table 1.3.25). All three taxa are deferred to the Southeast with one species, Great Hammerhead (*Sphyrna mokarran*) listed as RSGCN in SEAFWA at High Concern Level.

Table 1.3.25 Watchlist [Defer to Adjacent Region] Marine Fish 2023.

Scientific Name	Common Name	Deferred Region(s)	Listed in Deferred Region(s)
Sphyrna mokarran	Great Hammerhead	SEAFWA	RSGCN in SEAFWA
Syngnathus floridae	Dusky Pipefish	SEAFWA	No
Micropogonias undulatus	Atlantic Croaker	SEAFWA	No

REGIONAL EFFORTS IN NORTHEAST CONSERVATION

Several up-to-date sources of information can be useful to the Northeast states in developing the marine component of their Wildlife Action Plans. First, NOAA's National Marine Fisheries Service and the Atlantic States Marine Fisheries Commission maintain status information on species of conservation need. The Atlantic Coast Fish Habitat Partnership's recent plan[7], which presents important overview information on many of the Northeast states SGCN and RSGCN species. This plan summarizes key species, habitat, threat, and conservation action information. Finally, recent review articles by the American Fisheries Society and USGS with information about fish declines in North America can be found at Action Bioscience[8].

1.3.6 MAMMALS

There are 183 (Class Mammalia) that inhabit the NEAFWA regional footprint. Twenty-nine of these mammals met the criteria as RSGCN. Twenty are listed in one of the Watchlist categories: 12 Watchlist [Assessment Priority], five Watchlist [Deferrals], and three non-SGCN species met the criteria for Proposed Watchlist [Assessment Priority]. Twelve Mammals are federally listed.

Regional Priority Concern Highlights:
- Wind turbine threats (migratory bats).
- Offshore wind development (marine mammals).
- Cave hibernating bat populations may be stabilizing post-white nose syndrome.
- Regionally extirpated species could not manage/conserve at this time and were excluded from the RSGCN assessment.

Species Information, Research & Monitoring Needs:
- Regional status assessments.
- Research on small mammal populations.
- Small mammals are data deficient and need more surveys.

RSGCN: 29 MAMMALS

The 2023 Northeast RSGCN list includes 29 species of mammals, of which nine are bats, nine are small mammals, seven are marine mammals, two are mesocarnivores, and two are rabbits and hares (Table 1.3.26). Seven mammals (five marine mammals and two bats) are listed as Federally Endangered. Mammal Concern levels range from 48% Very High concern, 28% High concern, and 24% Moderate concern level (Table 1.3.26). The New England Cottontail (*Sylvilagus transitionalis*) and five small mammals are endemic within the Northeast.

Table 1.3.26 2023 Mammal RSGCN. Note that the Regional Responsibility listed is for the overall geographic range. Northeast regional responsibility may vary for breeding, migration, and wintering seasons.

Subtaxon	Scientific Name	Common Name	Regional Responsibility	Concern Level
Bats	*Myotis lucifugus*	Little Brown Myotis	25-50%	Very High
Bats	*Myotis septentrionalis*	Northern Long-eared Bat	25-50%	Very High
Bats	*Myotis sodalis*	Indiana Myotis	25-50%	Very High
Rabbits and Hares	*Sylvilagus transitionalis*	New England Cottontail	100% (NEAFWA Endemic)	Very High

Marine Mammals	*Physeter macrocephalus*	Sperm Whale	<25%	Very High
Marine Mammals	*Balaenoptera borealis*	Sei Whale	25-50%	Very High
Marine Mammals	*Balaenoptera physalus*	Fin Whale	<25%	Very High
Marine Mammals	*Balaenoptera musculus*	Blue Whale	25-50%	Very High
Marine Mammals	*Eubalaena glacialis*	North Atlantic Right Whale	50-75%	Very High
Other Mammals	*Lynx canadensis*	Canada Lynx	25-50%	Very High
Bats	*Corynorhinus townsendii virginianus*	Virginia Big-eared Bat	25-50%	Very High
Small Mammals:Rodentia	*Neotoma magister*	Allegheny Woodrat	50-75%	Very High
Small Mammals:Moles and Shrews	*Sorex cinereus nigriculus*	Tuckahoe Masked Shrew	100% (NEAFWA Endemic)	Very High
Bats	*Perimyotis subflavus*	Tricolored Bat	<25%	Very High
Bats	*Myotis leibii*	Eastern Small-footed Myotis	50-75%	High
Small Mammals:Rodentia	*Microtus chrotorrhinus*	Rock Vole	75-100%	High
Marine Mammals	*Megaptera novaeangliae*	Humpback Whale	50-75%	High
Small Mammals:Rodentia	*Glaucomys sabrinus fuscus*	Virginia Northern Flying Squirrel	100% (NEAFWA Endemic)	High
Small Mammals:Rodentia	*Sciurus niger cinereus*	Delmarva Fox Squirrel	100% (NEAFWA Endemic)	High
Small Mammals:Rodentia	*Synaptomys borealis sphagnicola*	Northern Bog Lemming	75-100%	High
Small Mammals:Rodentia	*Microtus chrotorrhinus carolinensis*	Southern Rock Vole	75-100%	High

Small Mammals:Rodentia	*Microtus pennsylvanicus provectus*	Block Island Meadow Vole	100% (NEAFWA Endemic)	High
Bats	*Lasionycteris noctivagans*	Silver-haired Bat	<25%	Moderate
Bats	*Lasiurus borealis*	Eastern Red Bat	<25%	Moderate
Bats	*Lasiurus cinereus*	Hoary Bat	<25%	Moderate
Other Mammals	*Spilogale putorius*	Eastern Spotted Skunk	25-50%	Moderate
Rabbits and Hares	*Sylvilagus obscurus*	Appalachian Cottontail	50-75%	Moderate
Small Mammals:Rodentia	*Sciurus niger vulpinus*	Fox Squirrel	100% (NEAFWA Endemic)	Moderate
Marine Mammals	*Phocoena phocoena*	Harbor Porpoise	50-75%	Moderate

Since all mammals of conservation concern were listed as SGCN in at least one state, no mammals were listed as Proposed RSGCN.

OVERVIEW

RSGCN Mammals use every habitat group and every habitat type described in *Chapter 2*. Sixty-nine percent of RSGCN Mammals use Forest Woodlands, 48% use Glade, Barren, and Savannah habitats, and 48% use Riparian Floodplains (Figure 1.3.23). The RSGCN Mammals are a diverse group of species, like bats, small mammals, and whales, explaining the large number of other habitats that less than 50% of them inhabit.

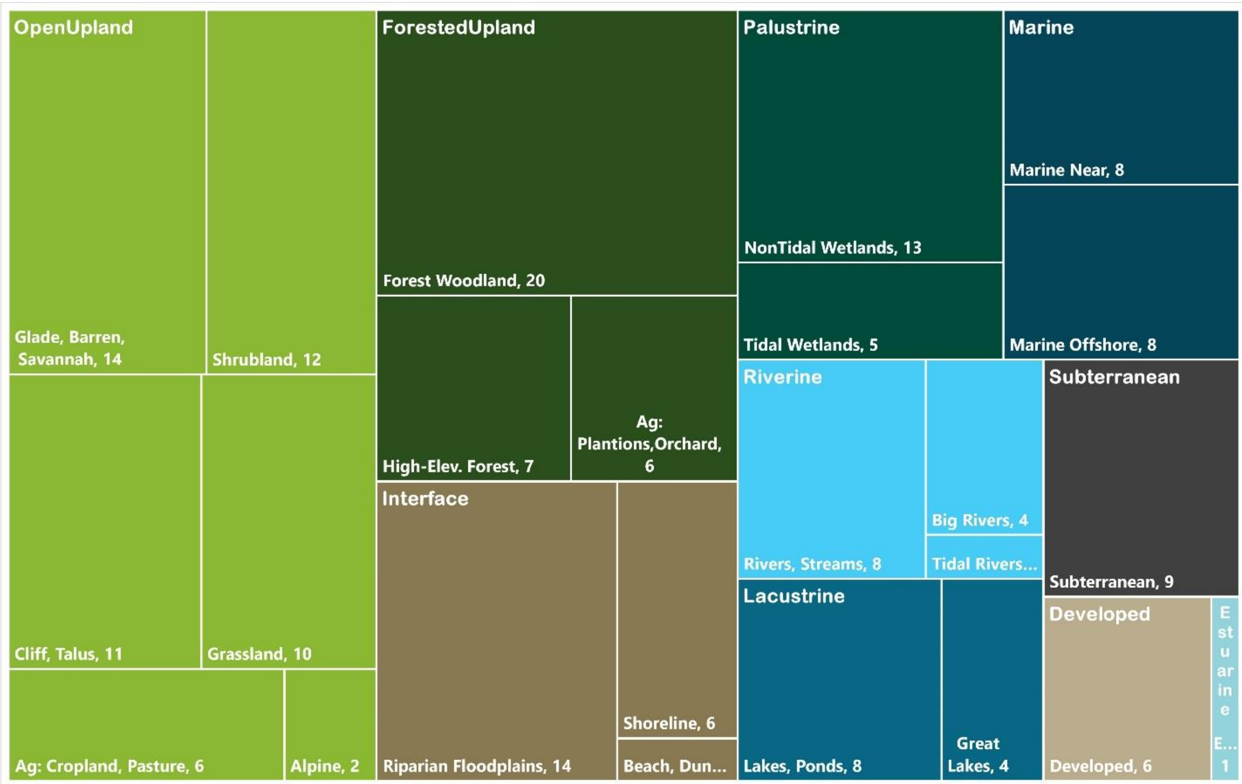


Figure 1.3.23 Number of RSGCN Mammal associated with each habitat in the Northeast. Species may be associated with multiple habitat types. Habitat group names are at the top of each color block and grouped by color; habitat type names appear at the bottom of each proportionally sized square and are colored by habitat group (see *Chapter 2* for more information on habitats). Estuaries are the smallest block in the lower right-hand corner, and one mammal uses this habitat.

RSGCN Mammals are all (100%) threatened by Climate Change. Climate change impacts include increased temperature fluctuations, changes in vegetation communities, and storms and severe weather. Ninety-seven percent of this taxon are threatened by Invasive and Problematic Species, Pathogens, and Genes; these threats are increased predation by mesopredators, and viral and fungal pathogens (Table 1.3.27). Biological Resource Use is the third Level 1 threat to Mammals, threatening 93% of them. Threats from this category fall under logging and wood harvesting, where mammals are threatened by complete or partial removal of the forest floor and management of cutting areas (Table 1.3.27). Forest management across regional landscapes can benefit mammals and other threatened species; see *Chapter 7* for Forest Service and other partners forest species lists, action plans, and more. Littlefield and D'Amato (2022) reviewed research on the trade-offs of forest habitat management and climate change via forest carbon, two top threats for mammals. Their study, and others, show that these top threats can be mitigated and managed properly across the landscape for the benefit of all wildlife. Research in Pennsylvania is one example showing the difference in species richness and abundance across wildlife taxa depending on forest management intensity (Fredericksen et al. 2000). Well-thought-out regional plans across varieties of land ownership can uphold the integrity of the forested mosaic landscape to counter many threats to RSGCN species.

Table 1.3.27 Level 1 threats with the number and percent of RSCGN Mammals threatened by each. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Climate Change (Threat 11.0)	29	100%
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	28	97%
Biological Resource Use (Threat 5.0)	27	93%
Transportation & Service Corridors (Threat 4.0)	25	86%
Pollution (Threat 9.0)	24	83%
Energy Production & Mining (Threat 3.0)	23	79%
Residential & Commercial Development (Threat 1.0)	21	72%
Natural System Modifications (Threat 7.0)	19	66%
Human Intrusions & Disturbance (Threat 6.0)	16	55%
Agriculture & Aquaculture (Threat 2.0)	14	48%
Other (Threat 12.0)	8	28%

WATCHLIST

In total, 20 mammals are listed as Watchlist species, 12 species that taxa teams identified as Watchlist [Assessment Priority], three species listed as Proposed Watchlist [Assessment Priority], and five species identified for deferral to adjacent regions.

WATCHLIST [ASSESSMENT PRIORITY]: 12 MAMMALS

Mammal Taxonomic Team experts assigned 12 Mammals to the 2023 Mammal Watchlist [Assessment Priority] list. These include seven small mammals, three mesocarnivores (Other Mammals), one hare, and one ungulate (Table 1.3.28). One small mammal is a northeastern endemic, and two other small mammals have a Regional Responsibility of 50-75%, indicating their range primarily occurs in the Northeast. Two other small mammals have Regional Responsibility between 50-75%. The other species have regional responsibility under 50%. Watchlist [Assessment Priority] species differ from RSGCN because they do not have a conservation Concern Level due to a lack of information on population status, natural history, and threats. Mammal Taxonomic Team experts stated that small mammals within the region are in dire need of additional assessment and information.

Table 1.3.28 2023 Watchlist [Assessment Priority] Mammals. Note that the Regional Responsibility listed is for the overall geographic range. Northeast regional responsibility may vary for breeding, migration, and wintering seasons.

Subtaxon	Scientific Name	Common Name	RSGCN Status	Regional Responsibility
Small Mammals: Moles and Shrews	*Sorex albibarbis*	Eastern Water Shrew	Watchlist [Assessment Priority]	75-100%
Small Mammals: Moles and Shrews	*Sorex palustris*	American Water Shrew	Watchlist [Assessment Priority]	25-50%
Small Mammals: Moles and Shrews	*Sorex dispar*	Long-tailed Shrew	Watchlist [Assessment Priority]	75-100%
Small Mammals: Moles and Shrews	*Cryptotis parva*	North American Least Shrew	Watchlist [Assessment Priority]	<25%
Rabbits and Hares	*Lepus americanus*	Snowshoe Hare	Watchlist [Assessment Priority]	25-50%
Small Mammals: Rodentia	*Synaptomys cooperi*	Southern Bog Lemming	Watchlist [Assessment Priority]	50-75%
Other Mammals	*Mustela nivalis*	Least Weasel	Watchlist [Assessment Priority]	25-50%
Other Mammals	*Martes americana*	American Marten	Watchlist [Assessment Priority]	25-50%
Other Mammals	*Urocyon cinereoargenteus*	Gray Fox	Watchlist [Assessment Priority]	<25%
Ungulates	*Alces alces*	Moose	Watchlist [Assessment Priority]	25-50%
Small Mammals: Moles and Shrews	*Sorex hoyi winnemana*	Southern Pygmy Shrew	Watchlist [Assessment Priority]	50-75%
Small Mammals: Rodentia	*Microtus pennsylvanicus shattucki*	Penobscot Meadow Vole	Watchlist [Assessment Priority]	100% (NEAFWA Endemic)

PROPOSED WATCHLIST [ASSESSMENT PRIORITY]: 3 MAMMALS

Three species of small mammals are not currently listed in NE SWAPS as SGCN but were of concern to the Taxonomic Team, who concurred with their qualification for the 2023 Proposed Watchlist [Assessment Priority] list. Two of these species are endemic, and one has a regional responsibility greater than 75% (Table 1.3.29).

Table 1.3.29 2023 Proposed Watchlist [Assessment Priority] 2023.

Subtaxon	Scientific Name	Common Name	RSGCN Status	Regional Responsibility
Small Mammals: Rodentia	*Microtus breweri*	Beach Vole	Proposed Watchlist [Assessment Priority]	100% (NEAFWA Endemic)
Small Mammals: Rodentia	*Glaucomys sabrinus macrotis*	Northern Flying Squirrel	Proposed Watchlist [Assessment Priority]	75-100%
Small Mammals: Rodentia	*Peromyscus leucopus ammodytes*	Monomoy White-footed Deermouse	Proposed Watchlist [Assessment Priority]	100% (NEAFWA Endemic)

WATCHLIST [DEFER TO ADJACENT REGION]: 5 MAMMALS

Mammal Taxonomic Team experts placed four bats and one small mammal on the deferral list due to conservation concerns but recognized the core of the ranges fall to the south, and therefore stewardship, are in the southeastern United States (Table 1.3.30). The only deferred small mammal, the Carolina Northern Flying Squirrel (*Glaucomys sabrinus coloratus*), and two of the bats, Southeastern Myotis (*Myotis austroriparius*) and Eastern Big-eared Bat (*Corynorhinus rafinesquii macrotis*), are already listed as RSGCN in the Southeast.

Table 1.3.30 2023 Mammal Watchlist [Deferral] list.

Subtaxon	Scientific Name	Common Name	Region Deferred	Listed in Deferred Region(s)
Small Mammals: Rodentia	*Glaucomys sabrinus coloratus*	Carolina Northern Flying Squirrel	SEAFWA	SEAFWA
Bats	*Myotis austroriparius*	Southeastern Myotis	SEAFWA	SEAFWA
Bats	*Lasiurus seminolus*	Seminole Bat	SEAFWA	No
Bats	*Corynorhinus rafinesquii*	Rafinesque's Big-eared Bat	SEAFWA	SEAFWA
Bats	*Corynorhinus rafinesquii macrotis*	Eastern Big-eared Bat	SEAFWA	No

REGIONAL EFFORTS IN MAMMAL NORTHEAST CONSERVATION

The Northeast Regional Conservation Needs Grant Program funded projects specific to Mammals. Bats have been a primary focus, rightfully so, considering there are 13 listed in an RSGCN category. One such project, **Design and Implement Conservation Strategies for Northeast Species of Greatest Conservation Need: Bat Cave Gating**[1]**,** provided funding to reduce human disturbance at bat hibernacula cave sites across the northeast in 2016. Another RCN project[1] developed a five-factor analysis status review for the little brown bat, while others focused on White-nose syndrome and its effects on bats and testing for treatments. Two reports on the Allegheny Woodrat were written in 2015 through the RCN program. One report examined the variation in acorn mast production and Allegheny Woodrat populations in Western Maryland (Duda et al. 2015). Another report assessed their populations in Maryland, where they are endangered (Pearce et al. 2015).

1.3.7 REPTILES

There are 115 (Class Reptilia) that inhabit the NEAFWA regional footprint. Sixteen of these Reptiles met the criteria as RSGCN, including seven freshwater turtles, five snakes, and four sea turtles. Nine are listed in one of the Watchlist categories: 16 Watchlist [Assessment Priority] and one Watchlist [Deferrals]. Seven of these Reptiles are listed as Federally Threatened or Endangered.


Bog Turtle @ Sean McCandless

Regional Priority Concern Highlights:

- Range constriction & habitat modifications.
- Climate change vulnerabilities.

- Illegal trade (especially turtles).
- Sea turtles: vessel strikes, offshore wind, fisheries interactions.
- Challenges for conservation posed by unique or disjunct populations across species ranges – taxonomy, distributions, population status, etc.

Species Information, Research & Monitoring Needs:

- Increased sampling of fossorial species.
- Conservation barriers need to be addressed.
- Lack of survey/population data for cryptic species, especially long-term datasets.

RSGCN: 16 REPTILES

The 2023 Northeast RSGCN list includes 16 species of reptiles. Concern levels across this group of Reptiles range from six turtles listed as Very High concern, six taxon considered High concern, and four species listed as Moderate Concern Level (Table 1.3.31). One snake, the Mountain Earthsnake (*Virginia valeriae pulchra*), and two populations of Freshwater turtles are NEAFWA endemics. In addition, there are seven entities on the Reptile RSGCN list that the Northeast has less than 25% Regional Responsibility; the Overriding Factors for low Regional Responsibility for this group include several Highly Imperiled, Migratory, Disjunct Populations that warrant RSGCN listing.

Table 1.3.31 2023 Reptile RSGCN. Note that the Regional Responsibility listed is for the overall geographic range. Northeast regional responsibility may vary for breeding, migration, and wintering seasons.

Subtaxon	Scientific Name	Common Name	Regional Responsibility	Concern Level
Sea Turtles (Marine)	*Dermochelys coriacea*	Leatherback Sea Turtle	<25%	Very High
Sea Turtles (Marine)	*Lepidochelys kempii*	Kemp's Ridley Sea Turtle	<25%	Very High
Sea Turtles (Marine)	*Caretta caretta*	Loggerhead Sea Turtle	<25%	Very High
Sea Turtles (Marine)	*Chelonia mydas*	Green Sea Turtle	<25%	Very High
Turtles	*Emydoidea blandingii*	Blanding's Turtle	<25%	Very High
Turtles	*Glyptemys muhlenbergii*	Bog Turtle (Northern pop.)	100% (NEAFWA Endemic)	Very High

Turtles	*Pseudemys rubriventris*	Northern Red-bellied Cooter (Massachusetts pop.)	100% (NEAFWA Endemic)	High
Snakes	*Crotalus horridus*	Timber Rattlesnake	<25%	High
Snakes	*Pituophis melanoleucus melanoleucus*	Northern Pinesnake	25-50%	High
Turtles	*Clemmys guttata*	Spotted Turtle	50-75%	High
Turtles	*Glyptemys insculpta*	Wood Turtle	75-100%	High
Snakes	*Sistrurus catenatus*	Eastern Massasauga	<25%	High
Snakes	*Thamnophis brachystoma*	Short-headed Gartersnake	75-100%	Moderate
Snakes	*Virginia valeriae pulchra*	Mountain Earthsnake	100% (NEAFWA Endemic)	Moderate
Turtles	*Malaclemys terrapin*	Diamond-backed Terrapin	25-50%	Moderate
Turtles	*Terrapene carolina*	Eastern Box Turtle	25-50%	Moderate

Since all Reptiles of conservation concern were listed as SGCN in at least one state, none were listed as Proposed RSGCN.

OVERVIEW

RSGCN Reptiles inhabit nine habitat groups and 21 habitat types (see *Chapter 2*). These Reptiles used two habitats more than all the others, Riparian Floodplains and Non-tidal Wetlands (each used by 50% of RSGCN Reptiles). Forty-four percent of RSGCN Reptiles inhabit each of these five habitat types: Forest Woodlands, Grassland, Glade, Barren, and Savannah, Shrubland, and Agriculture: Cropland (Figure 1.3.24). Four of those are Open Uplands, and one is Forested Upland. Thirty-eight percent or less of these reptiles use 14 other habitat types.

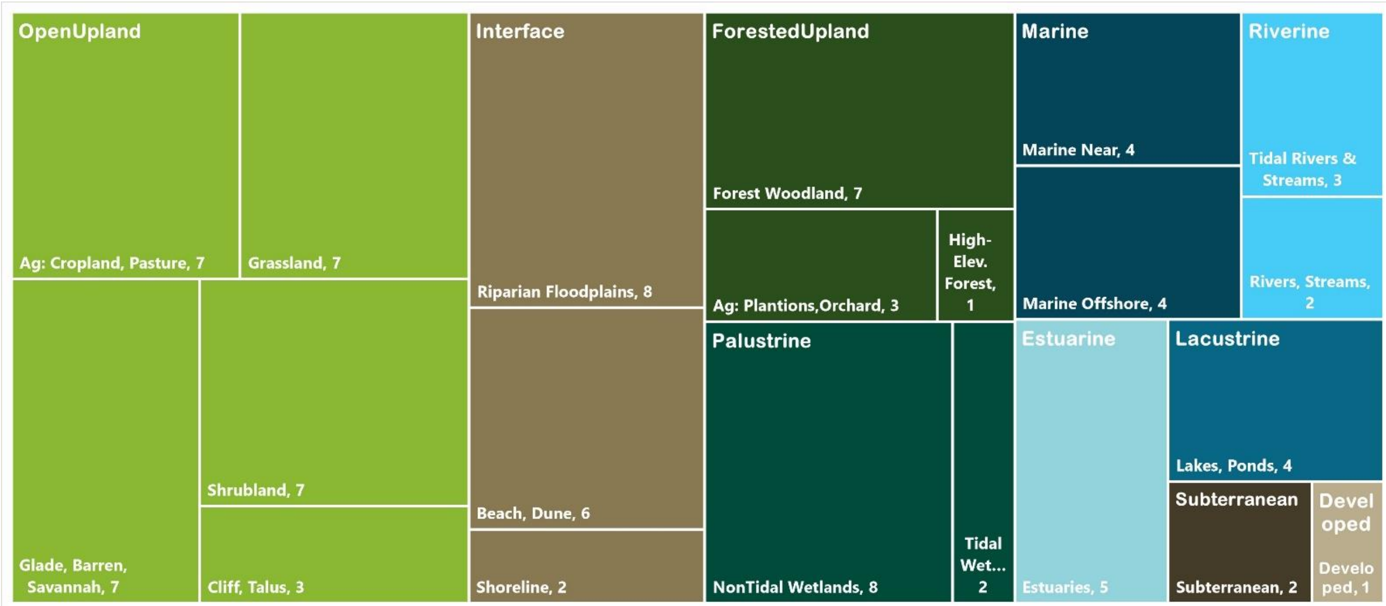


Figure 1.3.24 Number of RSGCN Reptile associated with each habitat in the Northeast. Species may be associated with multiple habitat types. Habitat group names are at the top of each color block and grouped by color, habitat type names appear at the bottom of each proportionally sized square and colored by habitat group (see *Chapter 2* for more information on habitats).

The top three Level 1 threats, Biological Resource Use, Climate Change, and Invasive and Problematic Species, Pathogens and Genes, impact 100% of RSGCN Reptiles. Ninety-four percent of these Reptiles are threatened by the following three Level 1 categories, Natural Systems Modifications, Residential & Commercial Development, and Transportation & Service Corridors (Table 1.3.32). Hunting and collection of reptiles is a concern as poaching/persecution of terrestrial animals from illegal animal trade, primarily for turtles. Climate change threats to reptiles include changes in vegetation communities and increases in temperature fluctuations; these mostly harm nest success and temperature-dependent sex determination in nests, skewing future populations sex ratios, along with storms and severe weather. Pathogens (bacterial, fungal, viral) and prion diseases all threaten >50% of RSGCN Reptiles, along with increased predation by mesopredators like raccoons (Table 1.3.32). Cox et al. (2022) found that conservation measures to protect other vertebrates can protect reptiles from these threats like habitat preservation, control of trade, and invasive species management.

Table 1.3.32 Level 1 threats with the number and percent of RSCGN Reptiles threatened by each. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Biological Resource Use (Threat 5.0)	16	100%
Climate Change (Threat 11.0)	16	100%

Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	16	100%
Natural System Modifications (Threat 7.0)	15	94%
Residential & Commercial Development (Threat 1.0)	15	94%
Transportation & Service Corridors (Threat 4.0)	15	94%
Agriculture & Aquaculture (Threat 2.0)	14	88%
Pollution (Threat 9.0)	14	88%
Human Intrusions & Disturbance (Threat 6.0)	12	75%
Energy Production & Mining (Threat 3.0)	10	63%
Other (Threat 12.0)	6	38%

WATCHLIST

In total, nine species are listed as Watchlist species, eight that the Reptile Taxonomic Team identified as Watchlist [Assessment Priority], and one that identified for deferral to adjacent regions. Watchlist Assessment Priority species inform 2025 SWAP revisions and serve as a tool to prioritize research and monitoring needs for these taxa. Watchlist species deferred to adjacent regions also inform nationwide cross-regional collaboration and conservation communication.

WATCHLIST [ASSESSMENT PRIORITY]: 8 REPTILES

The 2023 Reptile Watchlist [Assessment Priority] list contains six snakes, one lizard, and one freshwater turtle (Table 1.3.33). Two snake species, Northern Black Racer (*Coluber constrictor constrictor*) and Smooth Greensnake (*Opheodrys vernalis*), have a Regional Responsibility of 50-75%; both are dependent on early successional forests and require more research to inform conservation and management of these species. The Eastern Ribbonsnake (*Thamnophis saurita*) has 25-50% Regional Responsibility, and the other five species have Regional Responsibility under 25%. Watchlist [Assessment Priority] species differ from RSGCN in that they do not have a conservation Concern Level due to a lack of information on population status, natural history, and threats. Therefore, they are aptly highlighted as needing more assessment and data.

Table 1.3.33 Reptile Watchlist [Assessment Priority] list for 2023. Note that the Regional Responsibility listed is for the overall geographic range. Northeast regional responsibility may vary for breeding, migration, and wintering seasons.

Subtaxon	Scientific Name	Common Name	Regional Responsibility
Lizards	*Plestiodon anthracinus*	Coal Skink	<25%
Snakes	*Pantherophis guttatus*	Red Cornsnake	<25%
Snakes	*Lampropeltis getula*	Eastern Kingsnake	<25%

Snakes	*Heterodon platirhinos*	Eastern Hog-nosed Snake	<25%
Turtles	*Apalone spinifera*	Spiny Softshell	<25%
Snakes	*Thamnophis saurita*	Eastern Ribbonsnake	25-50%
Snakes	*Coluber constrictor constrictor*	Northern Black Racer	50-75%
Snakes	*Opheodrys vernalis*	Smooth Greensnake	50-75%

WATCHLIST [DEFER TO ADJACENT REGION]: 1 REPTILE

Atlantic Hawksbill Sea Turtle (*Eretmochelys imbricata imbricata*) is a highly migratory sea turtle with few occurrences in the Northeast. The Reptile Taxonomic Team still has concerns for this species and deferred it to the Southeast. While the occurrences in the Northeast are historically low, the Atlantic Hawksbill uses the Northeast for seasonal foraging habitat and is susceptible to cold stunning in bays and estuaries. Climate change could lead to more occurrences as the waters warm.

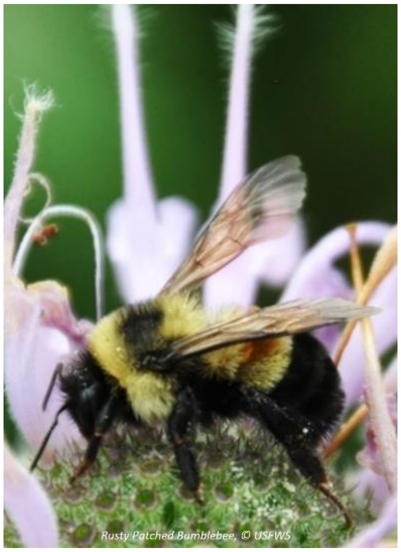
REGIONAL EFFORTS IN NORTHEAST CONSERVATION

Projects funded through the RCN Grant Program[1] for Reptiles include: **The Wood Turtle (*Glyptemys insculpta*) in the Northeastern United States: A Status Assessment and Conservation Strategy, Assessment and evaluation of prevalence of fungal dermatitis in New England Timber Rattlesnake populations, The Northern Diamondback Terrapin (*Malaclemys terrapin terrapin*) in the NE United States: A regional conservation strategy, Conservation genetics of the Wood Turtle from ME to VA, Northern Red Bellied Cooter Five Factor Analysis, Northern and peripheral populations of the Timber Rattlesnake, Spotted Turtle Conservation, Eastern Box Turtle Conservation, Road Mitigation, Wood & Blanding's Turtle Conservation, and Eastern Box Turtle Genetics**. Northeast Partners in Amphibian and Reptile Conservation (NEPARC)[2] and the Northeast Turtles website[9] has more information. The Working Lands for Wildlife has a Northeast Turtle Project[10] in seven states, where the Natural Resource Conservation Service (NRCS) works with private landowners towards conservation and wildlife improvements.

1.3.8 BUMBLE AND SOLITARY BEES

519 Bees (Order Hymenoptera) inhabit the NEAFWA regional footprint. Seven of these Bumble Bees (3 species) and Solitary Bees (4 species) met the criteria as RSGCN, and one Solitary Bee is listed as Proposed RSGCN. Thirty-five are listed in one of the

Watchlist categories: there are ten Watchlist [Assessment Priority], one Watchlist [Interdependent Species], 10 Watchlist [Defer to Adjacent Region], and 14 non-SGCN species met the criteria for Proposed Watchlist [Assessment Priority]. One RSGCN, the Rusty-patched Bumble Bee (*Bombus affinis*), is federally listed as Endangered.



Regional Priority Concern Highlights:
- Phenology mismatch due to climate change.
- Conflicts with invasive species control and the use of insecticides.
- Development, loss of host plants, all tied to habitat disturbance and loss.

Species Information, Research & Monitoring Needs:
- Targeted surveys for many Watchlist [Assessment Priority] species with data deficiencies.
- Identification of finer habitat details needed.
- Population occurrences to inform other data needs.

RSGCN: 7 BEES

The 2023 Northeast RSGCN list includes seven species of Bees. Concern levels across this group of Bees range from three species listed as Very High concern, two taxa considered as High concern, with two species listed as Moderate Concern Level (Table 1.3.34). All seven have a Regional Responsibility of 25-50% to 50-75%. The Overriding Factors for this group include several Highly Imperiled, Core populations, Disjunct Populations, among others that warrant RSGCN listing.

Table 1.3.34 2023 Bee RSGCN. Note that the Regional Responsibility listed is for the overall geographic range. Northeast regional responsibility may vary for breeding, migration, and wintering seasons.

Subtaxon	Scientific Name	Common Name	Regional Responsibility	Concern Level
Bumble Bees	*Bombus affinis*	Rusty-patched Bumble Bee	25-50%	Very High
Bumble Bees	*Bombus ashtonii*	Ashton Cuckoo Bumble Bee	25-50%	Very High
Solitary Bees	*Macropis patellata*	Patellar Oil-collecting Bee	50-75%	Very High

Solitary Bees	*Epeoloides pilosulus*	Macropis Cuckoo Bee	50-75%	High
Solitary Bees	*Protandrena abdominalis*	a mining bee pa	50-75%	High
Bumble Bees	*Bombus terricola*	Yellow-banded Bumble Bee	25-50%	Moderate
Solitary Bees	*Macropis ciliata*	Fringed Loosestrife Oil-collecting Bee	50-75%	Moderate

PROPOSED RSGCN: 1 BEE

One species of Solitary Bee is not currently listed in Northeast SWAPs as SGCN but was of concern to the Bee Taxonomic Team experts, who concurred with listing Parnassia Mining Bee (*Andrena parnassiae*) as a 2023 Proposed RSGCN species. This specialist solitary bee was recently found in Connecticut, Massachusetts, and New Jersey. It is dependent on calcareous fens and host plant *Parnissia palustris*.

OVERVIEW

RSGCN and Proposed RSGCN Bumble and Solitary Bees use five habitat groups and nine habitat types (see *Chapter 2*). Eighty-eight percent of these Bees use Grassland and Non-tidal Wetlands as the top two habitat types inhabited by this taxon. Sixty-three percent of this group use Shrubland and Forest Woodland (Figure1.3.25). Open Upland holds the greatest number of habitat types that these Bees use; the three Bees using developed lands is a surrogate for Open Upland habitat, with bees using gardens, parks, and man-made structures (NatureServe[11]).

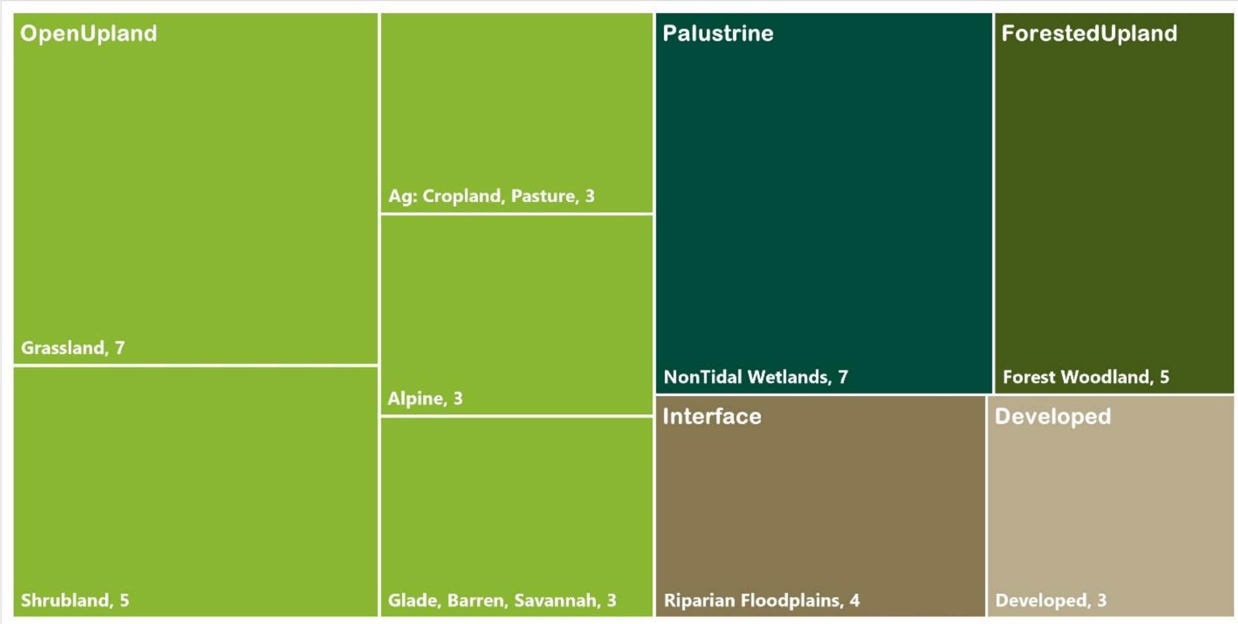


Figure1.3.25 Number of RSGCN and Proposed RSGCN Bumble and Solitary Bee associated with each habitat in the Northeast. Species may be associated with multiple habitat types. Habitat group names are at the top of each color block and grouped by color; habitat type names appear at the bottom of each proportionally sized square and are colored by habitat group (see *Chapter 2* for more information on habitats).

Bumble and Solitary Bees on the RSGCN list are threatened most by Residential and Commercial Development (88%), Climate Change (75%), and Invasive and Problematic Species, Pathogens and Genes (75%, Table 1.3.35). Low-density housing Areas, dense housing and urban areas, and commercial and industrial areas are the top threats within Development. Climate Change threats include phenological mismatch, changes in vegetation communities, and increased precipitation regime fluctuation. There are six top threats within Threat 8.0 impacting this taxon: terrestrial animals, increased grazing by vertebrates, bacterial and fungal pathogens, prion disease, and loss of genetic integrity. In addition, five additional Level 1 threats threaten 50% of these species (Table 1.3.35). With developed areas as the number one threat to native bee populations in the Northeast and climate change amplifying them, urban pollinator conservation can reduce these threats and connect people to nature in their urban environments (Baldock 2020). Mawdsley and Stoner gave a workshop to the North American Wildlife and Natural Resources Conference with a case study showing how Nebraska implemented pollinator conservation and partnerships in their 2015 SWAP revision.

Table 1.3.35 Level 1 threats with the number and percent of RSCGN and Proposed RSGCN Bumble and Solitary Bees threatened by each. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Residential & Commercial Development (Threat 1.0)	7	88%
Climate Change (Threat 11.0)	6	75%
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	6	75%
Agriculture & Aquaculture (Threat 2.0)	4	50%
Biological Resource Use (Threat 5.0)	4	50%
Energy Production & Mining (Threat 3.0)	4	50%
Other (Threat 12.0)	4	50%
Pollution (Threat 9.0)	4	50%
Human Intrusions & Disturbance (Threat 6.0)	3	38%
Natural System Modifications (Threat 7.0)	3	38%
Transportation & Service Corridors (Threat 4.0)	3	38%

WATCHLIST

In total, 35 Bees are listed as Watchlist species, ten species that Taxonomic Team experts identified as Watchlist [Assessment Priority], 14 species listed as Proposed Watchlist [Assessment Priority] because they are not SGCN in any of the 14 Northeast states, one species listed as Watchlist [Interdependent Species], and ten species that were identified for deferral to adjacent regions.

WATCHLIST [ASSESSMENT PRIORITY]: 10 BEES

The ten 2023 Watchlist [Assessment Priority] Bee species include seven Solitary Bees and three Bumble Bees (Table 1.3.36). One of them, the American Bumble Bee (*Bombus pensylvanicus*), is an RSGCN in the Midwest and Southeast. The Common Loosestrife Oil Bee (*Macropis nuda*) is a Proposed RSGCN in the Midwest. Five of these Bees were listed as RSGCN in the Northeast in 2018, but many of these species are data deficient. With the addition of the Watchlist [Assessment Priority] to flag species that need more research, these species were a better fit for this category. While these Watchlist Bees are flagged for more assessment, from the threat data in the RSGCN Database, the top three Level 1 threats for Watchlist [Assessment Priority] Bees are Climate Change, Invasive & Problematic Species, Pathogens & Genes, and Agriculture.

Table 1.3.36 Watchlist [Assessment Priority] Bees 2023.

Subtaxon	Scientific Name	Common Name	Regional Responsibility
Solitary Bees	*Andrena braccata*	a mining bee	100% (NEAFWA Endemic)

Solitary Bees	*Colletes bradleyi*	a cellophane bee	100% (NEAFWA Endemic)
Solitary Bees	*Lasioglossum arantium*	a sweat bee	50-75%
Solitary Bees	*Macropis nuda*	Common Loosestrife Oil Bee	50-75%
Bumble Bees	*Bombus citrinus*	Lemon Cuckoo Bumble Bee	25-50%
Solitary Bees	*Lasioglossum pectinatum*	a sweat bee	25-50%
Bumble Bees	*Bombus fervidus*	Yellow Bumble Bee	<25%
Bumble Bees	*Bombus pensylvanicus*	American Bumble Bee	<25%
Solitary Bees	*Anthophora walshii*	Walsh's Digger Bee	<25%
Solitary Bees	*Megachile integra*	a leafcutter bee	<25%

PROPOSED WATCHLIST [ASSESSMENT PRIORITY]: 14 BEES

14 Bees were not listed as SGCN in 2015 within the 14 Northeast states that Taxonomic Team experts flagged for Proposed Watchlist [Assessment Priority] (Table 1.3.37). These are Solitary Bees, three of which are endemic to the Northeast.

Table 1.3.37 Proposed Watchlist [Assessment Priority] Bees 2023.

Subtaxon	Scientific Name	Common Name	Regional Responsibility
Solitary Bees	*Lasioglossum izawsum*	Awesome Sweat Bee	100% (NEAFWA Endemic)
Solitary Bees	*Andrena daeckei*	a mining bee	100% (NEAFWA Endemic)
Solitary Bees	*Nomada electa*	a cuckoo bee	100% (NEAFWA Endemic)
Solitary Bees	*Hylaeus saniculae*	Sanicle Yellow-faced Bee	50-75%
Solitary Bees	*Nomada banksi*	Bank's Cuckoo Nomad Bee	50-75%
Solitary Bees	*Nomada rodecki*	a cuckoo bee	50-75%
Solitary Bees	*Nomada sphaerogaster*	a cuckoo bee	50-75%
Solitary Bees	*Triepeolus rugosus*	Punctate Central Florida Cuckoo Bee	50-75%
Solitary Bees	*Osmia felti*	Felt's Mason Bee	50-75%
Solitary Bees	*Colletes consors mesocopus*	a partner plasterer bee	25-50%
Solitary Bees	*Dianthidium simile*	Similar Carder Bee	25-50%

Solitary Bees	*Andrena persimulata*	Protuberance Miner Bee	<25%
Solitary Bees	*Andrena rehni*	Rehn's Miner Bee	<25%
Solitary Bees	*Epeolus canadensis*	Canadian Cuckoo Nomad Bee	<25%

WATCHLIST [INTERDEPENDENT SPECIES]: 1 BEE

One Solitary Bee, a melittid bee (*Melitta melittoides*), is listed as a Watchlist [Interdependent Species]. The melittid bee is interdependent with a Watchlist [Assessment Priority] cuckoo bee species, *Nomada rodecki*. It was considered by the taxa team as an important parasitic species to highlight for conservation. It can be used to umbrella additional similarly threatened bee species that specialize on *Lyonia ligustrina*, a wetland plant.

WATCHLIST [DEFER TO ADJACENT REGION]: 10 BEES

Taxonomic Team experts deferred ten Bees to adjacent regions with more Regional Responsibility, four Bumble Bees, and six Solitary Bess (Table 1.3.38). Over half of these Bees are not currently listed in the regions they are deferred to, creating opportunities for cross-regional collaboration.

Table 1.3.38 Watchlist [Interdependent Species] Bees 2023.

Subtaxon	Scientific Name	Common Name	Deferred Region(s)	Listed in Deferred Region(s)
Solitary Bees	*Colletes ciliatus*	a cellophane bee	MAFWA	No
Solitary Bees	*Osmia illinoensis*	a mason bee	MAFWA	RSGCN in MAFWA
Solitary Bees	*Megachile rugifrons*	a leafcutter bee	MAFWA	No
Solitary Bees	*Andrena fulvipennis*	an andrenid bee	SEAFWA	No
Solitary Bees	*Nomada seneciophila*	a cuckoo bee	SEAFWA	No
Solitary Bees	*Megachile ingenua*	a leafcutter bee	SEAFWA	RSGCN in MAFWA
Bumble Bees	*Bombus fraternus*	Southern Plains Bumble Bee	MAFWA/ SEAFWA	RSGCN in MAFWA/ SEAFWA
Bumble Bees	*Bombus variabilis*	Variable Cuckoo Bumble Bee	MAFWA/ SEAFWA	RSGCN in MAFWA/ SEAFWA

Bumble Bees	*Bombus insularis*	Indiscriminate Cuckoo Bumble Bee	WAFWA/ Canada	No
Bumble Bees	*Bombus suckleyi*	Suckley's Cuckoo Bumble Bee	WAFWA/ Canada	No

REGIONAL EFFORTS IN NORTHEAST BEE CONSERVATION

Pollinators help plants to complete their reproductive cycles and are vital to healthy functioning ecosystems. Most pollinator species are invertebrates, specifically insects. Major pollinator groups in the Northeast include social and solitary bees and many flies, beetles, butterflies, and moths. Given that Bumble and Solitary Bees use many habitats and have many threats, there is considerable concern about the conservation status and population trends of these important taxa across North America. RCN project **Habitat for Pollinators: Improving Management of Regionally Significant Xeric Grassland, Barrens, and Woodlands in the Northeast** (Milam 2018) gathered base bee datasets and developed a standardized pollinator protocol. Another RCN project: **Development of an Online Database to Enhance the Conservation of SGCN Invertebrates in the Northeastern Region** developed an online database[12] for SGCN Invertebrates. Cornell's Pollinator Network[13] is a great resource for research and guides to create habitats and combat threats. Reports focusing on pollinators are available for state fish and wildlife agencies from the Xerces Society[14] and the Heinz Center[15] for use by states in revising their SWAPs. Reports by Mawdsley and Humpert (2016), **Revised State Wildlife Action Plans Offer New Opportunities for Pollinator Conservation in the USA** and Mawdsley and Stoner (2016) **Urban Pollinator Conservation in the US State Wildlife Action Plans** have recommendations on incorporating and planning for pollinators in SWAPs.

1.3.9 CRAYFISH

The Northeast region has at least 78 species of crayfish (Family Cambaridae). More than one-third of Northeast species, 29, are listed in one of the RSGCN categories. The Crayfish Taxonomic Team identified 11 species as RSGCN, with one listed as Proposed RSGCN. Two of the Watchlist categories have the remaining listed Crayfish: three Watchlist [Assessment Priority] and 14 non-SGCN species met the criteria for Proposed Watchlist [Assessment Priority]. This list is missing one species previously included in the RSGCN list. In 2017, the taxa team added a crayfish population from western New York as a Proposed RSGCN under the epithet *Lacunicambarus cf. diogenes*. Subsequent work by Glon et al. (2022) indicated that this population belonged to the newly revived *L. nebrascensis*, which the 2022 taxa team did not list due to its wide distribution across the Midwest.

Regional Priority Concern Highlights:
• Invasive crayfish species are a primary threat to native species.
• Water quality impacts, especially due to pollution from coal mining, may eliminate populations.
• Numerous climate change impacts, including changes to water temperature, chemistry, and flow are detrimental, as are secondary consequences such as sedimentation and amplified pollution due to increased storm frequency and intensity.
• As detritivores, heavy metals may bioaccumulate in some crayfish species.
• Habitat loss, fragmentation, and degradation, especially due to sedimentation, are a concern for many species.

Species Information, Research & Monitoring Needs:

- Taxonomy, genetics, and descriptions of former *C. acuminatus* complex is necessary and may identify more than eight new species endemic to NEAFWA.
- The taxonomic split of *Creaserinus fodiens* into three species in the Northeast results in an additional need for description, habitat associations, and analysis of historical records.
- Inventory, research, and management needs are largely unknown for most species.

RSGCN: 11 CRAYFISH

The Taxonomic Team identified eleven crayfish species that met the criteria for RSGCN in the 2023 update (Table 1.3.39). Two of these species are federally protected under the Endangered Species Act. The Big Sandy Crayfish (*Cambarus callainus*) is Threatened, and the Guyandotte River Crayfish (*Cambarus veteranus*) is Endangered. Two additional species, Greenbrier Cave Crayfish (*Cambarus nerterius*) and Chowanoke Crayfish (*Faxonius virginiensis*), are currently Under Review for federal listing. Many crayfish are restricted to specific watersheds, and six RSGCN crayfish are endemic to the Northeast region. One of the species listed, Digger Crayfish (*Creaserinus fodiens*), has a regional responsibility below 25%. Still, recent work has illustrated that this species is ripe for revision and may be redescribed as three separate species. The Crayfish

Taxonomic Team elected to retain this species on the list until the redescription occurs and the potential for unique genetics and disjunct populations in the region is addressed.

Table 1.3.39 2023 Crayfish RSGCN list.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Cambarus magerae	Big Stone Crayfish	100% (NEAFWA Endemic)	Very High
Cambarus nerterius	Greenbrier Cave Crayfish	100% (NEAFWA Endemic)	Very High
Cambarus veteranus	Guyandotte River Crayfish	100% (NEAFWA Endemic)	Very High
Cambarus callainus	Big Sandy Crayfish	50-75%	High
Cambarus pauleyi	Meadow River Mudbug	100% (NEAFWA Endemic)	High
Cambarus elkensis	Elk River Crayfish	100% (NEAFWA Endemic)	High
Cambarus hatfieldi	Tug Valley Crayfish	75-100%	Moderate
Cambarus smilax	Greenbrier River Crayfish	100% (NEAFWA Endemic)	Moderate
Cambarus theepiensis	Coalfields Crayfish	50-75%	Moderate
Creaserinus fodiens	Digger Crayfish	<25%	Moderate
Faxonius virginiensis	Chowanoke Crayfish	50-75%	Moderate

PROPOSED RSGCN: 1 CRAYFISH

One species is on the 2023 Proposed RSGCN list, Allegheny Mountain Mudbug (*Cambarus fetzneri*). This species is a regional endemic of Moderate concern that recently split from *Cambarus monongalensis* (Loughman et al. 2019). The distribution of the species in Virginia is well understood, but further investigations of West Virginia populations are needed, and it may be a good target for citizen science.

OVERVIEW

Ten of the 14 Northeast states list crayfish as SGCN. Across the Northeast, RSGCN and Proposed RSGCN occur in five habitat groups and five habitat types (see *Chapter 2*). Eighty-three percent of these crayfish use rivers and streams, 25% use Non-tidal Wetlands, and 25% use Riparian Floodplains (Figure 1.3.26). The other two habitat types where these entities are found are subterranean habitats and developed areas. The Developed habitat type comes from NatureServe. It cites residential yards, roadside ditches, suburban areas, and orchards as one of the Allegheny Mountain Mudbug habitat types, alongside seeps, springs, and wetlands.

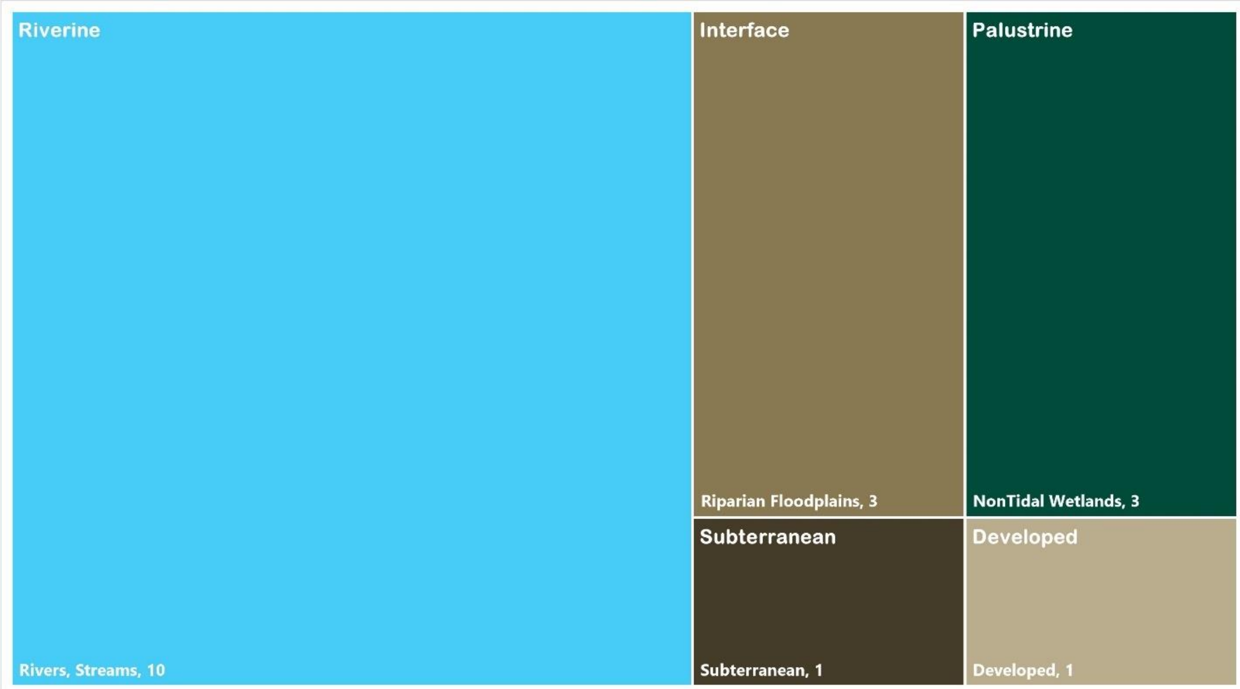


Figure 1.3.26 Number of RSGCN and Proposed RSGCN Crayfish associated with each habitat in the Northeast. Species may be associated with multiple habitat types. Habitat group names are at the top of each color block and grouped by color; habitat type names appear at the bottom of each proportionally sized square and are colored by habitat group (see *Chapter 2* for more information on habitats).

The 12 RSGCN and Proposed RSGCN Crayfish are threatened by Invasive and Problematic Species, Pathogens and Genes and Pollution over twice as much as other threats. Aquatic animals, specifically non-native crayfish, are out-competing native crayfish. Taxonomic Team experts report that Pollution would be a higher threat, except in some instances, it helps native species outcompete the non-native crayfish who cannot survive in heavily polluted areas. Soil erosion and sedimentation threaten 67% of listed crayfish. Together reducing non-native crayfish and sedimentation would alleviate pressure on these species. Climate Change is the third Level 1 threat to crayfish in the Northeast. Droughts, overabundant rains, and increased fluctuations in the precipitation regime all threaten these RSGCNs (Table 1.3.40).

Table 1.3.40 Level 1 threats with the number and percent of RSCGN and Proposed RSGCN Crayfish threatened by each. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	10	83%
Pollution (Threat 9.0)	10	83%
Climate Change (Threat 11.0)	4	33%
Natural System Modifications (Threat 7.0)	3	25%
Agriculture & Aquaculture (Threat 2.0)	2	17%

Biological Resource Use (Threat 5.0)	2	17%
Residential & Commercial Development (Threat 1.0)	2	17%
Transportation & Service Corridors (Threat 4.0)	1	8%

WATCHLIST

In total, 17 Crayfish species were listed as Watchlist species, three species that taxa teams identified as Watchlist [Assessment Priority], and 14 as Proposed Watchlist [Assessment Priority].

WATCHLIST [ASSESSMENT PRIORITY]: 3 CRAYFISH

Experts assigned three crayfish to the Watchlist [Assessment Priority] list (Table 1.3.41). One species, Blue Teays Mudbug (*Cambarus loughmani*), is recently described and requires further surveys to better establish its distribution, habitat needs, and potential threats. One species, Devil Crayfish (*Lacumicambarus diogene*), has undergone several taxonomic revisions in recent years, leaving their current status in the Northeast unclear without further refinement of the distribution of the various species that have split off. The third species, Spinycheek Crayfish (*Faxonius limosus*), is widespread and fairly common in the Northeast. Historically, it was found in several drainages in the region's southern parts, but recent surveys have not seen it at many of the historic sites. These declines may result from the spread of invasive crayfish species, especially Rusty and Virile Crayfish (*Faxonius rusticus* and *F. virilis*, respectively), in the southern parts of the Northeast. Though the Spinycheek Crayfish is not a major conservation concern, the taxa team included it as a Watchlist species to monitor potential status changes in the future.

Table 1.3.41 2023 Watchlist [Assessment Priority] Crayfish.

Scientific Name	Common Name	Regional Responsibility
Faxonius limosus	Spinycheek Crayfish	100% (NEAFWA Endemic)
Cambarus loughmani	Blue Teays Mudbug	100% (NEAFWA Endemic)
Lacunicambarus diogene	Devil Crawfish	50-75%

PROPOSED WATCHLIST [ASSESSMENT PRIORITY] SPECIES (2023)

There are 14 species on the Proposed Watchlist [Assessment Priority] list, most of which are recent divisions of two species complexes (Table 1.3.42). Most species on the list belong to the Acuminate Crayfish (*Cambarus acuminatus*) complex. This complex may contain as many as 30 species, 11 of which occur in the Northeast region, and nine may be regional endemics. The taxa team elected to include all potential *acuminatus* complex species in the Proposed Watchlist until their taxonomy and distribution has been clarified. The next two species on this list form a complex with Digger Crayfish.

Again, these species will remain on the Proposed Watchlist until their taxonomic validity and distribution are established, and their conservation Concern Level can be assessed. The final species on this list, Quinebaug River Crayfish (*Faxonius quinebaugensis*), requires additional genetic work to determine whether it is a valid species worthy of consideration or represents a population of Virile Crayfish.

Table 1.3.42 Proposed Watchlist [Assessment Priority] Crayfish 2023.

Scientific Name	Common Name	Regional Responsibility
Faxonius quinebaugensis	Quinebaug River Crayfish	100% (NEAFWA Endemic)
Cambarus sp. nov. Appomattox	an acuminate crayfish	100% (NEAFWA Endemic)
Cambarus sp. nov. Blackwater	an acuminate crayfish	100% (NEAFWA Endemic)
Cambarus sp. nov. MD-VA	an acuminate crayfish	100% (NEAFWA Endemic)
Cambarus sp. nov. mid-James	an acuminate crayfish	100% (NEAFWA Endemic)
Cambarus sp. nov. Pamunkey	an acuminate crayfish	100% (NEAFWA Endemic)
Cambarus sp. nov. PA-VA	an acuminate crayfish	100% (NEAFWA Endemic)
Cambarus sp. nov. Pigg	an acuminate crayfish	100% (NEAFWA Endemic)
Cambarus sp. nov. Rappahannock	an acuminate crayfish	100% (NEAFWA Endemic)
Cambarus sp. nov. Rivanna	an acuminate crayfish	100% (NEAFWA Endemic)
Cambarus sp. nov. Dan	an acuminate crayfish	50-75%
Cambarus sp. nov. Yadkin 1	an acuminate crayfish	<25%
Creaserinus uhleri	a crayfish	unknown
Creaserinus sp. nov.	a crayfish	unknown

REGIONAL EFFORTS IN NORTHEAST CRAYFISH CONSERVATION

The southern Appalachian Mountains, including Virginia and West Virginia, have nearly two-thirds of the world's crayfish diversity (Taylor et al. 2007). Like other aquatic taxa, crayfish are disproportionately more imperiled than other terrestrial taxa. The elevated risk for crayfish can be attributed to the restrictive nature of riverine systems, the general degradation of freshwater habitats, and the small distributions of many crayfish species (Richman et al. 2015, Crandall & Buhay 2008). Crayfish differ from other aquatic taxa in that they exhibit higher levels of endemism, with almost half of all American crayfish restricted to a single state (Taylor et al. 2007, Richman et al. 2015).

Despite the general acknowledgment of crayfish as a taxon of concern, little regional research and monitoring have targeted this group. Individual researchers are reviewing the taxonomy of some clades, resulting in the description of several new species as described above. In addition, several states use citizen science programs and public records posted to resources such as iNaturalist as tools to monitor crayfish species within their states. Still, no comprehensive assessments have occurred since Taylor et al.'s 2007 reassessment of the American Fisheries Society's list of crayfish conservation status and Richman et al.'s 2015 IUCN assessment of the drivers of crayfish decline globally. A targeted review of Northeastern species would provide a richer context for the regional conservation of this aquatic group.

1.3.10 EPHEMEROPTERA: MAYFLIES

Nearly 300 mayflies (Ephemeroptera) occur in the Northeast region. Approximately 22%, 62 species, are listed as SGCN in at least one of the 14 2015 Northeast SWAPs. The Taxonomic Team identified 13 Mayflies as meeting the criteria for RSGCN in the 2023 list. An additional three species met the criteria for Proposed RSGCN, nine for Watchlist [Assessment Priority], and 11 for Proposed Watchlist [Assessment Priority]. The 2023 revision of the RSGCN list is the first-time mayflies were assessed, so all these species are new to the Northeast RSGCN list.

Regional Priority Concern Highlights:

- Mayflies are susceptible to several aquatic threats, including pollution and sedimentation.
- Habitat disturbance and modifications can lead to local extirpations.
- Climate change may result in water temperature shifts, changing hydrology, and saltwater intrusion.

Species Information, Research & Monitoring Needs:

- More information is needed for nearly every species across multiple topics, including basic information on distribution, taxonomic validity, and status.
- Coordinating with Stroud Research Water Center would provide access to their "enormous number of unpublished records," which may include records on otherwise poorly known species.

- Many mayflies are described from the nymph or adult stages; efforts to rear species through the full lifecycle will help 'match' juvenile and adult forms.

RSGCN: 13 MAYFLIES

There are 13 Mayfly species on the 2023 Northeast RSGCN list. Concern level for this group is not as elevated as for the stoneflies and caddisflies, with ten species listed, High concern and three as Moderate, with no mayflies currently considered Very High concern (Table 1.3.43). Nearly half of the RSGCN mayflies are endemic to the Northeast; *Epeorus frisoni, Heptagenia culacantha*, *Siphlonisca aerodromia*, *Siphlonurus barbaroides*, and *Siphlonurus demaryi*. One mayfly, *Afghanurus rusticalis*, has regional responsibility below 50% but was still included as its known distribution is a series of disjunct populations scattered across the Northeast and Midwest.

Table 1.3.43 2023 RSGCN Mayflies.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Epeorus frisoni	Roaring Brook Mayfly	100% (NEAFWA Endemic)	High
Afghanurus horrida	Rough Flat-headed Mayfly	75-100%	High
Siphlonurus barbaroides	Wild Primitive Minnow Mayfly	100% (NEAFWA Endemic)	High
Siphlonurus barbarus	Barbarous Primitive Minnow Mayfly	75-100%	High
Siphlonisca aerodromia	Tomah Mayfly	100% (NEAFWA Endemic)	High
Parameletus midas	Midas Primitive Minnow Mayfly	50-75%	High
Ameletus browni	Brown's Comb Minnow Mayfly	75-100%	High
Baetisca rubescens	Provancher's Armored Mayfly	75-100%	High
Barbaetis benfieldi	Benfield's Bearded Small Minnow Mayfly	75-100%	High
Siphlonurus demaryi	Demary's Primitive Minnow Mayfly	100% (NEAFWA Endemic)	High
Heptagenia culacantha	a flat-headed mayfly	100% (NEAFWA Endemic)	Moderate
Epeorus punctatus	Dotted Flat-headed Mayfly	50-75%	Moderate
Afghanurus rusticalis	Rusty Flat-headed Mayfly	25-50%	Moderate

PROPOSED RSGCN: 3 MAYFLIES

Three mayflies not currently SGCN in the Northeast SWAPs otherwise met the criteria for the taxa team to include them as Proposed RSGCN on the 2023 list. One species is endemic to the region, one is primarily found in the Northeast, and the third is more widely distributed (Table 1.3.44). Like *Arghanurus rusticalis*, *Epeorus subpallidus* is located in many widespread but disjunct populations along the Appalachian Mountains, especially in high-quality streams, and may be highly sensitive to environmental impacts. The other two species have limited distribution and some specialized habitat requirements, though they are not currently facing any major known threats.

Table 1.3.44 Proposed RSGCN Mayflies 2023.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Rhithrogena brunneotincta	Brown Flat-headed Mayfly	100% (NEAFWA Endemic)	High
Epeorus subpallidus	a mayfly	25-50%	Moderate
Eurylophella coxalis	Barton's Spiny Crawler Mayfly	75-100%	Moderate

OVERVIEW

Eight of the 14 Northeast states list Mayflies as SGCN. Northeast RSGCN and Proposed RSGCN use four habitat groups and five habitat types (see *Chapter 2*). All these Mayflies (100%) can be found in Riparian Floodplains, 94% use Rivers and Streams, and 38% use Non-tidal Wetlands (Figure 1.3.27).

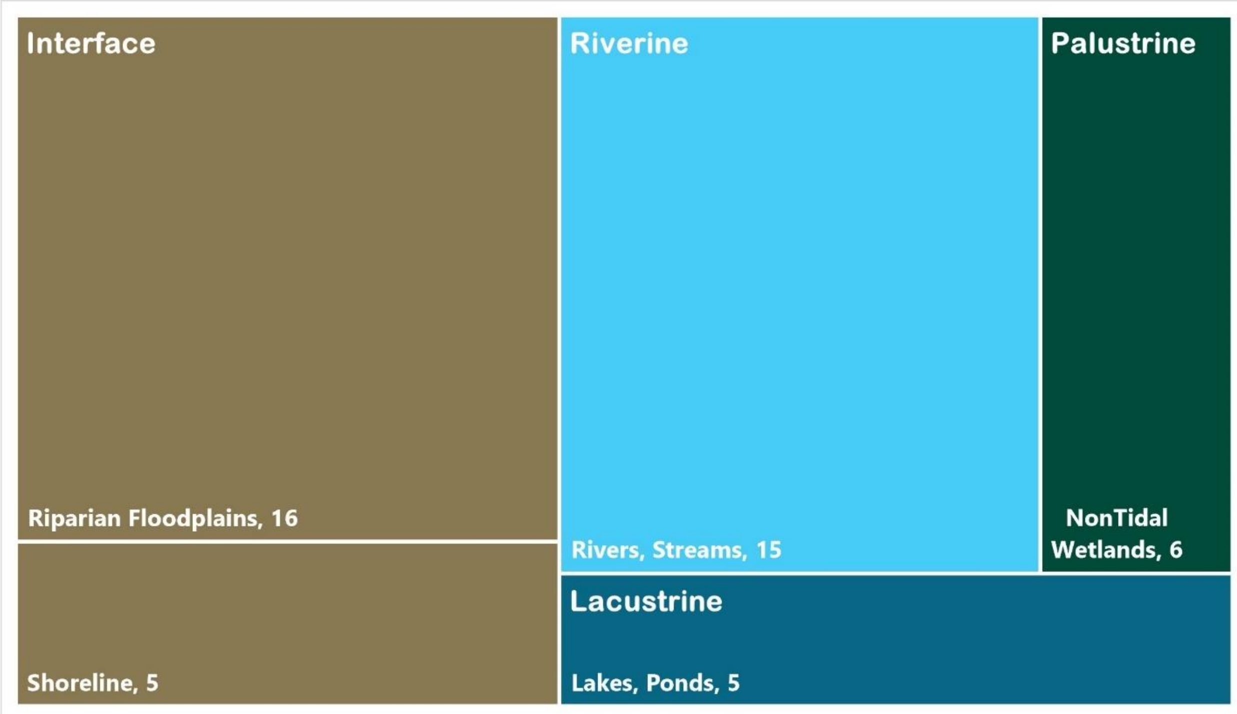


Figure 1.3.27 Number of RSGCN and Proposed RSGCN Mayfly associated with each habitat in the Northeast. Species may be associated with multiple habitat types. Habitat group names are at the top of each color block and grouped by color; habitat type names appear at the bottom of each proportionally sized square and are colored by habitat group (see *Chapter 2* for more information on habitats).

Climate Change threatens 100% of RSGCN and Proposed RSGCN Mayflies and other EPT: Stoneflies and Caddisflies. The top threats under this category are temperature related: gradual temperature change, increase in temperature fluctuations; and precipitation related: gradual change in the precipitation regime and increase in fluctuations in the precipitation regime (Table 1.3.45). In addition, runoff, nutrient loads, herbicides and pesticides, and domestic wastewater are top Pollution threats to Mayflies (Table 1.3.45).

Table 1.3.45 Level 1 threats with the percent of RSCGN and Proposed RSGCN Mayflies threatened by each. The top Level 3 threats from each Level 1 category with the percent of species threatened by each Level 3. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Climate Change (Threat 11.0)	16	100%
Pollution (Threat 9.0)	16	100%
Natural System Modifications (Threat 7.0)	6	38%
Transportation & Service Corridors (Threat 4.0)	5	31%
Other (Threat 12.0)	4	25%
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	3	19%
Residential & Commercial Development (Threat 1.0)	2	13%

Biological Resource Use (Threat 5.0)	1	6%
Energy Production & Mining (Threat 3.0)	1	6%

WATCHLIST

In total, 20 Mayfly species were listed as Watchlist species. In addition, the EPT Taxonomic Team identified nine Mayflies as Watchlist [Assessment Priority] and 11 Mayfly species listed as Proposed Watchlist [Assessment Priority].

WATCHLIST [ASSESSMENT PRIORITY]: 9 MAYFLIES

The taxa team included the nine species on the 2023 Watchlist [Assessment Priority] list for various reasons, though uncertainties related to species distributions were a factor for each species (Table 1.3.46). *Eurylophella poconoensis* was previously thought to be a narrow endemic but was recently discovered several states away from its type locality. Along with *P. vicinum*, it occupies lacustrine habitats infrequently targeted for mayfly surveys, explaining their current lack of occurrence records. *Anthopotamus verticis* and *Neoleptophlebia assimilis* are more widespread in other regions, but their distribution at their range edges in the Northeast are unknown. The remaining four mayflies on this list are uncommon, but uncertainties about their full distribution, sensitivity to threats, identification, and taxonomic issues warranted their inclusion as Watchlist [Assessment Priority] species.

Table 1.3.46 Watchlist [Assessment Priority] Mayflies for 2023.

Scientific Name	Common Name	Regional Responsibility
Eurylophella bicoloroides	Nova Scotia Spiny Crawler Mayfly	100% (NEAFWA Endemic)
Siphloplecton costalense	Speith's Great Speckled Olive Mayfly	75-100%
Epeorus suffusus	Blushing Flat-headed Mayfly	75-100%
Eurylophella poconoensis	Poconos Chocolate Dun	75-100%
Procloeon vicinum	Potomac Small Minnow Mayfly	75-100%
Rhithrogena anomala	Anomalous Flat-headed Mayfly	50-75%
Ameletus tertius	Trinity Comb Minnow Mayfly	50-75%
Neoleptophlebia assimilis	Southeastern Prong-gilled Mayfly	50-75%
Anthopotamus verticis	Walker's Tusked Sprawler	25-50%

PROPOSED WATCHLIST [ASSESSMENT PRIORITY]: 11 MAYFLIES

The eleven species on the Proposed Watchlist [Assessment Priority] list had no known major threats or concerns during the 2015 SWAP revisions and were thus not listed as

SGCN (Table 1.3.47). Continued data deficiencies are the primary reason the taxa team included these species in the 2023 RSGCN update. One species, *Rhithrogena jejuna*, has largely gone unreported as it was largely misidentified as one of two western species. Until these species descriptions are clarified, and historic records reviewed, our understanding of this species in the Northeast will remain confused. Two species, *Anafroptilum victoriae* and *Pseudocentroptiloides usa* have limited occurrence records. One species, *Procloeon pennulatum* is just at the southern end of its range in the Northeast; the taxa team elected to include it due to the potential for climate change-driven range shifts. The remaining seven species were included as generally data deficient, with little known about their habitats, distribution, and potential threats.

Table 1.3.47 Proposed Watchlist [Assessment Priority] Mayflies 2023.

Scientific Name	Common Name	Regional Responsibility
Leucrocuta umbratica	Shady Flat-headed Mayfly	75-100%
Ameletus walleyi	Walley's Comb Minnow Mayfly	75-100%
Rhithrogena amica	Loveable Flat-headed Mayfly	50-75%
Leucrocuta walshi	Walsh's Flat-headed Mayfly	50-75%
Rhithrogena jejuna	Hungry Flat-headed Mayfly	25-50%
Leucrocuta juno	Juno's Flat-headed Mayfly	25-50%
Afghanurus inconspicua	Inconspicuous Flat-headed Mayfly	25-50%
Acentrella nadineae	a mayfly	25-50%
Anafroptilum victoriae	Victoria's Small Minnow Mayfly	NA
Procloeon pennulatum	Eaton's Small Minnow Mayfly	NA
Pseudocentroptiloides usa	American Small Minnow Mayfly	NA

WATCHLIST [DEFER TO ADJACENT REGION] SPECIES (2023)

The taxa team identified nine mayfly species whose ranges fall predominantly in the Southeast region (Table 1.3.48). In general, though a portion of each species' range falls within the Northeast region, the EPT Taxa Team did not feel that they knew enough about these species to assess their conservation Concern Levels and will defer to experts from the Southeast on these species.

Table 1.3.48 Watchlist [Defer to Adjacent Region] Mayflies 2023.

Scientific Name	Common Name	Deferred Region	Listed in Deferred Region
Ameletus janetae	a mayfly	SEAFWA	No
Neoephemera eatoni	a large square-gilled mayfly	SEAFWA	No
Habrophlebiodes celeteria	a leptophlebiid mayfly	SEAFWA	No
Ephemera blanda	West Virginia Burrowing Mayfly	SEAFWA	No
Leptophlebia bradleyi	Bradley's Prong-gilled Mayfly	SEAFWA	No
Isonychia hoffmani	Hoffman's Isonychia Mayfly	SEAFWA	No
Dannella provonshai	an ephemerellid mayfly	SEAFWA	No
Acentrella barbarae	a mayfly	SEAFWA	No
Tsalia berneri	Berner's Ephemerella Mayfly	SEAFWA	No

REGIONAL EFFORTS IN NORTHEAST MAYFLY CONSERVATION

Mayflies are historically underrepresented and under-surveyed in the Northeast. Only eight states included mayflies as SGCN in their 2015 review – Connecticut, Maryland, Maine, New York, Pennsylvania, Rhode Island, Virginia, and Vermont. This reflects the historical lack of data and information on the taxon and the present lack of regional expertise. Regional surveys and assessments will be necessary to understand the current status of mayflies in the Northeast.

1.3.11 FAIRY, CLAM, AND TADPOLE SHRIMP

The Fairy, Clam, and Tadpole Shrimps (orders Diplostraca, Anostraca, and Notostraca, respectively) represent one of the smallest taxonomic groups in this review, with only 17 species identified as occurring in the Northeast region. Only two fairy shrimp and three clam shrimp species are listed as SGCN in the Northeast SWAPs. One fairy and two clam shrimp met the criteria for RSGCN, while the remaining two species were assigned to the Watchlist [Assessment Priority]. 2023 was the first year the shrimps were assessed, so these five species are all new to the 2023 list.

Regional Priority Concern Highlights:

- Lack of regional expertise & data deficiencies prevent a full understanding of threats.

Species Information, Research & Monitoring Needs:

- Several species are known only from anthropogenic habitats (e.g., tire ruts on dirt roads, flooded hay fields, or golf course sand traps); identifying their natural habitat associations would improve understanding of these species.
- Inventory and distribution surveys are needed for all species.
- Basic life history data is lacking for all species, as is information about behaviors, ecology, and seasonal activity.

RSGCN: 3 FAIRY OR CLAM SHRIMP

The three shrimp species on the 2023 RSGCN list include one fairy shrimp and two clam shrimp (Table 1.3.49). None of these species are regional endemics. Two clam shrimp are both High concern and, interestingly, found in anthropologically altered habitats, pools formed by tire treads. Hypotheses are that these species were historically associated with bison wallows. Although the habitat for the Smoothlip Fairy Shrimp (*Eubranchipus intricatus*) is a rare type of vernal pool in the disjunct population that occurs in the Northeast, its distribution is further reaching across southeastern Canada and the adjacent USA.

Table 1.3.49 RSGCN Fairy, Clam, Tadpole Shrimp 2023.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Cyzicus gynecia	Feminine Clam Shrimp	50-75%	High
Eulimnadia agassizii	Agassiz Clam Shrimp	75-100%	High
Eubranchipus intricatus	Smoothlip Fairy Shrimp	25-50%	Moderate

OVERVIEW

Four Northeast states (CT, MA, NJ, NY) list Fairy, Clam, and Tadpole Shrimp as SGCN. The three RSGCN Fairy and Clam Shrimp (100%) can be found in the Palustrine Habitat group in the Non-Tidal Wetland habitat type (Figure 1.3.28). These species are vernal pool specialists that live in freshwater, fish-free waterbodies to avoid predation.

Figure 1.3.28 Number of RSGCN Fairy and Clam Shrimp associated with each habitat in the Northeast. Species may be associated with multiple habitat types. Habitat group names are at the top of each color block and grouped by color; habitat type names appear at the bottom of each proportionally sized square and are colored by habitat group (see *Chapter 2* for more information on habitats).

Fairy, Clam, And Tadpole Shrimp are a data-deficient taxonomic group, including data deficiencies concerning threats. What is known is that Pollution and Residential and Commercial Development both threaten 67% of these species (Table 1.3.50). The other four Level 1 threats jeopardize 33% of RSGCN shrimp species. Runoff, low-density housing areas, commercial and industrial areas, and campgrounds are all identified as

Development threats. The key is filling gaps of knowledge and habitat use to get the big picture of how these threats, and possibly more, impact this new group of RSGCN.

Table 1.3.50 Level 1 threats with the number and percent of RSCGN Fairy, Clam, and Tadpole Shrimp threatened by each. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Pollution (Threat 9.0)	2	67%
Residential & Commercial Development (Threat 1.0)	2	67%
Biological Resource Use (Threat 5.0)	1	33%
Climate Change (Threat 11.0)	1	33%
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	1	33%
Natural System Modifications (Threat 7.0)	1	33%

WATCHLIST

Taxonomic Teams identified two species as Watchlist species, both as Watchlist [Assessment Priority].

WATCHLIST [ASSESSMENT PRIORITY]: 2 FAIRY OR CLAM SHRIMP

Only two species met the criteria for Watchlist [Assessment Priority], one fairy and one clam shrimp (Table 1.3.51). Unfortunately, both of these species are data deficient with poorly understood distributions. The Eastern Fairy Shrimp (*Eubranchipus holmanii*) has only a handful of confirmed locations in the Northeast and is undersampled. The Euroamerican Clam Shrimp (*Limnadia lenticularis*) is widely distributed but highly disjunct and is known from southern New England, Florida thru South Carolina, and across Europe.

Table 1.3.51 Watchlist [Assessment Priority] Fairy, Clam, and Tadpole Shrimps 2023.

Scientific Name	Common Name	Regional Responsibility
Eubranchipus holmanii	Eastern Fairy Shrimp	25-50%
Limnadia lenticularis	Euroamerican Clam Shrimp	25-50%

REGIONAL EFFORTS IN NORTHEAST FAIRY & CLAM SHRIMP CONSERVATION

The fairy, clam, and tadpole shrimps are historically underrepresented and under-surveyed in the Northeast. With their small body size and close association with temporary bodies of water, they can be extremely difficult to monitor and survey. Only four states included shrimp as SGCN in their 2015 review – Connecticut, Massachusetts, New Jersey, and New York. This reflects the historical lack of data and information on the taxon and the present lack of regional expertise. Regional surveys and assessments will be necessary to understand the current status of shrimp in the Northeast. Though no regional assessments of this taxonomic group are taking place, some state programs may improve our understanding of ephemeral shrimps. The **Gulf of Maine Research Institute's Ecosystem Investigation Network**[16] facilitates several citizen science projects intended to improve understanding of how climate change impacts species, habitats, and communities. One of their projects targets vernal pools, the primary habitat for fairy, clam, and tadpole shrimp. This project aims to assess the distribution of caddisflies, fairy shrimp, and amphibian species in vernal pools in the Northeast and determine how these distributions may shift in response to climate change.

In 2022, the Vermont Center for Ecostudies piloted an effort to locate fairy shrimp in vernal pools across the state as a part of their existing Vermont Vernal Pool Monitoring Project[17]. This project establishes a baseline of essential data on the health of these unique ecosystems and the species that inhabit them. Before this project, only one species of fairy shrimp was known to occur in Vermont, though other species occur in adjacent states. At the end of the 2022 season, they confirmed that at least one other species could be found in the state and hope to identify more species in future surveys.

1.3.12 FIREFLIES

There are 43 fireflies (Family Lampyridae) known to occur in the 14 Northeast region. Eight Fireflies met the criteria as RSGCN. The Taxonomic Team identified five additional species not listed as SGCN in the 2015 Northeast SWAPs as Proposed RSGCN. Six Fireflies are listed in Watchlist categories: one Watchlist [Assessment Priority], and five non-SGCN species met the criteria for Proposed Watchlist [Assessment Priority]. As 2023 is the first-year fireflies were assessed for the RSGCN list, all these species were additions.

Regional Priority Concern Highlights:

- Ecotourism of synchronous fireflies (and the resulting cultural values) is increasing awareness but may also be a threat if managed improperly.
- Artificial light pollution negatively impacts all photic insect species.
- Invasive species (e.g., *Phragmites* in coastal wetlands) significantly impact some species.
- Climate change, especially conversion of freshwater interdunal swale wetlands to salt marsh, saltwater intrusion of Atlantic White. Cedar floodplain forests, and inundation of salt marsh from sea level rise, impact some species with specialized habitat requirements.

Species Information, Research & Monitoring Needs:

- Especially for coastal species with apparent disjunct populations, distribution surveys may identify additional locations and expand known ranges.
- Recently described species need identification of habitat associations and preferences.
- Recent taxonomic splits of the *Photuris* genus and historical misidentifications may complicate our understanding of the distribution and status of these species.
- Some species need data to fill gaps in life history and habitat management information.

RSGCN: 8 FIREFLIES

The 2023 Northeast RSGCN list contains eight firefly species (Table 1.3.52). One of these species, the Bethany Beach Firefly (*Photuris bethaniensis*), is currently under review for federal listing as either endangered or threatened. Concern levels for the RSGCN fireflies are evenly distributed, with three species at Very High concern, three at High concern, and two a Moderate concern. Six of the eight species are regional endemics. The Regional Responsibility for the remaining two species, Florida Sprite (*Photinus floridanus*) and Keel-necked Firefly (*Pyractomena ecostata*) is below 25%. Still, both species have disjunct populations in the Northeast region that require particular attention.

Table 1.3.52 RSGCN Fireflies 2023.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Photuris pyralomima	Pyralis-mimicking Firefly	100% (NEAFWA Endemic)	Very High
Photuris bethaniensis	Bethany Beach Firefly	100% (NEAFWA Endemic)	Very High
Photuris mysticalampas	Mysterious Lantern Firefly	100% (NEAFWA Endemic)	Very High
Photuris pensylvanica	Dot-dash Firefly	100% (NEAFWA Endemic)	High
Pyractomena ecostata	Keel-necked Firefly	<25%	High
Photuris cinctipennis	Belted Firefly	100% (NEAFWA Endemic)	High
Photuris salina	Salt Marsh Firefly	100% (NEAFWA Endemic)	Moderate
Photinus floridanus	Florida Sprite	<25%	Moderate

PROPOSED RSGCN: 5 FIREFLIES

Five firefly species not current SGCN in the Northeast SWAPs met the criteria for Proposed RSGCN (Table 1.3.53). Anna's and Cowesalon Creek Firefly (*Photuris anna* and *Photuris cowaseloniensis*, respectively) are new species described after 2015. The other three species have existing concerns that would elevate them as RSGCN but do not occur in the states that reviewed fireflies for the 2015 SWAPs.

Table 1.3.53 Proposed RSGCN Fireflies 2023.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Photuris potomaca	Potomac River Firefly	75-100%	Very High
Photuris anna	Anna's Firefly	100% (NEAFWA Endemic)	High
Photuris cowaseloniensis	Cowesalon Creek Firefly	100% (NEAFWA Endemic)	Moderate
Photinus scintillans	Pale Firefly	50-75%	Moderate
Photinus carolinus	Synchronous Firefly	50-75%	Moderate

OVERVIEW

Only two states (DE and MD) list fireflies as SGCN, and MD lists a single species (Bethany Beach). RSGCN and Proposed RSGCN Firefly habitat include five habitat groups and nine habitat types (see *Chapter 2*). These Fireflies inhabit Riparian Floodplains (54%) and Non-Tidal Wetlands (31%) in greater numbers than the other habitat types. Twenty-three percent of Northeast listed Fireflies use Forest Woodlands, Grasslands, and Tidal Wetlands (Figure 1.3.29).

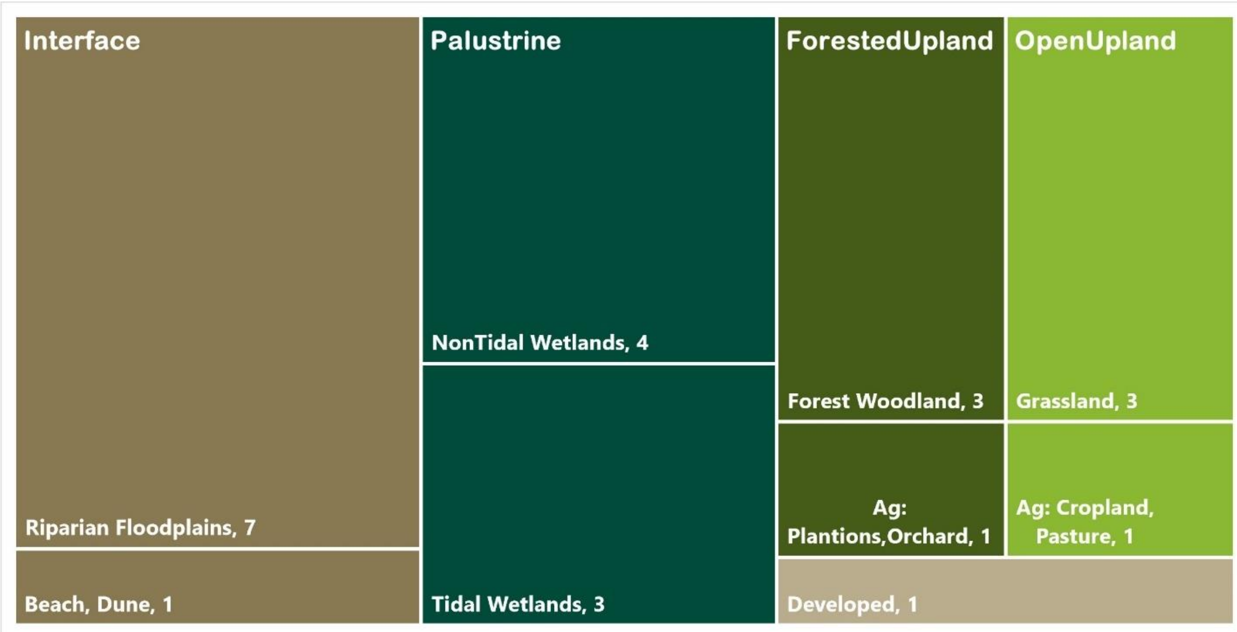


Figure 1.3.29 Number of RSGCN and Proposed RSGCN Firefly associated with each habitat in the Northeast. Species may be associated with multiple habitat types. Habitat group names are at the top of each color block and grouped by color; habitat type names appear at the bottom of each proportionally sized square and are colored by habitat group (see *Chapter 2* for more information on habitats).

Eight Level 1 threats are known to threaten RSGCN and Proposed RSGCN Fireflies. Pollution threatens 100% of these species, specifically light pollution (Table 1.3.54). Owens et al. (2022a) found that light pollution impacts both development and behaviors, especially courtship behaviors. Species-specific impacts from light pollution were exhibited in the genus Photinus; some had little effect on movement or mating, while other species had complete mate success failure (Owens et al. 2022b). Other factors threatening this taxon that aren't as well-known include Climate Change (31%) threats and Natural System Modifications (23%). These include gradual changes in precipitation regimes, increased fluctuations in precipitation regimes, and groundwater withdrawal (Table 1.3.54). Research is needed to continue filling gaps in knowledge of Firefly threats.

Table 1.3.54 Level 1 threats with the number and percent of RSCGN and Proposed RSGCN Fireflies threatened by each. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Pollution (Threat 9.0)	13	100%
Climate Change (Threat 11.0)	4	31%
Natural System Modifications (Threat 7.0)	3	23%
Residential & Commercial Development (Threat 1.0)	3	23%
Agriculture & Aquaculture (Threat 2.0)	2	15%

Biological Resource Use (Threat 5.0)	1	8%
Human Intrusions & Disturbance (Threat 6.0)	1	8%
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	1	8%

WATCHLIST

Six Firefly species are Watchlist species, one Firefly that Taxonomic Teams identified as Watchlist [Assessment Priority], and five species listed as Proposed Watchlist [Assessment Priority].

WATCHLIST [ASSESSMENT PRIORITY]: 1 FIREFLY

A single species met the criteria for Watchlist [Assessment Priority] on the 2023 list update. The Confusing Firefly (*Photuris tremulans*) lives up to its name; the species is part of a complex and, depending on which the description, is either a widespread, common species or is morphologically distinct and potentially rare and endemic to the region. Genetic research and field surveys will be necessary to delineate this species from its conspecifics. Therefore, it is listed as 25-50% Regional Responsibility and High Concern Level.

PROPOSED WATCHLIST [ASSESSMENT PRIORITY]: 5 FIREFLIES

The 2023 Proposed Watchlist [Assessment Priority] list includes five firefly species (Table 1.3.55). Two of these species, *Photuris eliza* and *P. sellicki* were recently described in 2021 and require additional research and surveys to determine distribution, habitat needs, and threats. The two *Pyractomena* species are associated with freshwater marshes. Although they were both historically considered common, the Firefly taxa team agreed that they are now uncommon and difficult to find, potentially due to the loss of suitable habitat over the last 50 years. The final species on this list, *Photinus consimilis* was included due to ongoing taxonomic uncertainty as this may represent a species complex. Genetic research will be necessary to resolve uncertainties.

Table 1.3.55 Proposed Watchlist [Assessment Priority] Fireflies 2023.

Scientific Name	Common Name	Regional Responsibility
Photuris eliza	Eliza's Firefly	100% (NEAFWA Endemic)
Photuris sellicki	Sellick's Firefly	100% (NEAFWA Endemic)
Pyractomena palustris	Marsh Diver Firefly	50-75%
Pyractomena similis	a firefly	50-75%
Photinus consimilis	Cattail Flash-train Firefly	<25%

REGIONAL EFFORTS IN NORTHEAST FIREFLY CONSERVATION

In 2015, fireflies were one of the taxonomic groups with the poorest representation across the region. For example, only two Northeast states, Delaware and Maryland, included fireflies as SGCN in their SWAPs; Maryland included only one species in their list, the Bethany Beach Firefly, which is now under review for federal listing under the Endangered Species Act. The extremely limited number of states, including fireflies in their 2015 lists, suggests that regional expertise was limited at that time.

Interest in fireflies has increased since 2015. **Firefly Watch**[18] started in 2008, is a citizen science initiative that tracks trends in firefly populations in backyards across the United States, though many observers are concentrated in the Northeast. The project is a collaboration between researchers at Tufts University and Massachusetts Audubon. During the 2015 SWAPs, no comprehensive review and assessment of the North American firefly fauna had occurred. Since then, the IUCN SSC Firefly Specialist Group, in collaboration with other researchers, published an extinction risk assessment for 132 North American fireflies (Fallon et al. 2021). This was followed by a report from the Xerces Society for Invertebrate Conservation, which synthesized the assessment results, including the greatest threats to fireflies and beneficial conservation actions, and provided species profiles for the most imperiled firefly species (Fallon et al. 2022). The primary threats to fireflies are habitat loss and degradation, light pollution, climate change, and severe weather. Of the 132 species reviewed, 14% are of conservation concern, 1% are Near Threatened, and 32% are of Least Concern. Unfortunately, these numbers are overwhelmed by the 53% of North American firefly species being data deficient, making more comprehensive assessment impossible.

1.3.13 FRESHWATER MUSSELS

Freshwater mussels (Order Unionoida) are a moderately sized taxonomic group in the Northeast, with 118 species known to occur in the region. In the 14 Northeast SWAPs, 106 mussels were listed as SGCN in at least one state. The taxa team identified 31 freshwater mussels that met the criteria for listing as RSGCN in the 2023 list update, one Proposed RSGCN, two Watchlist [Assessment Priority], and 13 Watchlist [Deferrals]. This revision removed two mussels that were previously included in the 2017 RSGCN list. The Carolina lance (*Elliptio angustata*) was historically thought to occur in Virginia, but recent genetic work has revealed that the species is not found in the state, and records are likely of the closely related Northern Lance (*Elliptio fisheriana*). The second species, Yellow Blossom (*Epioblasma florentina*), is now considered extirpated in the region and may be extinct throughout its range.

Regional Priority Concern Highlights:
- How to address extirpated or recently declared extinct species?
- Climate change, including water temperature, salinity changes, and sea level rise, is a major threat.
- Water quality is crucial for most mussels and is impacted by development, agriculture, and various sources of pollution.
- Invasive species are outcompeting native species in some watersheds.
-

Species Information, Research & Monitoring Needs:
- Taxonomic revisions and research studies for multiple species are ongoing.
- Population decline information is lacking.
- Glochidia hosts are largely unknown for many mussel species.
- Host species interactions and limitations; their influence on dependent mussels is poorly understood.

RSGCN: 31 FRESHWATER MUSSELS

The 31 mussels on the 2023 RSGCN list are disproportionate of elevated conservation concern, with 18 species at Very High concern, ten at High concern, and only three at Moderate concern (Table 1.3.56). In contrast to many other taxonomic groups, the mussels included are shared priorities with other regions, with 20 RSGCN with Regional Responsibility levels below 50% and only one regional endemic, the Eastern Pearlshell (*Margaritifera margaritifera*). Mussels are also disproportionately federally listed, with 16 Endangered species, 2 Threatened species, and 2 Proposed Threatened (Table 1.3.56). These federally listed species account for many of the region's RSGCN that fall under 50% responsibility.

Table 1.3.56 RSGCN Freshwater Mussels 2023. Includes column with the Federal Listing States: E = Endangered, T = Threatened, PT = Proposed Threatened.

Scientific Name	Common Name	Regional Responsibility	Concern Level	Federal Listing
Alasmidonta heterodon	Dwarf Wedgemussel	75-100%	Very High	E
Alasmidonta varicosa	Brook Floater	75-100%	Very High	NA
Fusconaia cor	Shiny Pigtoe	25-50%	Very High	E, XN
Fusconaia cuneolus	Finerayed Pigtoe	<25%	Very High	E, XN
Fusconaia masoni	Atlantic Pigtoe	25-50%	Very High	T
Pleurobema clava	Clubshell	<25%	Very High	E, XN
Parvaspina collina	James Spinymussel	50-75%	Very High	E
Pleurobema plenum	Rough Pigtoe	<25%	Very High	E, XN
Lasmigona subviridis	Green Floater	75-100%	Very High	NA
Villosa fabalis	Rayed Bean	25-50%	Very High	E
Venustaconcha trabalis	Tennessee Bean	<25%	Very High	E, XN
Plethobasus cooperianus	Orangefoot Pimpleback	<25%	Very High	E, XN
Plethobasus cyphyus	Sheepnose	<25%	Very High	E
Epioblasma triquetra	Snuffbox	<25%	Very High	E
Hemistena lata	Cracking Pearlymussel	<25%	Very High	E, XN
Epioblasma rangiana	Northern Riffleshell	50-75%	Very High	E
Theliderma sparsa	Appalachian Monkeyface	50-75%	Very High	E, XN
Theliderma intermedia	Cumberland Monkeyface	<25%	Very High	E, XN
Elliptio lanceolata	Yellow Lance	25-50%	High	T
Lampsilis cariosa	Yellow Lampmussel	50-75%	High	NA
Fusconaia subrotunda	Longsolid	<25%	High	PT
Lasmigona holstonia	Tennessee Heelsplitter	<25%	High	NA
Simpsonaias ambigua	Salamander Mussel	<25%	High	NA
Obovaria subrotunda	Round Hickorynut	25-50%	High	PT
Leptodea ochracea	Tidewater Mucket	75-100%	High	NA
Ligumia nasuta	Eastern Pondmussel	50-75%	High	NA
Ptychobranchus subtentus	Fluted Kidneyshell	<25%	High	E

Theliderma cylindrica	Rabbitsfoot	<25%	High	NA
Alasmidonta undulata	Triangle Floater	75-100%	Moderate	NA
Villosa constricta	Notched Rainbow	25-50%	Moderate	NA
Margaritifera margaritifera	Eastern Pearlshell	100% (NEAFWA Endemic)	Moderate	NA

PROPOSED RSGCN: 1 FRESHWATER MUSSEL

The single Proposed RSGCN on this list, the Golden Riffleshell (*Epioblasma aureola*), was elevated to a species in 2017. It is endemic, restricted to Indian Creek in southwestern Virginia after a chemical spill eliminated much of the population in the Clinch River. Therefore, the Taxonomic Team listed Golden Riffleshell as a Very High concern level species.

OVERVIEW

These mussels have been hard-hit by a broad range of factors, including water pollution, sedimentation, stream alteration, dams, gravel mining, and harvest of the mussels for use in button factories and more recently, for the cultured pearl industry (Williams et al. 1993). In recent years, considerable conservation resources have been dedicated to conserving and restoring remnant mussel populations. Conservation actions that can benefit mussels include removing pollution sources, restoring historic flow patterns in streams to reduce sedimentation, and removing dams and other barriers to the movement of fish hosts transporting larval mussels. In addition, formal protection for many of these species under the federal Endangered Species Act and the species protection statutes of many states prevent commercial harvest of the mussels for their shells. Another conservation action currently being used is the translocation of mussels gleaned from healthy populations to supplement other reduced populations whose viability is at risk. Research at **Virginia Tech's Freshwater Mollusk Conservation Center**[19] and **White Sulphur Springs National Fish Hatchery**[20], and other institutions are helping to determine the conditions necessary for captive propagation of freshwater mussel species. Captive propagation intends to develop source populations for future species restoration and reintroduction efforts and to re-establish populations where they have been extirpated.

RSGCN and Proposed RSGCN inhabit four habitat groups and seven habitat types (see *Chapter 2*). One hundred percent of Northeast listed Freshwater Mussels occur in Rivers and Streams. Big Rivers and Lakes and Ponds were the second most inhabited by these mussels, with 25% of them found in each (Figure 1.3.30).

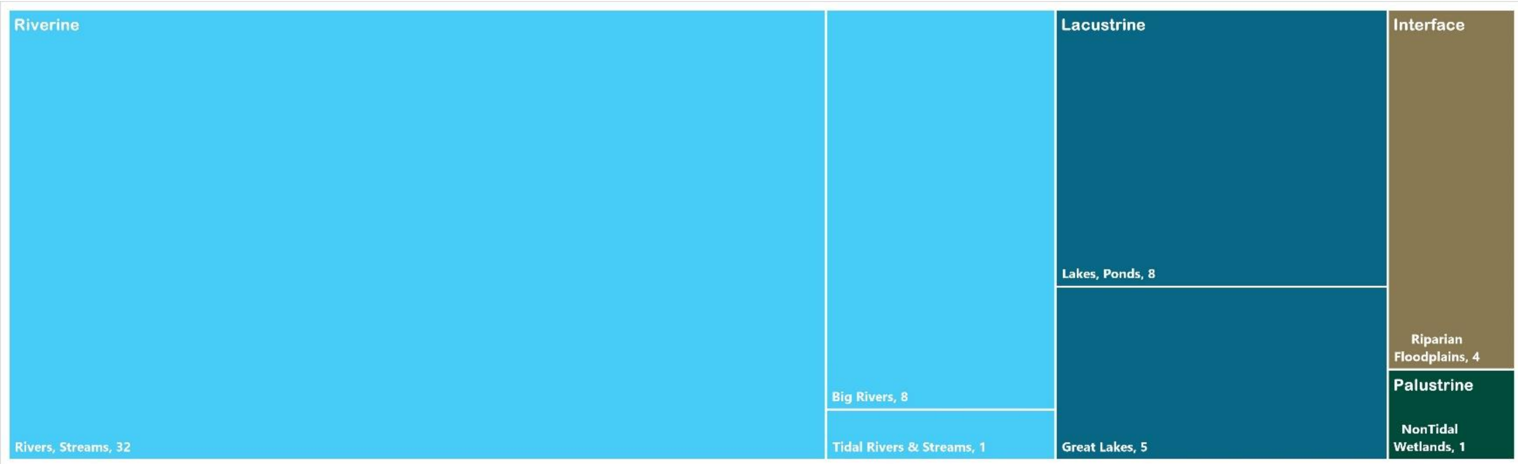


Figure 1.3.30 Number of RSGCN and Proposed RSGCN Freshwater Mussel associated with each habitat in the Northeast. Species may be associated with multiple habitat types. Habitat group names are at the top of each color block and grouped by color, habitat type names appear at the bottom of each proportionally sized square and colored by habitat group (see *Chapter 2* for more information on habitats).

Pollution, Invasive and Problematic Species, Pathogens and Genes, and Climate Change threaten Northeast RSGCN and Proposed RSGCN Freshwater Mussels more than any other threat (Table 1.3.57). Other industrial discharges threaten this taxon, followed by runoff and domestic wastewater. These 32 Mussels are also threatened by aquatic animals, loss of genetic integrity, and interspecific competition with a favored species. Climate change threats include storms and severe weather, increased fluctuation in the precipitation regime (11.4.4), and gradual temperature change. Finally, water level management using dams threatens 66% of these species.

Table 1.3.57 Level 1 threats with the number and percent of RSCGN and Proposed RSGCN Freshwater Mussels threatened by each. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Pollution (Threat 9.0)	32	100%
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	28	88%
Climate Change (Threat 11.0)	23	72%
Natural System Modifications (Threat 7.0)	22	69%
Energy Production & Mining (Threat 3.0)	16	50%
Transportation & Service Corridors (Threat 4.0)	15	47%
Agriculture & Aquaculture (Threat 2.0)	13	41%
Human Intrusions & Disturbance (Threat 6.0)	11	34%
Biological Resource Use (Threat 5.0)	10	31%
Residential & Commercial Development (Threat 1.0)	10	31%
Other (Threat 12.0)	8	25%

WATCHLIST

In total, 15 Freshwater Mussels are Watchlist species, two species that Taxonomic Teams identified as Watchlist [Assessment Priority], and 13 species identified for deferral to adjacent regions.

WATCHLIST [ASSESSMENT PRIORITY]: 2 FRESHWATER MUSSELS

The two mussel species included on the Watchlist [Assessment Priority] list have uncertain distributions due to taxonomic issues between the two (Table 1.3.58). There is a possibility that Northern Lance (*Elliptio fisheriana*) and Atlantic Spike (*Elliptio producta*) represent a single species that should be synonymized. If this occurs, the synonymized species will not reach the necessary Concern Levels for inclusion on the RSGCN list due to fairly wide distribution. Therefore, the Freshwater Mussel Taxonomic Team elected to add these species to the Watchlist until the taxonomy is resolved, making it possible to assess the resulting species accurately.

Table 1.3.58 Watchlist [Assessment Priority] Freshwater Mussels 2023.

Scientific Name	Common Name	Regional Responsibility
Elliptio fisheriana	Northern Lance	50-75%
Elliptio producta	Atlantic Spike	25-50%

WATCHLIST [DEFER TO ADJACENT REGION]: 13 FRESHWATER MUSSELS

A total of 13 species with low regional responsibility but high conservation concern in the Northeast were deferred to adjacent regions: ten to SEAFWA, one to MAFWA, and two to both SEAFWA and MAFWA (Table 1.3.59). Nine of these species are federally Endangered, explaining their high concern in the region. In addition, many of these deferred mussels occur in river basins that are part of the Cumberland Plateau rather than the Atlantic Slope drainages and are thus more ecologically aligned with the Southeast region.

Table 1.3.59 Watchlist [Defer to Adjacent Region] Freshwater Mussels 2023.

Scientific Name	Common Name	Deferred Region(s)	Listed in Deferred Region(s)
Elliptio crassidens	Elephantear	MAFWA	RSGCN in MAFWA
Dromus dromas	Dromedary Pearlymussel	SEAFWA	RSGCN in SEAFWA
Lemiox rimosus	Birdwing Pearlymussel	SEAFWA	RSGCN in SEAFWA
Cyprogenia stegaria	Fanshell	SEAFWA	RSGCN in MAFWA/ SEAFWA

Epioblasma brevidens	Cumberlandian Combshell	SEAFWA	RSGCN in SEAFWA
Epioblasma capsaeformis	Oyster Mussel	SEAFWA	RSGCN in SEAFWA
Pleurobema oviforme	Tennessee Clubshell	SEAFWA	RSGCN in SEAFWA
Medionidus conradicus	Cumberland Moccasinshell	SEAFWA	RSGCN in SEAFWA
Pegias fabula	Littlewing Pearlymussel	SEAFWA	RSGCN in MAFWA/ SEAFWA
Pleuronaia barnesiana	Tennessee Pigtoe	SEAFWA	RSGCN in SEAFWA
Pleuronaia dolabelloides	Slabside Pearlymussel	SEAFWA	RSGCN in SEAFWA
Margaritifera monodonta	Spectaclecase	MAFWA/ SEAFWA	RSGCN in MAFWA/ SEAFWA
Lampsilis abrupta	Pink Mucket	MAFWA/ SEAFWA	RSGCN in MAFWA/ SEAFWA

REGIONAL EFFORTS IN NORTHEAST FRESHWATER MUSSEL CONSERVATION

No formal assessment of the Northeastern freshwater mussel assemblage has yet occurred, but significant work within the taxa is ongoing. With nearly 40 federally listed or proposed species whose distribution includes part of the Northeast region, most have active Recovery Plans. These plans outline recovery objectives and proposed actions to help achieve those objectives. The ongoing conservation efforts to benefit these federally listed species may also benefit any other RSGCN mussels that co-occur with the targeted species.

Global assessments of freshwater mussel conservation status indicated that the greatest threats to North American species included natural system modification and pollution. However, invasive species, urban and residential development, agriculture, and energy production also impact mussel species (Böhm et al. 2021). In addition, many mussels in the United States have been undergoing declines since the 1960s that are not understood, highlighting the data deficiencies within this taxonomic group (Haag 2019). Further research is needed on poorly understood factors that may impact mussel health in the Northeast, including invasive species, disease, and the relative vulnerability of certain habitat types to anthropogenic influences (Haag 2019, Haag et al. 2019).

1.3.14 LEPIDOPTERA: BUTTERFLIES, SKIPPERS, AND MOTHS

There are 2,646 Butterflies, Skippers, and Moths (Order Lepidoptera) that inhabit the NEAFWA regional footprint. Fifty-five of these Butterflies, Skippers, and Moths met the criteria as RSGCN, including 26 Butterflies and Skippers and 29 Moths. Another 55 Butterflies, Skippers, and Moths are listed in one of the Watchlist categories: 39 Watchlist [Assessment Priority], 11 Watchlist [Deferrals], and five non-SGCN species met the criteria for Proposed Watchlist [Assessment Priority].

<u>Regional Priority Concern Highlights:</u>

- Overabundant herbivores threaten diverse forest ecosystems.
- Fire regime imbalance.
- Insectivore spraying for invasive control (Spongy moth).

<u>Species Information, Research & Monitoring Needs:</u>

- Targeted surveys for many Watchlist [Assessment Priority] species with data deficiencies, perhaps by grouping species assemblages.
- Not much is known about how climate change affects most Lepidoptera.
- Other gaps are present across species except for Monarch butterflies.

RSGCN: 55 BUTTERFLIES, SKIPPERS, AND MOTHS

The 2023 Northeast RSGCN list includes 55 species of Butterflies, Skippers, and Moths (Table 1.3.60). Three of these are Federally listed. The regional Lepidoptera Taxonomic Team listed 30 species at High concern, with an additional 11 species listed at Moderate Concern Level. Thirteen are endemic to the Northeast. Only four of these species have been new additions to the list since 2018.

Table 1.3.60 RSGCN Butterflies, Skippers, and Moths 2023.

Subtaxon	Scientific Name	Common Name	Regional Responsibility	Concern Level
Butterflies and Skippers	*Erynnis persius persius*	Persius Duskywing	50-75%	Very High
Butterflies and Skippers	*Callophrys irus*	Frosted Elfin	50-75%	Very High

Butterflies and Skippers	*Plebejus samuelis*	Karner Blue	25-50%	Very High
Moths	*Papaipema sp. 1*	Flypoison Borer Moth	100% (NEAFWA Endemic)	Very High
Moths	*Papaipema sp. 2 nr. pterisii*	Ostrich Fern Borer Moth	50-75%	Very High
Moths	*Crambus daeckellus*	Daecke's Pyralid Moth	100% (NEAFWA Endemic)	Very High
Moths	*Hemileuca maia menyanthevora*	Bogbean Buckmoth	100% (NEAFWA Endemic)	Very High
Moths	*Agrotis buchholzi*	Buchholz's Dart Moth	50-75%	Very High
Moths	*Chaetaglaea cerata*	Waxed Sallow Moth	25-50%	Very High
Moths	*Drasteria occulta*	Occult Drasteria Moth	100% (NEAFWA Endemic)	Very High
Moths	*Papaipema sulphurata*	Decodon Stem Borer Moth	100% (NEAFWA Endemic)	Very High
Moths	*Photedes carterae*	Carter's Noctuid Moth	25-50%	Very High
Moths	*Macaria exonerata*	Barrens Itame	100% (NEAFWA Endemic)	Very High
Moths	*Euchlaena milnei*	Milne's Looper Moth	25-50%	Very High
Butterflies and Skippers	*Problema bulenta*	Rare Skipper	50-75%	High
Butterflies and Skippers	*Erynnis martialis*	Mottled Duskywing	<25%	High
Butterflies and Skippers	*Atrytone arogos arogos*	Arogos Skipper	50-75%	High
Butterflies and Skippers	*Poanes massasoit chermocki*	Chermock's Mulberry Wing	100% (NEAFWA Endemic)	High
Butterflies and Skippers	*Pyrgus centaureae wyandot*	Appalachian Grizzled Skipper	25-50%	High
Butterflies and Skippers	*Euchloe olympia*	Olympia Marble	<25%	High
Butterflies and Skippers	*Callophrys hesseli*	Hessel's Hairstreak	50-75%	High

Butterflies and Skippers	*Erora laeta*	Early Hairstreak	50-75%	High
Butterflies and Skippers	*Calephelis borealis*	Northern Metalmark	50-75%	High
Butterflies and Skippers	*Argynnis diana*	Diana Fritillary	<25%	High
Butterflies and Skippers	*Tharsalea dorcas claytoni*	Clayton's Copper Butterfly	75-100%	High
Butterflies and Skippers	*Boloria chariclea montinus*	White Mountain Fritillary	100% (NEAFWA Endemic)	High
Butterflies and Skippers	*Oeneis polixenes katahdin*	Katahdin Arctic	100% (NEAFWA Endemic)	High
Butterflies and Skippers	*Oeneis melissa semidea*	White Mountain Arctic	100% (NEAFWA Endemic)	High
Butterflies and Skippers	*Argynnis idalia*	Regal Fritillary	25-50%	High
Moths	*Lithophane lepida*	Pale Pinion	50-75%	High
Moths	*Brachionycha borealis*	Boreal Fan Moth	<25%	High
Moths	*Abagrotis benjamini*	Benjamin's Coastal Heathland Cutworm Moth	75-100%	High
Moths	*Heterocampa varia*	a prominent moth	25-50%	High
Moths	*Acronicta dolli*	Doll's Dagger Moth	25-50%	High
Moths	*Apamea inebriata*	The Drunk Apamea	50-75%	High
Moths	*Catocala marmorata*	Marbled Underwing	75-100%	High
Moths	*Hadena ectypa*	The Starry Campion Moth	25-50%	High
Moths	*Psectrotarsia hebardi*	Hebard's Noctuid Moth	50-75%	High
Moths	*Catocala herodias gerhardi*	Herodias or Pine Barrens Underwing	75-100%	High
Moths	*Catocala pretiosa pretiosa*	Precious Underwing	100% (NEAFWA Endemic)	High
Moths	*Apodrepanulatrix liberaria*	New Jersey Tea Inchworm	50-75%	High
Moths	*Erastria coloraria*	Broad-lined Erastria	<25%	High

Moths	*Metarranthis apiciaria*	Barrens Metarranthis Moth	25-50%	High
Moths	*Metarranthis pilosaria*	Coastal Bog Metarranthis	100% (NEAFWA Endemic)	High
Butterflies and Skippers	*Euphyes bimacula*	Two-spotted Skipper	50-75%	Moderate
Butterflies and Skippers	*Erynnis lucilius*	Columbine Duskywing	25-50%	Moderate
Butterflies and Skippers	*Pieris virginiensis*	West Virginia White	50-75%	Moderate
Butterflies and Skippers	*Satyrium edwardsii*	Edwards' Hairstreak	25-50%	Moderate
Butterflies and Skippers	*Callophrys polios*	Hoary Elfin	25-50%	Moderate
Butterflies and Skippers	*Callophrys lanoraieensis*	Bog Elfin	100% (NEAFWA Endemic)	Moderate
Butterflies and Skippers	*Plebejus idas empetri*	Crowberry Blue	75-100%	Moderate
Butterflies and Skippers	*Danaus plexippus*	Monarch	<25%	Moderate
Moths	*Sthenopis pretiosus*	Gold-spotted Ghost Moth	50-75%	Moderate
Moths	*Papaipema duplicatus*	Dark Stoneroot Borer Moth	50-75%	Moderate
Moths	*Hypomecis buchholzaria*	Buchholz's Gray	25-50%	Moderate

Since all Butterflies, Skippers, and Moths of conservation concern were listed as SGCN in at least one state, none were listed as Proposed RSGCN.

OVERVIEW

RSGCN Butterflies, Skippers, and Moths inhabit five Northeast habitat groups and fourteen habitat types (see *Chapter 2*). Seventy-one percent of these species use Forest Woodland, 60% use Glade, Barren, and Savannah, and 58% use Grassland (Figure 1.3.31).

Figure 1.3.31 Number of RSGCN Butterfly, Skipper, and Moth associated with each habitat in the Northeast. Species may be associated with multiple habitat types. Habitat group names are at the top of each color block and grouped by color; habitat type names appear at the bottom of each proportionally sized square and are colored by habitat group (see *Chapter 2* for more information on habitats).

RSGCN Butterflies, Skippers, and Moths top Level 1 threats are Pollution (75%), Residential and Commercial Development (67%), and Natural System Modifications (60%, Table 1.3.61). Many of these Lepidoptera are threatened by herbicides and pesticides. Other Pollution threats come from soil erosion, sedimentation, and acid rain (Table 1.3.61). Low-density housing areas, commercial and industrial areas, and dense housing and urban areas are the top Residential and Commercial Development threats. Natural System Modifications are increased fire regime, suppression of the fire regime, and vegetation succession (Table 1.3.61). Other notable threats for this group of RSGCN are climate change threats, such as changes in vegetation communities, and problematic species threats like terrestrial animals due to White-tailed Deer (*Odocoileus virginianus*) browsing pressure in forested habitats. The common theme between these threats is habitat degradation and loss.

Table 1.3.61 Level 1 threats with the number and percent of RSCGN Butterflies, Skippers, and Moths threatened by each. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Pollution (Threat 9.0)	41	75%

Residential & Commercial Development (Threat 1.0)	37	67%
Natural System Modifications (Threat 7.0)	33	60%
Climate Change (Threat 11.0)	27	49%
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	27	49%
Biological Resource Use (Threat 5.0)	23	42%
Transportation & Service Corridors (Threat 4.0)	17	31%
Agriculture & Aquaculture (Threat 2.0)	16	29%
Human Intrusions & Disturbance (Threat 6.0)	16	29%
Energy Production & Mining (Threat 3.0)	14	25%
Other (Threat 12.0)	10	18%

WATCHLIST

In total, the Butterfly, Skipper, and Moth Taxonomic Team listed 55 species as Watchlist species, 39 species that taxa teams identified as Watchlist [Assessment Priority], five species listed as Proposed Watchlist [Assessment Priority], and 11 species that were identified for deferral to adjacent regions.

WATCHLIST [ASSESSMENT PRIORITY]: 39 BUTTERFLIES, SKIPPERS, AND MOTHS

The 39 2023 Watchlist [Assessment Priority] Lepidoptera species includes 11 Butterflies and Skippers and 28 Moths (Table 1.3.62). Two of them are RSGCN in the Midwest. Twelve of these Lepidoptera were listed as RSGCN in the Northeast in 2018, but many of these species are data deficient. With the addition of the Watchlist [Assessment Priority] to flag species that need more research, these species were a better fit for this category. In addition, two are endemics in the Northeast, Pink-edged Sulphur (High altitude pop.) (*Colias interior*) and Early Metarranthis Moth (*Metarranthis sp. 3*), and in need of research and taxonomic clarification.

Table 1.3.62 Watchlist [Assessment priority] Butterflies, Skippers, and Moths 2023.

Subtaxon	Scientific Name	Common Name	Regional Responsibility
Moths	*Metarranthis sp. 3*	Early Metarranthis Moth	100% (NEAFWA Endemic)
Butterflies and Skippers	*Colias interior*	Pink-edged Sulphur (High altitude pop.)	100% (NEAFWA Endemic)
Butterflies and Skippers	*Cupido amyntula maritima*	Western Tailed-Blue	75-100%
Moths	*Hemileuca lucina*	New England Buckmoth	75-100%
Moths	*Glena cognataria*	Blueberry Gray	75-100%

Moths	*Cyclophora culicaria*	Sand-myrtle Geometer	50-75%
Butterflies and Skippers	*Tharsalea epixanthe*	Bog Copper	50-75%
Butterflies and Skippers	*Chlosyne harrisii*	Harris's Checkerspot	50-75%
Moths	*Hemaris gracilis*	Slender Clearwing	50-75%
Moths	*Schizura apicalis*	Plain Schizura	50-75%
Moths	*Cerma cora*	Bird Dropping Moth	50-75%
Moths	*Eucoptocnemis fimbriaris*	Fringed Dart Moth	50-75%
Moths	*Exyra fax*	Pitcher Plant Moth	50-75%
Moths	*Papaipema appassionata*	Pitcher Plant Borer Moth	50-75%
Moths	*Papaipema stenocelis*	Chain Fern Borer Moth	50-75%
Moths	*Zanclognatha martha*	Pine Barrens Zanclognatha	50-75%
Moths	*Plagodis kuetzingi*	Purple Plagodis Moth	50-75%
Moths	*Neoligia semicana*	Northern Brocade Moth	25-50%
Moths	*Phoberia ingenua*	Uncommon Oak Moth	25-50%
Moths	*Psectraglaea carnosa*	Pink Sallow	25-50%
Moths	*Zale lunifera*	Pine Barrens Zale Moth	25-50%
Moths	*Acronicta albarufa*	Barrens Dagger Moth	25-50%
Moths	*Papaipema cerina*	Golden Borer Moth	25-50%
Moths	*Papaipema furcata*	Ash Borer Moth	25-50%
Moths	*Schinia septentrionalis*	Northern Flower Moth	25-50%
Moths	*Pyrrhia aurantiago*	Aureolaria Seed Borer	25-50%
Butterflies and Skippers	*Boloria myrina*	Silver-bordered Fritillary	25-50%
Moths	*Ceratomia undulosa*	Waved Sphinx	25-50%
Butterflies and Skippers	*Atrytonopsis hianna*	Dusted Skipper	25-50%
Butterflies and Skippers	*Tharsalea hyllus*	Bronze Copper	25-50%
Butterflies and Skippers	*Satyrium acadica*	Acadian Hairstreak	25-50%

Butterflies and Skippers	*Celastrina neglectamajor*	Appalachian Azure	25-50%
Butterflies and Skippers	*Chlosyne nycteis*	Silvery Checkerspot	25-50%
Butterflies and Skippers	*Satyrium favonius ontario*	Northern Oak Hairstreak	25-50%
Moths	*Sphinx chersis*	Great Ash Sphinx Moth	25-50%
Moths	*Chytonix sensilis*	Masked Marvel	25-50%
Moths	*Lycia rachelae*	Twilight Moth	<25%
Moths	*Manduca jasminearum*	Ash Sphinx	<25%
Moths	*Lithophane lemmeri*	Lemmer's Noctuid Moth	<25%

PROPOSED WATCHLIST [ASSESSMENT PRIORITY]: 5 BUTTERFLIES, SKIPPERS, AND MOTHS

Five species of Butterflies, Skippers, and Moths are not currently listed in Northeast SWAPs as SGCN but were of concern to the Taxonomic Teams who concurred with their qualification for the 2023 Proposed Watchlist [Assessment Priority] list. Two of the Moths are endemic to the Northeast (Table 1.3.63). Expert input indicates most of these are rare and vulnerable species across the region. The Fringe-tree Sallow (*Sympistis chionanthi*) is an ash obligate species.

Table 1.3.63 Proposed RSGCN Butterflies, Skippers, and Moths 2023.

Subtaxon	Scientific Name	Common Name	Regional Responsibility
Moths	*Caloptilia flavella*	Wax Myrtle Leafminer	100% (NEAFWA Endemic)
Moths	*Acleris comandrana*	a tortricid moth	100% (NEAFWA Endemic)
Moths	*Erannis tiliaria*	Linden Looper	25-50%
Moths	*Sympistis chionanthi*	Fringe-tree Sallow	25-50%
Butterflies and Skippers	*Plebejus idas scudderi*	Northern Blue	<25%

WATCHLIST [DEFER TO ADJACENT REGION]: 11 BUTTERFLIES, SKIPPERS, AND MOTHS

Taxonomic Team experts deferred 11 Butterflies, Skippers, and Moths to adjacent regions with more Regional Responsibility, five Butterflies and Skippers and six Moths

(Table 1.3.64). The Southeast does not list Lepidoptera yet; three are listed on the Midwest RSGCN list: one Proposed RSGCN and two Watchlist. The deferred regions do not list over half of these Butterflies, Skippers, and Moths, creating opportunities for cross-regional collaboration.

Table 1.3.64 Watchlist [Defer to Adjacent Region] Butterflies, Skippers, and Moths 2023.

Subtaxon	Scientific Name	Common Name	Deferred Region	Listed in Deferred Region
Butterflies and Skippers	*Neonympha mitchellii*	Mitchell's Satyr	MAFWA	Proposed RSGCN in MAFWA
Moths	*Sphinx canadensis*	Canadian Sphinx	MAFWA	No
Moths	*Papaipema astuta*	Yellow Stoneroot Borer	MAFWA	No
Moths	*Lytrosis permagnaria*	a geometrid moth	SEAFWA	No
Butterflies and Skippers	*Euphyes pilatka*	Palatka Skipper	SEAFWA	No
Butterflies and Skippers	*Satyrium kingi*	King's Hairstreak	SEAFWA	No
Moths	*Papaipema araliae*	Aralia Shoot Borer Moth	SEAFWA	No
Moths	*Melanapamea mixta*	Coastal Plain Apamea Moth	SEAFWA	No
Butterflies and Skippers	*Euphyes dukesi*	Dukes' Skipper	MAFWA/ SEAFWA	No
Moths	*Sphinx franckii*	Franck's Sphinx	MAFWA/ SEAFWA	No
Butterflies and Skippers	*Pontia protodice*	Checkered White	MAFWA/ SEAFWA	No

REGIONAL EFFORTS IN NORTHEAST LEPIDOPTERA CONSERVATION

RCN projects for Lepidoptera species include the **Conservation and Management of Rare Wetland Butterflies: Strategies for Monitoring, Modeling** and **Wetland Enhancement in the Mid-Atlantic Region and Development of an Online Database to Enhance the Conservation of SGCN Invertebrates in the**

Northeastern Region[1]**,** which includes the website database where at the final report listed 28% of its species are Lepidoptera**.** In addition, there are projects for the Frosted Elfin and the Monarch Butterfly to determine the region-wide conservation status of these species and other butterflies and moths in the Northeast. Finally, the USGS sponsors the **Butterflies and Moths of North America**[21], a citizen Science project recruiting volunteers to collect data on Butterfly and Moth occurrence.

1.3.15 MARINE INVERTEBRATES

This 2023 update to the Northeast RSGCN list is the first-time marine invertebrates were considered for assessment as RSGCN. Of the 13 Northeast states and DC, two are landlocked, Vermont and West Virginia, and thus were not involved in decisions for this taxonomic group. Moreover, jurisdiction for marine species often falls to separate state marine agencies rather than state wildlife agencies, so many states do not have expertise with marine invertebrates. At least 465 marine invertebrate species are known to occur within the state waters of the 11 Northeast states with coastal areas. Only 95 of these were listed as SGCN in the 2015 Northeastern SWAPs. The Marine Taxonomic Team identified four species as RSGCN and nine entities as Watchlist [Assessment Priority].

Regional Priority Concern Highlights:

- Offshore wind power sitting near/in shellfish grounds has unpredictable impacts on many species.
- Climate change range shifts due to ocean acidification and temperature increases.
- Loss of eelgrass habitat and other nursery areas is a major concern for many invertebrates that form the basis of oceanic food chains.
- New diseases are a major concern.
- New fisheries may change the pressures on some species.
- Innovative bait techniques (fishing) have contributed to meeting conservation goals.

Species Information, Research & Monitoring Needs:

- Inventory, management, and data needs are not identified for many species and their habitats.


Bay Scallop, © Peconic Estuary Partnership

RSGCN: 4 MARINE INVERTEBRATES

The taxa team identified four species as RSGCN in the 2023 update, including two arthropods and two bivalves (Table 1.3.65). None of these species are endemic to Northeastern waters, but the Northeast represents the bulk of these species' ranges or core populations. Horseshoe Crab (*Limulus polyphemus*) is an ecologically important species due to the dependence of some migratory shorebirds as a food source during migration. Still, the taxa team elevated the species to RSGCN due to longstanding concerns about population stability. American Lobster has long been a major conservation concern in the region due to harvest pressure, but disease and climate change may have more severe impacts in the future. Bay Scallops (*Argopecten irradians*) have been impacted by a loss of eelgrass habitat across the Northeast, and Atlantic Sea Scallops (*Placopecten magellanicus*) are facing potential future threats in the form of climate change and offshore wind installations.

Table 1.3.65 RSGCN Marine Invertebrates 2023.

Subtaxon	Scientific Name	Common Name	Regional Responsibility	Concern Level
Marine Bivalves	*Placopecten magellanicus*	Atlantic Sea Scallop	75-100%	High
Marine Bivalves	*Argopecten irradians*	Bay Scallop	25-50%	High
Marine Crustaceans	*Homarus americanus*	American Lobster	75-100%	High
Horseshoe Crabs	*Limulus polyphemus*	Horseshoe Crab	50-75%	Moderate

OVERVIEW

Nine of the 14 Northeast states list marine invertebrates as SGCN (nine of the ten coastal states). All these species are listed with overriding factors, including cultural values, climate vulnerability, and emerging threats. RSGCN Marine Invertebrates are found in four habitat groups and five habitat types (see *Chapter 2*). The top three habitat types are Estuaries, Marine Near-shore, and Marine Offshore, all inhabited by 75% of these RSGCN Marine Invertebrates (Figure 1.3.32).

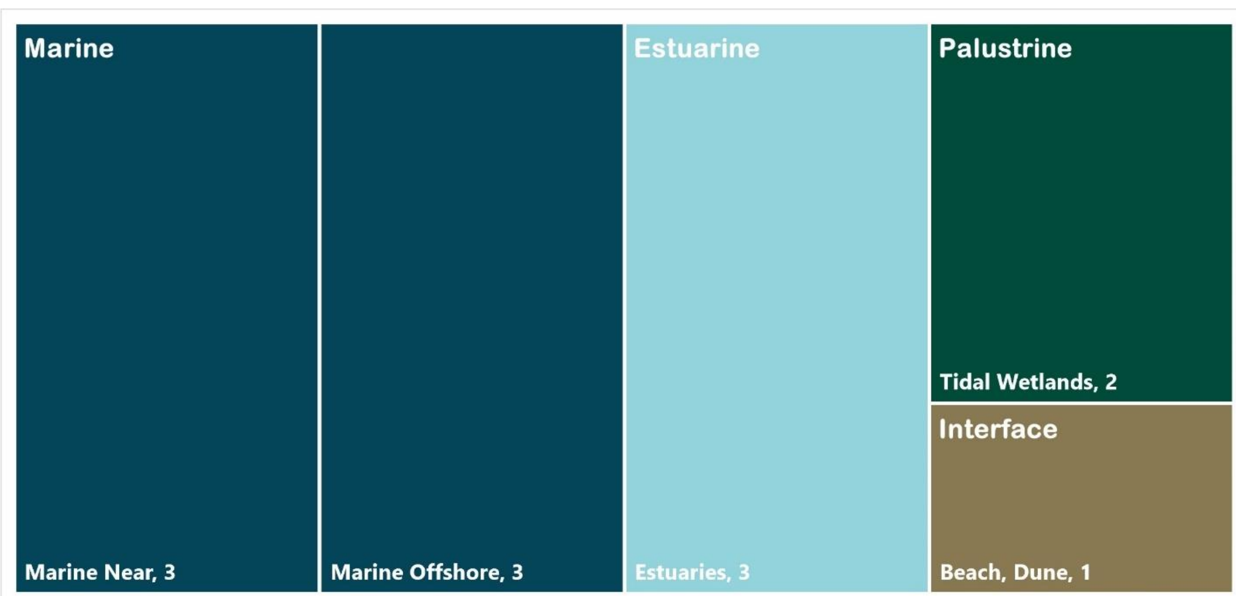


Figure 1.3.32 Number of RSGCN Marine Invertebrates associated with each habitat in the Northeast. Species may be associated with multiple habitat types. Habitat group names are at the top of each color block and grouped by color; habitat type names appear at the bottom of each proportionally sized square and are colored by habitat group (see *Chapter 2* for more information on habitats).

The four RSGCN Marine Invertebrates have four Level 1 threats impacting all of them (100%); Biological Resource Use, Climate Change, Invasive and Problematic Species, Pathogens and Genes, and Pollution, with four other threat categories that threaten at least half of them (Table 1.3.66). Commercial fishing is the top threat under Biological

Resource Use. Changes in vegetation communities, changes in the pH of habitats, and gradual temperature changes threaten 75% of Marine Invertebrates (Table 1.3.66). Harmful algae blooms and protozoan-induced diseases threaten 50% or more of these species (Table 1.3.66). Finally, the top threats under Pollution are domestic wastewater, nutrient loads, drifting plastic, and entanglement rubbish, all threatening 75% of this taxon (Table 1.3.66).

Table 1.3.66 Level 1 threats with the number and percent of RSCGN Marine Invertebrates threatened by each. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Biological Resource Use (Threat 5.0)	4	100%
Climate Change (Threat 11.0)	4	100%
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	4	100%
Pollution (Threat 9.0)	4	100%
Energy Production & Mining (Threat 3.0)	2	50%
Human Intrusions & Disturbance	2	50%
Natural System Modifications	2	50%
Transportation & Service Corridors	2	50%
Residential & Commercial Development	1	25%
Agriculture & Aquaculture	1	25%

WATCHLIST

Nine species were listed as Watchlist species, all identified as Watchlist [Assessment Priority].

WATCHLIST [ASSESSMENT PRIORITY]: 9 MARINE INVERTS

The nine marine invertebrates on the Watchlist [Assessment Priority] include three bivalves, three crabs, two snails, and one starfish (Table 1.3.67). Two of the bivalves, the Eastern Oyster (*Crassostrea virginica*) and Soft-Shell Clam (*Mya arenaria*), were heavily impacted by disease and overharvest and are still recovering in much of the Northeast. The third bivalve, Northern Quahog (*Mercenaria mercenaria*), was not affected the same way historically, but uncertainties about the status of current populations and extremely high cultural importance in several states prompted the taxa team to include the species to keep an eye on any changing trends. The three crab entities were included as data-limited species with high economic or ecological importance. The Taxonomic Team experts flagged the Knobbed and Channeled Whelks (*Busycon carica* and *Busycotypus caniculatus*, respectively) as species with emerging concerns related to changing harvest pressures and potential threats related to offshore wind and other disturbances to benthic habitats. Finally, the Common Seastar (*Asterias forbesi*) is included as anecdotal evidence suggests that they may have gone through recent declines due to disease. Further research is necessary to determine the status of this species.

Table 1.3.67 Watchlist [Assessment Priority] Marine Invertebrates 2023.

Subtaxon	Scientific Name	Common Name	Regional Responsibility
Marine Crustaceans	*Cancer borealis*	Jonah Crab	75-100%
Starfish and Brittle Stars	*Asterias forbesi*	Common Seastar	50-75%
Marine Snails	*Busycon carica*	Knobbed Whelk	50-75%
Marine Snails	*Busycotypus canaliculatus*	Channeled Whelk	50-75%
Marine Bivalves	*Crassostrea virginica*	Eastern Oyster	25-50%
Marine Bivalves	*Mercenaria mercenaria*	Northern Quahog	25-50%
Marine Bivalves	*Mya arenaria*	Soft Shell Clam	25-50%
Marine Crustaceans	*Callinectes sapidus*	Blue Crab	<25%
Marine Crustaceans	*Uca spp.*	fiddler crab spp.	<25%

REGIONAL EFFORTS IN NORTHEAST MARINE INVERTEBRATE CONSERVATION

This group is among the most diverse, including species from multiple Orders, Classes, and Phyla. Unfortunately, this group is also largely data deficient and not well represented in common sources of information such as NatureServe and the IUCN Redlist.

1.3.16 ODONATA: DRAGONFLIES AND DAMSELFLIES

There are 255 (Order Odonata) that inhabit the NEAFWA regional footprint. Twenty Dragonflies and Damselflies met the criteria as RSGCN, and two non-SGCN species met the criteria for Proposed RSGCN. Twenty-seven are listed in one of the Watchlist categories: 20 Watchlist [Assessment Priority] and seven Watchlist [Deferrals].

Regional Priority Concern Highlights:
- Climate change impacts: range shifts, water quality & quantity, water temp, loss of high elevation wetlands.
- The southern end of the range sees declines in abundance and disappearing populations.
- Coastal plain species hang on in New Jersey Pine Barrens but are rare elsewhere in the Northeast.

Species Information, Research & Monitoring Needs:
- Population estimates and surveys are needed for most species.
- Detailed research is required on ecology, behavior, and activity.
- No monitoring protocols exist for this RSGCN group.

RSGCN: 20 DRAGONFLIES AND DAMSELFLIES

The 2023 Northeast RSGCN list includes 20 species of Dragonflies and Damselflies. Concern levels across this group range from three species listed at Very High concern, ten taxa considered at High concern, with seven species listed at Moderate concern level (Table 1.3.68). Four endemic species and another four have Regional Responsibility of 75-100%. The species with lower Regional Responsibility in the Northeast have Overriding factors of being Highly Imperiled, and their Core Populations are within the Northeast. Three of these are RSGCN in the Midwest, Pygmy Snaketail (*Ophiogomphus howei*), Skillet Clubtail (*Gomphurus ventricosus*), Elfin Skimmer (*Nannothemis bella*); an additional four of these species are Watchlist [Assessment Prioritiy] in the Midwest.

Table 1.3.68 RSGCN Dragonflies and Damselflies 2023.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Gomphurus septima	Septima's Clubtail	25-50%	Very High
Williamsonia lintneri	Ringed Boghaunter	50-75%	Very High

Enallagma recurvatum	Pine Barrens Bluet	100% (NEAFWA Endemic)	Very High
Phanogomphus quadricolor	Rapids Clubtail	25-50%	High
Stenogomphurus rogersi	Sable Clubtail	50-75%	High
Ophiogomphus anomalus	Extra-striped Snaketail	50-75%	High
Ophiogomphus howei	Pygmy Snaketail	25-50%	High
Gomphurus ventricosus	Skillet Clubtail	25-50%	High
Somatochlora georgiana	Coppery Emerald	<25%	High
Somatochlora kennedyi	Kennedy's Emerald	50-75%	High
Somatochlora forcipata	Forcipate Emerald	75-100%	High
Somatochlora incurvata	Incurvate Emerald	75-100%	High
Cordulegaster erronea	Tiger Spiketail	50-75%	High
Nannothemis bella	Elfin Skimmer	50-75%	Moderate
Somatochlora elongata	Ski-tipped Emerald	75-100%	Moderate
Calopteryx angustipennis	Appalachian Jewelwing	25-50%	Moderate
Enallagma laterale	New England Bluet	100% (NEAFWA Endemic)	Moderate
Enallagma minusculum	Little Bluet	75-100%	Moderate
Neurocordulia michaeli	Broad-tailed Shadowdragon	100% (NEAFWA Endemic)	Moderate
Enallagma pictum	Scarlet Bluet	100% (NEAFWA Endemic)	Moderate

PROPOSED RSGCN: 2 DRAGONFLIES AND DAMSELFLIES

Two species of Dragonflies and Damselflies are not currently listed in Northeast SWAPs as SGCN but were of concern to the Odonata Taxonomic Team experts, who concurred with listing them as a 2023 Proposed RSGCN species (Table 1.3.69). Both are Highly Imperiled species; St. Croix Snaketail (*Ophiogomphus susbehcha*) is a Disjunct Population. The Midwest listed St. Croix as RSGCN.

Table 1.3.69 Proposed RSGCN Dragonflies and Damselflies 2023.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Ophiogomphus incurvatus	Appalachian Snaketail	25-50%	High
Ophiogomphus susbehcha	St. Croix Snaketail	25-50%	High

OVERVIEW

The 20 RSGCN and two Proposed RSGCN Dragonflies and Damselflies are found in five Northeast habitat groups and seven habitat types (see *Chapter 2*). These Odonate species use these four habitat types more than others; 86% use Rivers and Streams, 82% use Riparian Floodplains, and 77% use Non-tidal Wetlands and Forest Woodland (Figure 1.3.33). Therefore, protecting connectivity in the matrix of aquatic habitat types used by these taxa with the Forest Upland habitat group is vital across life stages.

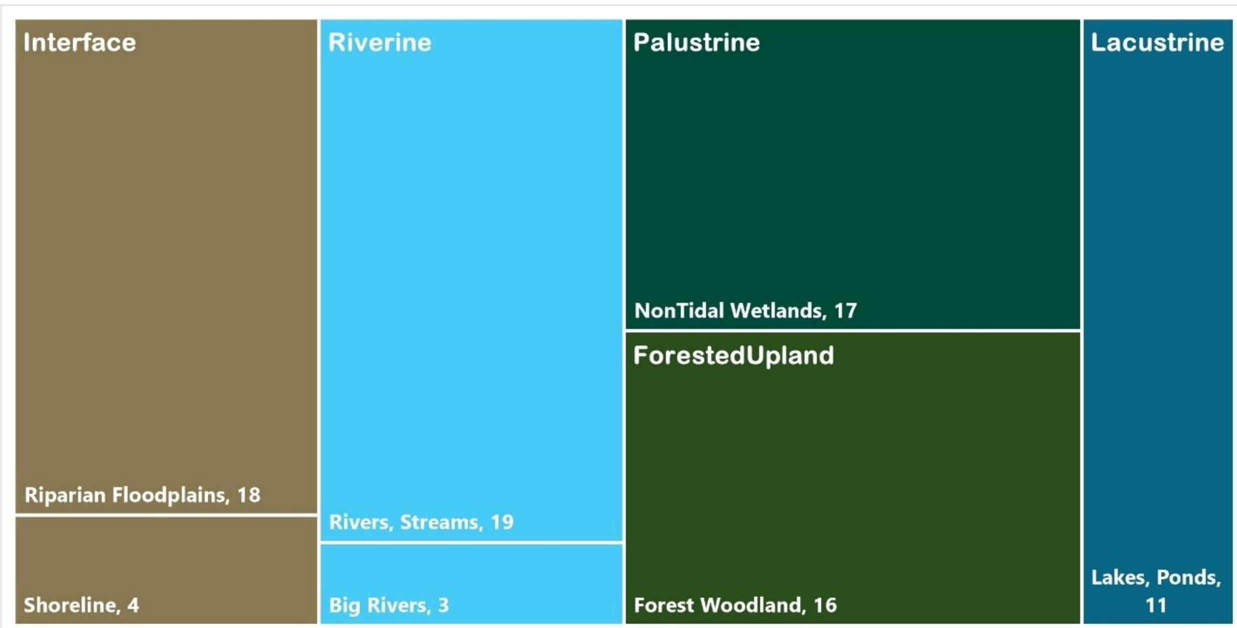


Figure 1.3.33 Number of RSGCN and Proposed RSGCN Dragonfly and Damselfly associated with each habitat in the Northeast. Species may be associated with multiple habitat types. Habitat group names are at the top of each color block and grouped by color; habitat type names appear at the bottom of each proportionally sized square and are colored by habitat group (see *Chapter 2* for more information on habitats).

Climate Change (95% of species), Natural Systems Modifications (86% of species), and Biological Resource Use (82% of species) threaten RSGCN and Proposed RSGCN Dragonflies and Damselflies (Table 1.3.70). Under the top two Level 1 threats, droughts, overabundant rain, and storms and severe weather, along with water level management using dams, water management using culverts, and shoreline alteration all threaten greater than 50% of these species (Table 1.3.70). Biological resource use top threats include complete removal of forest floor, partial removal of forest floor, and commercial harvesting (Table 1.3.70). Many of the threats to these Odonates can be alleviated with habitat protections and habitat management.

Table 1.3.70 Level 1 threats with the percent of RSCGN and Proposed RSGCN Dragonflies and Damselflies threatened by each. The top Level 3 threats from each Level 1 category with the percent of species threatened by each Level 3. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Climate Change (Threat 11.0)	21	95%
Natural System Modifications (Threat 7.0)	19	86%
Biological Resource Use (Threat 5.0)	18	82%
Pollution (Threat 9.0)	16	73%
Residential & Commercial Development (Threat 1.0)	13	59%
Human Intrusions & Disturbance (Threat 6.0)	10	45%
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	10	45%
Transportation & Service Corridors (Threat 4.0)	9	41%
Agriculture & Aquaculture (Threat 2.0)	6	27%
Other (Threat 12.0)	5	23%
Energy Production & Mining (Threat 3.0)	3	14%

WATCHLIST

In total, 27 species were listed as Watchlist species, 20 species that the Taxonomic Team identified as Watchlist [Assessment Priority], and seven species were identified for deferral to adjacent regions.

WATCHLIST [ASSESSMENT PRIORITY]: 20 DRAGONFLIES AND DAMSELFLIES

The 20 2023 Watchlist [Assessment Priority] Dragonflies and Damselflies include one endemic species and 11 species with Regional Responsibility of 75-100% in the Northeast (Table 1.3.71). Thirteen of these Watchlisted species did not get listed in the previous 2018 RSGCN list in the Northeast primarily to data deficiencies. Seven others were listed in 2018 but fit better as Watchlist species because they require more research to conserve and manage them properly. The Midwest listed four of these species as RSGCN, two others as Watchlist [Assessment Priority].

Table 1.3.71 Watchlist [Assessment Priority] Dragonflies and Damselflies 2023.

Scientific Name	Common Name	Regional Responsibility
Celithemis martha	Martha's Pennant	100% (NEAFWA Endemic)
Phanogomphus descriptus	Harpoon Clubtail	75-100%
Boyeria grafiana	Ocellated Darner	75-100%
Ophiogomphus mainensis	Maine Snaketail	75-100%
Ophiogomphus carolus	Riffle Snaketail	75-100%

Ophiogomphus aspersus	Brook Snaketail	75-100%
Lanthus parvulus	Northern Pygmy Clubtail	75-100%
Lanthus vernalis	Southern Pygmy Clubtail	75-100%
Hylogomphus abbreviatus	Spine-crowned Clubtail	75-100%
Williamsonia fletcheri	Ebony Boghaunter	75-100%
Somatochlora brevicincta	Quebec Emerald	75-100%
Calopteryx amata	Superb Jewelwing	75-100%
Stylurus scudderi	Zebra Clubtail	50-75%
Rhionaeschna mutata	Spatterdock Darner	50-75%
Gomphurus fraternus	Midland Clubtail	25-50%
Tachopteryx thoreyi	Gray Petaltail	25-50%
Leucorrhinia glacialis	Crimson-ringed Whiteface	25-50%
Cordulegaster obliqua	Arrowhead Spiketail	25-50%
Stylurus amnicola	Riverine Clubtail	25-50%
Lestes unguiculatus	Lyre-tipped Spreadwing	<25%

WATCHLIST [DEFER TO ADJACENT REGION]: 7 DRAGONFLIES AND DAMSELFLIES

Taxonomic Team experts deferred seven Dragonflies and Damselflies to adjacent regions with more Regional Responsibility (Table 1.3.72). The Midwest is currently the only other region to list Dragonflies and Damselflies; therefore, over half of these Odonates are not presently listed in the regions they are deferred to, creating opportunities for cross-regional collaboration.

Table 1.3.72 Watchlist [Defer to Adjacent Region] Dragonflies and Damselflies 2023.

Scientific Name	Common Name	Deferred Region(s)	Listed in Deferred Region(s)
Ophiogomphus colubrinus	Boreal Snaketail	Canada	No
Leucorrhinia patricia	Canada Whiteface	Canada	No
Hylogomphus viridifrons	Green-faced Clubtail	to MAFWA	RSGCN in MAFWA
Stylurus notatus	Elusive Clubtail	MAFWA	RSGCN in MAFWA
Cordulegaster obliqua fasciata	Banded Spiketail	SEAFWA	No

Hylogomphus apomyius	Banner Clubtail	SEAFWA	No
Enallagma weewa	Blackwater Bluet	Watchlist [Defer to SEAFWA]	No

REGIONAL EFFORTS IN NORTHEAST DRAGONFLY AND DAMSELFLY CONSERVATION

The RCN project **A Conservation Status Assessment of Odonata in the Northeastern US**[1] was the first regional Odonate assessment. It contains information on habitat vulnerability and conservation concerns. White et al. (2015) published the results of Odonate prioritization in the Northeast. New Hampshire Audubon has a conservation plan for the endemic damsels too[22].

1.3.17 PLECOPTERA: STONEFLIES

A total of 253 stoneflies (Order Plecoptera) are known to occur in the Northeast region. Just over a quarter of these species (67) are listed as SGCN in at least one of the NEAFWA SWAPs. Unlike the other taxa reviewed for the 2023 RSGCN list, a taxonomic team did not formally assess the stoneflies. Instead, changes to listed stoneflies will be deferred until later, as a regional assessment of the taxon is already planned for 2023-2026 and is described below. At the time of this synthesis, the stoneflies included on the 2023 list are the same as those in the 2018 list and have 28 RSGCN, three Proposed RSGCN, and two Watchlist [Assessment Priority] species.

Regional Priority Concern Highlights:
- One of the most environmentally sensitive aquatic insects.
- The taxonomic team deferred decisions to the upcoming RCN 3.0 Status Assessment.

Species Information, Research & Monitoring Needs:
- More information is needed for nearly every species across multiple topics, including basic information on distribution, taxonomic validity, and current status.
- Details on habitat vulnerabilities, use, and management are also needed.

RSGCN: 28 STONEFLIES

There are a total of 28 Stoneflies on the 2023 RSGCN list. Across this group, nine stoneflies are considered Very High concern, 15 are High concern, and four are Moderate concern (Table 1.3.73). Just over 57% of the caddisflies on the RSGCN list are regional endemics; six of these species are narrow range endemics, restricted to a single state. *Isoperla myersi* is found only in New York, *Soyedina merritti* in Pennsylvania, and four species are found only in Virginia: *Acroneuria flinti*, *Isoperla major*, *Taeniopteryx nelsoni*, and *Tallaperla lobata*. These single-state endemics are evenly split between High and Very High concern. The Midwest listed Illinois Snowfly (*Allocapnia illinoensis*) as RSGCN and Maine Stone (*Neoperla mainensis*) as Proposed RSGCN.

Table 1.3.73 RSGCN Stoneflies 2023.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Allocapnia frumi	Monongahela Snowfly	100% (NEAFWA Endemic)	Very High
Taeniopteryx nelsoni	Cryptic Willowfly	100% (NEAFWA Endemic)	Very High
Acroneuria arida	Elegant Stone	50-75%	Very High
Neoperla mainensis	Maine Stone	50-75%	Very High
Isoperla major	Big Stripetail	100% (NEAFWA Endemic)	Very High
Diura washingtoniana	Presidential Springfly	100% (NEAFWA Endemic)	Very High
Alloperla vostoki	Scotia Sallfly	50-75%	Very High
Soyedina merritti	Powdermill Forestfly	100% (NEAFWA Endemic)	Very High
Sweltsa holstonensis	Holston Sallfly	100% (NEAFWA Endemic)	Very High
Tallaperla lobata	Lobed Roachfly	100% (NEAFWA Endemic)	High
Prostoia hallasi	Swamp Forestfly	75-100%	High
Ostrocerca prolongata	Bent Forestfly	75-100%	High

Allocapnia harperi	Stonyfork Snowfly	100% (NEAFWA Endemic)	High
Allocapnia simmonsi	Spatulate Snowfly	100% (NEAFWA Endemic)	High
Acroneuria flinti	Manassas Stonefly	100% (NEAFWA Endemic)	High
Isoperla myersi	Paddle Stripetail	100% (NEAFWA Endemic)	High
Diploperla kanawholensis	Kanawhole Springfly	50-75%	High
Alloperla voinae	Lawrence Sallfly	75-100%	High
Alloperla aracoma	Aracoma Sallfly	75-100%	High
Alloperla biserrata	Dusky Sallfly	100% (NEAFWA Endemic)	High
Sweltsa palearata	Shenandoah Sallfly	100% (NEAFWA Endemic)	High
Utaperla gaspesiana	Gaspe Sallfly	75-100%	High
Sweltsa pocahontas	Pocahontas Sallfly	100% (NEAFWA Endemic)	High
Remenus kirchneri	Blue Ridge Springfly	100% (NEAFWA Endemic)	High
Allocapnia illinoensis	Illinois Snowfly	50-75%	Moderate
Megaleuctra flinti	Shenandoah Needlefly	100% (NEAFWA Endemic)	Moderate
Hansonoperla appalachia	Appalachian Stonefly	75-100%	Moderate
Isoperla gibbsae	Quebec Stripetail	75-100%	Moderate

PROPOSED RSGCN: 3 STONEFLIES

Three stoneflies not currently listed as SGCN in the Northeast SWAPs are included in the 2023 Proposed RSGCN list (Table 1.3.74). Two of these species are single-state endemics, with *Alloperla stipitata* found only in Virginia and *Leuctra laura* found only in New Hampshire. *Isoperla stewarti* was described in 2015 from North Carolina and was located in Virginia too late for inclusion in their 2015 SGCN list. Described before 2015, *Alloperla stipitate,* concern for the species did not increase until later surveys determined that the species occurs in only a handful of locations in the James River drainage. *Leuctra laura,* described earlier, but New Hampshire did not include stoneflies in its 2015 SGCN list.

Table 1.3.74 Proposed RSGCN Stoneflies 2023.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Leuctra laura	Hampshire Needlefly	100% (NEAFWA Endemic)	Very High
Alloperla stipitata	Blue Ridge Sallfly	100% (NEAFWA Endemic)	High
Isoperla stewarti	Stewart Stripetail	50-75%	Moderate

OVERVIEW

Nine of 14 Northeast states list Stoneflies as SGCN. RSGCN Stoneflies inhabit four habitat groups and six habitat types across the Northeast; all are aquatic (see *Chapter 2*). Ninety-seven percent of Stoneflies use Rivers and Streams, and 94% use Riparian Floodplains. The four other habitat types identified below are used by less than 15% of these Stoneflies (Figure 1.3.34).

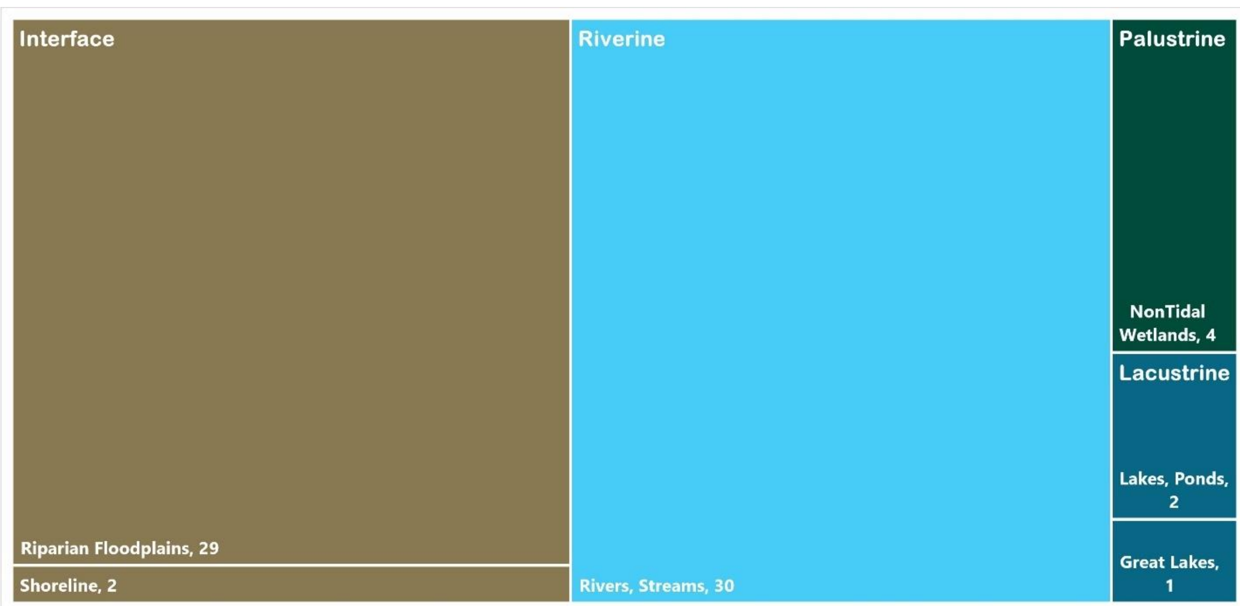


Figure 1.3.34 Number of RSGCN and Proposed RSGCN Stonefly associated with each habitat in the Northeast. Species may be associated with multiple habitat types. Habitat group names are at the top of each color block and grouped by color; habitat type names appear at the bottom of each proportionally sized square and are colored by habitat group (see *Chapter 2* for more information on habitats).

Climate Change and Pollution threaten all RSGCN and Proposed RSGCN Stoneflies. Top Climate Change threats include gradual temperature changes, increase in temperature fluctuations, gradual changes in precipitation regime, and increased fluctuations in the precipitation regime (Table 1.3.75). Top Pollution threats include domestic wastewater, runoff, nutrient loads, and herbicides and pesticides (Table 1.3.75). The Stonefly RCN 3.0 project may highlight these threats and their impact on Stoneflies.

Table 1.3.75 Level 1 threats with the number and percent of RSCGN and Proposed RSGCN Stoneflies threatened by each. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Climate Change (Threat 11.0)	31	100%
Pollution (Threat 9.0)	31	100%
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	2	6%
Natural System Modifications (Threat 7.0)	2	6%
Transportation & Service Corridors (Threat 4.0)	2	6%

WATCHLIST

Two Stoneflies are listed as Watchlist species, both as Watchlist [Assessment Priority].

WATCHLIST [ASSESSMENT PRIORITY]: 2 STONEFLIES

The 2017 RSGCN list included two species as data deficient, now listed as Watchlist [Assessment Priority] in the 2023 list (Table 1.3.76). These two species are known from only a handful of locations; more surveys will be necessary to establish the full distribution, habitat needs, and current threats to these species. In addition, the Midwest listed the Splendid Stonefly (*Hansonoperla hokolesqua*) as a Proposed Watchlist [Assessment Priority].

Table 1.3.76 Watchlist [Assessment Priority] Stoneflies 2023.

Scientific Name	Common Name	Regional Responsibility
Leuctra monticola	Montane Needlefly	50-75%
Hansonoperla hokolesqua	Splendid Stonefly	50-75%

REGIONAL EFFORTS IN NORTHEAST STONEFLY CONSERVATION

Stoneflies are one of the most environmentally sensitive taxa after freshwater mussels and crayfish (Hogan and Grubbs 2022). This sensitivity makes them a potential tool for monitoring changes due to pollution, climate change, and habitat degradation. Despite their possible status as a bioindicator, the stoneflies have not been well researched or monitored in the Northeast region. Only nine states included stoneflies in their 2015 SGCN lists: Delaware, Maryland, Maine, New York, Pennsylvania, Rhode Island, Virginia, Vermont, and West Virginia. Lack of expertise may be preventing the other states from assessing this taxon.

To address regional data and expertise deficiencies, the Northeast Diversity Technical Team is planning an upcoming RCN project to assess northeastern stoneflies. This formal assessment will inform the management and protection of stonefly species. Project objectives include developing standardized survey protocols, compiling data from published literature and museum collections, and implementing field surveys. These data will describe species' habitat needs and threats, and specimens will be barcoded to assess regional genetic diversity. Ultimately, this project will determine the conservation status of all northeastern stonefly species. This project is expected to begin in 2023; final reports should be available in 2027.

1.3.18 TERRESTRIAL SNAILS

At least 268 terrestrial snails (Class Gastropoda) are known to occur in the 14 NEAFWA states. More than half of these species, 182, were listed as SGCN in at least one of the fourteen 2015 Northeast SWAPs. Of these 182 Northeast SGCN, 21 snails (Orders Stylommatophora and Neritopsina) met the criteria for RSGCN. Taxonomic Team experts listed 28 in one of the Watchlist categories: 22 Watchlist [Assessment Priority], two non-SGCN species met the criteria for Proposed Watchlist [Assessment Priority], and four for Watchlist [Deferrals]. Three species that were RSGCN on the 2018 Northeast list were removed in this 2023 revision. *Anguispira clarkii* was originally included as a data-deficient species but has since been synonymized with *Anguispira alternata*. The Round Supercoil (*Paravitrea reesei*) and Carter Threetooth (*Triodopsis anteridon*) were considered Moderate concern in 2018 based primarily on their apparent scarcity. However, the Snail Taxonomic Team indicated that the rarity of these species is due to being naturally uncommon rather than a response to any threats.

Regional Priority Concern Highlights:

- Many terrestrial snails require specific microclimates, making them vulnerable to climate change, changing water patterns & hydrology.
- Deforestation & habitat fragmentation may eliminate important microhabitats or isolate populations.
- Exotic earthworms disrupt forest floor nutrient cycles and remove leaf litter, eliminating shelter and food resources.

Species Information, Research & Monitoring Needs:

- The lack of regional expertise and survey work has left many species data deficient.
- Taxonomic and genetic studies are needed to clarify misidentification issues from occurrence records, especially for cryptic species such as members of the family Succineidae.
- Data needs include abundance and distribution of terrestrial snails, habitat conditions, availability, management data, seasonal and behavior, and threat information.

RSGCN: 21 TERRESTRIAL SNAILS

Of the 21 terrestrial snails included on the 2023 Northeast RSGCN list, 15 are regional endemics occurring only in the Northeastern states (Table 1.3.77). Three of these regional endemics are protected under the US Endangered Species Act. Chittenango Ambersnail (*Novisuccinea chittenangoensis*) and Cheat Threetooth (*Triodopsis platysayoides*) are both threatened, while Virginia Coil (*Polygyriscus virginianus*) is endangered. Several of the regional endemics, including the Greenbrier Tigersnail (*Anguispira stihleri*), Shaggy Coil (*Helicodiscus diadema*), Rubble Coil (*Helicodiscus lirellus*), Greenbrier Coil (*Helicodiscus villosus*), Chittenango Ambersnail, Virginia Coil, Brush Creek Threetooth (*Triodopsis juxtidens robinae*), and Cheat Threetooth are narrow-range endemics, restricted to incredibly small areas such as single valleys, stream reaches, and bluffs. The limited distribution of many terrestrial snails elevates the Concern Level for these species, with 12 of the RSGCN considered Very High concern, six species considered High concern and only three species listed as Moderate concern.

Table 1.3.77 RSGCN Terrestrial Snails 2023.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Novisuccinea chittenangoensis	Chittenango Ambersnail	100% (NEAFWA Endemic)	Very High
Webbhelix multilineata	Striped Whitelip	<25%	Very High
Paravitrea ceres	Sidelong Supercoil	100% (NEAFWA Endemic)	Very High
Paravitrea hera	Spirit Supercoil	100% (NEAFWA Endemic)	Very High
Vertigo clappi	Cupped Vertigo Snail	50-75%	Very High
Mesomphix luisant	Glossy Button	100% (NEAFWA Endemic)	Very High
Helicodiscus villosus	Greenbrier Coil	100% (NEAFWA Endemic)	Very High
Helicodiscus diadema	Shaggy Coil	100% (NEAFWA Endemic)	Very High
Helicodiscus lirellus	Rubble Coil	100% (NEAFWA Endemic)	Very High
Polygyriscus virginianus	Virginia Coil	100% (NEAFWA Endemic)	Very High
Anguispira stihleri	Greenbrier Tigersnail	100% (NEAFWA Endemic)	Very High
Triodopsis juxtidens robinae	Brush Creek Threetooth	100% (NEAFWA Endemic)	Very High
Glyphyalinia raderi	Maryland Glyph	75-100%	High
Paravitrea mira	Funnel Supercoil	75-100%	High
Paravitrea septadens	Brown Supercoil	50-75%	High
Helicodiscus triodus	Talus Coil	100% (NEAFWA Endemic)	High
Stenotrema simile	Bear Creek Slitmouth	100% (NEAFWA Endemic)	High
Triodopsis platysayoides	Cheat Threetooth	100% (NEAFWA Endemic)	High
Vertigo parvula	Smallmouth Vertigo	50-75%	Moderate
Glyphyalinia picea	Rust Glyph	100% (NEAFWA Endemic)	Moderate
Paravitrea pontis	Natural Bridge Supercoil	100% (NEAFWA Endemic)	Moderate

No terrestrial snails not currently listed as SGCN in at least one Northeastern SWAP were considered by the taxa team to be of sufficient concern to elevate to the Proposed RSGCN.

OVERVIEW

Eleven of 13 states list snails as RSGCN. The 21 RSGCN Terrestrial Snails inhabit five habitat groups and six habitat types (see *Chapter 2*). The three habitat types they use most are staggered across three habitat groups, with 62% occurring in Forest Woodland, 48% occurring in open Cliff and Talus habitat, and 24% in Riparian Floodplains (Figure 1.3.35). Taxonomic Team experts have indicated that this taxon's data needs are habitat condition, availability information, and additional occupancy studies.

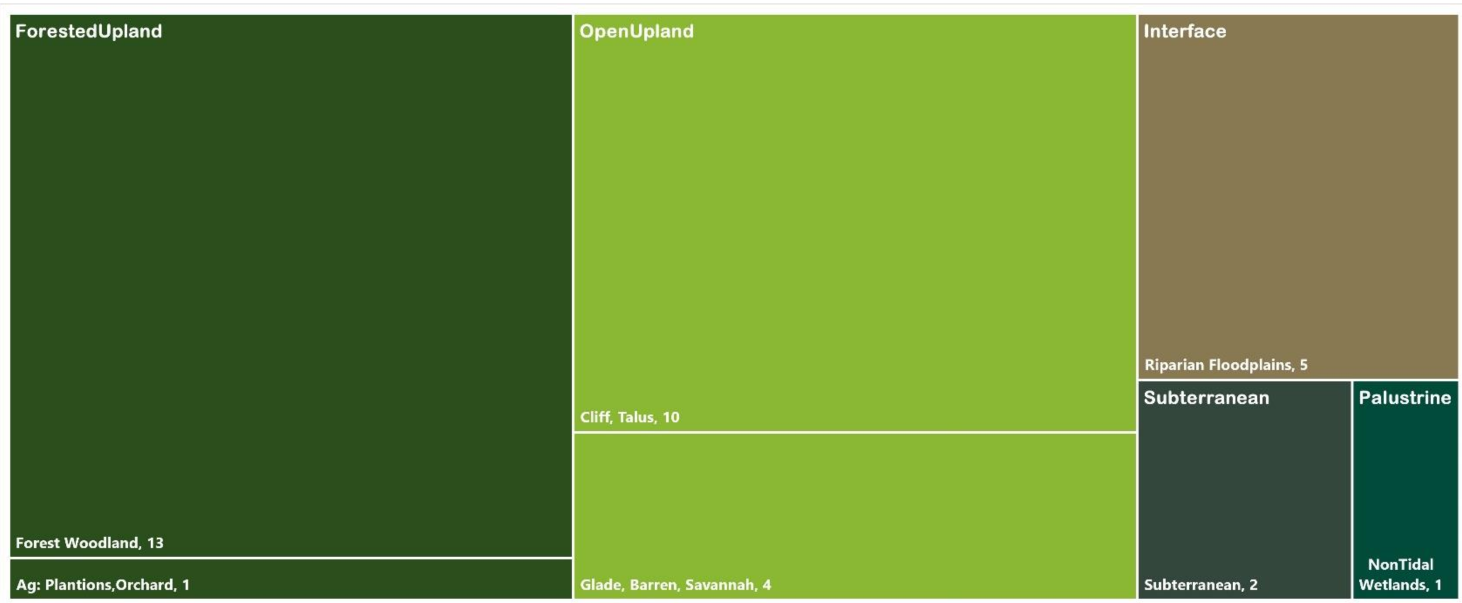


Figure 1.3.35 Number of RSGCN and Proposed RSGCN Terrestrial Snail associated with each habitat in the Northeast. Habitat group names are at the top of each color block and grouped by color, habitat type names appear at the bottom of each proportionally sized square and colored by habitat group (see *Chapter 2* for more information on habitats).

RSGCN Terrestrial Snails threat information is limited because many species need more research, as the habitat data needs above. However, while not an actual threat, the lack of natural history information in combination with known steep declines for these RSGCN snails could be seen as the top threat as indicated by 86% of these species' Level 1 threat category is Other. In addition, Climate Change threatens fourteen percent of these snails with threats of increase in temperature fluctuations, overabundant rains, droughts, gradual change in precipitation regime, increased fluctuations in the precipitation regime, and storms and severe weather (Table 1.3.78). Finally, the Geological Event that threatens one of these RSGCN snails is landslides.

Table 1.3.78 Level 1 threats with the number and percent of RSCGN Terrestrial Snails threatened by each. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Other (Threat 12.0)	18	86%
Climate Change (Threat 11.0)	3	14%
Geological Events (Threat 10.0)	1	5%
Human Intrusions & Disturbance (Threat 6.0)	1	5%
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	1	5%
Natural System Modifications (Threat 7.0)	1	5%
Pollution (Threat 9.0)	1	5%
Residential & Commercial Development (Threat 1.0)	1	5%

WATCHLIST

In total, Taxonomic Teams identified 28 Terrestrial Snails as Watchlist. No snails were identified as interdependent species by the taxa team members. However, snails are crucial in cycling certain nutrients, especially calcium, in forested ecosystems (Hotepp 2002). Birds, in particular, may depend on snails to obtain sufficient levels of calcium for egg production (Graveland 1996; Mänd et al. 2000).

WATCHLIST [ASSESSMENT PRIORITY]: 22 TERRESTRIAL SNAILS

Data deficiency across this taxon resulted in a comparatively large number of Terrestrial Snails in this list. There are 22 Watchlist [Assessment Priority] species in the 2023 list (Table 1.3.79). These species can be broken into two groups; those included due to taxonomic uncertainty and those requiring additional survey work. Ten species require genetic work to ascertain their validity or taxonomic review of specimens to ensure proper classification. Twelve species require further research and survey work to determine habitat requirements, distribution, and population status. The remaining two species, West Virginia Glyph (*Glphalinia sp. 1*) and Balsam Globe (*Mesodon andrewsae*), require taxonomic and survey work.

Table 1.3.79 Watchlist [Assessment Priority] Terrestrial Snails 2023.

Scientific Name	Common Name	Regional Responsibility
Glyphyalinia sp. 1	West Virginia Glyph	100% (NEAFWA Endemic)
Triodopsis sp. 1	Piney Creek Threetooth	100% (NEAFWA Endemic)
Triodopsis rugosa	Buttressed Threetooth	100% (NEAFWA Endemic)
Triodopsis picea	Spruce Knob Threetooth	100% (NEAFWA Endemic)
Oxyloma subeffusum	Chesapeake Ambersnail	100% (NEAFWA Endemic)
Mesomphix sp. 1	Pygmy Button	100% (NEAFWA Endemic)

Gastrodonta fonticula	Appalachia Bellytooth	75-100%
Appalachina sayana	Spike-lip Crater Snail	75-100%
Patera panselenus	Virginia Bladetooth	50-75%
Pallifera secreta	Severed Mantleslug	50-75%
Vitrina angelicae	Eastern Glass-snail	50-75%
Striatura exigua	Ribbed Striate Snail	50-75%
Patera laevior	Smooth Bladetooth	25-50%
Oxyloma retusum	Blunt Ambersnail	25-50%
Megapallifera wetherbyi	Blotchy Mantleslug	25-50%
Paravitrea blarina	Shrew Supercoil	25-50%
Vertigo ventricosa	Five-tooth Vertigo Snail	25-50%
Pallifera ohioensis	Redfoot Mantleslug	25-50%
Pallifera hemphilli	Black Mantleslug	<25%
Ventridens coelaxis	Bidentate Dome	<25%
Mesodon andrewsae	Balsam Globe	<25%
Helicodiscus multidens	Twilight Coil	<25%

PROPOSED WATCHLIST [ASSESSMENT PRIORITY] SPECIES (2023)

Two species, Mudbank Ambersnail (*Catinella vagans*) and Penn Ambersnail (*Succinea pennsylvanica*), were identified by the taxa team as meeting the criteria for Watchlist [Assessment Priority] that are not already listed as SGCN in the Northeast (Table 1.3.80). These two species belong to the family Succineidae, whose members are extremely difficult to identify. Much of this family requires serious genetic and morphological work to determine the validity of various species, and further review of historical records will also be necessary as specimens are often only identified at the family level, not the genus or species.

Table 1.3.80 Proposed Watchlist [Assessment Priority] Terrestrial Snails 2023.

Scientific Name	Common Name	Regional Responsibility
Succinea pennsylvanica	Penn Ambersnail	100% (NEAFWA Endemic)
Catinella vagans	Mudbank Ambersnail	100% (NEAFWA Endemic)

WATCHLIST [DEFER TO ADJACENT REGION]: 4 TERRESTRIAL SNAILS

The taxa team identified four terrestrial snails with elevated conservation concerns but whose distribution falls primarily in other regions (Table 1.3.81). The Banded Tigersnail (*Angispira kochi*) is mainly a Midwestern species but has undergone severe declines in the Northeast, resulting in disjunct populations. The Cherrystone Drop (*Hendersonia occulta*) appears to have a split distribution, with one population in the Midwest and one in the southern Appalachians. Additional surveys across the Southeast and Midwest may locate populations that link the two together. The remaining species, Malleated Vertigo (*Vertigo malleata*) and Swamp Vertigo (*V. teskeyae*), are primarily southeastern species. The former occurs in unique, acidic habitats, while the latter is taxonomically uncertain and may be impacted by climate change-related threats.

Table 1.3.81 Watchlist [Defer to Adjacent Region] Terrestrial Snails 2023.

Scientific Name	Common Name	Deferred Region(s)	Listed in Deferred Region(s)
Anguispira kochi	Banded Tigersnail	MAFWA	No
Vertigo malleata	Malleated Vertigo	SEAFWA	No
Vertigo teskeyae	Swamp Vertigo	SEAFWA	No
Hendersonia occulta	Cherrystone Drop	MAFWA/ SEAFWA	No

REGIONAL EFFORTS IN NORTHEAST TERRESTRIAL SNAIL CONSERVATION

At the time of the 2013 Northeast Conservation Synthesis, very little was known about the terrestrial snail fauna of the Northeast. This prompted a Regional Conservation Needs Program project to assess the status of Northeastern terrestrial snails. State agencies worked with the Carnegie Museum of Natural History to conduct a comprehensive survey of snails, with particular effort applied to under-surveyed species and habitats. The Carnegie Museum took the results from these inventories to update their website, "**Land Snails and Slugs of the Mid-Atlantic and Northeastern United States**"[23]. This website includes basic information on snail ecology and species profiles for over 300 Northeastern species, including range maps and museum records for most species, including 50 non-native species. When the website was completed in 2017, it provided a comprehensive picture of the current state of knowledge for all terrestrial snails in the Northeast.

1.3.19 TIGER BEETLES

Approximately 40 tiger beetles occur in the Northeast region. Of those species, 35 are SGCN in at least one of the 14 2015 SWAPs, the highest proportion amongst all the taxon reviewed. Only eight species ultimately met the criteria for RSGCN, with an additional four qualifying Watchlist [Assessment Priority] and a single Watchlist [Deferral]. None of the RSGCN in the 2018 list have been removed from the 2023 list.


Eastern Beach Tiger Beetle, © Evan Dankowicz

Regional Priority Concern Highlights:

- Climate change is a major concern for several species, including sea level rise and inundation of salt marsh for coastal species, and inundation and scouring caused by large storm events for riparian species.
- Dam release schedules and invasive plant species may heavily impact some riparian species.
- Disturbance in the form of development and human activities (e.g., beach and ORV use) are largely detrimental.
- Management of disturbance-based habitats is necessary for some species, especially in fire-adapted habitats.

Species Information, Research & Monitoring Needs:

- One of the RCN 3.0 projects will be a Tiger Beetle Status Assessment, hopefully addressing many data deficiencies.
- Conservation barriers due to climate change are largely unknown.

RSGCN: 8 TIGER BEETLES

The 2023 update of the Northeast RSGCN list includes eight tiger beetle species, three at the nominal level and five at the subspecies level (Table 1.3.82). One nominal species, Puritan Tiger Beetle (*Ellipsoptera puritana*), and one subspecies, Eastern Beach Tiger Beetle (*Habroscelimorpha dorsalis dorsalis*), are federally threatened species. The two federally listed species are Very High concern. Of the remaining six, all but one species, the Appalachian Tiger Beetle (*Cicindela ancocisconensis*), are High Concern. Half of the Northeast RSGCN tiger beetles are regional endemics, including the New Jersey Pine Barrens Tiger Beetle (*Cicindela patruela consentanea*), Hentz's Tiger Beetle (*Cicindela rufiventris hentzii*), Puritan Tiger Beetle, and Eastern Beach Tiger Beetle. The first two subspecies may be narrow-range endemics, with the New Jersey Pine Barrens Tiger

Beetle found only in the Jersey barrens and Hentz's Tiger Beetle from the rocky hills surrounding Boston. The Puritan Tiger Beetle is a bit more widespread but is restricted to sites along the Connecticut River and the Chesapeake Bay.

Table 1.3.82 RSGCN Tiger Beetles 2023.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Ellipsoptera puritana	Puritan Tiger Beetle	100% (NEAFWA Endemic)	Very High
Habroscelimorpha dorsalis dorsalis	Eastern Beach Tiger Beetle	100% (NEAFWA Endemic)	Very High
Cicindela marginipennis	Cobblestone Tiger Beetle	50-75%	High
Cicindela patruela consentanea	New Jersey Pine Barrens Tiger Beetle	100% (NEAFWA Endemic)	High
Cicindela patruela patruela	Northern Barrens Tiger Beetle	50-75%	High
Cicindela rufiventris hentzii	Hentz's Tiger Beetle	100% (NEAFWA Endemic)	High
Habroscelimorpha dorsalis media	White Tiger Beetle	25-50%	High
Cicindela ancocisconensis	Appalachian Tiger Beetle	75-100%	Moderate

Considering how comprehensively the tiger beetles have been in the SWAPs, it is unsurprising that the taxa team did not identify any tiger beetles with high conservation concerns but were not already SGCN.

OVERVIEW

All but one of the 14 Northeast states list tiger beetles as SGCN. Despite their relatively low total number, the RSGCN Tiger Beetles use a wide range of habitat types (10) in three habitat groups (see *Chapter 2*). The most used habitats are Beach and Dune and Non-tidal Wetlands, each used by 38% of the species (Figure 1.3.36). After that, several different Open Upland and Interface habitats are used by one to three species each.

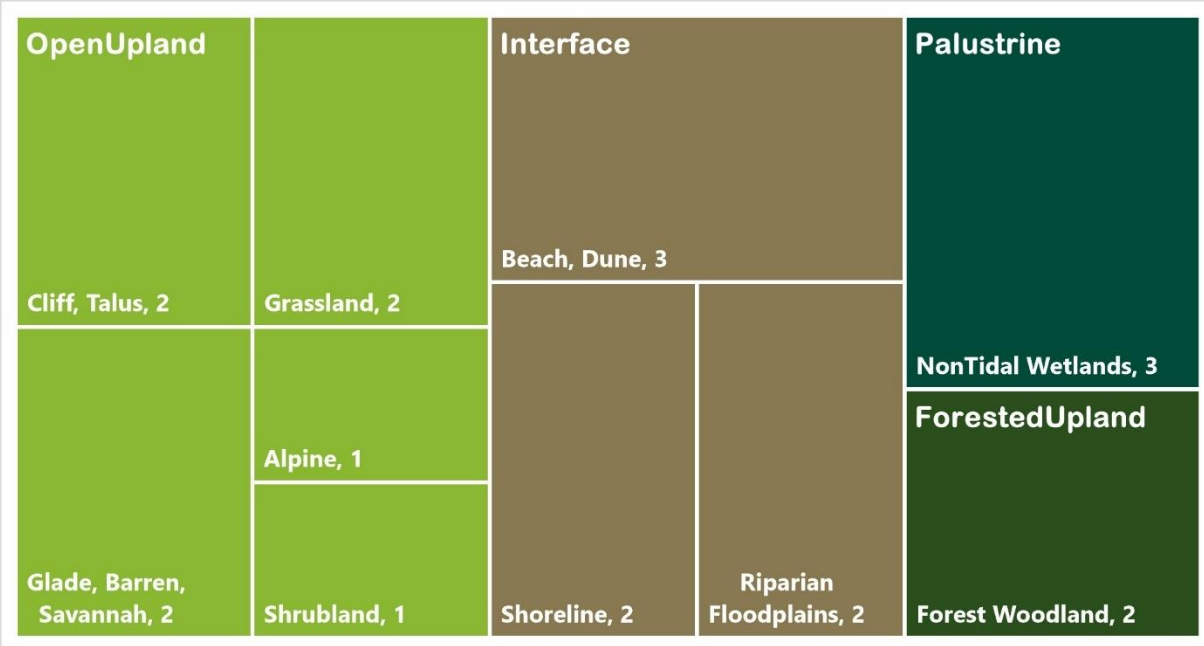


Figure 1.3.36 Number of RSGCN Tiger Beetle associated with each habitat in the Northeast. Species may be associated with multiple habitat types. Habitat group names are at the top of each color block and grouped by color; habitat type names appear at the bottom of each proportionally sized square and are colored by habitat group (see *Chapter 2* for more information on habitats).

Human Intrusions and Disturbance and Residential and Commercial Development are top Level 1 threats to Tiger Beetles, threatening 100% of RSGCN species (Table 1.3.83). Natural Systems Modifications and Climate Change are not far behind, threatening 88% and 75% of RSGCN Tiger Beetles, respectively (Table 1.3.83). The top threats all fall under recreational activities, motor vehicles, recreational uses of beaches, hiking, and boating (Table 1.3.83). Low-density housing areas, commercial and industrial areas, and dense housing and urban areas are the top threats within residential and commercial development (Table 1.3.83). Not surprisingly, the Natural Systems Modifications that threaten these Tiger Beetles most are shoreline alteration, vegetation succession, and water level management using dams (Table 1.3.83).

Certain guilds of tiger beetles are known to be at elevated risk for extirpation or even extinction. Documented population declines in many species of tiger beetles associated with ocean beaches, including two Northeast RSGCN, the federally listed *Cicindela dorsalis dorsalis* and its southern counterpart *Cicindela dorsalis media*. Riverine tiger beetles, such as RSGCN *Cicindela ancocisconensis* and *Cicindela marginipennis,* are also highly vulnerable to extirpation due to human activities. The federally listed (and RSGCN) tiger beetle *Cicindela puritana* combines both vulnerability types across its highly disjunct distribution, with populations found on riverine sandbars in New England and at cliffside beaches along the shores of the Chesapeake Bay.

Table 1.3.83 Level 1 threats with the number and percent of RSCGN Tiger Beetles threatened by each. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Human Intrusions & Disturbance (Threat 6.0)	8	100%
Residential & Commercial Development (Threat 1.0)	8	100%
Natural System Modifications (Threat 7.0)	7	88%
Climate Change (Threat 11.0)	6	75%
Biological Resource Use (Threat 5.0)	5	63%
Invasive & Problematic Species, Pathogens & Genes (Threat 8.0)	5	63%
Energy Production & Mining (Threat 3.0)	3	38%
Pollution (Threat 9.0)	3	38%
Other (Threat 12.0)	2	25%
Agriculture & Aquaculture (Threat 2.0)	1	13%
Transportation & Service Corridors (Threat 4.0)	1	13%

WATCHLIST

In total, five Tiger Beetles are listed in a Watchlist category. In addition, Taxonomic Teams identified four as Watchlist [Assessment Priority] and one species for deferral to an adjacent region.

WATCHLIST [ASSESSMENT PRIORITY]: 4 TIGER BEETLES

The 2023 Watchlist [Assessment Priority] includes four tiger beetles with regional responsibilities below 50% (Table 1.3.84). For one species, the Eastern Pinebarrens Tiger Beetle (*Cicindela abdominalis*), the taxa team elected to include this species despite being near its northern range limits as the status of the species outside of New Jersey is tenuous, and even within the New Jersey pine barrens, its distribution and status is uncertain. The Taxonomic Team included the Hairy-necked Tiger Beetle (*Cicindela hirticollis*); despite relatively stable populations as there were some questions about the presence and validity of two subspecies, *hirticollis* and *rhodensis* and as a coastal species, it is vulnerable to future climate change. Conservation concern is elevated for the last two species, Ghost and Margined Tiger Beetle (*Ellipsoptera lepida* and *E. marginata*, respectively), due to small and declining populations in the Northeast due to habitat loss.

Table 1.3.84 Watchlist [Assessment Priority] Tiger Beetles 2023.

Scientific Name	Common Name	Regional Responsibility
Ellipsoptera marginata	Margined Tiger Beetle	25-50%
Cicindela abdominalis	Eastern Pinebarrens Tiger Beetle	25-50%
Ellipsoptera lepida	Ghost Tiger Beetle	<25%

Cicindela hirticollis	Hairy-necked Tiger Beetle	<25%

WATCHLIST [DEFER TO ADJACENT REGION]: 1 TIGER BEETLE

A single species, Whitish Tiger Beetle (*Ellipsoptera gratiosa*) was deferred to the Southeast Region. Unfortunately, there is only one known population of this species in the Northeast located on the Virginia-North Carolina border, greatly restricting the ability to enact meaningful conservation actions in this region.

REGIONAL EFFORTS IN NORTHEAST TIGER BEETLE CONSERVATION

Tiger beetles attract researchers, citizen scientists, and photographers as they are often brightly colored, patterned, highly active, predatory, and easily observed. Yet, despite being highly charismatic, very few regional efforts have focused on this group. The Northeast Fish and Wildlife Diversity Technical Team intends to advance tiger beetle conservation with an upcoming RCN project. This project intends to comprehensively assess all tiger beetles in the Northeast using a framework like Odonate Conservation Assessment described above. This assessment will determine the status and distribution of all northeastern tiger beetles, identify knowledge gaps, develop standardized survey protocols, and implement surveys to comprehensively assess the current status, distribution, habitat needs, and potential threats for selected target species. This project is expected to begin in 2023; final reports should be available in 2027.

1.3.20 TRICHOPTERA: CADDISFLIES

At least 565 caddisflies (Trichoptera) are known to occur in the Northeast region. Of those, 40 caddisflies are listed as SGCN in at least one of the 14 northeast 2015 SWAPs. The EPT Taxonomic Team identified four caddisflies that met the criteria as RSGCN and 11 non-SGCN caddisflies as Proposed RSGCN. Ten are listed in one of the Watchlist categories: seven Watchlist [Assessment Priority], two Proposed Watchlist [Assessment Priority], and a single Watchlist [Deferrals]. This is the first-time caddisflies have been reviewed for the Northeast RSGCN list; all of these species are additions to the 2023 list.

Regional Priority Concern Highlights:
•Caddisflies are susceptible to several aquatic threats, including pollution and climate change-induced precipitation patterns and hydrology changes.
•Lack of regional expertise & data deficiencies precludes a full understanding of threats.

Species Information, Research & Monitoring Needs:
•Many species are under-surveyed and require inventory assessments.
•Location data is limited for some species, which may lead to erroneous claims of a rarity as an artifact of collection bias.
•Winter activity and life history data are lacking.

RSGCN: 4 CADDISFLIES

All four Caddisflies on the 2023 RSGCN list are regional endemics (Table 1.3.85). The two members of the genus *Beraea* are both of Very High concern. This genus is poorly represented, known from very few locations, and is likely highly sensitive to habitat loss or degradation as they appear to be spring specialists. They are also one of the only partially terrestrial caddisflies; nymphs live in organic matter and mud on the banks rather than within the water column.

Table 1.3.85 RSGCN Caddisflies 2023.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Beraea fontana	American Spring-loving Caddisfly	100% (NEAFWA Endemic)	Very High
Beraea nigritta	a caddisfly	100% (NEAFWA Endemic)	Very High
Polycentropus chenoides	a polycentropodid caddisfly	100% (NEAFWA Endemic)	High
Ceraclea uvalo	Spatulate Long-horned Caddisfly	100% (NEAFWA Endemic)	Moderate

PROPOSED RSGCN: 11 CADDISFLIES

Eleven caddisflies are listed as Proposed RSGCN in the 2023 list (Table 1.3.86). These species were not eligible in the 2017 list as they are not currently listed as SGCN in any

Northeast SWAP. Three of the eleven Proposed RSGCN are endemic to the region – *Adicrophleps hitchcoki*, *Banksiola calva*, and *Neophylax ottawa*.

Table 1.3.86 11 Proposed RSGCN Caddisflies 2023.

Scientific Name	Common Name	Regional Responsibility	Concern Level
Brachycentrus incanus	Hoary Humpless Caddisfly	50-75%	Very High
Manophylax altus	Mount Mitchell Caddisfly	50-75%	Very High
Banksiola calva	a giant casemaker caddisfly	100% (NEAFWA Endemic)	High
Polycentropus pixi	Pitch Trumpet-net Caddisfly	75-100%	High
Homoplectra monticola	a hydropsychid caddisfly	75-100%	High
Ceraclea ruthae	Ruth's Long-horned Caddisfly	75-100%	High
Lepidostoma ontario	Ontario Bizarre Caddisfly	50-75%	Moderate
Theliopsyche grisea	a caddisfly	50-75%	Moderate
Adicrophleps hitchcocki	a brachycentrid caddisfly	100% (NEAFWA Endemic)	Moderate
Heteroplectron americanum	American Comb-lipped Caddisfly	50-75%	Moderate
Neophylax ottawa	Ottawa Little Caddisfly	100% (NEAFWA Endemic)	Moderate

OVERVIEW

RSGCN and Proposed RSGCN Caddisflies are found in five habitat groups and eight habitat types (see *Chapter 2*). Of these, 73% inhabit Riparian Floodplains, and 67% inhabit Rivers and Streams (Figure 1.3.37). Only one caddisfly, the Mount Mitchell Caddisfly, is found in a terrestrial habitat type, High Elevation Forests.

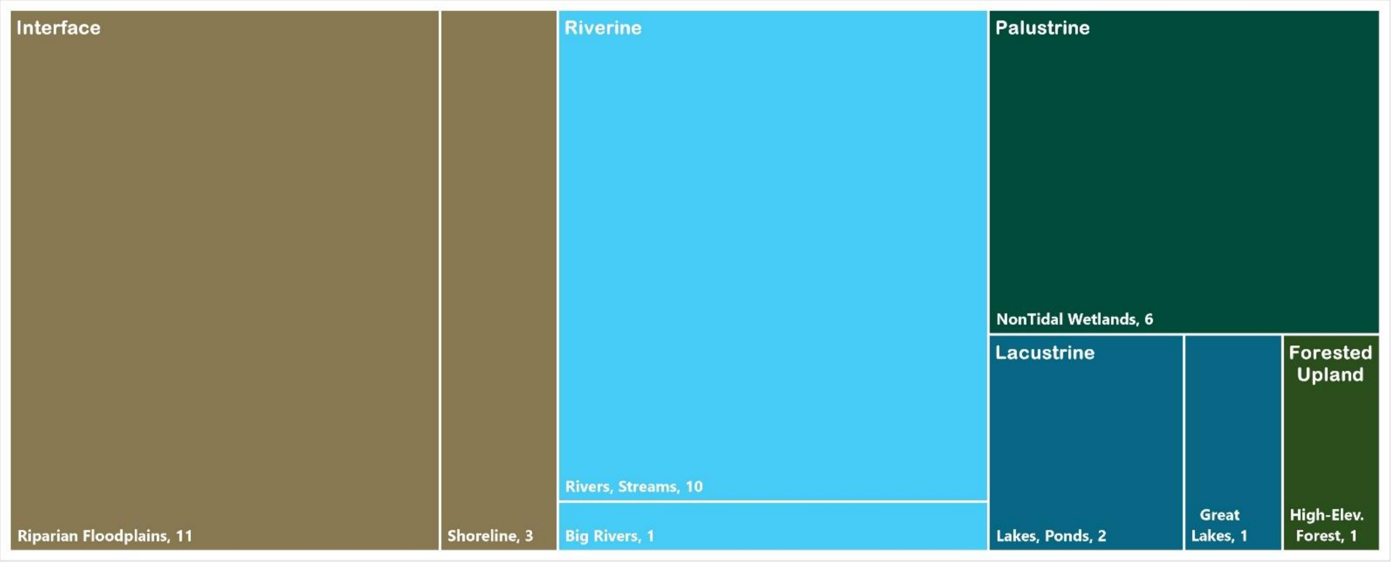


Figure 1.3.37 Number of RSGCN and Proposed RSGCN Caddisfly associated with each habitat in the Northeast. Species may be associated with multiple habitat types. Habitat group names are at the top of each color block and grouped by color, habitat type names appear at the bottom of each proportionally sized square and colored by habitat group (see *Chapter 2* for more information on habitats).

Two Level 1 Threats threaten nearly all these Caddisfly species. First, Climate Change threatens 100% of Northeast RSGCN and Proposed RSGCN Caddisflies (Table 1.3.87). The top Climate Change threats are changes in temperature and precipitation. Temperature-related threats are gradual temperature changes and an increase in temperature fluctuations. Precipitation-related threats due to Climate Change are gradual changes in the precipitation regime and increased fluctuations in the precipitation regime. Pollution threatens 93% of Caddisflies. Domestic wastewater, runoff, nutrient loads, and herbicides and pesticides all threaten 93% of species (Table 1.3.87). All pollution threats to Caddisflies are pollution to aquatic ecosystems, which makes sense because Caddisflies are mostly aquatic insects.

Table 1.3.87 Level 1 threats with the number and percent of RSCGN and Proposed RSGCN Caddisflies threatened by each. See *Supplemental Information 3* for threat categories and explanations.

Level 1 Threats	Number Taxon	Percent Taxon
Climate Change (Threat 11.0)	15	100%
Pollution (Threat 9.0)	14	93%

WATCHLIST

Ten Caddisflies were listed as Watchlist species; Taxonomic Teams identified seven as Watchlist [Assessment Priority], two species as Proposed Watchlist [Assessment Priority], and one species identified for deferral to adjacent regions.

WATCHLIST [ASSESSMENT PRIORITY]: 7 CADDISFLIES

Due to data deficiencies, the taxa team included most of the seven caddisflies on the Watchlist [Assessment Priority] (Table 1.3.88). The genus *Hydroptila* are known from only a few element occurrences; this apparent rarity may be an artifact of collection bias, as members of this genus are exceedingly small. For the remaining species, very little information is available, making it difficult to assess the current conservation concerns for the species. One species, *Cheumatopsyche vannotei*, is known only from historic records and may be extinct. Most species included are potentially regional endemics; further survey work would help determine their full distribution and assess whether they would rise to the level of regional concern.

Table 1.3.88 Watchlist [Assessment Priority] Caddisflies 2023.

Scientific Name	Common Name	Regional Responsibility
Hydatophylax victor	Conquering Northern Caddisfly	100% (NEAFWA Endemic)
Cheumatopsyche vannotei	Vannote's Cheumatopsyche Caddisfly	100% (NEAFWA Endemic)
Hydroptila blicklei	a purse casemaker caddisfly	100% (NEAFWA Endemic)
Hydroptila parachelops	a purse casemaker caddisfly	100% (NEAFWA Endemic)
Hydroptila tomah	a purse casemaker caddisfly	100% (NEAFWA Endemic)
Cernotina pallida	Pale Trumpet-net Caddisfly	50-75%
Cheumatopsyche helma	Helma's Net-spinning Caddisfly	25-50%

PROPOSED WATCHLIST [ASSESSMENT PRIORITY]: 2 CADDISFLIES

The two species in the Proposed Watchlist [Assessment Priority] list are similar to the other Assessment species in that they are largely data deficient, making their assessment difficult (Table 1.3.89). In addition, one of the two species again belongs to the genus *Hydroptila,* which is frequently under-surveyed due to the small size of the species.

Table 1.3.89 Proposed Watchlist [Assessment Priority] Caddisflies 2023.

Scientific Name	Common Name	Regional Responsibility
Hydroptila eramosa	Prolonged Microcaddisfly	100% (NEAFWA Endemic)
Ceraclea punctata	Dotted Long-horned Caddisfly	25-50%

WATCHLIST [DEFER TO ADJACENT REGION]: 1 CADDISFLY

One species was deferred to the Midwest region. This species, *Ceraclea albosticta*, was known to occur historically in New York and Pennsylvania. However, most known occurrences fall outside the region, and none have been recent. The species is suspected to be extinct. The EPT Taxonomic Team elected to leave the assessment of this species to the Midwest states, as they represent more of the historical core of the range rather than the range edges.

REGIONAL EFFORTS IN NORTHEAST CADDISFLY CONSERVATION

Caddisflies are historically underrepresented and under-surveyed in the Northeast. Only six states included caddisflies as SGCN in their 2015 review, Delaware, Maryland, Maine, Pennsylvania, Virginia, and Vermont. This reflects the historical lack of taxon data and the region's present lack of expertise. The disproportionate number of species in Watchlist categories rather than RSGCN further confirms the overall data deficiency of this taxon. Regional surveys and assessments will be necessary to understand the current status of caddisflies in the Northeast.

Though no regional assessments of this taxonomic group are taking place, some state programs may improve our understanding of caddisflies. The Gulf of Maine Research Institute's Ecosystem Investigation Network[16] facilitates several citizen science projects intended to enhance understanding of how climate change impacts species, habitats, and communities. One of their projects targets vernal pools, an important habitat for some giant and northern casemaker caddisflies. This project aims to assess the distribution of caddisflies, fairy shrimp, and amphibian species in vernal pools in the Northeast and determine how these distributions may shift in response to climate change.

1.4 PARTNERSHIP OPPORTUNITIES

Partnership opportunities for the 2025 SWAPs are listed below. For more in-depth partner information and sources, see *Chapter 7*.

1.4.1 US FISH AND WILDLIFE SERVICE, NORTHEAST REGION AT-RISK SPECIES LIST

The USFWS has an important role and responsibility in conserving wildlife and the habitats they occupy. The Endangered Species Act (ESA) provides the framework for addressing the most critically imperiled species. In the Northeast, more than 100 fish, wildlife, and plant species are listed as Threatened or Endangered under the Act, with

~75 more scheduled for review. However, hundreds of other species are facing threats and are declining and at risk of becoming candidates as well. For many of these species, pre-listing conservation actions may be able to address these threats and reverse declines before they become too severe.

The Science Applications program, in coordination with other USFWS programs and state partners, generated a list of 76 Priority At-Risk Species (ARS) representing a diverse array of taxa and habitats from across the Northeast Region where coordinated conservation effort may preclude the need to list these species under the ESA. Eleven At-Risk teams formed in 2021 around either single-species or multi-species groups. These teams include individuals from multiple USFWS programs, providing diverse experiences and capabilities to each group. Descriptions of the target, scope, and proposed actions for each team are below:

CHESAPEAKE LOGPERCH

The Chesapeake Logperch (*Percina bimaculata*) is listed as threatened in Pennsylvania and Maryland. Historically, this species was found in the Chesapeake Bay watershed in the District of Columbia, Maryland, Pennsylvania, and Virginia. It was limited the lower sections of the Potomac and Susquehanna rivers and their tributaries, and a few direct tributaries to the Chesapeake Bay. It thought to have been extirpated from the Potomac River drainage due to pollution and sedimentation. Threats to the Chesapeake Logperch are many: nutrient loading/sediment loading; Polychlorinated Biphenyls (PCBs) and Chlordane; pollution; and habitat loss/modification of natural systems (i.e., dams fragmenting riverine habitat, development, conversion to agricultural use); impingement (Peach Bottom Nuclear Facility intake structures); stranding in shallow pools (mid-summer months); introduced aquatic species (hybridization, introduction of foreign parasites and pathogens, habitat shifts) and invasive aquatic species, such as the Northern Snakehead (Channa argus), the Flathead Catfish (*Pylodictis olivaris*), and Zebra Mussels (*Dreissena polymorpha*).

Conservation goals and actions include 1) protect, conserve, and enhance viable extant populations in Maryland and Pennsylvania, 2) reintroduce this species to historical range (including the Potomac drainage), and augment existing populations, 3) monitor the species, and 4) protect streams and habitat from agricultural and urban run-off, 5) genetic characterization. The Team is working with state and federal partners to implement a captive rearing operation (multiple facilities). In addition, our state partners are working hard to complete the last year of a 5-year Comp-SWG study on the Logperch including determining life history, behavior, and habitat characteristics; identifying suitable release sites; releasing wild and propagated Logperch stocks; developing a Conservation Action Plan for logperch in Maryland. Federal partners have initiated genetic analysis to advise genetic diversity implications for propagation efforts. The Team also works with academia on behavior, predator avoidance, and other studies.

NEW ENGLAND COTTONTAIL

The New England cottontail rabbit (*Sylvilagus transitionalis*) is the only rabbit native to the northeastern United States from the Hudson River Valley of New York eastward. The NEC is currently threatened by the loss of its habitat through development and forest succession. It may also be imperiled by encroachment into its range by the introduced eastern cottontail (Sylvilagus floridanus), which may compete with NEC and seems more able to use diverse and fragmented habitats and avoid predators. In 2012, state wild agencies from Connecticut, Maine, Massachusetts, New Hampshire, New York, and Rhode Island worked with U.S Fish and Wildlife Service and the Natural Resources Conservation Service to finalize a conservation strategy to conserve the New England cottontail throughout its current range.

ATLANTIC COAST BEACH AND SHOREBIRDS (AMERICAN OYSTERCATCHER, RUDDY TURNSTONE, WHIMBREL)

Shorebirds are among the most imperiled birds in North America, with population declines of 33% since 1980. Coastal areas of the Northeast Region host substantial populations of breeding, wintering, and migrating shorebirds, and some of the densest human populations in North America. Anthropogenic threats include habitat loss and degradation, human disturbance, predation, hunting, and sea level rise across their vast hemispheric ranges. The Beach and Shorebirds Team focuses on three species that represent a cross-section of shorebird life histories, seasonal habitat use, and management needs in the region. Each is listed as a USFWS Bird of Conservation Concern, and Species of Greatest Conservation Need in most coastal states in the region. To date, the team has focused on identifying our role in supporting existing conservation planning, such as the American Oystercatcher Hemispheric Conservation Plan, the Whimbrel Conservation Plan, and the Atlantic Flyway Shorebird Initiative. We have also prioritized increased engagement between USFWS staff from five programs and collaborative conservation entities such as the American Oystercatcher Working Group and groups of external partners with specific expertise in the three species (e.g., NGOs, state wildlife agencies, and universities). Lastly, the ARS team has initiated efforts to improve internal coordination across programs in our region. Although implementation is just getting underway, specific 2023 priorities include:

- Initiating actions to address human disturbance at priority regional refuges
- Planning and pursuing opportunities for habitat acquisition, restoration, & enhancement
- Increasing efficacy and stability of predation management at locations experiencing poor outcomes

- Initiating research to identify priority stopovers (Ruddy Turnstone & Whimbrel) and understand importance of marsh habitat for breeding American Oystercatchers
- Helping initiate the first conservation plan for Ruddy Turnstone, a poorly understood species
- Engaging with partners outside our region to support priority conservation activities in other areas

FOREST SONGBIRDS (GOLDEN-WINGED WARBLER, CERULEAN WARBLER, WOOD THRUSH)

More than 1 billion breeding birds have been lost from forest habitats across North America over the past 50 years. Declines of birds associated with early successional, mature, and structurally diverse Eastern deciduous forest have contributed to these overall losses of forest birds, with golden-winged warbler, cerulean warblers, and wood thrush exhibiting some of the steepest declines. These three SGCN species represent those different forest ages and structures that are missing from many Northeastern deciduous forests today. The Forest Songbirds Team is partnering closely with the Appalachian Mountains Joint Venture (AMJV), whose geography overlaps with the core breeding areas of these three forest birds, to engage and support private and public forest landowners in implementing forest management practices that enhance the age and structural diversity of Eastern deciduous forests. A good example of this is a collaborative project this Team initiated between the Service's Partners for Fish and Wildlife program, NRCS, and West Virginia DNR that is providing assistance to private landowners in implementing the forest management activities identified as required practices under landowner incentive programs. We look to collaborate on these kinds of activities within focal landscapes identified within the AMJV geography as well as additional focal areas outside of the AMJV that are important for these three at-risk forest songbirds. We plan to identify key audiences in each focal area for outreach regarding beneficial forest management practices for birds and available resources to assist in implementing them. We seek to collaborate with other agencies, especially state agencies and USDA, and NGOs with interests in forest bird conservation and creating healthy forest landscapes across the Northeast.

SALTMARSH SPARROW

Science Applications is working on Saltmarsh conservation across the Atlantic Coast.

PINE BARRENS INHABITANTS

Pine barrens are a unique habitat type often characterized by sandy soils and fire-dependent plant communities dominated by pine species, though oaks are often also a major component of the ecosystem. Many rare species utilize pine barren habitats, but the team is focused on two inhabitants, Frosted Elfin and Eastern Whip-poor-will. The

Pine Barrens Team is analyzing data from Science Application's Rapid Response Team, eBird, and other sources to identify priority sites for co-management of the two species. Once sites are identified, the Team will work with Refuges, state conservation agencies, and other partners to enact on-the-ground management to improve conditions for both species. The team also intends to develop Best Management Practices for the two target species within pine barrens and to develop a network of conservation practitioners for sharing research, management practices and needs, and information across the Northeast.

DIADROMOUS FISHES (ALEWIFE, BLUEBACK HERRING)

Alewife (*Alosa pseudoharengus*) and Blueback herring (*Alosa aestivalis*), collectively known as River Herring, are categorized as Species of Greatest Conservation Need (SGCN) in all New England states, New York, Pennsylvania, New Jersey, Delaware, and Virginia. Blueback herring are additionally categorized as SGCN in South Carolina and Florida [outside of Region 5]. River Herring Conservation Plans have been released by NOAA Fisheries and the Atlantic States Marine Fisheries Commission (ASMFC) within the last decade. Threats to River Herring populations include exclusion or reduced access to historic freshwater spawning and nursery habitats, barriers with inadequate fish passage measures, freshwater and estuarine habitat/water quality degradation, climate change impacts, and indirect (bycatch) fishing pressure. In both the marine and freshwater environments, shifts in water temperature, related temporal/spatial shifts in environmental conditions, prey availability, and predators may be negatively influencing River Herring populations.

Conservation goals for River Herring are aligned with those established in the ASMFC Amendment 2 to the Interstate Fishery Management Plan for American Shad and River Herring (River Herring) (2009): "Protect, enhance, and restore East Coast migratory spawning stocks of alewife and blueback herring in order to achieve stock restoration and maintain sustainable levels of spawning stock biomass." Priority objectives include 1) preventing further declines in population abundance, 2) promoting improvements in degraded or historic habitat throughout the species range, 3) improving access to historic freshwater spawning and nursery habitat, and 4) increasing understanding of the influences of River Herring bycatch in commercial fisheries as well as updating the status of stock dynamics and health.

FARMLAND POLLINATORS (MONARCH, AMERICAN AND YELLOW-BANDED BUMBLEBEE, ASHTON'S, LEMON, AND VARIABLE CUCKOO BUMBLE BEE)

In the Northeast, native bumble bee species are experiencing habitat loss, climate related threats, and competition form non-native species. The USFWS has identified five bumble bee species (American bumble bee, yellow banded bumble bee, Ashton's cuckoo bumble bee, lemon cuckoo bumble bee, and variable cuckoo bumble bee) as well as Monarch butterfly as priority at-risk species in need of proactive conservation. These species, collectively referred to as "farmland pollinators" are in need of region-wide habitat restoration and management. Additionally, little is known on the population status and distribution for many of these rare species. The USFWS provided funding to the Native Bee Inventory and Monitoring Lab for a multi-part project that includes surveys, floral resource research, public outreach, and developing a regional conservation strategy for bumble bees. Additional projects supported by the farmland pollinator team include bumble bee surveys on National Wildlife Refuges across the Region, native thistle seed collection and propagation, and continued support for the New England Pollinator Partnership.

FRESHWATER MUSSELS (BROOK FLOATER, CUMBERLAND MOCCASINSHELL, PHEASANTSHELL, TENNESSEE CLUBSHELL, TIDEWATER MUCKET, YELLOW LAMPMUSSEL)

Across the continent, freshwater mussels have experienced drastic declines. Over 74 % of the 298 species found in North America are in some state of imperilment, with 93 species federally listed as endangered or threatened (Williams et al. 2017). Habitat degradation, which includes water pollution and impoundments, is by far the leading cause of these declines. Non-native species also have outcompeted some of our native species. Freshwater mussels also provide ecological and economic benefits to people and aquatic ecosystems. Like oysters, they filter millions of gallons of water and act as ecosystem engineers. They're crucial to a multi-billion-dollar pearl jewelry industry, and harvest of mussels is a reserved treaty right for some Native American tribes. Without intervention, freshwater mussels will continue to disappear within their range, and with loss of valuable ecosystem services at risk.

Using adaptive management and working at landscape scales in partnership with states and Tribes, The ARS team aims to restore and conserve these at-risk species of mussels and proactively address threats so that the USFWS can avoid the need to list these species under the Endangered Species Act.

With input from partners, the ARS team has been building a conservation plan called the Northeast Region Conservation Strategy for Freshwater Mussels that provides a framework and strategies for conserving and restoring at-risk species of freshwater mussels and their habitats from Maine to Virginia and West Virginia. Ultimately, the ARS team wants to decide on feasible, cost-effective actions that Service programs can take with partner support over the next five years to increase representation, redundancy, and resiliency (3 Rs) of each species, and ensure their long-term viability. In 2022, the ARS team interviewed biologists from 12 States, the Partnership for Delaware Estuary, USGS, and representatives from the Penobscot Nation. The ARS team developed a suite of questions aimed at identifying priority areas and management and science needs for conservation of mussels. They are synthesizing the information from these interviews into priority area maps and tables, which will highlight areas for conducting surveys, habitat restoration, land protection, propagation and stocking, and science needs. Discussions held in 2021 with the Rappahanock, the Chickahominy, and the Upper Mattaponi Indian Tribes are also informing priority areas for conservation of at-risk mussels and their host fish in the Northeast Region Conservation Strategy for Freshwater Mussels.

In 2022, the ARS team also identified priority science needs for mussels that were included in the request for proposals through the USGS. And the ARS team identified priority projects for BIL funding that would benefit at-risk mussels.

In 2023, the ARS team will complete interviews with Tribal partners to further identify priority areas for conducting conservation for mussels. They will distribute the strategy to State and Tribal partners and other Service offices for review, incorporate comments and edits, and complete the At-Risk Conservation Strategy. Also in 2023, the RAS team will work to build local action plans within target watershed and implement projects.

MOUNTAIN BUTTERFLIES (WHITE MOUNTAIN ARCTIC, WHITE MOUNTAIN FRITILLARY)

The White Mountain arctic (*Oeneis melissa semidea*) and the White Mountain fritillary (*Boloria chariclea monitus*) are endemic butterflies that were left isolated at the summit of Mt. Washington after the last glaciation period approximately 13,000 years ago. Their distribution is limited to a 2800-acre alpine zone of the Presidential Range at the White Mountain National Forest. Potential stressors include trampling of habitat and individuals from off-trail recreational use, lack of redundancy due to the species' limited range, and potential negative effects to both species and their habitat from climate change. We are partnering with New Hampshire Fish and Game (NHFG), the White Mountain National Forest, the Mount Washington Observatory (WMO), and the Appalachian Mountain Club to develop and produce a public awareness and education campaign to inform the public of the presence and predicament of these species and develop signage to mark sensitive areas. There are ongoing research projects with NHFG, WMO, the University of New Hampshire, and the Northeast Adaptation Science Center to collect life history and abundance information on these two butterfly species. To date, these studies have successfully identified host species critical to complete the White Mountain Fritillary's reproductive cycle. Captive rearing protocols have been developed and implemented at the WMO and at the NHFG captive rearing facility. Studies that will continue into 2023 include DNA analysis to assess population structure, collection of demographic data, evaluation of impacts of climate change, species distribution modeling, and overwintering experiments.

NORTHEAST TURTLES (BLANDINGS, SPOTTED, AND WOOD TURTLE)

Habitat fragmentation and degradation is the biggest threat to these three species that occur in the northeast region. Human development contributes to additional threats such as road mortality, predation, and illegal collection. The At-Risk Turtle team is focused on working with the states to implement conservation plans that are informed by standardized monitoring and genetic analysis. All three species have conservation area networks (CAN) that identify focal area sites which are targeted for land protection, management opportunity sites which are targeted for restoration, and finally sites in need of surveys. Due to data sensitivity, the Service does not have spatial information for the CANs. The team is working with individual states on the following objectives: 1) securing viable populations through land conservation (using grant programs like Land and Water Conservation Fund, Delaware Bay, Chesapeake WILD, and America the Beautiful, and NRCS's Wetland Reserve Easement program); 2) enhancing populations through restoration of habitat (work on refuge lands, Department of Defense (DoD) lands, and working with NRCS on private lands); 3) decreasing road mortality in areas with high mortality rates (work on refuges and with individual states using Department of Transportion funds); 4) addressing illegal trade in turtles (continue to provide leadership on the Collaborative to Combat Illegal Trade in Turtles; support law enforcement by identifying housing for confiscated turtles, and helping the states get turtles back to the wild through genetic and disease screening; development of outreach tools and human dimensions work to help develop a long term strategy to address illegal trade in turtles; assess population status (continue surveys on refuges and DoD lands, and through projects with the Northwest Atlantic Fisheries Organization; continue to support states in developing Competitive State Wildlife Grant projects); assess population status (lead for Spotted and Wood Turtle Species Status Assessments and assisting with Blanding's Turtle); augment populations (work with the states to identify needs particularly for Blanding's Turtle); and raise awareness (continue to feature conservation work and addressing threats through Environmental Assessments).

1.4.2 BIRDS

- Joint Ventures[24]
- Atlantic Flyway Shorebird Initiative[25]
- United States Shorebird Conservation Plan[26]
- Atlantic Marine Bird Cooperative[27]
- North American Waterbird Conservation Plan[28]
- North American Waterfowl Management Plan[29]
- Partners in Flight[30]
- U.S. Fish and Wildlife Service Birds of Conservation Concern[31]
- Audubon Survival by Degrees: 389 Bird Species on the Brink list[32]
- SHARP: Saltmarsh Habitat & Avian Research Program[33]

1.4.3 FISHES, CRAYFISH, AND FRESHWATER MUSSELS

- American Fisheries Society[34]
- National Fish Habitat Partnership[35]
- Atlantic Coastal Fish Habitat Partnership[36]
- Eastern Brook Trout Joint Venture[37]
- Great Lakes Basin Fish Habitat Partnership[38]
- Atlantic States Marine Fisheries Commission[39]
- New England Fishery Management Council[40]
- Mid-Atlantic Fishery Management Council[41]
- NOAA Northeast Fisheries Science Center[42]
- NOAA Greater Atlantic Regional Fisheries Office[43]

1.4.4 NATURAL RESOURCES CONSERVATION SERVICE

- New England Pollinator Partnership[44]
- Working Lands for Wildlife Program[45]
- Other conservation program priority species[46]

1.4.5 U.S. FOREST SERVICE SENSITIVE SPECIES LISTS

- USFS 2020 State Forest Action Plans Multistate Priority Areas: Supporting Landscape Scale Conservation and Shared Stewardship Across the Northeast and Midwest[47]
- USFS: Landscape Scale Conservation Interactive Web Map[48]

1.4.6 XERCES SOCIETY FOR INVERTEBRATE CONSERVATION AT-RISK INVERTEBRATES LIST

- Xerces.org[49]

1.4.7 OPPORTUNITIES WITH OTHER AFWA REGIONS

The Northeast continues to lead the RSGCN effort nationally as it updates its list for the 4th revision in 2023. This effort allows the 14 states to prioritize through analysis, evaluation, and consensus of the best scientific data and expertise, and focus their efforts together at a landscape or watershed scale where many of these species and issues are more effectively addressed. This enables each state to see the important role it plays in the species/ overall conservation. Similarly, this concept when expanded to the species entire range, provides the opportunity for interregional coordination. Table 1.4.1

shows the number of shared RSGCN/Proposed RSGCN between AFWA regions and these overlaps represent opportunities for additional coordination. Just as the coordination of federally listed Threatened and Endangered species are afforded coordination through USFWS At-Risk and ESA recovery efforts, states and their partners can proactively work together to conserve these species across their ranges to preempt the need for federal listing. This is often most effectively accomplished at the multi-species landscape or watershed scale.

Table 1.4.1 Number of RSGCN and Proposed RSGCN Species listed by multiple AFWA regions.

AFWA Region	**Number of Shared RSGCN and Proposed RSGCN Species**
NEAFWA and SEAFWA	120
NEAFWA and MAFWA	64
NEAFWA, SEAFWA, and MAFWA	30

The advancements in the RSGCN method now offer NEAFWA additional coordination opportunities with other regions. The Watchlist Deferral category provides not only an effective way to deal with "peripheral species" at the state and regional level, but also provides opportunities to coordinate conservation of those species with neighboring regions for more holistic management across their range. Table 4.7.2 shows the number of Watchlist Deferral Species from the 2023 Northeast RSGCN update, indicating significant opportunities for collaboration and coordination for these species as each region continues to fulfill its role in the overall conservation of each species.

The Northeast deferred 56 species to the Southeast as a reflection of those species with more secure populations centered the Southeast that reach the northern extent of their range in the mid-Atlantic states (Virginia and West Virginia watersheds, Appalachian Mountains, or Atlantic coast). Almost 20 species were deferred to the Midwest region (MAFWA) reflecting species whose populations primarily occur in the Midwest but overlap with NEAFWA in the Ohio River drainage, Great Lakes, or eastern Midwest landscapes. In all, almost 100 species provide opportunities for coordinated interregional conservation that secures both the core and peripheral range of these species.

Table 1.4.2 Number of Watchlist [Deferral] species identified in the RSGCN list update to other AFWA regions.

Watchlist [Deferral] Region	**Number of Species**
SEAFWA	56
MAFWA	18

SEAFWA and MAFWA	15
Canada	2
Canada and WAFWA	3
MAFWA and WAFWA	1
Total	**95**

1.5 DISCUSSION

1.5.1 THE NORTHEAST PROCESS ADVANCEMENTS

The refinement of the RSGCN process created a more inclusive list of RSGCN and allowed for the addition of new categories to focus on conservation needs. RSGCN criteria were applied to all Northeast species (17,000+) within 20 taxonomic groups resulting in a more inclusive prescreening process. The process resulted in identifying taxa not currently listed as SGCN in a northeast SWAP, which were added to new "Proposed" categories. This is a valuable advancement to inform 14 Northeast states' upcoming 2025 SWAP SGCN selection. Improvement in the additional RSGCN criteria broadens the ability and purpose of the RSGCN list to include taxa that may not be ranked high on one status ranking system but does not slip through the cracks as criteria can pick it up on other ranking systems (federal, state, IUCN, and NatureServe ranks). The addition of the Watchlist categories provides an additional proactive focus for conservation efforts. It prioritizes data-deficient species, including the 25 endemic Northeast species for which experts express concern but lack data.

1.5.2 CHANGES TO THE RSGCN LIST SINCE 2018

Tracking conservation regionally is vital in meeting the goals of RSGCN and the charges of the NEFWDTC. Analyzing taxa conservation status and needs over time allows managers to focus conservation efforts and plan with an adaptive management capacity. While RSGCN numbers have increased over the previous iterations of the process, this is primarily due to more inclusive methods and additions of taxa groups. As a result, concern has decreased for some species, and future analysis and technical services can provide a dashboard and regional tracking systems to ensure the region's most effective and productive conservation and management.

For example, Bees and Lepidoptera were more data-deficient. Many species were moved to the Watchlist [Assessment Priority] for further assessment due to the region's lack of data and expertise. Previously in the 2018 revision, these taxa were added as RSGCN but noted as data deficient. The 2018 list included more species that had concerns with not as much information. The RSGCN Watchlist [Assessment Priority] was valued and used by teams for consistent themes: taxonomic uncertainty, data deficiency, and variable patterns across the region needing more evaluation and assessment.

1.5.3 RSGCN DISCUSSION

Experts have vetted **382 RSGCN** across the Northeast, with an additional 37 Proposed RSGCN positioned to inform the 2025 SWAP revisions. More invertebrates are listed than vertebrates across all list categories, with almost twice as many invertebrate taxa groups than vertebrates. However, even with these differences, there is coherence across taxa and RSGCN status (including new Watchlist categories) in the numbers of species across Concern Levels and regional responsibilities. This is true even with the variability in expertise across taxon groups and the information available across all these species. Since this is the 4th iteration, the process has been refined, ensuring consistency, including increasing consistency between regions.

Variability in the available information and expertise limits the complete coverage for some taxa. For example, more expertise exists in each state fish and wildlife agency for vertebrates than invertebrates. This speaks to the need for additional invertebrate expertise and has informed the RCN 3 prioritization for an invertebrate coordinator and tiger beetle and stonefly assessment projects. It also speaks to the need for coordination with sister state agencies that regulate marine species, invertebrates, and plants.

1.5.4 RECOMMENDATIONS

Priorities moving forward include filling data gaps identified through gap analysis in the RSGCN database. Data gaps in the RSGCN database should be filled to analyze species conservation needs via habitat and threats while also searching for key life history information on data-deficient species.

Refining a method to track conservation changes over time within the RSGCN process with taxa expert confirmation will be important. The deferral categories also indicate the need for follow-up and coordination between the regions and their conservation priorities. Building an action tracker informed by changing conservation status, threats, and management could mobilize the region under an adaptive management framework while tracking the most effective conservation actions.
Additionally, it is vital to include partners like the Northeast Climate Adaptation Science Center to prioritize climate change threats and actions for build adaptive capacity for species resilience and working with the new invertebrate coordinator to bolster the information needed to conserve invertebrates regionally. Meanwhile, focusing on subgroups such as small mammals can ensure conservation uniformity within the taxon. All these conservation actions are tied to threats and habitats. Building the data, expertise, and tools needed to represent taxa groups more proportionately remains a priority.

There is a continuing need to develop web-enabled platforms for data access to the RSGCN list and supportive data. Collaboration with the forthcoming Competitive State Wildlife Grant (C-SWG) SWAP database and enhanced NEFWDTC website will provide better access to this information on regional priorities with portals for conservation actions to be documented and shared across state lines. Lastly, continued refinements and improvements to the RSGCN process and better communication of results and information are needed so that the Northeast remains a regional conservation leader. These needs reflect a lack of capacity of both funding and expertise for states to be ready for the proposed Restoring America's Wildlife Act (RAWA) and to address the full complement of fish and wildlife diversity in the Northeast.

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1.7 ENDNOTES

Many online resources are available for learning about the topics in this chapter. However, URLs are not permanent resources; pathways may be changed or removed over time. These endnotes were all accessed in January and February of 2023 and were active at that point in time.

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CHAPTER 2: HABITATS OF THE NORTHEAST

SWAP Element 2

Descriptions of locations and relative condition of key habitats and community types essential to conservation of species identified in the 1st element.

Suggested components:

A. *The Plan provides a reasonable explanation for the level of detail provided; if insufficient, the Plan identifies the types of future actions that will be taken to obtain the information.*
B. *Key habitats and their relative conditions are described in enough detail such that the State can determine where (i.e., in which regions, watersheds, or landscapes within the State) and what conservation actions need to take place.*

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HOW TO USE THIS CHAPTER:

Chapter 2 of this Regional Conservation Synthesis provides a summary of available information on habitats for Northeast Regional Species of Greatest Conservation Need (RSGCN) and Watchlist species and the condition of those habitats at the regional and national scale.

- The Regional Overview (Section 2.0) describes habitat classification systems and tools (Section 2.0.1), spatial datasets of habitat (Section 2.0.2), and habitat prioritization resources available for the Northeast region (Section 2.0.3).
- The remaining sections of this Chapter provide the best available information describing each of 24 regional habitat types, its known distribution and level of protection, condition, management tools and resources, and monitoring programs and projects. Conservation partners protecting, managing, or restoring each habitat are listed. Citizen science projects and programs that engage the public in conservation of each habitat are described. Information, research, and monitoring needs for each habitat are identified.
- The habitat types are organized into natural and anthropogenic habitat types, in this order:
    - Section 2.1 Forests and Woodlands
    - Section 2.2 High Elevation Forests
    - Section 2.3 Grasslands
    - Section 2.4 Shrublands
    - Section 2.5 Glades, Barrens & Savanna
    - Section 2.6 Alpine
    - Section 2.7 Cliff & Talus
    - Section 2.8 Subterranean Areas
    - Section 2.9 Non-tidal Wetlands
    - Section 2.10 Big Rivers
    - Section 2.11 Rivers & Streams
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    - Section 2.20 Marine Nearshore
    - Section 2.21 Marine Offshore & Oceanic
    - Section 2.22 Agriculture: Croplands & Pasture
    - Section 2.23 Agriculture: Plantations & Orchards
    - Section 2.24 Developed Areas

- Appendices for this and all Conservation Synthesis chapters can be found together in the appendices document so the reader can open the chapters and appendices side-by-side if desired. Chapter 2 Appendices include a Crosswalk of SWAP Key Habitats with the 24 habitats and Crosswalk of DSLland Formations and Ecosystems with the 24 habitats.
- Supplemental information, such as RSGCN and Watchlist species with associated habitats, are in the Supplemental Information Excel file.

2.0 REGIONAL OVERVIEW

From the Alpine peaks of the northern Appalachians and the Great North Woods to the marshes and beaches of the Atlantic Coast and the offshore submarine canyons of deep-sea coral, the Northeast region is rich in biodiversity and natural resources. The region is also home to some of the nation's most urban areas. Stretching from the Bay of Fundy to beyond the mouth of the Chesapeake Bay, the region includes boreal, temperate, and subtropical climates and habitats. Large landscapes, watersheds, and seascapes include the Appalachian Mountains, Great Lakes, Connecticut River valley, Long Island Sound, Delaware Bay, Chesapeake Bay, and Gulf of Maine. The ecological and natural resources of the region have been described by Ferree and Anderson (2013, p. 5):

> *This is an area of almost 62 million hectares (155 million acres) spanning 11 degrees of latitude from the Virginia-North Carolina state line to Maine's northern border with Canada…. The region is an area of tremendous physiographic, geologic, and biological diversity, and has a long human history as well. The ancient Appalachian Mountain chain is the oft-described "backbone" of the Northeast, connecting smaller ranges like the Cumberlands and Alleghenies of Virginia, West Virginia, and Pennsylvania, the Catskills and the Adirondacks of New York, the Green and White Mountains of northern New England. A number of large rivers steeped in American history drain the region, from the Penobscot and the Kennebec in Maine to the Potomac and the James in Virginia. Maritime and coastal plain lowlands, the low hills of the piedmont, and the more extreme mountain environments, all support a complex array of upland and wetland habitats. Seventy-eight percent of the region is currently in natural or semi-natural cover, 17% is in cropland or pasture (a figure that has been considerably higher historically in parts of the Northeast) and 5% is developed. The latter includes scores of large population centers, including the "megalopolis" … described as running from Boston to Washington DC.*
>
> *The region's complex set of geophysical environments, including high granite mountains, limestone valleys, shale slopes, basalt ridges, silt or clay plains, coastal sand flats, and many others, determine the range and variety of habitats found (Anderson and Ferree 2012). These have formed as a result of geomorphic processes operating over vast time scales and relatively more recently, and over large and small spatial scales. A map of Northeastern habitats tracks our understanding of these settings and*

Niagara Corridor

New York's Niagara Corridor has been designated as both a Ramsar Wetland of international importance and an IBA of global ornithological significance. The Niagara Corridor includes multiple habitat types – Rivers and Streams, Great Lakes, Non-Tidal Wetlands, Riparian and Floodplain, and adjacent upland habitats.

processes, and how they shape distributions of natural communities across Northeastern landscapes.

The terrestrial landscape of the Northeast is over 60% forested, with an average forest age of 60 years, and the region contains more than 200,000 miles of rivers and streams (Anderson and Olivero-Sheldon 2011), 36,675 water bodies (Olivero-Sheldon and Anderson 2016), and more than 6 million acres of wetlands. Eleven globally unique habitats, from sandy barrens to limestone glade, support 2,700 restricted rare species (Anderson and Olivero-Sheldon 2011).

More than 150 sites in the Northeast have been designated as **National Natural Landmarks** for their national significance as exemplars of their habitat types or geologic uniqueness. Six Northeast sites have been designated as **Ramsar Wetlands** of global importance. Globally significant **Important Bird Areas (IBA)** have been designated at 93 sites, representing 13% of the nation's total IBA of global ornithological significance. Important Bird Areas of continental significance have been designated at another 74 sites in the Northeast region, 65% of the national total. Five coastal areas of the Northeast have been identified as **Western Hemisphere Shorebird Reserves**, one of international importance (Maryland-Virginia barrier islands), one of hemispheric importance (Delaware Bay), and three of regional importance.

Four areas in the Northeast have been designated international **Biosphere Reserves** by the United Nations Educational, Scientific and Cultural Organization (UNESCO) – the Virginia Coast, New Jersey Pinelands, Southern Appalachians, and Champlain-Adirondack Biosphere Reserves. UNESCO Biosphere Reserve sites are those that conserve biodiversity while promoting sustainable development and use practices.

Nationally, the Northeast has extensive areas of habitat identified as landscapes important to protecting biodiversity. NatureServe published a national **Map of Biodiversity Importance** for the continental United States in 2022 based on habitat models for 2216 imperiled species and more than 200 high-resolution environmental data layers (Hamilton et al. 2022; Figure 2.0.1). Hamilton et al. (2022) also developed a series of national maps identifying areas of unprotected biodiversity importance of imperiled species (Figure 2.0.2); species richness for more than 2200 plant and wildlife species; species richness of imperiled vertebrates, freshwater invertebrates, pollinators, vascular plants; and range-size rarity of multiple imperiled groups (available on the **Living Atlas**[1]). Hamilton et al. (2022) found that inclusion of diverse taxa beyond those typically studied (birds, mammals and amphibians) identifies important areas of biodiversity not previously identified, and that using finer resolution model inputs (990 meters [m]) resulted in a more geographically disperse pattern of identified areas.

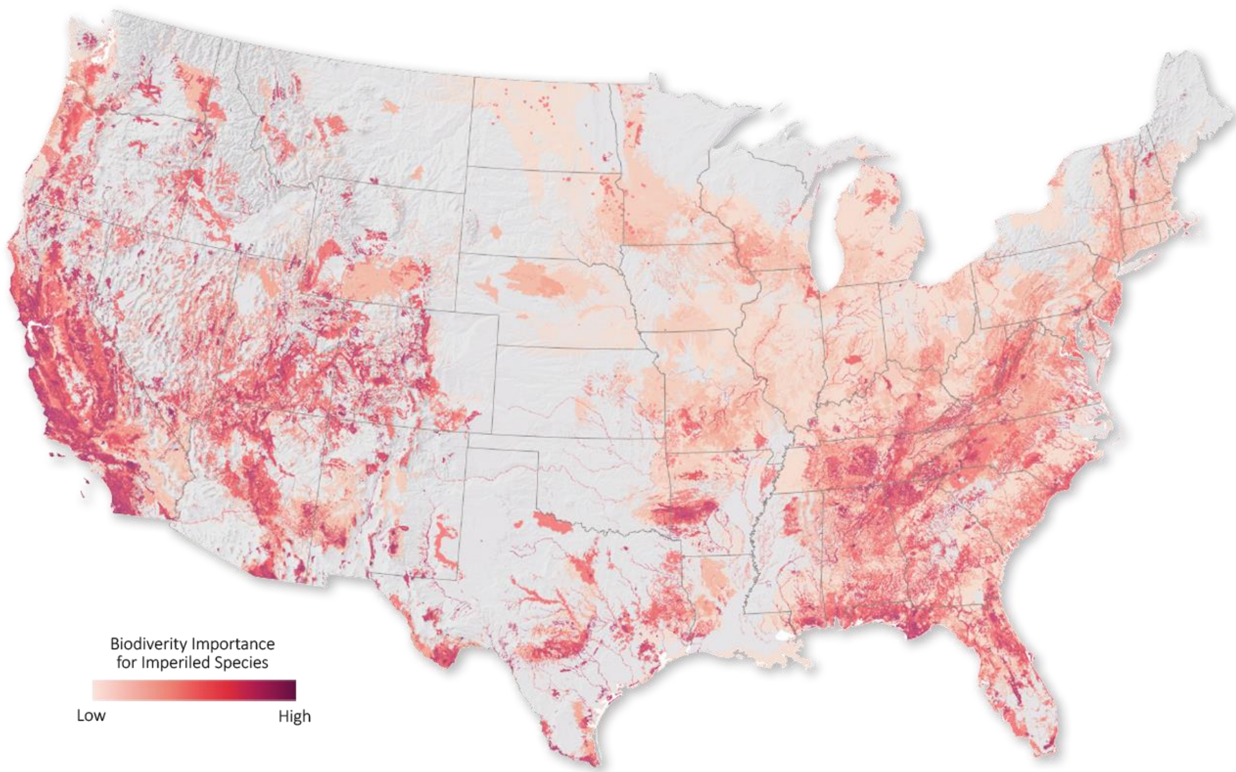

Figure 2.0. 1 NatureServe developed a Map of Biodiversity Importance in 2022 highlighting (darker shades of red) the relative importance of the United States landscape to prevent the extinction of more than 2200 imperiled species (Hamilton et al. 2022).

This chapter provides information about important wildlife habitats in the Northeast that are in need of conservation consideration as identified by the Northeast states and their partners through the State Wildlife Action Plans and the Regional Conservation Needs grant program. **This document uses the term "habitat" to include ecological communities, vegetation communities, geographic features, and other discrete, mappable entities that support fish or wildlife Regional Species of Greatest Conservation Need (RSGCN). Information is provided about the extent and condition of major habitat groupings, as required in Element 2 for the Wildlife Action Plans (WAPs).** TCI and NEFWDTC (2013) synthesized available habitat information to assist the development of the 2015 Northeast SWAPs, including summaries of RCN and other regional projects that have developed or applied standardized classification systems, assessed habitat condition, and identified priority habitats for regional conservation. Case studies and project summaries illustrate actions taken by the Northeast states to assess, monitor, and restore wildlife habitats. Please see *Chapter 4*, Appendix 4A, and TCI and NEFWDTC (2013) for additional information on each of the habitat assessment and conservation projects that have been funded through the RCN Grant Program. The habitat information in TCI and NEFWDTC (2013) is herein incorporated by reference.

2.0.1 HABITAT CLASSIFICATION SYSTEMS AND TOOLS

The second required SWAP component "identifies the extent and condition of wildlife habitats and community types essential to conservation of species identified" in required Element 1 (Fiscal Year 2001 Commerce, Justice, State, and Related Agencies Appropriations Act 2000). States apply regional and national guidance for consistency, but also develop individual approaches to assess and map habitats. The landscapes and seascapes of the Northeast region have several spatial assessment and planning tools available to assist fish and wildlife habitat assessments for RSGCN and Watchlist species, including several advancements since the 2015 SWAPs.

The **Northeast Terrestrial Wildlife Habitat Classification System** was developed in 2008 to provide a coarse but cohesive system to describe the physical and biological characteristics relevant to wildlife conservation (Gawler 2008). This habitat classification consists of two levels – a habitat system and a structural modifier. As developed by NatureServe, the habitat system corresponds to the ecological system units that occur in the Northeast, with additional systems for altered habitats and land-use types. The hierarchical system includes seven Formation Classes at the top level, 15 formations in the second tier, 35 macrogroups in the third tier, and 143 habitat types in the bottom level (fourth tier). Structural modifiers can be added to describe cover (e.g., herbaceous, shrub, open water), age classes, disturbance history, or geologic features like karst.

The **Northeast Aquatic Habitat Classification System** is a standardized classification system and geographic information system (GIS) dataset to describe and map stream systems across the Northeast (Olivero-Sheldon et al. 2015, Olivero and Anderson 2008). The system and data consistently represent the natural flowing-water aquatic habitat types across this region in a manner that is useful for conservation planning. The system was designed to unify state classifications and promote an understanding of aquatic biodiversity patterns across the entire region. It is not intended to supplant local stream classifications, but rather to put them into a broader context. This approach can be implemented across regional scales using GIS modeled variables that shape aquatic habitats such as stream size, slope, elevation, climate, geology, lake size, elevation, shoreline sinuosity, and connectivity. This dataset can be used similarly to the Terrestrial Habitat Classification.

The **Northeast Lake and Pond Classification** allows for the classification and mapping of lake and pond habitats that uses four key variables: water temperature, alkalinity, trophic state, and light penetration depth (Olivero-Sheldon and Anderson 2016). Water bodies are assigned to one of 18 primary habitat types by combining their estimated:

- Temperature class (Very Cold, Cold, Cool-Warm)
- Trophic class (Oligotrophic-mesotrophic, Eutrophic-hypereutrophic)
- Alkalinity class (Low: Acidic, Medium: Circumneutral, High: Alkaline)

These types were further subdivided into lake or pond categories based on depth within their trophic class to yield the final mapped occurrences of 36 waterbody types across the Northeast.

The **Classification of Wetlands and Deepwater Habitats of the United States** is the standardized classification system for tidal and non-tidal wetlands plus permanently submerged aquatic substrates, originally developed by Cowardin et al. (1979) and updated by the Federal Geographic Data Committee (FGDC 2013). This hierarchical classification scheme includes five systems (marine, estuarine, riverine, lacustrine, and palustrine) which are divided into 11 classes. The 11 classes are rock bottom, unconsolidated bottom, aquatic bed, reef, rocky shore, unconsolidated shore, streambed, moss-lichen wetland, emergent wetland, scrub-shrub wetland, and forested wetland. Subclasses divide the wetland classes using the specific life form that has the greatest areal coverage. Deepwater subclasses separate submerged systems on the basis of substrate material or the presence of at least 30% vegetation cover. Subclasses are further categorized by dominance type, including both plant and animal species. System modifiers further characterize wetland and deepwater habitats by describing water regime, water chemistry, soil, and special modifiers (i.e., modifications due to beavers or humans).

The **Coastal and Marine Ecological Classification Standard (CMECS)** allows for a standardized classification of coastal and marine aquatic habitats (FGDC 2012). The CMECS defines the Marine System by salinity, (typically about 35 but as low as 0.5) during the period of average annual low flow near fresh outflows. This system has little or no significant dilution from fresh water except near the mouths of estuaries and rivers. The Marine System includes all non-estuarine waters from the coastline to the central oceans. The landward boundary of this system is either the linear boundary across the mouth of an estuary or the limit of the supratidal splash zone affected by breaking waves. Seaward, the Marine System includes all ocean waters. The Marine System is typified by waves, currents, and coastal water regimes determined by oceanic tides. Coastal indentations and bays that do not receive appreciable and regular freshwater inflow are part of the Marine System. Areas where river plumes discharge directly into marine waters without geomorphological enclosure are also part of the Marine System. In such areas, (e.g., Mississippi River plume, Chesapeake Bay plume), low salinity water and fresh plumes may discharge from the seaward boundary of the estuary, extending far into the Marine System beyond the enclosed part of the estuary. These freshwater features are considered to be Hydroforms within the Marine System. The Marine System has three subsystems (which are defined by depth): Nearshore (0 to 30 m depth), Offshore (30 m depth to the continental shelf break), and Oceanic (open ocean extending seaward of the continental shelf break).

The **Northeast Lexicon** provides terminology conventions and a data framework for SWAPs in the region (Crisfield and NEFWDTC 2022). The Lexicon recommends habitat classification systems as well as factors which can describe the extent and condition of Key Habitats, and information deficiency. A coarse regional habitat classification system combining the terrestrial, freshwater, estuarine, and marine systems was developed in conjunction with the Northeast Lexicon and associated with the RSGCN and Watchlist species described in *Chapter 1* (Table 2.0.1).

Table 2.0. 1 The Northeast RSGCN and Watchlist species have been associated with 24 coarse habitat types that consolidate the finer scale Key Habitats in the 14 Northeast 2015 SWAPs. Twenty-one of the habitats are natural and three are anthropogenic.

Forests & Woodlands	Riparian & Floodplains
High Elevation Forest	Great Lakes
Grasslands	Lakes & Ponds
Shrublands	Shorelines
Glades, Barrens & Savannas	Beaches & Dunes
Alpine	Tidal Wetlands & Flats
Cliff & Talus	Estuaries
Subterranean Areas	Marine Nearshore
Non-tidal Wetlands	Marine Offshore & Oceanic
Big Rivers	Agriculture: Croplands & Pastures
Rivers & Streams	Agriculture: Plantations & Orchards
Tidal Rivers & Streams	Developed Areas

The **Northeast RSGCN Database**, as updated in 2023 (version 1.0; TCI and NEFWDTC 2023), includes numerous data fields that characterize describe habitat associations and management needs for RSGCN and Watchlist species in the Northeast. Northeast RSGCN and Watchlist species have been associated with the coarse regional habitat classification system of 24 habitat types in the updated Northeast RSGCN Database (Table 2.0.2; see *Supplemental Information 2 for a full list*). Each species may be associated with multiple habitat types, with no distinction for primary, secondary, etc., habitat associations. Habitats where use is incidental were not included. Habitat related data fields described in the Lexicon and included in the Northeast RSGCN Database (version 1.0) are provided to capture the life stage(s) when RSGCN and Watchlist species use each habitat along with habitat characteristics (structural modifiers) associated with the species' use. Habitat modifiers vary by habitat type, with upland habitats including vegetation density, vegetation type, age class, substrate type, soil moisture, and fire dependency. Aquatic habitat modifiers characterize associated upland habitats, salinity, size, temperature, oxygen level, alkalinity, substrate, gradient, vegetation density, and trophic state. Palustrine habitat characteristics include substrate, hydroperiod, vegetation density, temperature, and fire dependency. Interface habitats like shorelines, beaches, and riparian floodplains include salinity, tidal zone, substrate, and vegetation density data fields.

Other habitats have modifiers specific to their type, such as zones (entry, twilight, dark) within Subterranean Areas or development density (high, medium, low) for Developed Areas. Habitats features and formations (e.g., tidal pools, burrows, snags, surface litter) important to RSGCN and Watchlist species also are available in the database to inform habitat enhancement or restoration projects. As information and resources become available regarding habitat needs of RSGCN and Watchlist species, the Northeast RSGCN Database (version 1.0) will be updated. *Appendix 2A* includes a list of Key Habitats identified in the fourteen 2015 Northeast SWAPs (TCI and NEFWDTC 2020) that were associated with each of the 24 coarse regional habitats to inform the species associations, as were habitat associations and characteristics from NatureServe[2], IUCN[3], and the World Register of Marine Species[4].

Rivers and Streams are associated with the highest number of RSGCN and Watchlist species in the Northeast with 349 species (Table 2.0.2). Riparian and Floodplain habitat immediately adjacent to these Rivers and Streams is associated with the second highest number of species (301). Non-tidal Wetlands and Forests and Woodlands habitats also are associated with high numbers of RSGCN and Watchlist species with 262 each. More than 100 RSGCN and Watchlist species are associated with Glades, Barrens and Savanna, Grasslands, Lakes and Ponds, and Shrubland habitats.

Table 2.0. 2 The number of Northeast RSGCN and Watchlist species, including Proposed RSGCN and Proposed Watchlist species, associated with each of the 24 regional habitat types. Species may be associated with multiple habitat types.

	Number of RSGCN and Proposed RSGCN	Number of Watchlist and Proposed Watchlist Species	Total Number of RSGCN and Watchlist Species
Forests & Woodlands	132	130	262
High-Elevation Forests	22	21	43
Grasslands	69	66	135
Shrublands	58	60	118
Glades, Barrens & Savanna	77	87	164
Alpine	12	7	19
Cliff & Talus	45	22	67
Subterranean Areas	17	5	22
Non-Tidal Wetlands	130	27	262
Big Rivers	26	17	43
Rivers & Streams	189	160	349
Tidal Rivers & Streams	26	22	48
Riparian & Floodplains	154	147	301
Great Lakes	17	19	36
Lakes & Ponds	66	60	126
Shorelines	32	32	64
Beaches & Dunes	27	26	53
Tidal Wetlands & Flats	38	47	85
Estuaries	43	39	82
Marine Nearshore	56	37	93
Marine Offshore & Oceanic	51	24	75
Agriculture: Plantations & Orchards	18	22	40
Agriculture: Croplands & Pastures	29	46	75
Developed Areas	14	23	37

2.0.2 HABITAT SPATIAL DATASETS

Several national and regional geospatial datasets provide high-resolution information on terrestrial and aquatic habitats in the Northeast that can help states in their Wildlife Action Plan revisions by providing resources for habitat availability and status. The **National Land Cover Dataset** (NLCD)[5] issues geo-spatial land cover datasets at 30-meter resolution for the entire country every three to five years, with the dataset for 2019 issued in 2022. The 2019 NLCD release includes a suite of 28 different land cover products that characterize the nation's land cover changes from 2001 to 2019, the extent and change of impervious surfaces in urban areas, and the characterization of tree canopy and its changes. Sixteen land cover classes are included in NLCD datasets, including both natural (e.g., forest, wetlands) and anthropogenic types (e.g., developed, agricultural). NLCD products are available at the **Multi-Resolution Land Characteristics Consortium**, a federal partnership[6].

The **Landscape Fire and Resource Management Planning Tools (LANDFIRE) Program** provides and periodically updates more than 30 national geo-spatial datasets, databases and ecological models of land cover, disturbance, and fire-management related variables at a 30-meter pixel resolution[7]. LANDFIRE land cover datasets are based on NatureServe terrestrial ecological systems, a subset of the International Ecological Classification Standard for the continental United States (NatureServe 2018). In recent years LANDFIRE spatial datasets have been updated every two to three years. As of 2022 the Program plans to issue updates on an annual basis. The Nevada Department of Wildlife recently has incorporated LANDFIRE tools in their 2023 SWAP revision[8].

Regionally, several partner programs have developed geo-spatial datasets for the Northeast region. The Nature Conservancy (TNC) and several partners utilized the 2001 NLCD dataset and other datasets to develop the **Map of Terrestrial Habitats of the Northeastern United States** (Ferree and Anderson 2013). Separate projects to classify the Northeast's freshwater aquatic habitats classified and mapped the region's rivers and streams (Olivero-Sheldon et al. 2015) and lakes and ponds (Olivero-Sheldon and Anderson 2016). Products associated with these spatial datasets of the region's habitats include the distribution, extent, and condition of 140 terrestrial and aquatic habitat macrogroups based on NatureServe ecological systems (NatureServe 2018). Anderson et al. (2013a) and (2013b) provide guides for each habitat (or ecological system) with detailed information on its characteristics, distribution, and condition, which are available online[9].

The **Designing Sustainable Landscapes (DSL)** project at the University of Massachusetts built upon the Map of Terrestrial Habitats of the Northeastern United States by augmenting it with additional spatial datasets, including more detailed datasets for aquatic and wetland habitats and developed areas and transportation infrastructure. DSL datasets include 153 land cover types or ecosystems[10]. The DSL Index of Ecological Integrity dataset for the region's habitats (at a 30-meter resolution) includes metrics on the habitat's ecological setting, intactness, connectedness, and resiliency (McGarigal et al. 2018a). This project has also developed several ecological models to assess the landscape capability to support many individual RSGCN and Watchlist species, including Moose (*Alces alces*), American Woodcock (*Scolopax minor*), Blackpoll Warbler (*Setophaga striata*), Eastern Meadowlark (*Sturnella magna*), Prairie Warbler (*Setophaga discolor*), Ruffed Grouse (*Bonasa umbellus*), Wood Thrush (*Hylocichla mustelina*), Brook Trout (*Salvelinus fontinalis*), and Wood Turtle (*Glyptemys insculpta*). The DSL SPRAWL model predicts the location and extent of development in the Northeast for 2030 to 2080 (McGarigal et al. 2018b), recently updated to 2040 and 2080[11]. Other geo-spatial datasets developed by DSL for the Northeast region include terrestrial and aquatic core areas, local and regional landscape conductance for animal and plan dispersal, future condition impacts of development and climate change, and several tools to inform restoration project impacts[12].

Table 2.0.3 summarizes the composition of the Northeast region for the non-marine, surface habitats as of 2011-2013 from the most recent DSL land cover map and dataset (DSLland ver. 5.0). More than 161 million acres of land was mapped, with the majority (52%) consisting of Forest and Woodland habitat. Nearly 17% of the landscape, more than 27 million acres, was in Agricultural land uses and more than 13% Developed Areas (21.8 million acres). The habitats of the marine area of the Northeast region were mapped in a separate project by The Nature Conservancy in 2010, delineating over 88.9 million acres of benthic marine habitat (Greene et al. 2010). Altogether the Northeast region therefore includes approximately 250 million acres of lands and waters, 36% of which are marine waters.

Table 2.0. 3 The known extent of mapped regional habitats for Northeast RSGCN and Watchlist species as of 2011-2013 from Designing Sustainable Landscapes (DSLland data layer, version 5.0). See Appendix 2B for the list of DSLland ecosystems associated with each type.

Habitat Type	Northeast Area as of 2011-2013 (acres)	Proportion of Mapped Area
Forests & Woodlands (inc. High Elevation Forest)	84,035,730	52.2%
Grasslands & Shrublands	1,794,455	11.1%
Glades, Barrens & Savanna	1,755,155	1.1%
Alpine	8214	0.0%
Cliff & Talus	667,681	0.4%
Non-tidal Wetlands	7,923,851	4.9%
Rivers & Streams (inc. Big Rivers)	4,626,298	2.9%
Tidal Rivers & Streams	181,218	0.1%
Riparian & Floodplains	1,153,649	0.7%
Great Lakes	3,082,769	0.3%
Lakes & Ponds	458,192	1.9%
Rocky Shorelines	23,929	0.0%
Beaches & Dunes	113,387	0.1%
Tidal Wetlands & Flats	1,199,413	0.7%
Estuaries	5,018,787	3.1%
Agriculture: Plantations & Orchards	1,816,311	1.1%
Agriculture: Croplands & Pastures	25,375,270	15.8%
Developed Areas	21,809,856	13.5%
Total Area Mapped†	**161,044,165 acres**	**100%**

† Note that the DSLland data layer (ver. 5.0 issued in 2020), included an additional 5.8 million acres of the Marine Nearshore seascape, which is not the entirety of the Northeast region's area for that habitat type.

‡ Note that Grassland and Shrubland are merged, Big Rivers are included in Rivers and Streams, High Elevation Forest is included in Forests and Woodlands, Subterranean Areas are excluded since they are underground, and regional data are incomplete for the Marine Nearshore and Marine Offshore and Oceanic habitats.

2.0.3 HABITAT PRIORITIZATION RESOURCES

This section reviews 11 habitat prioritization resources that can help states identify or evaluate habitats as part of their Wildlife Action Plan revisions. Nationally, Hamilton et al. (2022) identified priority landscapes for conservation to protect biodiversity (Figure 2.0.2). Virginia contains the 8th highest total area of unprotected biodiversity importance for imperiled vertebrate species (4774 acres) and the 9th highest for freshwater invertebrates (2939 acres) according to this analysis. No other NEAFWA states are ranked in the top ten nationally in the area of unprotected biodiversity importance for all taxa, plants, vertebrates, freshwater invertebrates or pollinators.

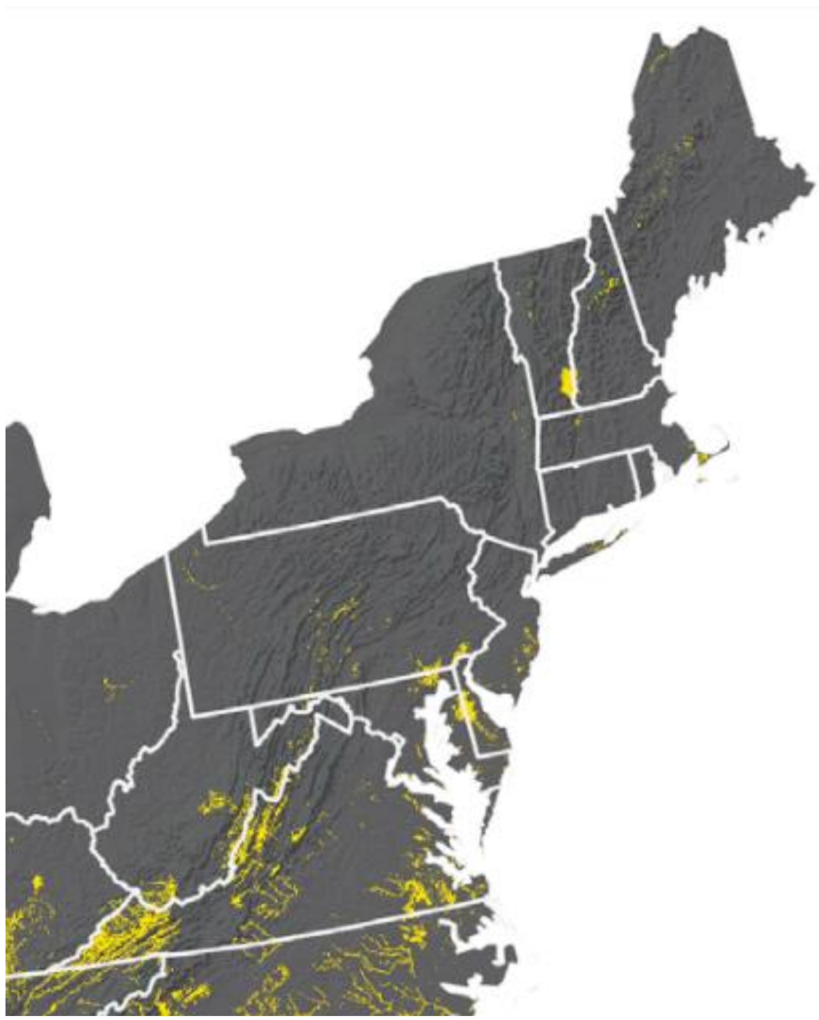

Figure 2.0. 2 Areas of Unprotected Biodiversity Importance in the Northeast (shown in yellow) identified by Hamilton et al. (2022).

Regionally, Terwilliger Consulting Inc. (TCI) and the Northeast Fish and Wildlife Diversity Technical Committee (NEFWDTC; 2017) synthesizes habitat information in the 14 Northeast SWAPs of 2015, identifying common themes and trends to inform regional conservation priorities. The most common threats to Northeast habitats identified in 2015 SWAPs were 1) pollution, 2) invasive species, 3) natural system modification (e.g., dams and barriers to flow, fire management, and activities or lack thereof that result in vegetation community succession), 4) residential and commercial development and 5) climate change. The habitat type with the greatest number of unique threats was wetlands, followed by rivers and streams and forests.

Tracey and Fuller (2017) analyzed habitat associations for SGCN in the 14 Northeast SWAPs of 2015. Species observations were overlaid on a map of refined habitat classifications based on the Northeast Terrestrial Wildlife Habitat Classification System (Ferree and Anderson 2013) but also considering ecological system information, distance from aquatic features, and hydrologic units. This assessment of each habitat type's importance across all SGCN allowed for habitat ranking based on strong association with imperiled species (Tracey and Fuller 2017, see Table 4). This is a summary of the types of habitats that were highlighted in the top 25:

- Small streams
    - Cool with low or moderate flow
    - Warm with low or moderate flow
- River Floodplains
- Small Ponds
- Headwaters and creeks
    - Warm with low flow
    - Cool with low flow
- Southern Ridge and Valley/Cumberland Dry Calcareous Forest
- North Atlantic Coastal Plain Heathland and Grassland
- North Atlantic Coastal Plain Pitch Pine Barrens
- Atlantic Coastal Plain Beach and Dune

TCI and NEFWDTC (2017) then identified Regional Habitats of Greatest Conservation Need (RHGCN). The RHGCN are based on the SWAP Analysis, the RCN-funded habitat condition analysis (Anderson et al. 2013b, Anderson and Weaver 2015), and the regional analysis of habitat for imperiled species (Tracey and Fuller 2017). These analyses, taken together, assess habitat importance by considering imperiled species associated with habitats, current level of habitat protection, and the number and severity of threats affecting the habitat. Based on the available information, the following habitats are considered RHGCN:

- Forests – particularly:
    - Large intact cores in Central Oak-Pine and Northern Hardwood forests

    - Pine Barrens
- Wetlands – particularly:
    - Riparian and Floodplains
    - Peatlands
    - Swamps and Marshes
- Rivers and Streams – particularly:
    - Small to medium streams with low to moderate flow
    - Large Rivers
- Estuaries

Forest types, particularly Central oak-pine and Northern Hardwood are priority habitats because so many SGCN and RSGCN are found in these habitats and so many threats are associated with them. However, some smaller spatial extent habitats are also high priorities because comparatively large numbers of species are found in them. Many of these habitats are hydrologically defined – wetlands, rivers and streams, and estuaries are all high priority habitats.

Habitat fragmentation, degradation, and loss of natural system functions were key impacts to be addressed in forested habitats across the region. SWAPS cited the need for landscape level planning for fish and wildlife diversity to maintain large core areas with connectivity for RSGCN in habitat management efforts in the Northeast (TCI and NEFWDTC 2017).

Nature's Network provides a more detailed regional habitat prioritization tool developed in 2017 by the USFWS and partners. The **Nature's Network Conservation Design** "depicts an interconnected network of lands and waters that, if protected, will support a diversity of fish, wildlife, and natural resources that the people of the Northeast and Mid-Atlantic region depend upon. This [Conservation Design] … outlines some of the most important natural areas in the region and provides an entry point to learn more about the information used to identify them"[13]. The **Prioritization Tool** allows users to interactively display and then download custom datasets for a particular area and range of environmental, species or habitat data layers to inform decision-making[14].

Datasets available on Nature's Network include several developed by the DSL project[15]:

- Habitats for Imperiled Species, Northeast US (including Core Habitat, Habitat Condition, and Habitat Importance)
- Terrestrial and Wetland Core Network (including Terrestrial Ecosystem Core Areas, Grassland Bird Core Areas, Index of Ecological Integrity, Resilience by Setting and Ecoregion, Probability of Development 2030, and Probability of Development 2080)

- Aquatic Core Networks (including Lotic Core Areas, Lentic Core Areas, Aquatic Buffers, Aquatic Index of Ecological Integrity, Freshwater Resilience by Watershed, Important Anadromous Fish Habitat, and data layers for Brook Trout and Common Loon)
- Connectivity (including Marsh Migration Zones and Regional Flow with Anthropogenic Resistance)
- Terrestrial and Aquatic Habitat Map (from DSL)
- Landscape Capability Species Models

The Northeast Climate Adaptation Science Center (NE CASC) and the **Refugia Research Coalition** also have developed regional habitat prioritization data, namely priority areas that can serve as climate change refugia for the region's wildlife[16].

The Nature Conservancy and partners have conducted a series of assessments to identify resilient and connected landscapes in the Northeast region and beyond (Anderson et al. 2016a, 2016b). Their **Resilient Land Mapping Tool identifies a Resilient and Connected Network** with areas "where high microclimatic diversity and low levels of human modification provide species with connected, diverse climatic conditions they will need to persist and adapt to changing regional climates"[17]. Priority areas that serve as **National Strongholds** support exemplary habitats, wildlife, or rare species that may provide climate change refugia. Sites are characterized with a **Resilience Score** that estimates the capacity of the site to maintain species diversity and ecological function with a changing climate. Recognized **Biodiversity Values** are incorporated into these analyses and available on the interactive mapping tool (Figure 2.0.3).

The **Predicting Biodiversity with Generalized Joint Attribute Models (PBGJAM)** project soon will be an updated open-access, interactive web portal that tracks climate change effects on thousands of North American species and their food webs over time[18]. Currently the PBGJAM database includes recorded observations over time for more than 2000 species of small mammals, birds, beetles, and trees. An effort adding millions of additional observations is underway, expanding the capabilities of the datasets and models. The goal of the project is to identify critical habitats for priority conservation.

The **Staying Connected Initiative** is an international public-private partnership that seeks to maintain landscape connectivity in the Northeast region[19]. The partnership focuses on land conservation to protect critical wildlife corridors, land use planning tools to inform sustainable development, efforts to improve the safety of roads for wildlife and people, conservation science projects, education and outreach, and

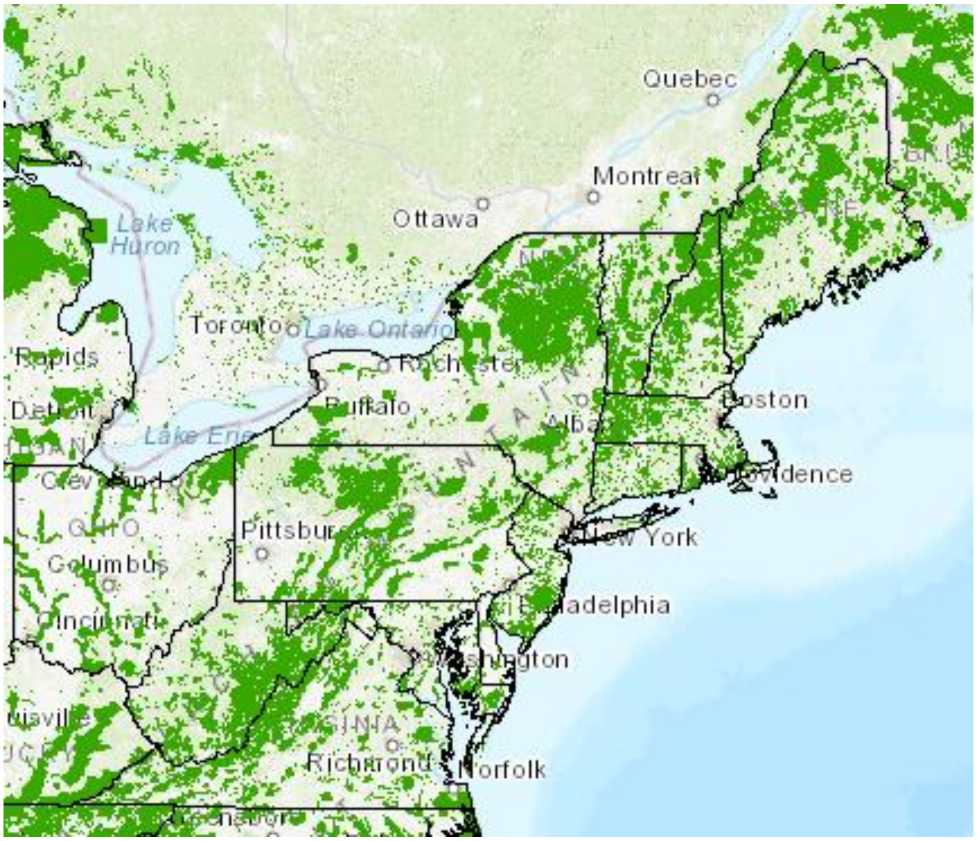

Figure 2.0. 3 Areas of the Northeast region identified with Recognized Biodiversity Value (shown in dark green) as part of the Resilient and Connected Network by Anderson et al. (2016a, 2016b).

development of policies to promote connectivity best practices. The Initiative has a collection of more than 100 resources for the region that can assist in habitat prioritization, including multiple state and local connectivity assessments, planning toolboxes, maps, and guidance documents.

Several NEAFWA states have habitat prioritization resources to inform state and local scale conservation. In Massachusetts, **BioMap3** was released in late 2022[20]. The Massachusetts SWAP used Key Sites, based on BioMap2, to identify and target the most important sites for biodiversity protection and habitat management. Key sites were identified using three criteria:

1. Sites with a concentration of co-occurring rare species listed under Massachusetts Endangered Species Act
2. Sites with the best-quality occurrences of high-priority species or natural communities (e.g., globally rare species)

3. Multiple, co-occurring, landscape-level resources, as identified by BioMap2.

The clear selection criteria, strategic nature, and limited spatial extent (key sites account for about 10% of Massachusetts) help justify conservation efforts by states and partners. Actions taken in key sites are typical land protection or restoration and may be intended to limit the impact of threats like development, climate change, and vegetative succession. An approach to prioritizing biodiversity hotspots that promise to be resilient under changing climates is to preserve geodiversity across landscapes.

The **Pennsylvania Conservation Opportunity Area Tool**[21] is a component of the 2015-2025 Pennsylvania Wildlife Action Plan with an update released in November 2022. The Pennsylvania Conservation Opportunity Area (COA) Tool can be explored in several ways:

- Discover Species of Greatest Conservation Need in a user-defined area of interest.
- Develop an output report with actions identified to support the species and habitats in an area of interest.
- Produce a list of Species of Greatest Conservation Need by county or watershed.
- See range maps for most Species of Greatest Conservation Need.

The COA Tool expands access to core components and facilitates use of the Pennsylvania Wildlife Action Plan.

In late 2022 the **Connecting Habitats Across New Jersey (CHANJ)** tool was updated to provide a strategic plan for wildlife conservation in the state, identifying key areas and the actions needed to preserve and restore habitat connectivity for terrestrial wildlife[22]. CHANJ includes both an interactive mapping tool that facilitates state and local scale conservation planning and a guidance document for mitigation of road barriers to wildlife and their habitats. The 2015 **Vermont Conservation Design**[23], identifies the lands and waters identified in state that are of highest priority for maintaining ecological integrity. Together they comprise a connected landscape of large and intact forested habitat, healthy aquatic and riparian systems, and a full range of physical features on which plant and animal SGCN depend. An update using LIDAR data will be completed in December 2023.

NATURAL HABITATS

Habitat utilized by Northeast RSGCN and Watchlist species are predominantly natural but occasionally anthropogenic as well, particularly as Developed Areas and Agricultural habitats convert and fragment natural habitats across the region. RSGCN and Watchlist species may be habitat specialists or generalists found in multiple habitat types. The Northeast RSGCN Database (version 1.0) does not prioritize habitat associations for each species but does note whether the species is a habitat specialist and habitat characteristics or preferences associated with the use of each habitat type. The remainder of this Chapter provides the best available information on each of the 24 habitat types at the regional level for availability, status, and condition. Resources and tools available for habitat management and monitoring are described, as well as conservation partners and citizen science programs and projects contributing to the conservation of each habitat type. A list of habitat information, research, and monitoring needs complete each habitat section.

2.1 FORESTS AND WOODLANDS

Figure 2.1.1 Forest and Woodland habitats support 262 Northeast RSGCN and Watchlist species.

2.1.1 HABITAT DESCRIPTION

Forest and Woodland habitats in the Northeast include multiple types, from the Boreal Upland forests of New England to the Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland of Virginia. Forests have at least 10% tree cover with tree heights exceeding 5 meters (Gawler 2008). The status and condition of Forest and Woodland habitat in the Northeast was assessed in 2011 by Anderson and Olivero-Sheldon (2011) and updated by Anderson et al. (2023), divided into four major forest types: Boreal Upland, Northern Hardwood and Conifer, Central Oak-Pine, and Ruderal. Ruderal forests are discussed under Agriculture: Plantations and Orchards (Section 2.23) below. Anderson et al. (2023) describes the characteristic trees and settings for each of these major forest types.

Forest and Woodland habitats are those with at least 25% tree canopy with woody vegetation of at least 5 meters (m) in height (NatureServe 2022). Forests have at least 60% canopy closure, while Woodlands have a discontinuous canopy cover that ranges from 25 to 60%. In the NEAFWA region, the 14 SWAPs of 2015 included 109 Key Habitats for SGCN within Forests and Woodlands habitat (*Appendix 2A*, Table 2A.1). Examples include maritime, hardwood, pine, conifer, and early successional forests. Note that Pine Barrens are classified as Glades, Barrens, and Savanna habitat for Northeast RSGCN and Watchlist species (Section 2.5).

A few very large blocks of forest in the region are designated as Important Bird Areas of global importance by the National Audubon Society. Nearly 17.8 million acres of forest in northern Maine, nearly 6.1 million acres in the Allegheny Mountains of West Virginia, more than 4.7 million acres in the Adirondack Mountains of New York, and more than 3.3 million acres on the southern Allegheny Plateau of West Virginia all are recognized for their global importance to birds.

Forest and Woodland habitat in the Northeast is tied with Non-tidal Wetlands (Section 2.9) as having the third highest number of RSGCN and Watchlist species (262) of any habitat type. There are 126 RSGCN, six Proposed RSGCN, 98 Watchlist [Assessment Priority], and nine Proposed Watchlist species across ten taxonomic groups associated with Northeast Forest and Woodland habitat (*Supplementary Information 2*, Table 2.1.1, Figure 2.1.2). Another 23 species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. Lepidoptera are the largest group of RSGCN and Watchlist species in Forest and Woodland habitats of the Northeast (Figure 2.1.2). Nineteen RSGCN and Proposed RSGCN species are of Very High Concern with at least 75% of their range in the Northeast: nine amphibians, four Lepidoptera, four terrestrial snails, one firefly, and one mammal.

Table 2. 1.1 The number of species in each RSGCN and Watchlist category associated with Forests and Woodlands habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	126
Proposed RSGCN	6
Watchlist [Assessment Priority]	98
Proposed Watchlist [Assessment Priority]	9
Watchlist [Deferral to adjacent region]	23
TOTAL	**262**

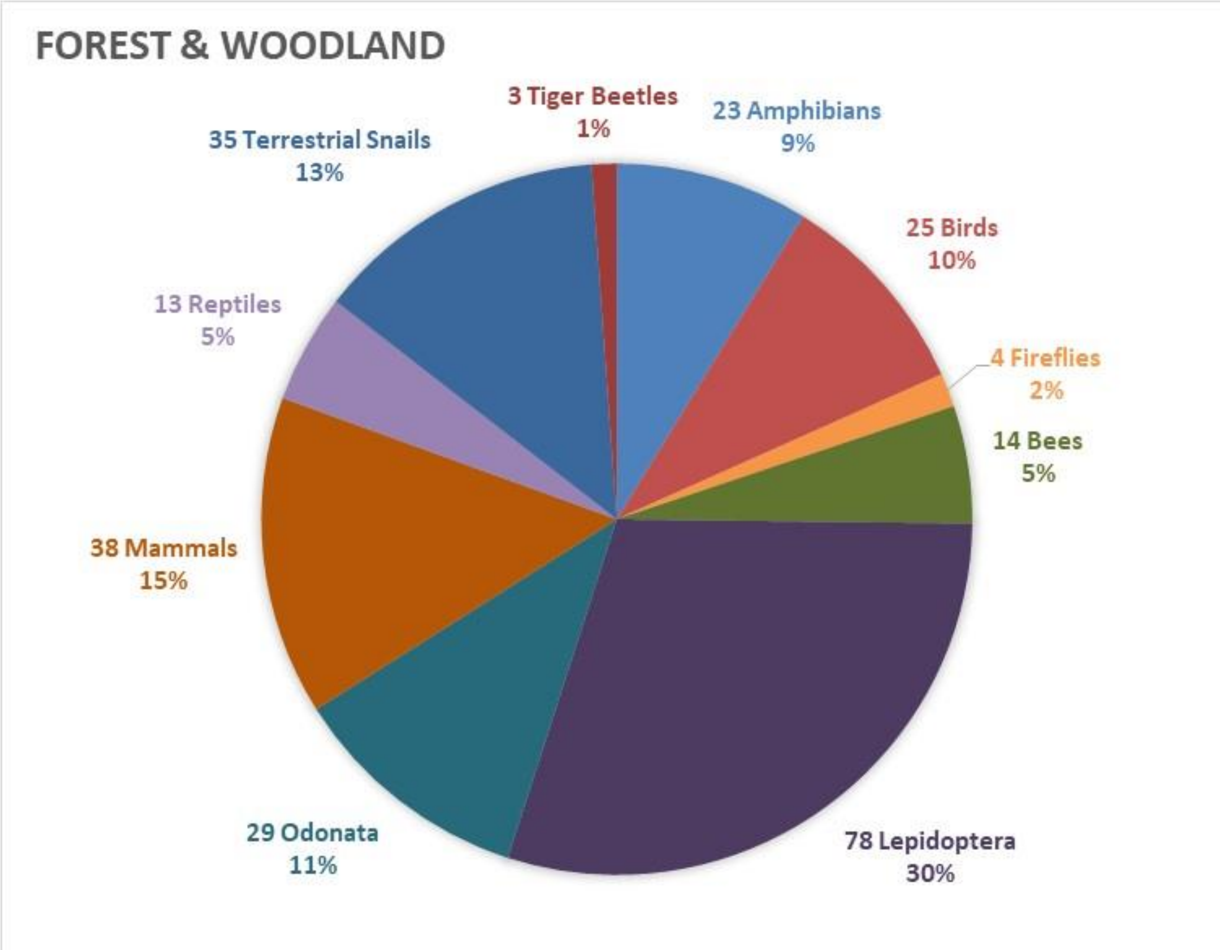

Figure 2.1. 1 Northeast RSGCN and Watchlist species associated with Forest and Woodland habitats represent ten taxonomic groups.

Habitat features and formations of Forests and Woodlands associated with RSGCN and Watchlist species in the Northeast RSGCN Database (version 1.0) include preferences for interior or edge habitat, snags, logs and woody debris, surface litter, burrows, the presence of outcrops and epikarst, and anthropogenic structures (TCI and NEFWDTC 2023). Other habitat data fields related to RSGCN species use of Forest and Woodland habitat include preferences for specific forest types, age classes, substrate characteristics, vegetation densities, and fire dependency.

2.1.2 HABITAT DISTRIBUTION AND CONSERVATION

Forest and Woodland habitat is the most extensive terrestrial habitat type in the Northeast, covering 96 million acres in 2009 (Anderson and Olivero Sheldon 2011). Forest types vary across the region, with the forests of New England and New York predominantly composed of northern hardwoods and boreal upland forests mostly restricted to the northern portion of the region. Central oak-pine is the most common forest type in the southern, Mid-Atlantic portion of the region (Anderson and Olivero Sheldon 2011).

Of the Forest and Woodland habitat in the Northeast, 20 million acres were known to be conserved as of 2011 (Anderson and Olivero Sheldon 2011). Boreal forests were the most protected, with 30% known to be secured against conversion in 2011, while 23% of northern hardwood forests and 17% of central oak-pine forests were secured against habitat conversion. However, only a fraction of these conserved Forest and Woodland habitats are protected specifically for conservation purposes as opposed to management for multiple uses, including forest management. Anderson et al. (2023) provides an updated assessment of conserved Forest and Upland habitat throughout the Northeast region.

The **Old-Growth Forest Network** is a national network of old-growth or mature native forests that are protected, established in 2011, and headquartered in Maryland[24]. As of 2022, the Old-Growth Forest Network included 185 Forests in 32 states. The goal of the Network is to locate and designate at least one protected Forest in every county that can sustain a native forest. Each Forest in the network must be protected from logging and open to the public. Pennsylvania has the highest number of registered Forests of all participating states, with 26, and New York has the third highest, with 18 (Ohio is number two). Every NEAFWA state except Maine and the District of Columbia has at least one Forest in the Old Growth Forest Network, for a total of 92 (50% of the national total as of 2022).

2.1.3 HABITAT CONDITION

The Northeast region historically (pre-Colonial) was 91% covered by forests but nearly one-third, 38.6 million acres, had been converted to agriculture and development as of 2009. An estimated 25 million acres of historical Forest and Woodland habitat have been converted to agriculture, and 13 million acres lost to development. More Forest and Woodland habitat has been lost, proportionally, in the Mid-Atlantic than in New England and New York (Anderson and Olivero Sheldon 2011). Anderson and Olivero-Sheldon (2011) assessed the status and condition of Forest and Woodland habitat in the Northeast as of the early 2000s.

Threats to the multiple finer scale habitat types within this coarse Northeast Forest and Woodland habitat vary by location and type but include Development (Threat 1.0), Agriculture (Threat 2.0), Roads and Transportation (Threat 4.1), Logging (Threat 5.3), and Invasive Species, Pests, and Pathogens (Threat 8.0) like excessive deer herbivory (Threat 8.2.2),. These threats convert and fragment Forest and Woodland habitats, with a significant proportion converted to other habitat types at least temporarily between 2001 and 2021 (Anderson et al. 2023).

732,000 miles of permanent roads fragment Northeast Forest and Woodland habitat. Large forest habitat blocks of at least 250,000 acres in patch size are uncommon, reducing Forest and Woodland connectivity by nearly 60% as of 2011 (Anderson and Olivero Sheldon 2011). The most fragmented forest type is oak-pine forest, while boreal upland forest is the most connected. The least fragmented areas of Forest and Woodland habitat as of 2019 were in northern New York, Maine and New Hampshire (Anderson et al. 2023). Between 2010 and 2019 changes in Forest and Woodland habitat fragmentation appear to be localized with increasing fragmentation in areas of suburban development. Anderson et al. (2023) found that land protection appears to have been an effective strategy to prevent habitat fragmentation in Forest and Woodland habitat because there is a high proportion of protected land within the remaining large contiguous forest blocks.

Anderson et al. (2023) provides a detailed assessment of habitat condition, loss, fragmentation, and resilience of Northeast Forest and Woodland habitat as of 2019 as well as trends over the past two decades. Anderson et al. (2016a and 2016b) assessed the resiliency and connectedness of habitats of the eastern United States at the landscape scale, identifying resilient sites for conservation. Staudinger et al. (2023) summarizes the state of knowledge of Forest and Woodland habitat resiliency to climate change.

2.1.4 HABITAT MANAGEMENT

Forest and Woodlands are managed at the state level with a **State Forest Action Plan (SFAP)** outlining conservation strategies and priorities similar to a SWAP to receive federal funding as authorized by the Cooperative Forestry Assistance Act[25]. State Forest Action Plans are required to incorporate SWAP information, which states have done in their habitat assessments, strategies, and shared priorities or goals. The State Forest Action Plans of the Northeast were updated in 2020. The US Forest Service and **Northeast-Midwest State Foresters Alliance** synthesized the 2020 State Forest Action Plans of the Northeast and Midwest and released a regional summary report in 2022 (USFS and Northeast-Midwest State Foresters Alliance 2022a). With State Forest Action Plans updated on a ten-year cycle that falls halfway between the ten-year cycle of SWAPs, the regional summary report identified “tremendous opportunities for further collaboration on wildlife habitat strategies with state and regional wildlife and forestry agencies, organizations, and other partners” (USFS and Northeast-Midwest State Foresters Alliance 2022a, p. 15).

The regional summary report identifies 14 common themes across the 21 State Forest Action Plans, including wildlife habitat, adaptation to climate change and carbon management, forest health, clean water, wildfire and prescribed fire, sustainable forest management on public and private lands, forest-based recreation, and others. Three regional themes address wildlife habitat (USFS and Northeast-Midwest State Foresters Alliance 2022a, p. 15):

- Wildlife habitat protection: *Use land conservation tools to provide forests for wildlife habitat and corridors for wildlife diversity and species of greatest conservation need as identified in the SWAP.*
- Wildlife habitat enhancement and restoration: *Proactively manage for wildlife diversity with techniques that increase age-class and structural diversity. Support nurseries to provide native trees and shrubs important for wildlife. Use prescribed burns and other practices to restore natural disturbance regimes and provide diversity in forest age structure. Improve tools to identify where rare ecological features are located and help forest landowners manage for them.*
- Collaborative engagement: *Work with the state fish and wildlife agency and other partners and support strategies in the SWAP and SFAP for landscape-level habitat conservation and enhancement.*

The US Forest Service and Northeast-Midwest State Foresters Alliance produced an accompanying **Landscape Scale Conservation Interactive Web Map** that displays multistate priorities identified in the 2020 State Forest Action Plans. There are 15 landscape scale priority areas in the Northeast and 18 in the Mid-Atlantic, with five of them shared across the subregions (USFS and Northeast-Midwest State Foresters Alliance 2022b). Individual State Forest Action Plans are available online through the **National Association of State Foresters**[26].

The **Best Management Practices (BMPs) for RSGCN Species in Northeast Forests** RCN Project (see *Chapter 4* for details) collaborated with several species-level conservation and research initiatives and with key forest stewards to integrate current ecological and biogeographic information into on-the-ground Forest and Woodland habitat enhancement. This collaboration produced spatially explicit management and conservation support for five SGCN: Bicknell's Thrush (*Catharus bicknelli*), Wood Thrush (*Hylocichla mustelina*), Canada Warbler (*Cardellina canadensis*), Rusty Blackbird (*Euphagus carolinus*), and American Marten (*Martes americana*). The project produced scientifically sound and practical guidelines for conserving these species and other SGCN in their guilds. Available occurrence data, distribution models, and stakeholder input delineated and prioritized areas with high management and conservation potential. Working directly with habitat stewards ensured that the recommended practices are implemented in management and conservation opportunity areas. Results include compiled field guides and guidelines to managing habitat for RSGCN in the Northeast and Mid-Atlantic Forests (2017), a final report and compiled spatial prioritization for implementing these guidelines for RSGCN.

The **Young Forest Project** is a partnership with a mission to enhance and maintain the availability of early successional, young Forests and Shrublands for wildlife. Partners include state and federal agencies, the Mashpee Wampanoag Tribe, NGOs, National Fish and Wildlife Foundation, businesses, academia, land trusts, and NEAFWA. Best management practices, instructional guides and manuals, and a list of demonstration site projects in the Northeast, Mid-Atlantic and Midwest are provided on the project website[27]. Specific guidance to enhance Forest habitat is available for RSGCN New England Cottontail (*Sylvilagus transitionalis*), Golden-winged Warbler (*Vermivora chrysoptera*), Eastern Whip-poor-will (*Antrostomus vociferus*), Rusty Blackbird, and Bicknell's Thrush and the Watchlist Canada Warbler.

Managing Grasslands, Shrublands, and Young Forest Habitats for Wildlife: A Guide for the Northeast includes recommendations on improving wildlife habitat condition in Forests and Woodlands (Oehler et al. 2006). Chapter 5 of this guide, "Managing Regenerating and Young Forest Habitat," describes options for wildlife and timber management from a landscape perspective. Chapter 6 focuses on management guidelines for small Forest openings.

As the climate continues to change, vulnerable Forest and Woodland-associated wildlife species need management strategies to help them adapt to these changes. One specific management strategy is based on the idea that in certain locations, climate conditions will remain suitable for species to continue to inhabit into the future. The main objective of the **Refugia are Important but are they Connected? Mapping Well-Connected Climate Refugia for Species of Conservation Concern in the Northeastern U.S.** project by the Northeast Climate Adaptation Science Center (NE CASC) was to provide a map of projected refugia networks present in 2080 for each of ten SGCN in the Northeast (DeLuca 2021). This project provides maps of well-connected potential refugia that could remain crucial habitat for wildlife given current and future changes in climate projections[28]. Maps of refugia connectivity will also support the prioritization of on-the-ground habitat management in the region. Forest and Woodland habitats for RSGCN Bicknell's Thrush (*Catharus bicknelli*), Cerulean Warbler (*Setophaga cerulea*), American Woodcock (*Scolopax minor*), Eastern Box Turtle (*Terrapene carolina*), Wood Turtle (*Glyptemys insculpta*), Spotted Turtle (*Clemmys guttata*), and Watchlist species Moose (*Alces alces*) are included in this project.

The **US Forest Service Forecasts of Climate-Associated Shifts in Tree Species (ForeCASTS)** has developed maps identifying future suitable Forest habitat ranges for

213 tree species across the US and globally[29]. Future Forest habitat suitability maps are available for 2050 and 2100 under multiple climate and emissions scenarios. The atlas of maps also identifies the minimum required movement, which quantifies the distance between current habitat locations that may become unsuitable and the nearest future suitable habitat. ForeCASTS intends to assist conservation partners and managers to target priority tree species for monitoring, conservation, and adaptive management.

Another adaptive management strategy for Forest and Woodland habitat is assisted natural regeneration. Cook-Patton et al. (2020) assessed the best techniques for forest regeneration and potential carbon accumulation. This assessment developed a map at 1-kilometer resolution that identifies the best techniques for the entire world – natural regeneration, assisted natural regeneration, or planting of seeds or saplings.

Staudinger et al. (2023) describes the state of knowledge of adaptive management of Forest and Woodland habitats to climate change. State Forest Action Plans also describe climate adaptation strategies for the region's Forests and Woodlands[26].

2.1.5 HABITAT MONITORING

Forest and Woodland habitat is included as a regional performance monitoring metric for the Northeast (NEAFWA 2008). Anderson and Olivero-Sheldon (2011) conducted a conservation status assessment for Forests and Woodlands in the Northeast as per this regional monitoring framework prior to the 2015 SWAPs. Anderson et al. (2023) updates the conservation status of Forest and Woodland habitat in the Northeast for the 2025 SWAPs.

The US Forest Service conducts an annual census of Forests and Woodlands with its **Forest Inventory and Analysis (FIA) Program**[30]. The program assesses Forests and Woodlands by collecting data on tree species composition, size and health as well as tree growth, mortality and removals by harvest. Anderson and Olivero Sheldon (2011, p. 4-22) analyzed FIA data for the region and found that "forests in this region are not simply growing back after 19th century clearing but are actively being maintained in a young state with small diameter trees."

The distribution and extent of Forest and Woodland is monitored through several remote sensing land cover assessment programs. The National Land Cover Dataset maps the extent of three types of Forest (deciduous, evergreen and mixed) every three years. LANDFIRE includes multiple types of Forest and Woodland habitats within their spatial land cover datasets, which have been updated every two to three years but will be updated annually starting in 2022. Regionally, the Designing Sustainable Landscapes program at the University of Massachusetts monitors the extent of two subtypes of Forest and Woodland (boreal upland forest and northeastern upland forest) in the Northeast by combining multiple spatial datasets, including NLCD.

The US Forest Service also monitors Forests and Woodlands via remote sensing and has developed a field sampling protocol to pair with remote sensing data to monitor carbon in Forests and Woodlands[31].

2.1.6 PARTNERS

Multiple programs, projects, and initiatives of the US Forest Service offer partnership opportunities in the Northeast to conserve Forests and Woodlands. The federal agency manages the tribally guided **Intertribal Nursery Council** to advance the interests of Indigenous peoples involved with plant production in nurseries[32]. The goals of the Intertribal Nursery Council are to share information and technology transfer, preserve ecological knowledge, provide nursery training, conduct conservation education, and contribute to reforestation and habitat restoration projects by propagating native plants. The **Nursery Manual for Native Plants: A Guide for Tribal Nurseries** handbook contains detailed information on native plant propagation from seed collection to holistic pest management (Dumroese et al. 2009).

The US Forest Service maintains a **National Seed Laboratory** that propagates seeds of native plants for conservation and restoration projects and conducts research on restoring and sustaining native plant communities[33]. The Laboratory has developed a **Native Plant Protocol** for handling, germinating and storing seeds, provides training materials to transfer technology, and conserves seeds for genetic diversity. The **Reforestation, Nurseries and Genetic Resources Program** is a collaborative partnership sponsored by the US Forest Service to share technical information with land managers and nurseries related to the production and planting of trees and other native plant species for reforestation, restoration and conservation of Forests and Woodlands[34]. Numerous guidelines and resources have been developed by the Program and its partners, including a **Propagation Protocol Database** and the **Native Plant Network**.

The US Forest Service **Landscape Scale Restoration Grant Program** is a competitive grant program to address landscape level issues on state, tribal, and private Forests and Woodlands such as watershed protection and restoration, the spread of invasive species, disease, insect infestation, and wildfire risk reduction. Conservation strategies of State Forest Action Plans are prioritized and projects are evaluated and awarded regionally. A **Landscape Scale Restoration Manual** and **Landscape Scale Restoration Project Planning Tool** are available to guide conservation

Maine Woodlands

In 2020 the Maine Forest Service and Maine Natural Areas Program were awarded Landscape Scale Restoration Grant funding for the ***Mapping, Prioritizing, and Controlling Invasive Plants in Maine Woodlands*** *project. This project will develop an invasive plant landscape plan, a manual of science-based strategies detailing how to survey, map, prioritize, and control invasive plants, and conduct in-depth training. Financial incentives for private landowners to prepare Invasive Plant Control Practice Plans will be competitively funded, with follow-up monitoring of treatment efficacy.*

projects. An inventory of Landscape Scale Restoration Projects is available online through the program[35].

The **Northeast-Midwest State Foresters Alliance** is a partnership of state forestry agencies across 20 states in the Northeast, Midwest and the District of Columbia[36]. The mission of the organization is to collaboratively protect, conserve, and manage the Forests and Woodlands of the region. Best management practices have been developed by the **National Association of State Foresters** for forestry practices to protect water quality in adjacent aquatic habitats and are available[37].

The USFWS Forest Songbirds Team is partnering closely with the **Appalachian Mountains Joint Venture (AMJV)**, whose geography overlaps with the core breeding areas of three forest birds identified as At-Risk Species (Golden-winged Warbler, Cerulean Warbler, and Wood Thrush), to engage and support private and public forest landowners in implementing forest management practices that enhance the age and structural diversity of Eastern deciduous forests. A good example of this is a collaborative project this Team initiated between the USFWS's Partners for Fish and Wildlife program, Natural Resources Conservation Service, and West Virginia Department of Natural Resources that is providing assistance to private landowners in implementing the forest management activities identified as required practices under landowner incentive programs. The Forest Songbirds Team looks to collaborate on these kinds of activities within focal landscapes identified within the AMJV geography as well as additional focal areas outside of the AMJV that are important for these three At-Risk forest songbirds. They plan to identify key audiences in each focal area for outreach regarding beneficial forest management practices for birds and available resources to assist in implementing them. The team seeks to collaborate with other agencies, especially state agencies and the USDA, and NGOs with interests in forest bird conservation and creating healthy forest landscapes across the Northeast.

2.1.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of Forest and Woodland habitat through several ongoing citizen science projects. The **GLOBE Program**, an international citizen science initiative sponsored by the National Aeronautics and Space Administration (NASA), engages the public in numerous environmental monitoring projects[38]. The **GLOBE Observer: Trees** project engages the public to measure tree heights and circumferences using a smartphone app to document changes in forest biomass. The **GLOBE Observer: Land Cover** project recruits the public to "adopt a pixel" to photograph and identify land cover to ground-truth remote sensing imagery.

Leafsnap is a mobile app that uses visual recognition software to identify tree species from leaf photographs submitted by citizen scientists and geo-locates the tree species on a map to record tree diversity and distribution[39]. This project is part of a series of electronic field guides developed by the University of Maryland, Columbia University and the Smithsonian Institution.

The **Redbud Phenology Project** engages the public to monitor when Eastern Redbud (*Cercis canadensis*) trees flower and fruit across its range to determine if the timing of these events varies with location and elevation[40]. Researchers with the **National Phenology Network** intend to use the citizen science data (contributed online or via a smartphone app) to determine whether the timing of flowering and fruiting has changed with climate change.

The **Assessing Vegetation Impacts by Deer (AVID)** project is sponsored by Cornell University and the New York Department of Environmental Conservation to engage citizen scientists in monitoring plants for one year to document the impact of deer browsing on forest health[41].

The **Ghosts of the Coast** project documents the formation of ghost forests, or loss of Forest and Woodland habitat to sea level rise, saltwater intrusion and/or land subsidence[42]. Citizen scientists submit observations of ghost forests online using an ArcGIS Survey123 form, allowing researchers to create a collaborative ghost forest map. The project is sponsored by the **Long-Term Ecological Research Network**[43] and academia along the Mid-Atlantic coast.

Some citizen scientist projects address forest health by monitoring diseases and invasive species. **TreeSnap** collects sightings of trees threatened by invasive diseases or pests to allow researchers to conduct genetic sequencing of resilient trees[44]. The **Forest Restoration Alliance** seeks the identification of hemlock and fir trees that have survived infestation by woolly adelgids using the TreeSnap app[45]. The **New York State Hemlock Initiative** similarly engages the public to locate and report healthy stands of hemlock trees through its **Hemlock and HWA Hunters** project using the **NYiMapInvasives** mobile app[46].

The Maine Soil and Water Conservation District offers the **Healthy Beech Project** to engage the public in monitoring healthy American Beech (*Fagus grandifolia*) trees[47]. Researchers aim to locate trees that are possibly resistant to beech bark scale disease. The **Honeysuckle Leaf Blight Survey** tracks the distribution and prevalence of the fungal pathogen honeysuckle leaf blight (*Insolibasidium deformans*) by public reports of diseased honeysuckle via the iNaturalist app[48].

Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

2.1.8 HABITAT INFORMATION, RESEARCH, AND MONITORING NEEDS

Habitat information, research and monitoring needs exist for Forest and Woodland habitat in the Northeast:

- Monitor the conversion of Forests and Woodlands in coastal areas to forested wetlands or ghost forests due to rising sea level and saltwater intrusion
- Improve understanding on the landscape level impacts to Forest health and type from pervasive invasive species Emerald Ash Borer (*Agrilus planipennis*), Spongy Moth (*Lymantria dispar dispar*), and Hemlock Woolly Adelgid (*Adelges tsugae*)

2.2 HIGH ELEVATION FORESTS

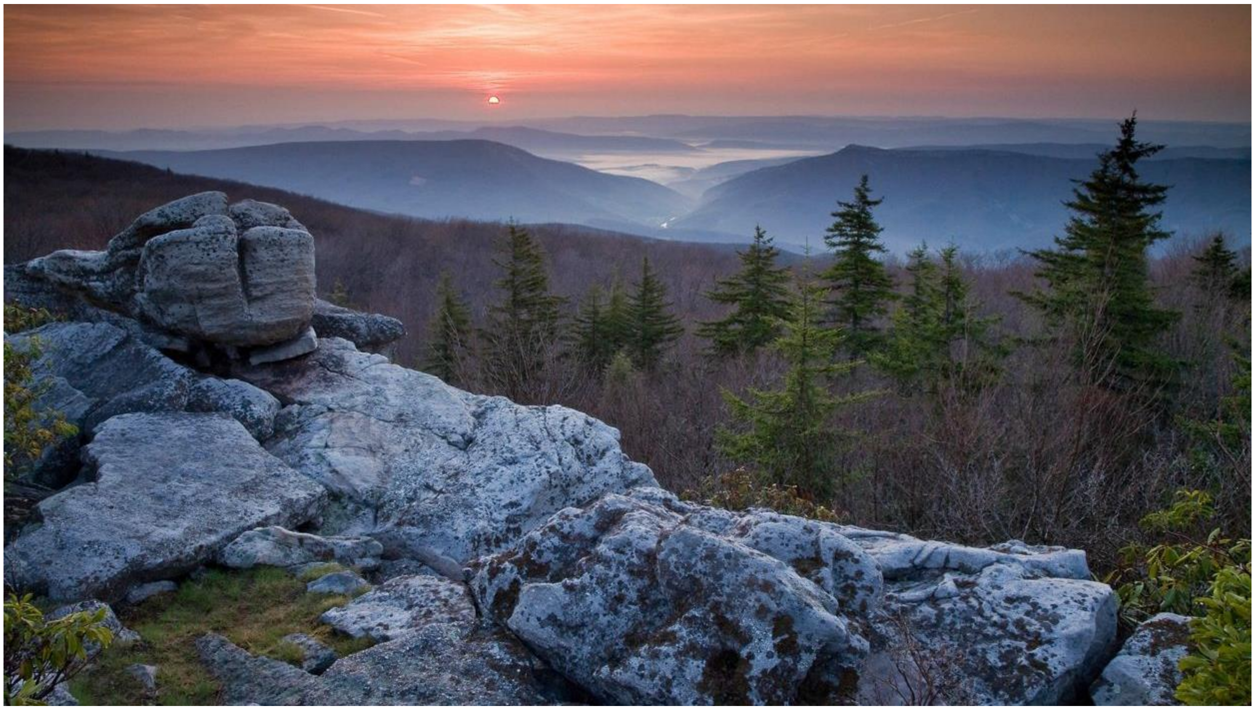

Figure 2.2. 1 High-Elevation Forest habitats support 43 Northeast RSGCN and Watchlist species (Red spruce forest in WV photo credit: Kent Mason).

2.2.1 HABITAT DESCRIPTION

High-Elevation Forests are those that occur above a certain land elevation, which varies by state or region. Publicover et al. (2021) define High-Elevation Forests as those above 2700 ft in elevation in New England and New York. In the Mid-Atlantic, High-Elevation Forests are defined above 3000 to 3500 ft depending on the ecological community[49]. In the NEAFWA region, the fourteen 2015 SWAPs included nine Key Habitats for SGCN that are within High-Elevation Forest habitat, predominantly montane spruce-fir communities (*Appendix 2A*, Table 2A.2).

There are 19 RSGCN, three Proposed RSGCN, and 18 Watchlist [Assessment Priority] species across seven taxonomic groups associated with Northeast High-Elevation Forest habitat (*Supplementary Information 2*, Table 2.2.1, Figure 2.2.2). Three other species associated with this habitat is a Watchlist [Deferral] species deferred to adjacent AFWA regions. Six RSGCN and Proposed RSGCN salamanders are endemic to the Northeast region and of Very High Concern and a seventh salamander has at least 75% regional responsibility.

Habitat features, formations and other habitat characteristics preferred by RSGCN and Watchlist species within High-Elevation Forests included in the Northeast RSGCN

Database (version 1.0) are the same as those for Forest and Woodland habitats (Section 2.1).

Table 2.2. 1 The number of species in each RSGCN and Watchlist category associated with High-Elevation Forest habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	19
Proposed RSGCN	3
Watchlist [Assessment Priority]	18
Watchlist [Deferral to adjacent region]	3
TOTAL	**43**

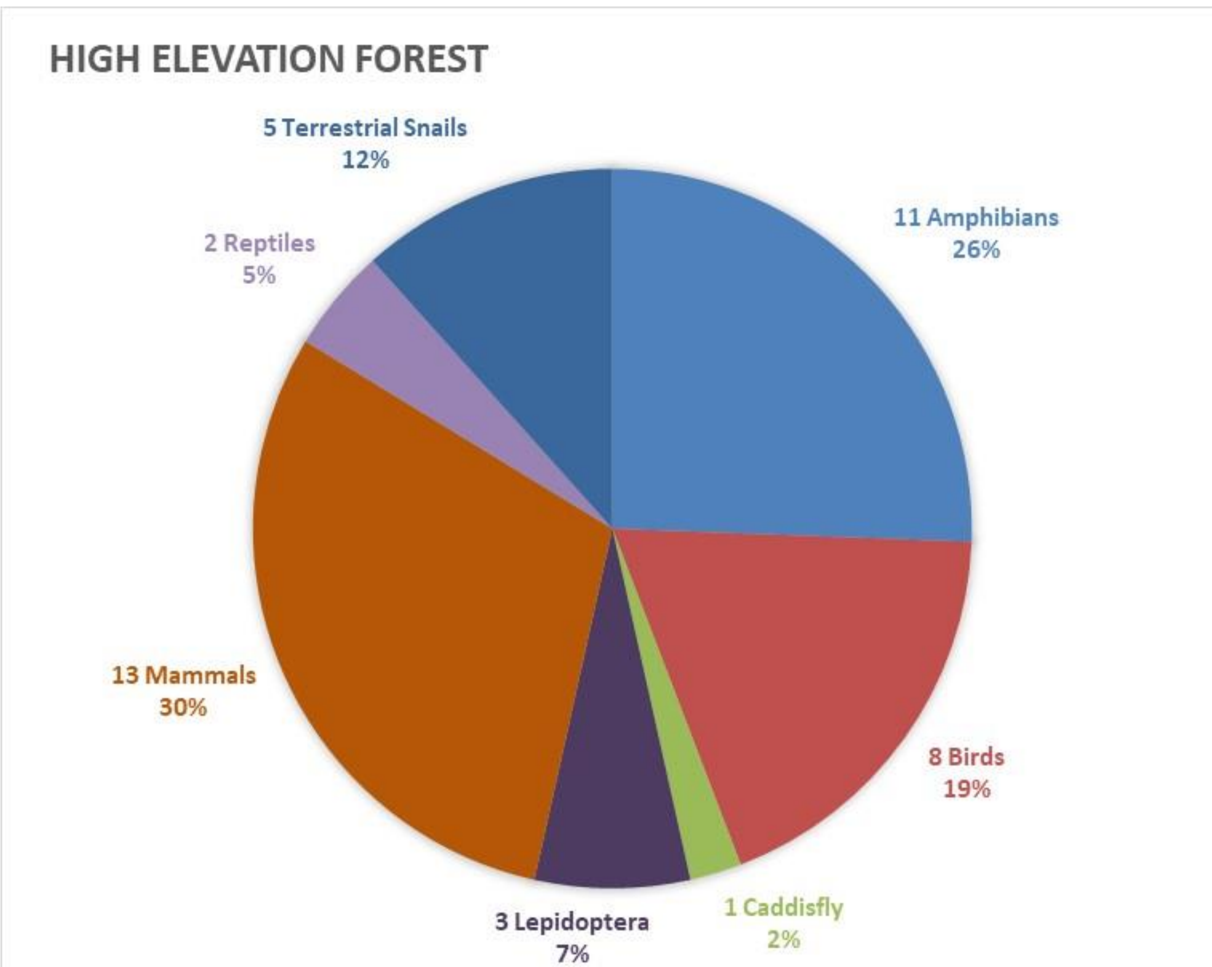

Figure 2.2. 2 Northeast RSGCN and Watchlist species associated with High-Elevation Forest habitats represent five taxonomic groups.

2.2.2 HABITAT DISTRIBUTION AND CONSERVATION

Anderson et al. (2023) provides an updated assessment of the status and distribution of High Elevation Forest habitat throughout the Northeast region. Publicover et al. (2021) assessed the ecological value of High-Elevation Forests in New England and New York for conservation priorities, finding 14 areas exceeding 10,000 acres in size. Eleven of the 14 large blocks of High-Elevation Forest are at least 95% protected and two of the remaining three are at least 80% conserved. The largest block of protected High-Elevation Forest identified by Publicover et al. (2021) is the Adirondack High Peaks in New York with more than 50,400 acres. Three High-Elevation Forest blocks in the White Mountains of New Hampshire and a block in the Catskills State Park of New York round out the top five largest areas of High-Elevation Forest in New England and New York.

2.2.3 HABITAT CONDITION

Anderson and Olivero-Sheldon (2011) assessed the status and condition of all Forest and Woodland habitat in the Northeast as of the early 2000s. That conservation status assessment is updated in Anderson et al. (2023) with habitat status and condition information as of 2019 as well as trends over the past two decades, now including information for High-Elevation Forests.

Threats to the multiple finer scale habitat types within this coarse High-Elevation Forest habitat vary by location and type but include Climate Change (Threat 11.0), Wind Energy Development (Threat 3.3.2), and Acid Rain (Threat 9.5.1) (Bennett 2010, Anderson et al. 2016a, Publicover et al. 2021). Anderson et al. (2013b) predicted future habitat loss of Northeast habitats to development over the next 50 years. High-Elevation Forests and associated Alpine and Cliff and Talus macrogroups were the least threatened by habitat loss to development predicted over the next five decades.

Special Issue 11 of **Northeastern Naturalist**, published in 2021, presents recent research on the effects of climate change in the mountains of Maine and the Northeast[50]. Publicover et al. (2021) summarizes the state of knowledge of the current habitat condition, conservation status, and ecological values of High-Elevation Forest and Alpine habitats in New England and New York. Other articles discuss specific mountain habitats of Maine, New York, New Hampshire, and Quebec.

High-Elevation Forest habitats have been found to have some of the best landscape context indices of all habitat types, along with Alpine and Cliff and Talus habitats, meaning patches of High-Elevation Forest habitat are surrounded by more natural land cover types and less human conversion or fragmentation (Anderson et al. 2013b).

Anderson et al. (2023) provides a detailed assessment of habitat condition, loss, fragmentation, and resilience of Northeast High Elevation Forest habitat as of 2019 as well as trends over the past two decades. Anderson et al. (2016a and 2016b) assessed the resiliency and connectedness of habitat macrogroups of the eastern United States at the landscape scale, identifying resilient sites for conservation. Staudinger et al. (2023) summarizes the state of knowledge of High Elevation Forest habitat resiliency to climate change.

Publicover et al. (2021) discuss three possible scenarios for High-Elevation Forest and Alpine habitats in the Northeast with climate change – full transition as all vegetation moves upwards in elevation, full resistance where montane vegetation is relatively stable and limits the upward movement of lower vegetation communities, and partial resistance where High-Elevation Forests are restricted by a rising hardwood community from lower elevations and a resistant Alpine community at higher elevations.

Publicover et al. (2021, p. 149) describe the uncertainty surrounding the resilience of High-Elevation Forests and Alpine habitats of New England and New York:

> *Given the observed relationship between temperature and the lower montane ecotone, the full resistance scenario is unlikely, and an upward retreat [of High-Elevation Forest]… appears inevitable (Hill 2020, Wason et al. 2017). This retreat will combine with the inexorable decline of total area with elevation. Based on an examination of USGS Digital Elevation Model data for New England and New York, above 810 m (2000 ft), the total area declines consistently by 50% with about every 115 m (285 ft) rise in elevation. Given the magnitude of observed climate shifts in our region's mountains, large parts of the montane spruce–fir zone may already be out of equilibrium with suitable climatic conditions, though coniferous vegetation may persist in areas where thin, acidic, and organic montane soils inhibit colonization by hardwood species (Lee et al. 2005).*

2.2.4 HABITAT MANAGEMENT

Management guidance or BMPs for High Elevation Forests are limited. The University of New Hampshire Cooperative Extension developed voluntary forest management recommended practices for the state, including BMPs for High Elevation Forests that are identified as sensitive areas (Bennett 2010). Recommended best practices include retaining Mountain Ash (*Sorbus* spp.) trees for mast production when harvesting timber at high elevations, avoiding pockets of old-growth forest and clearcutting, lay out timber harvest during snow-free conditions but schedule harvest for winter conditions, and leave limbs, tree tops, large cull and cavity trees at harvest sites. If uncut reserve zones are planned, they should incorporate prominent ridgelines, ledge outcrops, game trails, complex stands, older stands, streams, wetlands, and seeps.

2.2.5 HABITAT MONITORING

The distribution and extent of High Elevation Forests is monitored directly or indirectly through several remote sensing land cover assessment programs. The National Land Cover Dataset maps the extent of three subtypes of Forests (Deciduous, Mixed, and Evergreen) regardless of elevation every three years. LANDFIRE includes multiple Montane Forest ecological systems within their spatial land cover datasets, which have been updated every two to three years but will be updated annually starting in 2022. Regionally, the Designing Sustainable Landscapes program at the University of Massachusetts monitors the extent of several High-Elevation Forest macrogroups (e.g., Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest) as land cover classes in the Northeast.

2.2.6 PARTNERS

The **Appalachian Mountain Club** organization is involved in several conservation activities as well as adventure-based outdoor recreation in the Northeast region[51]. The conservation priorities of the group include trail stewardship, understanding and addressing climate change, and land, air, and water protection in the Northern Appalachian Mountains and other priority areas in the region. The organization conducts and supports climate change research in High Elevation Forest and Alpine habitats, contributing several assessments to understanding the impacts of this threat (e.g., Kimball et al 2021, Publicover et al. 2021). For more than 100 years the Appalachian Mountain Club has protected lands and trails in the northern Appalachian Mountains, including technical and financial assistance programs as well as direct land ownership. The **Maine Woods International Dark Sky Park**, the first and only International Dark Sky Park in New England, is owned and managed by the organization[52]. Their **Maine Woods Initiative** manages over 100,000 acres of land with certified responsible forestry practices.

2.2.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of High-Elevation Forest habitat through several ongoing citizen science projects. The Appalachian Mountain Club tracks plant phenology events in Alpine and High-Elevation Forest habitats of the Appalachian mountains with a citizen science project called **Mountain Watch**[53]. A second project, **Appalachian Trail Seasons**, tracks plant and animal development along the Appalachian Trail corridor to gather information on the impacts of climate change at high elevations as part of the National Phenology Network[54].

Mountain Birdwatch is a citizen science project that recruits volunteers to collect observations of bird populations in High-Elevation Forests of New York and New England[55]. Sponsored by the Vermont Center for Ecostudies, the project monitors ten bird species and one squirrel, including the RSGCN Bicknell's Thrush (*Catharus bicknelli*) and Watchlist Blackpoll Warbler (*Setophaga striata*).

Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

2.2.8 HABITAT INFORMATION, RESEARCH, AND MONITORING NEEDS

A number of habitat information, research and monitoring needs exist for High-Elevation Forest habitat in the Northeast:

- Continued monitoring of changes in temperature in high mountain areas compared to lower elevations to inform community responses to future climate change (Publicover et al. 2021)
- Species range shift studies in the upper montane zone to inform community responses to future climate change (Publicover et al. 2021)

2.3 GRASSLANDS

Figure 2.3. 1 Grassland habitats support 135 Northeast RSGCN and Watchlist species. (Shenandoah Valley, VA, photo credit: Jim Carithers).

2.3.1 HABITAT DESCRIPTION

Grasslands are defined globally as a non-wetland ecological unit with at least 10% vegetation cover that is dominated by graminoids and/or forbs and where shrub canopy is less than 25% and tree canopy is less than 10% and 5 meters in height in temperate zones like the Northeast. In the United States, Grasslands are limited in the Northeast and much more common in the Great Plains of the Midwest, which contain the second largest area of Grasslands in the world (Dixon et al. 2014).

Grasslands habitat for Northeast RSGCN and Watchlist species include natural Grasslands on dunes, prairies, and meadows as well as anthropogenic public utility transmission corridors, old fields, and early successional clearcuts. Mowed grasses for urban or suburban parks, airports, golf courses or athletic fields are considered within Developed Areas anthropogenic habitat (see Section 2.24). In the NEAFWA region, the 14 SWAPs of 2015 included 30 Key Habitats for SGCN that are within Grasslands habitat, including both natural and anthropogenic Grasslands (*Appendix 2A*, Table 2A.3).

There are 67 RSGCN, two Proposed RSGCN, 46 Watchlist [Assessment Priority], and five Proposed Watchlist species across eight taxonomic groups associated with Northeast Grassland habitat (*Supplementary Information 2*, Table 2.3.1, Figure 2.3.2). Another 15 species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. Thirty-six percent (36%; 21 spp.) of Grassland RSGCN and Proposed RSGCN are of Very High Concern. Fifteen RSGCN and Watchlist species associated with Grasslands have at least 75% Regional Responsibility, nearly half of which are Lepidoptera. Five RSGCN are of Very High Concern, endemic to the Northeast, and associated with Grasslands habitat – three moths, one turtle and one firefly.

Table 2.3. 1 The number of species in each RSGCN and Watchlist category associated with Grassland habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	67
Proposed RSGCN	2
Watchlist [Assessment Priority]	46
Proposed Watchlist [Assessment Priority]	5
Watchlist [Deferral to adjacent region]	15
TOTAL	**135**

The Northeast RSGCN Database (version 1.0) contains data on habitat characteristics associations for Grassland-associated RSGCN and Watchlist species, such as fire dependency, vegetation density, substrate, soil moisture, rights-of-way, and artificial structures.

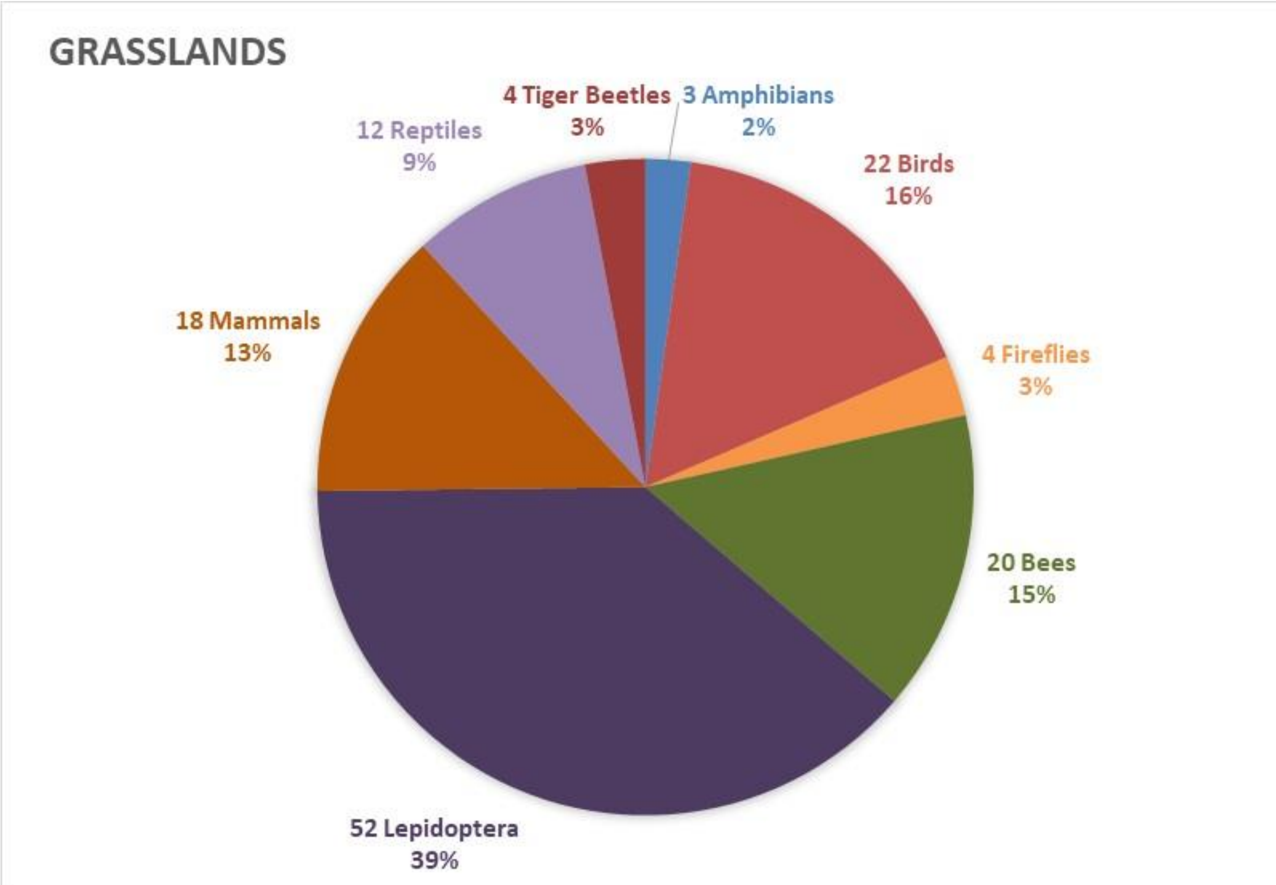

Figure 2.3. 2 Northeast RSGCN and Watchlist species associated with Grasslands habitats represent eight taxonomic groups.

2.3.2 HABITAT DISTRIBUTION AND CONSERVATION

The most recent land cover dataset from the Designing Sustainable Landscapes program (DSLland version 5.0, issued 2020) identified nearly 1.8 million acres of combined Grasslands and Shrublands habitat in the Northeast as of 2011-2013 (Table 2.0.3). The updated habitat condition assessment from Anderson et al. (2023) provides information on the status and conservation of Grasslands habitat in the Northeast as of 2019.

2.3.3 HABITAT CONDITION

Nationally, Grasslands habitat is threatened by invasive species (Threat 8.0), vegetation succession (Threat 7.3.2), suppression of wildfire (Threat 7.1.2), agriculture (Threat 2.0), and development (Threat 1.0) (Glaser 2012). Anderson et al. (2013b) characterized the condition of Northeast habitats as of the early 2000s and predicted future habitat loss of Northeast habitats to development over the next 50 years. Patches of Grasslands habitat macrogroups were found to be highly fragmented and less connected to surrounding natural land cover types. North Atlantic Coastal Plain Heathland and

Grassland was the most threatened macrogroups by habitat loss to development, with a loss of 22% predicted over the next five decades. Anderson et al. (2013b) also assessed the landscape complexity, a measure of climate resilience, of Northeast habitats. Maritime Grassland communities had low landscape complexity and resiliency.

Anderson et al. (2023) provides a detailed assessment of habitat condition, loss, fragmentation, and resilience of Northeast Grassland habitat as of 2019 as well as trends over the past two decades. Anderson et al. (2016a and 2016b) assessed the resiliency and connectedness of habitat macrogroups of the eastern United States at the landscape scale, identifying resilient sites for conservation. Staudinger et al. (2023) summarizes the state of knowledge of Grassland habitat resiliency to climate change.

2.3.4 HABITAT MANAGEMENT

The state of New York, the USFWS, Audubon, and the Grassland Bird Trust have developed BMPs for managing Grasslands or areas to be converted into Grassland habitat for breeding and/or wintering birds[56]. Guidelines include removing or thinning hedgerows, removing woody vegetation within fields, mowing at the appropriate times and rotations, removing excess thatch, and managing or removal of invasive or undesirable plant species.

Managing Grasslands, Shrublands, and Young Forest Habitats for Wildlife: A Guide for the Northeast includes recommendations on improving wildlife habitat condition in Grasslands (Oehler et al. 2006). Chapter 3 of this guide, "Maintaining and Restoring Grasslands," describes the ecological values of Northeast Grasslands to wildlife and the comparative values of cool-season versus warm-season grasses for wildlife management. Management practices are recommended to maintain and enhance wildlife habitat in Grassland habitats, including mowing, weed control, prescribed burning, and prescribed grazing. Considerations for establishing native warm-season grasses are listed. Chapter 8 of the guide describes common invasive, exotic plants in early successional habitats and methods to manage and control them.

Staudinger et al. (2023) describes the state of knowledge of adaptive management of Grassland habitats to climate change.

2.3.5 HABITAT MONITORING

The **Prairie Reconstruction Initiative**, a partnership led by the USFWS, has developed monitoring protocols for reconstructed prairie Grassland habitat and maintains a database of prairie reconstruction projects[57].

The distribution and extent of Grasslands is monitored through several remote sensing land cover assessment programs. The National Land Cover Dataset maps the extent of Grasslands as an herbaceous land cover type every three years. LANDFIRE includes multiple Grassland ecological systems within their spatial land cover datasets, which have been updated every two to three years but will be updated annually starting in 2022. Regionally, the Designing Sustainable Landscapes program at the University of Massachusetts monitors the extent of a merged Shrubland and Grassland land cover class in the Northeast.

2.3.6 PARTNERS

The **New England Pollinator Partnership** is a partnership between the USDA Natural Resources Conservation Service, USFWS, the Xerces Society and others to assist the restoration of the Monarch butterfly (*Danaus plexippus*) and ten bumblebee species (including three RSGCN and five Watchlist bees) on private lands throughout New England[58]. The partnership seeks to improve pollinator habitat, reduce the exposure of these species to pesticides and pathogens, and provide assurances to participating landowners. The Partnership provides BMPs to accomplish these goals.

The **Grassland Bird Trust** is a non-profit organization dedicated to conserving Grasslands habitat for threatened, endangered, and rapidly declining birds[59]. The organization maintains a Grasslands preserve in New York and has assisted multiple partners to conserve thousands of acres of Grasslands habitat across the eastern United States. Other programs of this partner address preserving biodiversity and mitigating climate change. The **Grassland Restoration Network**, originally founded by The Nature Conservancy in 2003, is a loose affiliation of projects and land managers working to restore native Grasslands habitat across the country[60]. The goals of the Network are to share information, identify and close knowledge gaps about successful Grasslands restoration, and to increase the quantity and quality of restored Grasslands. The **Southeast Grasslands Initiative** includes unglaciated portions of the region in their restoration efforts for Grasslands and Glades, Barrens, and Savanna habitats[61].

2.3.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of Grasslands habitat through a limited number of ongoing citizen science projects applicable to the Northeast region, most likely because this particular habitat type is much more widespread in other regions. Some projects are localized to a particular park or nature preserve. The **GLOBE Observer: Land Cover** national project recruits the public to "adopt a pixel" to photograph and identify land cover to ground-truth remote sensing imagery, including grass, trees, pavement, outcrops, or bare soil[62]. Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

2.3.8 HABITAT INFORMATION, RESEARCH AND MONITORING NEEDS

Habitat information, research and monitoring needs exist for Grasslands habitat in the Northeast:

- Identify conservation targets and associated monitoring indicators for the **Monitoring and Performance Reporting Framework for the Northeast Association of Fish and Wildlife Agencies** (NEAFWA 2008), as described in *Chapter 5*

2.4 SHRUBLANDS

Figure 2.4. 1 Shrubland habitats support 118 Northeast RSGCN and Watchlist species. (Rodman's Hollow on Block Island, RI)

2.4.1 HABITAT DESCRIPTION

Shrubland habitats consist of at least 10% shrub cover that is generally less than 5 m tall and are not Forest or Grassland (Gawler 2008, NatureServe 2022). Shrubland habitats for RSGCN and Watchlist species in the Northeast include natural Shrublands and early successional clearcuts, hedgerows, old fields, and anthropogenic or introduced

Shrublands. Often associated or lumped with Grasslands habitats, the 14 Northeast SWAPs of 2015 included 22 Key Habitats for SGCN that are within Shrubland habitat (*Appendix 2A*, Table 2A.4).

There are 58 RSGCN, 47 Watchlist [Assessment Priority], and four Proposed Watchlist species across eight taxonomic groups associated with Northeast Shrubland habitat (*Supplementary Information 2*, Table 2.4.1, Figure 2.4.2). Another nine species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. The New England Cottontail (*Sylvilagus transitionalis*), Peaks of Otter Salamander (*Plethodon hubrichti*), and Daecke's Pyralid Moth (*Crambus daeckellus*) are endemic RSGCN of Very High Concern that are associated with Northeast Shrublands habitat.

Table 2.4. 1 The number of species in each RSGCN and Watchlist category associated with Shrublands habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	58
Watchlist [Assessment Priority]	47
Proposed Watchlist [Assessment Priority]	4
Watchlist [Deferral to adjacent region]	9
TOTAL	**118**

The Northeast RSGCN Database (version 1.0) contains data on habitat characteristics associations for Shrubland-associated RSGCN and Watchlist species, such as fire dependency, vegetation density, substrate, soil moisture, rights-of-way, and artificial structures.

2.4.2 HABITAT DISTRIBUTION AND CONSERVATION

The most recent land cover dataset from the Designing Sustainable Landscapes program (DSLland version 5.0, issued 2020) identified nearly 1.8 million acres of combined Grasslands and Shrublands habitat in the Northeast as of 2011-2013 (Table 2.0.3). The updated habitat condition assessment from Anderson et al. (2023) provides information on the status and conservation of Shrublands habitat in the Northeast as of 2019.

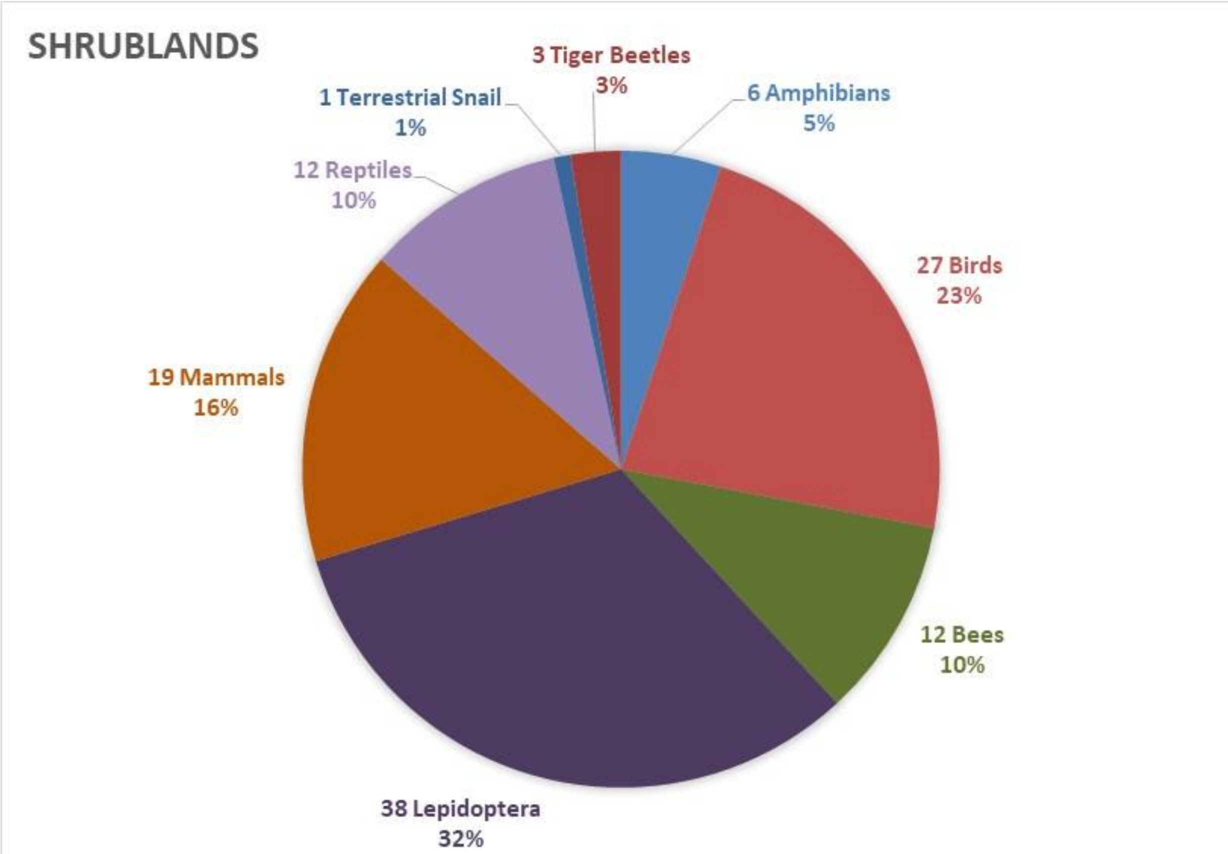

Figure 2.4. 2 Northeast RSGCN and Watchlist species associated with Shrubland habitats represent eight taxonomic groups.

2.4.3 HABITAT CONDITION

Threats to the multiple finer scale habitat types within this coarse Northeast Shrubland habitat vary by location and type but include Invasive Plant Species (Threat 8.1.2), Vegetation Succession (Threat 7.3.2), Development (Threat 1.0), and Suppression of Wildfire (Threat 7.1.2). Anderson et al. (2013b) predicted future habitat loss of Northeast habitats to development over the next 50 years but did not include any purely Shrublands macrogroups.

Anderson et al. (2023) provides a detailed assessment of habitat condition, loss, fragmentation, and resilience of Northeast Shrubland habitat as of 2019 as well as trends over the past two decades. Anderson et al. (2016a and 2016b) assessed the resiliency and connectedness of habitat macrogroups of the eastern United States at the landscape scale, identifying resilient sites for conservation. Staudinger et al. (2023) summarizes the state of knowledge of Shrubland habitat resiliency to climate change.

2.4.4 HABITAT MANAGEMENT

Managing Grasslands, Shrublands, and Young Forest Habitats for Wildlife: A Guide for the Northeast includes recommendations on improving wildlife habitat condition in Shrublands (Oehler et al. 2006). *Chapter 4* of this guide, "Managing Shrublands and Old Fields," describes the ecological values of Northeast Shrublands to wildlife and the early successional habitat provided by old fields. Management practices are recommended to maintain and enhance wildlife habitat in these early successional habitats, including vegetation management, invasive species control, selective clearing, prescribed burning, prescribed grazing, and the timing of management activities. Chapter 8 of the guide describes common invasive, exotic plants in early successional habitats and methods to manage and control them.

One of the goals of the **New England Cottontail** Partnership is to maintain Shrublands and young Forests habitat for the RSGCN New England Cottontail (*Sylvilagus transitionalis*) in the Northeast[63]. **Best Management Practices for the New England Cottontail** describes methods to create, enhance, and maintain these early successional habitats (Fergus 2017).

The University of New Hampshire Extension provides educational resources and management recommendations to maintain Shrublands habitat in New England[64]. Chapter 7 of **Wildlife Habitat Management for Lands in Vermont – A Landowner's Guide** describes the ecological values of Shrublands habitat and management recommendations for maintaining the habitat on private lands in the Northeast[65].

Staudinger et al. (2023) describes the state of knowledge of adaptive management of Shrublands habitats to climate change.

2.4.5 HABITAT MONITORING

The distribution and extent of Shrublands is monitored through several remote sensing land cover assessment programs. The National Land Cover Dataset maps the extent of Shrub / Scrub as a land cover type every three years. LANDFIRE includes multiple Shrubland ecological systems within their spatial land cover datasets, which have been updated every two to three years but will be updated annually starting in 2022. Regionally, the Designing Sustainable Landscapes program at the University of Massachusetts monitors the extent of a merged Shrubland and Grassland land cover class in the Northeast.

2.4.6 PARTNERS

The **Young Forest Project** is a partnership with a mission to enhance and maintain the availability of early successional, young Forests and Shrublands for wildlife. Partners include state and federal agencies, the Mashpee Wampanoag Tribe, NGOs, National Fish and Wildlife Foundation, businesses, academia, land trusts, and NEAFWA. Best management practices, instructional guides and manuals, and a list of demonstration site projects in the Northeast, Mid-Atlantic and Midwest are provided on the project website[27]. Specific guidance to enhance Shrubland habitat is available for multiple wildlife species.

2.4.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org. No citizen science projects focused on Shrubland habitat in the Northeast are currently known.

2.4.8 HABITAT INFORMATION, RESEARCH AND MONITORING NEEDS

Habitat information, research and monitoring needs exist for Grasslands habitat in the Northeast:

- Identify conservation targets and associated monitoring indicators for the **Monitoring and Performance Reporting Framework for the Northeast Association of Fish and Wildlife Agencies** (NEAFWA 2008), as described in *Chapter 5*

2.5 GLADES, BARRENS & SAVANNA

Figure 2.5. 1 Glades, Barrens and Savanna habitats support 164 Northeast RSGCN and Watchlist species. (Albany Pine Bush Preserve, NY)

2.5.1 HABITAT DESCRIPTION

Barrens are defined as "Areas of persisting sparse, low, open, or otherwise distinctive vegetation (when compared with characteristic vegetation of the region), typically on thin, patchy xeric soils or rocky substrates, often with unusual rock or soil chemistry or in special topographic settings" (NatureServe 2022). Gawler (2008) defines Savanna as a Grassland with widely scattered trees. Glades, Barrens and Savanna do not include Cliff and Talus (Section 2.7), Alpine (Section 2.6), or Beaches and Dunes (Section 2.17).

In the NEAFWA region, the 14 SWAPs of 2015 included 35 Key Habitats for SGCN that are within Glades, Barrens and Savanna habitat (*Appendix 2A*, Table 2A.5). SWAP Key Habitats include sand barrens, pine barrens, serpentine barrens, shale barrens, balds, oak savannas, and glades of various types. Other analogous habitats included in this group include sandplain grasslands, heathlands, and pitch pine-oak woodlands.

Glades, Barrens and Savanna habitat in the Northeast has the fifth highest number of RSGCN and Watchlist species (164) of any habitat type. There are 77 RSGCN, 63

Watchlist [Assessment Priority], and six Proposed Watchlist species across nine taxonomic groups associated with Northeast Glades, Barrens and Savanna habitat (*Supplementary Information 2*, Table 2.5.1, Figure 2.5.2). Another 18 species

Table 2.5. 1 The number of species in each RSGCN and Watchlist category associated with Glades, Barrens and Savanna habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	77
Watchlist [Assessment Priority]	63
Proposed Watchlist [Assessment Priority]	6
Watchlist [Deferral to adjacent region]	18
TOTAL	**164**

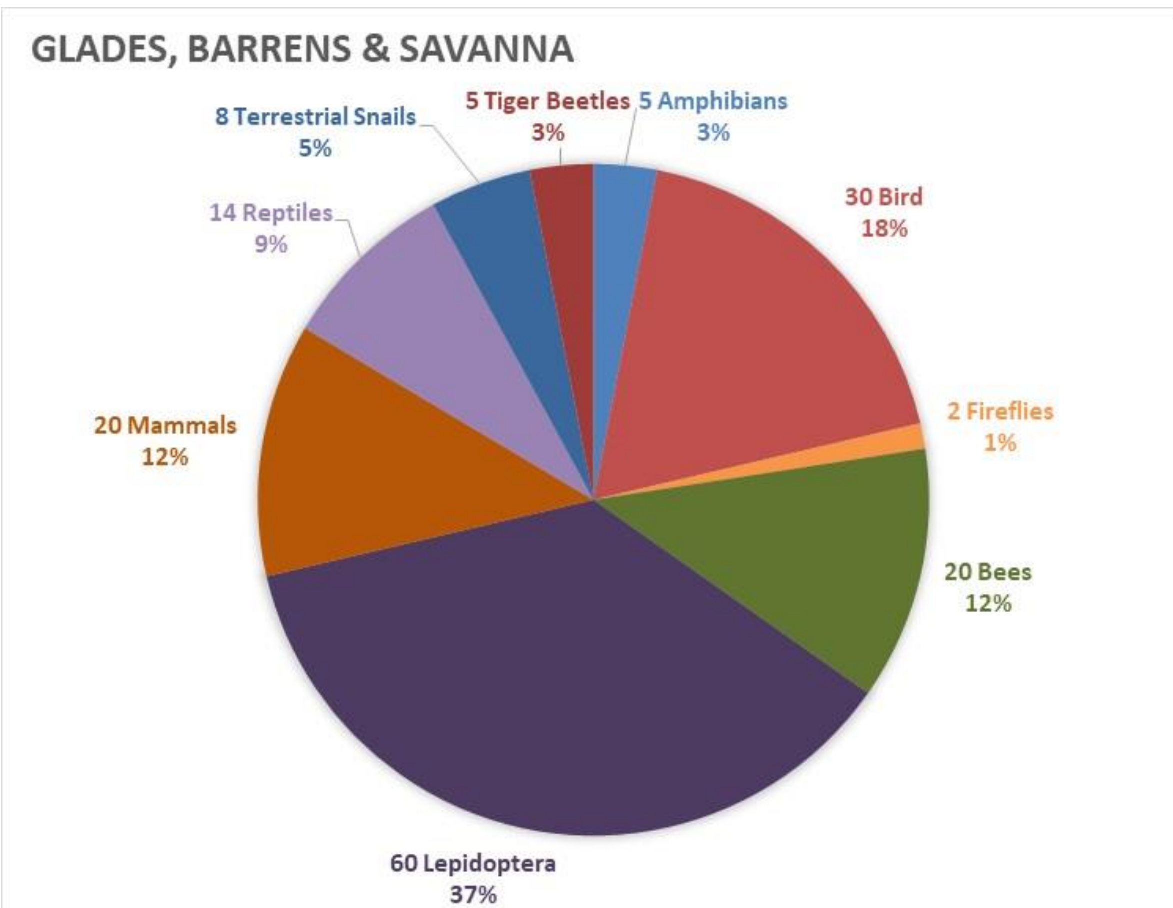

Figure 2.5. 2 Northeast RSGCN and Watchlist species associated with Glades, Barrens and Savanna habitats represent nine taxonomic groups.

associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. Eight RSGCN and Proposed RSGCN are of Very High Concern and endemic to the Northeast region – two salamanders, four moths, and two terrestrial snails.

The Northeast RSGCN Database (version 1.0) contains data on habitat characteristics associations for Glades, Barrens and Savanna-associated RSGCN and Watchlist species, such as fire dependency, vegetation density, substrate, soil moisture, surface litter, logs and woody debris, rights-of-way, and artificial structures.

Special Issue 5 of Northeastern Naturalist, published in 2009, presents the **Proceedings of the Sixth International Conference on Serpentine Ecology**, with several papers on serpentine barrens geoecology, soil, endemic species of eastern North America, climate change, and hyperaccumulation of metals by plants[66].

The RCN **Habitat for Pollinators: Improving Management of Regionally Significant Xeric Grasslands, Barrens and Woodlands in the Northeast Project** (henceforth The RCN Xeric Habitat for Pollinators Project) conducted vegetation, bee, and moth surveys and management treatment assessments at 20 xeric habitats throughout the Northeast[67]. The project found significant differences in flora and fauna communities across sites and ecoregions, documenting differences related to management history, soil sand fraction, organic matter, and bulk density, percent cover, and climatic conditions.

The RCN Xeric Habitat for Pollinators Project determined the following RSGCN or Watchlist bees and moths were associated with, or obligate to, Northeast Barrens habitat and documented occurrences in Northeast xeric sites (Crisfield et al, 2023a and 2023b, *in prep*):

<u>Bees</u>

- *Andrena braccata* (associate)
- *Andrena fulvipennis* (obligate)
- *Anthophora walshii* (obligate)
- *Lasioglossum arantium* (obligate)
- *Colletes bradleyi* (associate)
- *Nomada electa* (associated)

<u>Moths</u>

- *Heterocampa varia* (obligate)
- *Macaria exonerata* (obligate)
- *Apopdrepanulatrix liberaria* (obligate)
- *Chaetaglaea cerata* (obligate)
- *Erastria coloraria* (obligate)
- *Metarranthis pilosaria* (obligate)
- *Drasteria occulta* (obligate)
- *Abogrotis benjamini* (associated)
- *Zanclognatha martha* (obligate)
- *Schinia septentrionalis* (obligate)
- *Cyclophora culicaria* (obligate)

Bees

Moths

- *Eucoptocnemis fimbriaris* (obligate)
- *Zale lunifera* (obligate)

2.5.2 HABITAT DISTRIBUTION AND CONSERVATION

The most recent land cover dataset from the Designing Sustainable Landscapes program (DSLland version 5.0, issued 2020) identified more than 1.7 million acres of Glades, Barrens, and Savanna habitat in the Northeast as of 2011-2013 (Table 2.0.3). The updated habitat condition assessment from Anderson et al. (2023) provides information on the status and conservation of Glades, Barrens, and Savanna habitat in the Northeast as of 2019.

2.5.3 HABITAT CONDITION

Many sites characterized as barrens or other xeric habitats are early successional habitats that require fire or other disturbances to maintain them. The RCN Habitat for Pollinators Project acknowledges that habitat objectives are unique to each site, but for grasslands they may be specified in terms of a low percent cover of woody or shrubby biomass (e.g., <25% canopy cover), and a higher percent cover of grasses and forbs (e.g., >75% cover) (Crisfield et al. 2023c, *in prep*). Some sites are characterized as woodlands, with higher percent cover of woody biomass (e.g., 25-60%) and lower percent cover of grasses and forbs (e.g., 30-50%). These habitat objectives are important to support rare obligate pollinators requiring bare soil and dead wood for nesting and floral resources for pollen and nectar.

The RCN Xeric Habitat for Pollinators Project identified lack of natural disturbance or habitat management as the greatest threat to xeric habitats that already have secure land management. At sites that have seriously degraded due to lack of management, changes in soil chemistry, loss of native seed bank, and invasive species can interfere with recovery (Crisfield et al. 2023c, *in prep*).

Anderson et al. (2013b) predicted future habitat loss of Northeast habitats to development over the next 50 years. The Glades, Barrens, and Savanna macrogroups predicted to have the lowest habitat loss rates to development in the next five decades were Southern Ridge and Valley Calcareous Glade and Woodland (1.3%), Great Lakes Alvar (1.9%), and Southern and Central Appalachian Mafic Glade and Barrens (2.5%). The highest habitat loss rates were predicted for Eastern Serpentine Woodland (17.0%). Additionally, some losses may be attributed to habitat succession in the absence of natural disturbances (e.g., fire) or, as a proxy, anthropogenic management (Crisfield et al. 2023c, *in prep*).

Glades, Barrens, and Savanna habitats were found to have some of the poorest landscape context indices of all terrestrial habitat types, especially the eastern serpentine woodlands macrogroup, meaning patches of Glades, Barrens, and Savanna habitat are surrounded by more human conversions of natural land cover types causing habitat fragmentation (Anderson et al. 2013b).

Anderson et al. (2013b) assessed the landscape complexity, a measure of climate resilience, of Northeast habitats. North Atlantic Coastal Plain Pitch Pine Barrens was one of the lowest scoring terrestrial habitats, indicating lower landscape diversity and resiliency to climate change. Southern Glades and Barrens habitat macrogroups had high landscape diversity and resiliency, with Appalachian Shale Barren habitat scoring the highest of all terrestrial habitat macrogroups.

The RCN Xeric Habitat for Pollinators Project followed methods outlined in the **Northern Institute of Applied Climate Science Adaptation Workbook** to investigate habitat vulnerabilities and adaptation strategies. The workbook revealed that barrens are comparatively less vulnerable than many other habitat types because they are adapted to drought, have well drained soils to facilitate recovery from flood, and are adapted to fire and other disturbances (Janowiak et al. 2014). The project documented a number of bee and particularly moth species considered to be obligate to, or at least strongly associated with, xeric habitats in the Northeast. But many of these species were considered to be at the northern edge of the species' range, and it was further noted that in the more southern core of their range, the species were considered habitat generalists. In many ways, xeric barrens in the Northeast already feature habitat conditions more commonly found in southeastern US, potentially facilitating climate-induced range shifts for these invertebrates.

Anderson and Olivero-Sheldon (2011) assessed the status and condition of Glades, Barrens and Savanna habitat in the Northeast as of the early 2000s. Anderson et al. (2023) provides a detailed assessment of habitat condition, loss, fragmentation, and resilience of Northeast Glades, Barrens, and Savanna habitat as of 2019 as well as trends over the past two decades. Anderson et al. (2016a and 2016b) assessed the resiliency and connectedness of habitat macrogroups of the eastern United States at the landscape scale, identifying resilient sites for conservation. Staudinger et al. (2023) summarizes the state of knowledge of Glades, Barrens, and Savanna habitat resiliency to climate change.

2.5.4 HABITAT MANAGEMENT

This key regional habitat supporting multiple RSGCN taxa was prioritized by the NEFWDTC in a project focused on conservation of the fire-adapted xeric habitats that support a diverse fauna including pollinators. The RCN **Xeric Habitat for**

Pollinators Project developed a regional network of experimental adaptive management sites where coordinated management and monitoring is improving management over time[67]. The project resulted in improved coordination and sharing of early successional habitat management expertise among states. Standardized, regional vegetation and pollinator monitoring protocols enabling more effective pooling of data and providing a framework for informed, science-based management decisions were developed. The project improved understanding of the abundance and distribution of select, vulnerable pollinator taxa (e.g., bees and moths), and how these species respond to habitat management over time. The project assessed management trends at 20 sites in more than 45,000 acres of xeric/barrens habitats and demonstrated that sites with a strong history of targeted management exhibited greater diversity and abundances of bees and moths. Importantly, the project also found little evidence of negative impacts to bees and moths from management activities. The project served as a framework for the longer-term monitoring and experimental adaptive management to improve management for these complex, fire-influenced systems.

The project affirmed that selecting best management practices for xeric habitats depends heavily upon the current condition of the site compared to the habitat objectives. Sites found to have been without fire or other natural disturbance for some time require more aggressive restoration and have a higher percent cover, particularly of woody plants, than the habitat objectives for the site. As a consequence, canopy thinning or related forestry practices are a common first step to shift tree species composition and allow light penetration. Herbicide and scarification can be used to remove woody shrubs. For sites with current conditions closer to the habitat objectives, maintenance activities such as mowing and prescribed fire (as often as every 2-4 years) can be used to prevent succession and maintain grasses, forbs, and patches of bare soil. For the conservation of rare invertebrates, the most important consideration is to implement management rotationally in a landscape mosaic to provide refugia and source populations for recolonization after intensive management (Crisfield et al. 2023c, *in prep*).

Restoration and maintenance of high-quality xeric habitats require the removal or release of some carbon from the ecosystem. Barrens typically have low soil organic matter due to low inputs from sparse woody vegetation combined with aerobic decomposition in sandy, well-drained soils (Jones 2010, Quigley et al. 2021). Additionally, the characteristic low percent cover means less accumulation of carbon in above ground biomass. Therefore, managing xeric or barrens habitats, as is necessary to maintain the rare fauna and flora that have co-evolved with dependencies on these unique habitat conditions, would not appreciably alter carbon sequestration or storage rates, either to a positive or negative extent.

Staudinger et al. (2023) describes the state of knowledge of adaptive management of Glades, Barrens and Savanna habitats to climate change.

2.5.5 HABITAT MONITORING

The distribution and extent of Glades, Barrens and Savanna are monitored through several remote sensing land cover assessment programs. LANDFIRE includes multiple Glades, Barrens and Savanna ecological systems within their spatial land cover datasets, which have been updated every two to three years but will be updated annually starting in 2022. Regionally, the Designing Sustainable Landscapes program at the University of Massachusetts monitors the extent of Glades, Barrens, and Savanna macrogroups (e.g., Appalachian Shale Barrens, North Atlantic Coastal Plain Pitch Pine Barrens) as land cover classes in the Northeast.

Habitat condition at specific sites should be monitored using a method that supports calculations of percent cover in each strata (e.g., line-point intercept assessments) (Crisfield et al. 2023c, *in prep*). Monitoring for the diversity and abundance of fauna native to barrens habitats can also be a valuable tool to assess the quality of existing habitat. This would also be a critical component on any monitoring program if management goals are dictated by species conservation concerns.

2.5.6 PARTNERS

The USFWS Science Applications program, in coordination with other USFWS programs and state partners, generated a list of 76 Priority At-Risk Species representing a diverse array of taxa and habitats from across the Northeast Region where coordinated conservation effort may preclude the need to list these species under the Endangered Species Act. Eleven At-Risk teams were formed in 2021 around either single species or multi-species groups. These teams include individuals from multiple USFWS programs, providing diverse experience and capabilities to each group.

Many rare species utilize pine barren habitats, but the At-Risk team is focused on two inhabitants, Frosted Elfin (*Callophrys irus*) and Eastern Whip-poor-will which are both RSGCN. The Pine Barrens Team is analyzing data from Science Application's Rapid Response Team, eBird, and other sources to identify priority sites for co-management of the two species. Once sites are identified, the Team will work with Refuges, state conservation agencies, and other partners to enact on-the-ground management to improve conditions for both species. The team also intends to develop Best Management Practices for the two target species within pine barrens and to develop a network of conservation practitioners for sharing research, management practices and needs, and information across the Northeast.

The RCN Habitat for Pollinators: Improving Management of Regionally Significant Xeric Grasslands, Barrens and Woodlands in the Northeast Project also established a network of management practitioners in the Northeast and facilitated a greater capacity to assist with regional invertebrate identification needs[67]. While these were born of a time constrained grant project, it is hoped that an overall commitment to continue these partnerships will prevail and continue to facilitate regional dialog and support for xeric habitat management initiatives.

The **Southeast Grasslands Initiative** includes unglaciated portions of the region in their restoration efforts for Grasslands and Glades, Barrens, and Savanna habitats[61].

2.5.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org. No citizen science projects focused on Glades, Barrens, and Savanna habitat in the Northeast are currently known.

2.5.8 HABITAT INFORMATION, RESEARCH AND MONITORING NEEDS

The RCN Xeric Habitat for Pollinators Project (Crisfield et al. 2023c, *in prep*) summarizes current habitat information, research, and monitoring needs for Glades, Barrens, and Savanna habitat in the Northeast.

2.6 ALPINE

Figure 2.6. 1 Alpine habitats support 19 Northeast RSGCN and Watchlist species. (Mount Washington, NH, photo credit: K.P. McFarland)

2.6.1 HABITAT DESCRIPTION

Alpine habitats are defined as those above the mountain timberline that are barren or have an herbaceous and low shrubby vegetation (NatureServe 2022). In the NEAFWA region, the 14 SWAPs of 2015 included five Key Habitats for SGCN that are within Alpine habitat in Maine, New Hampshire, Vermont, and New York (*Appendix 2A*, Table 2A.6).

There are 12 RSGCN and seven Watchlist [Assessment Priority] species across five taxonomic groups associated with Northeast Alpine habitat (*Supplementary Information 2*, Table 2.6.1, Figure 2.6.2). No species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. Five RSGCN and Proposed RSGCN associated with Alpine habitats are of Very High Concern – two bumble bees, one butterfly, one moth and one mammal. The White Mountain Fritillary (*Boloria chariclea montinus*), White Mountain Arctic (*Oeneis melissa semidea*), and Katahdin Arctic (*Oeneis polixenes katahdin*) are three endemic RSGCN butterflies of High Concern and primarily associated with Alpine habitat. The first two butterflies are endemic to the White Mountains of New Hampshire and the third to Mount Katahdin in Maine. All three are critically imperiled or imperiled subspecies (G-Rank of T1 or T2).

Table 2.6. 1 The number of species in each RSGCN and Watchlist category associated with Alpine habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	12
Watchlist [Assessment Priority]	7
TOTAL	**19**

The Northeast RSGCN Database (version 1.0) contains data on habitat characteristics associations for Alpine-associated RSGCN and Watchlist species, such as substrate, soil moisture, vegetation density, balds, outcrops and epikarst, and surface litter.

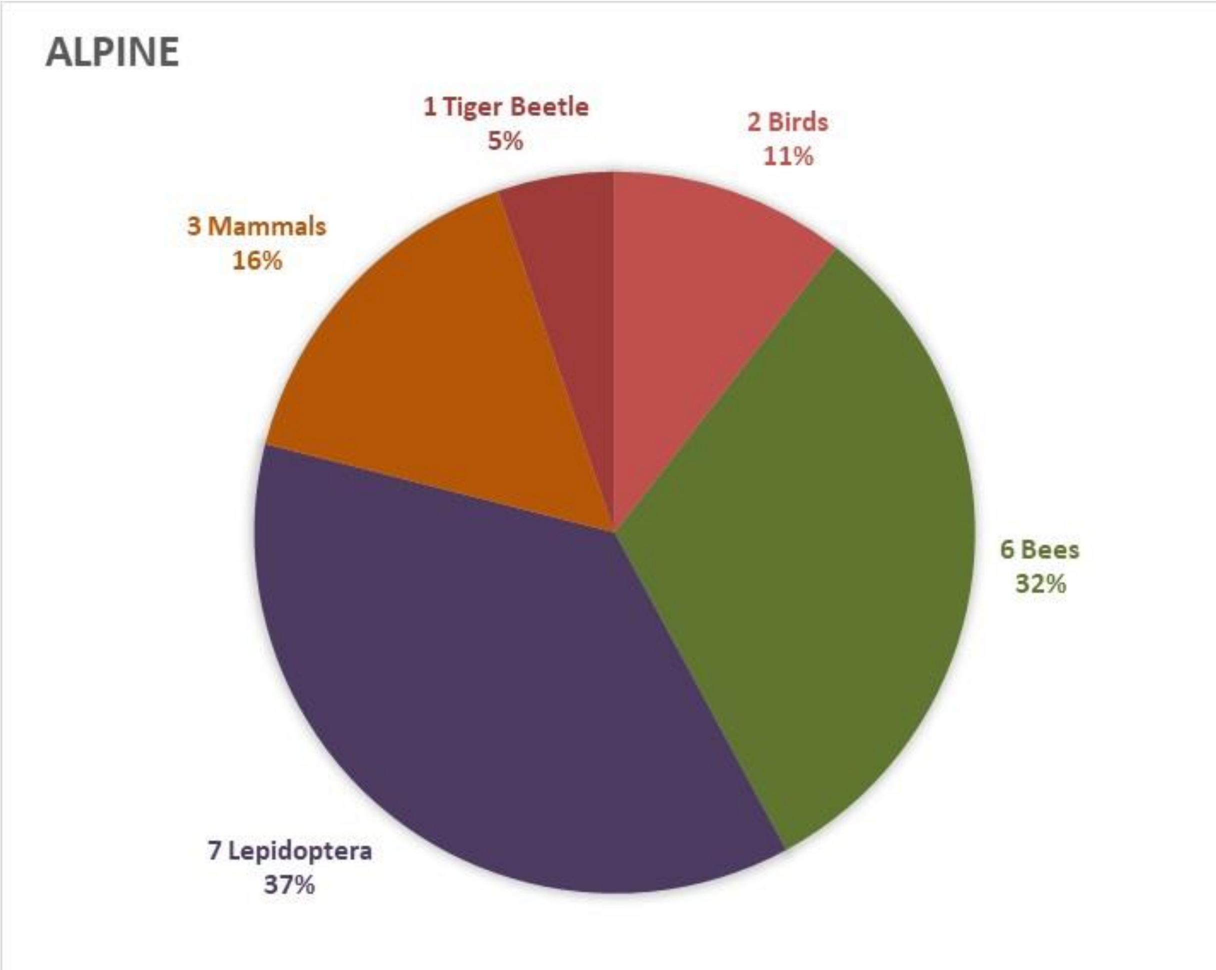

Figure 2.6. 2 Northeast RSGCN and Watchlist species associated with Alpine habitats represent five taxonomic groups.

2.6.2 HABITAT DISTRIBUTION AND CONSERVATION

The most recent land cover dataset from the Designing Sustainable Landscapes program (DSLland version 5.0, issued 2020) identified over 8200 acres of Alpine habitat in the Northeast as of 2011-2013, the least extensive of the 24 habitat types (Table 2.0.3). The updated habitat condition assessment from Anderson et al. (2023) provides information on the status and conservation of Grasslands habitat in the Northeast as of 2019.

2.6.3 HABITAT CONDITION

Threats to the multiple finer scale habitat types within this coarse Northeast Alpine habitat vary by location and type but include Climate Change (Threat 11.0), Acid Rain (Threat 9.5.1), and Human Disturbance from Outdoor Recreation (Threat 6.1). Anderson et al. (2013b) predicted future habitat loss of Northeast habitats to development over the next 50 years. Alpine and associated High-Elevation Forests and Cliff and Talus macrogroups were the least threatened by habitat loss to development predicted over the next five decades, with virtually no loss of Alpine habitat.

Alpine habitat blocks were found to have some of the best landscape context indices of all habitat types, along with High-Elevation Forest and Cliff and Talus habitats, meaning patches of Alpine habitat are surrounded by more natural land cover types and less human conversion or fragmentation (Anderson et al. 2013b). Anderson et al. (2013b) assessed the landscape complexity, a measure of climate resilience, of Northeast habitat macrogroups. Acadian-Appalachian Alpine Tundra had low landscape complexity and resiliency, a reflection of the small and uniform nature of these types of habitats. Anderson et al. (2016a and 2016b) assessed the resiliency and connectedness of habitat macrogroups of the eastern United States at the landscape scale, identifying resilient sites for conservation.

Publicover et al. (2021) found that uncertainty remains for how resistant upper montane habitats are to climate change, whether community types will fully transition or exhibit partial resistance to conversion. Kimball et al. (2021) hypothesizes that arctic-alpine vegetation of the Northeast may persist through this century under low to medium greenhouse-gas emissions scenarios.

Anderson et al. (2023) provides a detailed assessment of habitat condition, loss, fragmentation, and resilience of Northeast Alpine habitat as of 2019 as well as trends over the past two decades. Staudinger et al. (2023) summarizes the state of knowledge of Alpine habitat resiliency to climate change.

2.6.4 HABITAT MANAGEMENT

Alpine habitats are threatened by human disturbance, specifically off-trail recreational use and trampling. Alpine plants are not adapted to being walked on, and it may take decades for bare ground that has been impacted by trampling to fully recover with a healthy plant community. In New York the **Adirondack Mountain Club** established a summit steward program more than 30 years ago that protects alpine areas from visitor impacts using education to engage hikers in appreciating the habitat and to foster a sense of responsibility for its care[68]. The stewards enlist visitors to carry rocks from trailheads to the alpine areas to line designated trails and restore degraded areas.

Two Northeast RSGCN butterflies, the White Mountain Arctic (*Oeneis melissa semidea*) and the White Mountain Fritillary (*Boloria chariclea monitus*), are endemic to the alpine habitat on Mount Washington in New Hampshire. The USFWS At-Risk Species Program is partnering with New Hampshire Fish and Game, the White Mountain National Forest, the Mount Washington Observatory, and the Appalachian Mountain Club to develop and produce a public awareness and education campaign to inform the public of the presence and predicament of these species and develop signage to mark sensitive areas.

Staudinger et al. (2023) describes the state of knowledge of adaptive management of Alpine habitats to climate change.

2.6.5 HABITAT MONITORING

The Appalachian Mountain Club and other partners monitor the condition of Alpine habitat in the Northeast alongside High Elevation Forest, as described in Section 2.2.5. The distribution and extent of Alpine habitats are monitored through several remote sensing land cover assessment programs. LANDFIRE includes multiple Alpine ecological systems (e.g., Eastern North America Alpine Tundra) within their spatial land cover datasets, which have been updated every two to three years but will be updated annually starting in 2022. Regionally, the Designing Sustainable Landscapes program at the University of Massachusetts monitors the extent of Acadian-Appalachian Alpine Tundra as land cover macrogroup in the Northeast.

2.6.6 PARTNERS

The conservation activities of the Appalachian Mountain Club are described in Section 2.2.6. The RSGCN White Mountain Arctic (*Oeneis melissa semidea*) and the White Mountain Fritillary (*Boloria chariclea monitus*) are endemic butterflies that were left isolated at the summit of Mt. Washington after the last glaciation period approximately 13,000 years ago. Their distribution is limited to a 2800-acre Alpine zone of the Presidential Range at the White Mountain National Forest. Potential stressors include trampling of habitat and individuals from off-trail recreational use, lack of redundancy due to the species' limited range, and potential negative effects to both species and their habitat from climate change. The USFWS At-Risk Species Program is partnering with New Hampshire Fish and Game (NHFG), the White Mountain National Forest, the Mount Washington Observatory (WMO), and the Appalachian Mountain Club to develop and produce a public awareness and education campaign to inform the public of the presence and predicament of these species and develop signage to mark sensitive areas. There are ongoing research projects with NHFG, WMO, the University of New Hampshire, and the Northeast Climate Adaptation Science Center to collect life history and abundance information on these two butterfly species. To date, these studies have successfully identified host species critical to complete the White Mountain Fritillary's reproductive cycle. Captive rearing protocols have been developed and implemented at the WMO and at the NHFG captive rearing facility. Studies that will continue into 2023 include DNA analysis to assess population structure, collection of demographic data, evaluation of impacts of climate change, species distribution modeling, and overwintering experiments.

2.6.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of Alpine habitat through several ongoing citizen science projects. The Mountain Watch and Appalachian Trail Seasons projects are described in Section 2.2.7. Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

The **Islands in the Sky: Alpine Flowers and Climate Change** project investigates the effects of climate change on Alpine plants through a citizen science project sponsored by the Appalachian Mountain Club and the New York Botanical Garden[69]. Citizen scientists study historic records of Alpine species in the New York Botanical Garden herbarium collection to transcribe and interpret specimen collection records. The associated Northeast Alpine Flower Watch project allows hikers to document the flowering and fruiting of Alpine plants using iNaturalist.

2.6.8 HABITAT INFORMATION, RESEARCH AND MONITORING NEEDS

Habitat information, research and monitoring needs exist for Alpine habitat in the Northeast:

- Improve understanding of habitat resiliency and potential conversion to other habitat types as a result of climate change, given the oftentimes geologic constraints of Alpine habitat

2.7 CLIFF & TALUS

Figure 2.7. 1 Cliff and Talus habitats support 67 Northeast RSGCN and Watchlist species. (Blue Mountain, PA, photo credit: Purebound.com)

2.7.1 HABITAT DESCRIPTION

The Northeast Terrestrial Wildlife Habitat Classification defines Talus as "piles of broken rock accumulating below a cliff or other outcrop as a result of weathering and freeze-thaw cycles" (Gawler 2008, p. 39). Cliffs are defined as vertical or nearly vertical rock outcrops that may or may not be vegetated (NatureServe 2022). In the NEAFWA region, the 14 SWAPs of 2015 included 26 Key Habitats for SGCN that are within Cliff and Talus habitat (*Appendix 2A*, Table 2A.7). SWAP Key Habitats include cliffs and rocky outcrops of various geologies, talus slopes, and coastal bluffs.

There are 44 RSGCN, one Proposed RSGCN and 20 Watchlist [Assessment Priority] species across seven taxonomic groups associated with Northeast Cliff and Talus habitat (*Supplementary Information 2*, Table 2.7.1, Figure 2.7.2). Another two species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. Eleven RSGCN and Proposed RSGCN associated with Cliff and Talus habitat are of Very High Concern and at least 75% regional responsibility in the Northeast – five salamanders and six terrestrial snails. The Chittenango Ambersnail (*Novisuccinea chittenangoensis*) is restricted to Chittenango Falls in New York, a 167-foot-high staircase Cliff protected as a State Park.

2.7.2 HABITAT DISTRIBUTION AND CONSERVATION

The most recent land cover dataset from the Designing Sustainable Landscapes program (DSLland version 5.0, issued 2020) identified more than 667,000 acres of Cliff and Talus habitat in the Northeast as of 2011-2013 (Table 2.0.3). The updated habitat condition assessment from Anderson et al. (2023) provides information on the status and conservation of Cliff and Talus habitat in the Northeast as of 2019.

Table 2.7. 1 The number of species in each RSGCN and Watchlist category associated with Cliff and Talus habitat in the Northeast as of 2023

Category	Number of Species
RSGCN	44
Proposed RSGCN	1
Watchlist [Assessment Priority]	20
Watchlist [Deferral to adjacent region]	2
TOTAL	**67**

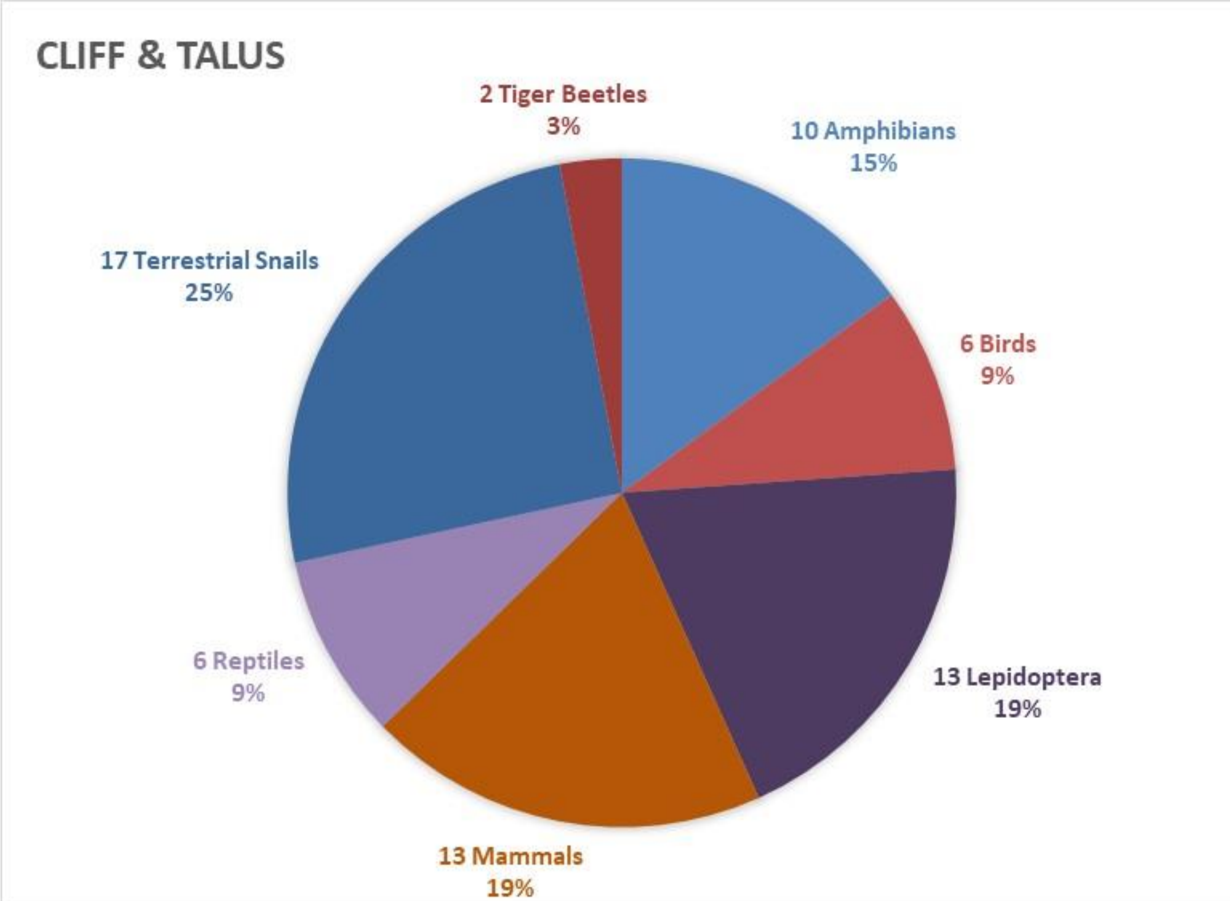

Figure 2.7. 2 Northeast RSGCN and Watchlist species associated with Cliff and Talus habitats represent seven taxonomic groups.

2.7.3 HABITAT CONDITION

Anderson et al. (2013b) predicted future habitat loss of Northeast habitats to development over the next 50 years. Cliff and Talus and associated High-Elevation Forests and Alpine macrogroups were the least threatened by habitat loss to development predicted over the next five decades, with less than 1% habitat loss for most Cliff and Talus macrogroups.

Threats to the multiple finer scale habitat types within this coarse Northeast Cliff and Talus habitat vary by location and type but include Recreational Use (Threat 6.1.3) and along coastlines by Shoreline Stabilization (Threat 7.3.1). In some cases, Cliff and Talus habitat could be threatened by geologic events like Landslides (Threat 10.3.2), but these events can also create or expand Cliff and Talus areas.

Anderson and Olivero-Sheldon (2011) assessed the status and condition of Cliff and Talus habitat in the Northeast as of the early 2000s. That conservation status assessment is updated in Anderson et al. (2023) with habitat status and condition information as of 2019 as well as trends over the past two decades.

Cliff and Talus habitats have been found to have some of the best landscape context indices of all habitat types, along with Alpine and High-Elevation Forest habitats, meaning patches of Cliff and Talus habitat are surrounded by more natural land cover types and less human conversion or fragmentation (Anderson et al. 2013b). Anderson et al. (2013b) assessed the landscape complexity, a measure of climate resilience, of Northeast habitats. Cliff and Talus habitats had high scores for landscape diversity and resilience.

Fones Cliffs

In 2022 the Rappahannock Tribe acquired and protected 465 acres surrounding and including their ancestral Pissacoack village and Fones Cliffs along the east side of the Rappahannock River in Virginia. The area is the former site of at least three Rappahannock Tribe villages and currently supports one of the most important nesting site for the Bald Eagle (Haliaeetus leucocephalus) on the East Coast. Additional Cliffs habitat is protected as part of the adjacent Rappahannock River Valley National Wildlife Refuge and the Chesapeake Conservancy and other partners are continuing efforts to protect the remaining portion of the iconic Cliffs.

Anderson et al. (2016a and 2016b) assessed the resiliency and connectedness of habitats of the eastern United States at the landscape scale, identifying resilient sites for conservation. Staudinger et al. (2023) summarizes the state of knowledge of Cliff and Talus habitat resiliency to climate change.

2.7.4 HABITAT MANAGEMENT

No national or regional management guidelines or best practices are available for Cliff and Talus habitat in the Northeast region. The conservation and management recommendations of sea cliffs in the United Kingdom, however, may be applicable to the New England coast. A Special Issue of the Journal of Coastal Conservation[70] was dedicated to the conservation and management of sea cliffs in 2015. Doody and Rooney (2015) summarize the habitat characteristics, conservation status, and management history for sea cliffs along the coasts of Great Britain, calling Cliff habitat as important but neglected in conservation. Earlie et al. (2015) describe how airborne LiDAR can be utilized successfully to measure recession of rocky cliffs. Howe (2015) shows how soft cliff invertebrates are reliant upon dynamic geomorphological processes that are threatened by human activities.

Staudinger et al. (2023) describes the state of knowledge of adaptive management of Cliff and Talus habitats to climate change.

2.7.5 HABITAT MONITORING

The distribution and extent of Cliff and Talus habitat are monitored through several remote sensing land cover assessment programs. LANDFIRE includes multiple Cliff and Talus ecological systems (e.g., North-Central Appalachian Acidic Cliff and Talus) within their spatial land cover datasets, which have been updated every two to three years but will be updated annually starting in 2022. Regionally, the Designing Sustainable Landscapes program at the University of Massachusetts monitors the extent of multiple subtypes of Cliff and Talus (based on the LANDFIRE ecological systems) as land cover macrogroups in the Northeast.

2.7.6 PARTNERS

Conservation activities of the **Appalachian Trail Conservancy** focus on the protection and stewardship of the landscape along the 2160-mile long Appalachian Trail (AT) that traverses the Northeast region along the spine of the Appalachian Mountains. The Appalachian Mountain landscape along the AT includes Cliff and Talus habitat along with Forest and Woodland, High Elevation Forest, Alpine, and headwater River and Stream habitats. The Appalachian Trail Conservancy protects high priority tracts of land along the AT corridor through land acquisition and management with numerous federal, state, and local partners. These partners, collaborating as **The Appalachian Trail Landscape Partnership**, conserve the scenic vistas and the natural and cultural heritage of the AT corridor under the National Trail Systems Act[71].

Most of the conservation partners working to protect and manage Cliff and Talus habitat are acting locally, such as the Rappahannock Tribe and Chesapeake Conservancy along the Rappahannock River in Virginia or the Mohank Preserve in New York.

2.7.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of Cliff and Talus habitat through a limited number of ongoing citizen science projects. **Peregrine Watch** is a community science project at the 8000-acre Mohonk Preserve in New York to monitor breeding of the Watchlist Peregrine Falcon (*Falco peregrinus*) in Cliff habitat[72]. Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

2.7.8 HABITAT INFORMATION, RESEARCH AND MONITORING NEEDS

Habitat information, research and monitoring needs for Cliff and Talus habitat in the Northeast is generally lacking.

2.8 SUBTERRANEAN AREAS

Figure 2.8. 1 Subterranean habitats support 22 Northeast RSGCN and Watchlist species. (Organ Cave, WV)

2.8.1 HABITAT DESCRIPTION

Subterranean habitat includes natural cave, cavern and karst systems, rock shelters, and anthropogenic extractive areas including mines, tunnels, quarries and sand/gravel pits. Karst systems require carbonate rock to form, but caves can form in multiple rock types. Caves and caverns may have stalactites, stalagmites and other mineral formations, or underground streams, lakes, springs or seeps. Karst terrain may contain sinkholes, springs, disappearing streams and important groundwater aquifers. The definition of what is considered a cave varies by state, region and county, often with minimum lengths that range between 5 to 100 feet, making it challenging to make comparisons across states (Culver et al. 2015). The **National Cave and Karst Research Institute** (NCKRI)[73] and **Karst Waters Institute**[74] both provide a number of scientific and educational resources on natural cave and karst systems in the US.

There are several types of natural caves that occur in the Northeast region. Solution or karst caves are the most common type of cave, formed when water dissolves carbonate or evaporite rocks to form cavities. Sea caves are formed by the erosional forces of waves and tides along coastlines, some of which are found within Acadia National Park in coastal Maine. Ice caves are formed in rock but contain ice year-round. Talus caves form in the spaces under and between large slabs of rock or giant boulders and are the most common type of cave in Maine (Hendrickson 1998). Fissure or fracture caves form where geologic faults or tectonic processes form breaks or joints in rock, which can widen sufficiently to form cave passageways. Maze caves are those has intersecting sets of parallel passageways, with notable regional examples in New York and New Jersey. Lava tubes can also create caves after molten lava has drained away, some of which are found in Jew Jersey (Dalton et al. 1976). Solution or karst caves are most common type in Maryland, West Virginia and Virginia within the Northeast region, while talus caves are the most common type of cave in Maine.

Sixteen (16) SWAP Key Habitats are Subterranean Areas, a mix of natural cave and karst habitats with anthropogenic, extractive habitats (*Appendix 2A*, Table 2A.8). There are 15 RSGCN, two Proposed RSGCN and two Watchlist [Assessment Priority] species across nine taxonomic groups associated with Northeast Subterranean Areas habitat (*Supplementary Information 2*, Table 2.8.1, Figure 2.8.2). Seven of the RSGCN species associated with Subterranean Areas are bats. Three are salamanders and one is a crayfish. The RSGCN West Virginia Spring Salamander (*Gyrinophilus subterraneus*) is endemic to the General Davis Cave in West Virginia. The Dixie Cavern Salamander (*Plethodon dixi*) is a Proposed RSGCN that is endemic to Virginia, known from only three localities, two of which are cavern systems. The RSGCN Greenbrier Cave Crayfish (*Cambarus nerterius*) is endemic to the caves of West Virginia.

Table 2.8. 1 The number of species in each RSGCN and Watchlist category associated with Subterranean Areas habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	15
Proposed RSGCN	2
Watchlist [Assessment Priority]	2
Watchlist [Deferral to adjacent region]	3
TOTAL	**22**

Another three species – all bats - associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. Habitat features and formations associated with RSGCN and Watchlist species in the Northeast RSGCN Database (version 1.0) in Subterranean Areas include logs and woody debris, surface litter, cave pools, cave streams, cave springs and seeps, wells, whether pits or mines are active or inactive, and whether the species is associated with caves, mines, tunnels and/or pits.

Natural cave and cavern systems can lead to speciation, with highly endemic species only known from one or a few cave systems with specialized ecologies (Grant et al. 2022). Culver et al. (2000) inventoried the cave obligate fauna of the conterminous US, with the known distribution of each, finding 927 species and 46 subspecies exclusively associated with Subterranean habitats. Arachnids, insects and crustaceans have the highest number of described obligate species and subspecies described within caves of the US. Nationally, concentrations of terrestrial cave-obligate fauna are located in Virginia, West Virginia, Kentucky, Alabama and Texas. Aquatic cave-obligate fauna are concentrated in Virginia, West Virginia, Texas, Oklahoma and Florida. Cave-obligate fauna are highly endemic, with 54% of the species restricted to single counties. Culver et al. (2000) describe the various ecological communities located within Subterranean habitats. The list of species inventoried by Culver et al. (2000), with updates since publication, is available at the Karst Waters Institute of West Virginia[74].

In addition to natural cave and karst systems, Subterranean Areas that serve as habitat for RSGCN and Watchlist species in the Northeast include several anthropogenic habitats, albeit suboptimal, including mines, tunnels, quarries and sand and gravel pits. In some areas of the region these anthropogenic Subterranean habitats are more abundant than natural cave and karst systems. As of 2019, for example, nearly 50% of the RSGCN and federally-listed Indiana Bat population hibernated in man-made systems (USFWS 2019a).

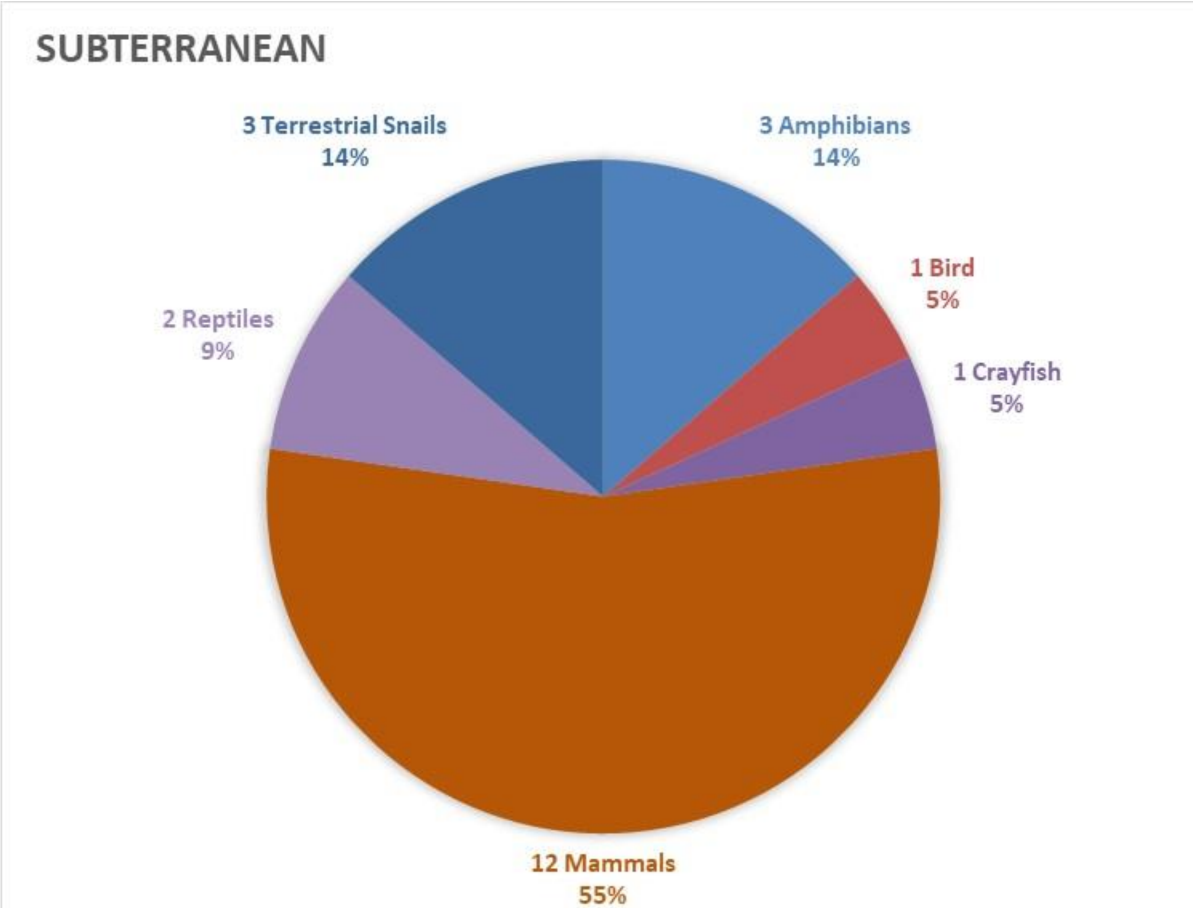

Figure 2.8. 2 Northeast RSGCN and Watchlist species associated with Subterranean Areas habitat represent five taxonomic groups.

2.8.2 HABITAT DISTRIBUTION AND CONSERVATION

The full extent of Subterranean Areas in the Northeast region is unknown, with many cave systems not fully explored and anthropogenic extractive mines and tunnels privately-owned and operated. Mines and tunnels undergoing active extraction will change in length and location daily. Cave systems in New England are less documented and known than those in the southern portion of the region.

Subterranean Areas habitat of one type or another occur in every NEAFWA state and District. Although they provide suboptimal habitat, mines, tunnels, quarries and pits do provide habitat for several RSGCN and Watchlist species, particularly in areas where natural Subterranean Areas are absent or sparse. Large bat hibernacula are more often found in abandoned mines in New England than caves, given the larger number of mines than deep or large caves. All of New Hampshire's 16 known or potential Subterranean bat hibernacula are in abandoned mines[75]. Only 12 of the 23 known large bat hibernacula in Massachusetts are known from natural caves, with the rest located in abandoned mines[76].

There are an estimated 45,000 caves and caverns in the US but the exact number is unknown. Similarly, the precise number of natural cave and karst systems in the Northeast region is unknown but exceeds 10,100 (Table 2.8.2). Comprehensive surveys are particularly lacking in most of the New England states, New York and West Virginia. New cave systems are discovered and explored continuously, often by state or local speleological societies or organizations. In 2015, for example, the Virginia Speleological Survey had documented 3805 caves of at least five feet in length in the state (Lera 2015). In 2022 the total number of documented caves had increased to 4117 (Futrell 2022). The National Speleological Society encourages the exploration and survey of cave and karst systems by its members and local chapters, awarding Cartographic Awards at their annual convention. In 2021 the national award was presented to the team that developed a cartographic survey of the Sunshine Canyon Complex in New York.

Kastning (2018) describes the importance of the Appalachian region, from New England south to Alabama, for cave and karst systems. Approximately 30% of the 1130 caves longer than one mile documented in the US are located in the Appalachian Mountains. The cave and karst systems of the Appalachians have been studied for their natural and ecological resource values since the 1770s. Two of the nation's first three "show caves" were discovered and opened to the public in the Northeast region – Weirs Cave in Virginia and Howe Caverns in New York. The first map of an American cave was of Madison's Cave in Virginia, drawn by Thomas Jefferson.

More recently, the former Appalachian LCC completed the **Classification and Mapping of Cave and Karst Resources** project to inventory available information on these habitats and develop tools to inform decision making within the central and southern Appalachian region. Datasets and products available from this project include several summarizing Subterranean fauna (e.g., diversity, richness, distribution), a classification scheme, maps of known karst and cave areas, and a model to predict the occurrence of cave-inhabiting species based on the features of the surrounding terrestrial and aquatic surface environment. Northeast states included in these analyses include portions of New York, Pennsylvania, New Jersey, West Virginia and Virginia. These resources, published in 2015, are available online through ScienceBase[77].

In the Northeast region, natural karst terrain is concentrated in the mountainous areas of Pennsylvania, Virginia and West Virginia plus western Maryland (Culver et al. 2015). Natural caves are virtually all located in karst areas of the central and southern Appalachians. Data are limited from Pennsylvania and New York in the Culver et al. (2015) inventory due to a lack of comprehensive surveys and were identified as an information need.

In West Virginia, karst terrain is concentrated in the eastern and panhandle parts of the state. Cave systems located out of the karst terrain area tend to be very small and isolated. A comprehensive inventory of cave systems in West Virginia has not been updated since 1965 (WV Geological and Economic Survey 2019). As of 2004 there were 4241 caves in West Virginia, with 1810 of them at least 33 feet in length and 106 with at least one mile in surveyed passageways (Jones 2012). The **West Virginia Speleological Society** publishes a series of Bulletins and Monographs with surveys of individual or county cave systems as they are explored[78].

Three of the ten longest known cave systems in the US are in West Virginia. The Great Savannah Cave System (WV) is reportedly the sixth longest in the US and the longest in the Northeast, with approximately 51 miles of mapped passageways. The Friars Hole Cave System, also in West Virginia, is thought to be the seventh longest with nearly the same length (Gulden 2022). The Hellhole pit cave system is the tenth longest system in the nation with nearly 44 miles of mapped passageways (Gulden 2022) and supports large wintering populations of RSGCN Virginia Big-Eared, Indiana and Little Brown Bats.

As of April 2022, there are 4117 caves of at least five feet in length in Virginia with more than 588 miles of passageways surveyed. Virginia caves more than 1000 feet in length number 411 (Futrell 2022). The **Virginia Cave Board** and **Virginia Speleological Survey** have designated 375 Significant Caves in the state (Lera 2015). Natural Bridge Caverns are the deepest caverns in the eastern US, reaching 34 stories underground (Virginia Tourism Corporation 2022). Eight cave and karst systems in Virginia and West Virginia have been designated as **National Natural Landmarks**: Butler Cave – Breathing Cave, Grand Caverns, Luray Caverns, Germany Valley Karst Area, Greenville Saltpeter Cave, Lost World Caverns, Organ Cave System, and Sinnett-Thorn Mountain Cave System. Ellenville Fault-Ice Caves in New York has also been designated a National Natural Landmark.

The NEAFWA region provides important Subterranean wintering habitat for four federally-listed RSGCN bats – Indiana, Virginia Big-eared, Northern Long-eared, and Tricolored Bats (USFWS 2019a, 2019b, 2021, 2022). Barton Hill Mine (NY) contains 93% of the Northeast Recovery Unit for the Indiana Bat's remaining population. Prior to the introduction of WNS, the largest hibernacula in the Northeast Recovery Unit was located in the Williams Hotel Mine of NY, with 45% of the wintering population. Within the Appalachia Recovery Unit, the Hellhole cave system in West Virginia hosted 51% of the wintering Indiana Bat population prior to the arrival of WNS, but after the arrival of WNS the largest wintering hibernacula shifted to a cave in Tennessee (USFWS 2019a). Of the ten major Subterranean hibernacula for the federally-endangered Virginia Big-eared Bat, seven are located in Virginia and West Virginia. The Hellhole cave system in West Virginia hosted more than two-thirds (~69%) of the wintering population of the species surveyed in 2017-2018 (USFWS 2019b). The number of wintering hibernacula for all four of these species has been declining and is forecast to continue to decline substantially by 2030, increasing the importance of each hibernacula to each species. Remaining RSGCN bat populations are expected to become concentrated in fewer and fewer Subterranean hibernacula (USFWS 2019a, 2019b, 2021, 2022).

Subterranean Areas of the Northeast include anthropogenic mines, tunnels, quarries, and pits that provide habitat to RSGCN and Watchlist species, although it is suboptimal compared to natural cave and karst systems. The USGS maintains a spatial dataset of mineral resources in the US, including the known locations and types of mines, in their **Mineral Resources Online** interactive map viewer[79]. Notably, data from West Virginia are absent but the remaining NEAFWA states are included.

The USGS also has spatial data layers of prospect- and mine-related landform features identified on topographic maps, including prospect pits, mine shafts and adits (horizontal mine entry shafts), open-pit mines, quarries, tailings ponds and piles, gravel and borrow pits, and related features (Horton and San Juan 2022). Data layers are available for every state except West Virginia at https://mrdata.usgs.gov/usmin/. These datasets include historical and active mine and quarry operations, to the extent that they have readily identifiable surface features. The Vermont dataset, for example, includes 1172 prospect- and mine-related features on the landscape, from granite and marble quarries to talc and asbestos mines. Altogether Horton and San Juan (2022) have identified 35,732 mine-related features on the Northeast landscape, excluding West Virginia (Table 2.8.2). As of 2020 there were 406 active quarries, surface mines and underground mines in West Virginia (WV Office of Miners' Health, Safety and Training [WV OHMS&T] 2020), indicating more than 36,100 sites throughout the region that have the potential to provide Subterranean habitat for RSGCN and Watchlist species.

The Connecticut Geological and Natural History Survey (CGNHS) completed an inventory of all active and historic bedrock mines and quarries in the state in 2022, finding a total of 1070 sites, only 77 of which were active (CGNHS 2022).

The level of protection for Northeast Subterranean habitats is not well known, although some data exist documenting the protection of numerous individual cave and karst systems throughout the region. A number of caves have been protected as part of state parks and other publicly owned lands in the Northeast. Acadia National Park in Maine has protected several land and sea caves. Caves located within National Forests are protected and managed by **the Caves and Karst Program** of the US Forest Service. The state of Virginia owns and protects 173 caves (Lera 2015). Approximately 13% of the known 1100 or so caves in Pennsylvania occur within conserved lands[80].

Table 2.8. 2 The availability and distribution of known Subterranean Areas habitat, both natural cave systems and sites with anthropogenic mine-related landscape features identified by Horton and San Juan (2022) present within each state of the NEAFWA region.

State / District	Estimated Number of Cave Systems	Number of Sites with Mine-related Features identified by Horton and San Juan (2022)
Connecticut	10+	1290
Delaware	3	227
District of Columbia	0	1
Maine	43+	5102
Maryland	148+	1089
Massachusetts	70+	2097
New Hampshire	0±	2181
New Jersey	152	2023
New York	200+	6773
Pennsylvania	1100+	8224
Rhode Island	7+	205
Vermont	22+	1172
Virginia	4117	5348
West Virginia	4241	Unknown†
TOTAL	**10,103+**	**35,732**

± The New Hampshire 2015 SWAP states that there are no true caves in the state.
† There were 406 active quarries, surface mines and undergrounds mines in WV in 2020 (WV OMHS&T 2020).

The **National Speleological Society** owns 17 cave preserves and manages two others nationally, of which seven are located in the Northeast region: the Tytoona Cave Nature Preserve in Pennsylvania, the James Gage Karst Preserve, McFail's Cave Nature Preserve and Schoharie Caverns Nature Preserve in New York, the John Guilday Caves Nature Preserve in West Virginia, and the New River Cave Preserve and Perkins Cave Nature Preserve in Virginia. The **West Virginia Cave Conservancy**[81] is a nonprofit

Virginia Caves

*Virginia protects natural cave and karst systems with **the Virginia Cave Protection Act**, enacted in 1966 and revised in 1979. The **Virginia Cave Board (VCB)** consists of geologists, biologists, engineers, educators, conservationists, cave owners and cavers an advises government agencies, organizations and the public on management, conservation and preservation of cave resources in the state. The Cave Protection Act includes provisions to protect Native American burial remains, archaeological resources, mineral formations, endangered species, and other cave resources and features from removal, burial or collapse, vandalism, pollution, and other forms of natural system modification (e.g., hydrology) and disturbance. The VCB and Virginia Speleological Survey may designate **Significant Caves**, which are afforded natural heritage resource status and are subject to environmental project reviews. The VCB has developed Karst Assessment Guidance to assist communities and developers in the preparation of Karst Management Plans.*

NGO that protects and manages cave and karst systems in the state, with 15 preserved as of 2022.

Many larger caves and cavern systems have been developed as commercial caves, sites open for tourism but protected from other development and presumably with a vested interest in maintaining the underground systems.

2.8.3 HABITAT CONDITION

Access to Subterranean habitats for wildlife may be lost due to collapse of the underground spaces, the natural or anthropogenic closure of cave entrances, the intentional closure of abandoned mines, or the filling of sinkholes and other karst features. Changes in groundwater flow may alter the extent or maintenance of karst systems, as can alterations to connected surface hydrology. No data are available on the extent of historical habitat loss of Subterranean habitats in the Northeast, especially given the lack of comprehensive data on the extent of the habitat historically and currently. Dalton et al. (1976) note the blockage, sealing or destruction of seven caves in New Jersey, one of the few accountings of habitat loss in the region.

Caves and karst systems are threatened by pollution, especially agricultural chemicals (Threat 9.3.3), invasive species (Threat 8.1), human-caused erosion washing into caves (Threat 9.3.2), multiple aspects of climate change (Threat 11.3.3 and 11.4), mining (Threat 3.2 and 9.2.2), and human disturbance from caving and tourism (Threat 6.1.7) (Tuttle 2013, NCKRI 2022).

Multiple types of natural system modifications (Threat 7.3) also threaten cave and karst habitats. Creation of new cave openings (e.g., quarries or mines that breach a cave system) can modify the microclimate inside caves, which can be important habitat characteristics for bat hibernation or other wildlife. Closing cave openings can have similar climactic effects, plus physically limit access for wildlife (Tuttle 2013). Natural cave systems have sometimes been modified by mines or quarries that extend off of or cut into them. On the other hand, some historical quarries or mines can be mistaken for caves.

Pollution (Threat 9.0) can affect habitat conditions in cave and karst systems in multiple ways. These Subterranean systems are connected to the surface not only through physical openings into which garbage, waste, and sediment can enter or be dumped, but they are also connected aquatically to surface and groundwater flows. Caves with underground springs, seeps, streams, and rivers are connected to surface waters and shallow aquifers, providing a hidden route for pollution to enter the cave system. Karst geology can be characterized by sinkholes and other surface depressions that have been used as garbage or waste pits, and karst aquifiers are especially vulnerable to surface pollution. Streater (2009) describes several examples of cave and karst pollution and the resultant impacts to wildlife and drinking water supplies.

Many large cavern systems are open to the public for tours and exploration and are oftentimes referred to as “commercial caves” or “show caves.” These cave and cavern systems have been impacted by human disturbance (Threat 6.1.7), sometimes for more than a century. Grand Caverns in Virginia has been open to visitors since 1806 and Howe Caverns in New York since 1843.

Anthropogenic Subterranean Areas lack natural habitat qualities and features but their condition for fish and wildlife can be affected by similar threats. For active extraction Subterranean Areas (i.e., mines, tunnels, quarries), the systems are continuously modified by system modifications (Threat 3.2.1, 3.2.2 and 3.2.3), human disturbance (Threat 6.3), and multiple types of pollution (Threat 9.6.3 for noise, Threat 9.5.4 for air, Threat 9.2 For water, Threat 9.6.2 for thermal).

Natural caves and caverns are discrete systems that are not connected at the landscape level. Cave and karst systems are connected to their surrounding surface landscapes, however, linked through both terrestrial and aquatic systems. A regional assessment of the connectedness of individual cave and karst systems with their surrounding landscapes and watersheds is not available and is rarely available for individual cave or karst systems. Culver et al. (2015) developed a predictive model for cave-obligate species communities in the central and southern Appalachian Mountains using multiple variables characterizing the surrounding surface landscape, providing new information on the importance of several connected habitat characteristics between the surface landscape and its underground Subterranean habitats.

Natural cave and cavern systems are sensitive to alterations in temperature, air flow, humidity, hydrology, light and other climactic factors. The collapse or closure of existing openings, or the creation of new openings, can significantly alter the microclimate of a cave system and the adaptations of endemic or obligate wildlife inhabiting the system. Habitat modifications to the surrounding surface landscape can directly and indirectly impact underground Subterranean habitats. As a result, Subterranean habitats are not inherently resilient but assessments of habitat resiliency are lacking. A new project initiated in 2022 by the SE CASC is undertaking research to assess the resilience of cave microclimates to habitat modifications on the surrounding surface landscape (i.e., clearcutting forest) and climate change, which may address this information gap.

2.8.4 HABITAT MANAGEMENT

Management plans for cave and karst systems are localized to individual protected or managed systems. There are no known regional or landscape scale management plans for Subterranean habitats in the Northeast.

In 2016, the RCN Program awarded funding to Connecticut, New Jersey, New Hampshire, Pennsylvania and Rhode Island to increase the suitability of identified bat winter hibernation sites by reducing human disturbance as part of the **Gating Caves for Bat Conservation and Protection** project. Project funds supported construction or improvements of gates to the openings in caves and mines, structural enhancements to the sites to create better habitats, installation of a sign template for consistent messaging, and the placement of remote site surveillance if needed (see *Chapter 4* for additional project details).

The National Speleological Society has developed recommended methods for the restoration and repair of cave and karst systems, available on their website[82]. The Conservation Division of the National Speleological Society has developed recommended management practices to minimize the impacts of caving by humans on cave and karst systems.

2.8.5 HABITAT MONITORING

The National Speleological Society has developed protocols for inventorying and monitoring cave and karst systems, including photomonitoring techniques[82]. The Survey and Cartography Section of the National Speleological Society maintains a list of resources and protocols for surveying caves and a list of the current knowledge of the world's longest and deepest caves[83].

Since 2015 the **North American Bat Monitoring Program** conducts standardized monitoring of bat populations across North America, including in Subterranean roosting and hibernating sites[84]. While this standardized monitoring program is species-based, surveys of bat colonies in Subterranean habitats should capture data on habitat conditions as well. The Northeast region falls within two regional hubs in the international program – the **Atlantic Canada Bat Hub** and the **Mid-Atlantic Bat Hub**.

2.8.6 PARTNERS

The **National Speleological Society**[85] is a national NGO that has been exploring, conserving, and researching caves in the US since 1941. The organization's website includes several environmental education resources on cave fish and wildlife, threats like White Nose Syndrome, safety, and responsible caving practices. The Conservation Division of the National Speleological Society focuses on decontamination procedures to reduce the spread of WNS, restoration and repair techniques, and minimizing the impact of caving by humans with recommended conservation and preservation policy guidelines. Another focus area of the National Speleological Society is supporting cave science, which is implemented through scientific grants and publication of **The Journal of Cave and Karst Studies**[86].

Cave Outreach

Cave Softly. Take nothing but pictures. Kill nothing but time. Leave nothing but footprints.
Communication messaging from the National Speleological Society to encourage responsible, low impact caving.

The **Northeastern Cave Conservancy** is an NGO dedicated to the conservation, management, study and acquisition of significant caves and karst areas[87]. This regional organization protects or manages 11 caves in New York. Research projects are encouraged within their preserves, with recent projects including topics related to WNS, fungal biocontrols, amphipod genetics and hydrology. The **Mid-Atlantic Karst Conservancy** is another NGO that has protected or manages 18 cave and karst systems in the Northeast region (PA, WV, and VA) and supports research within those systems[88]. Both organizations require permits for scientific research conducted in their preserves.

The **Karst Waters Institute**, headquartered in West Virginia, is dedicated to improving the understanding of karst water systems through scientific research and education. As part of that mission, the organization provides access to multiple datasets, databases and publications[74]. Datasets available include the Karst Information Portal (an open-access digital library, a digital map and database of karst areas in the US, updated lists of terrestrial cave-obligate species from Culver et al. (2000), subterranean species diversity maps for cave dwelling species of the eastern US, a lexicon of cave and karst terminology, and techniques for monitoring groundwater in karst terrains. The Karst Waters Institute also publishes the scientific journal **Frontiers of Karst Research**.

The **National Cave and Karst Research Institute** is a non-profit NGO created by the US Congress to "conduct, support, facilitate, and promote programs in cave and karst research, education, environmental management, and data acquisition and sharing"[73]. One current effort of the NCKRI is a partnership with ASTM International as part of a Karst Subcommittee to develop standards to guide and/or assist the protection of karst resources. The NCKRI also created and maintains a **National Cave Sample Archive** that provides open, online access to cave and karst research materials and publications. The Institute provides scientific and research grants as well.

The **USFS Caves and Karst Program** identifies significant caves within National Forests, manages them in accordance with the federal **Cave Resources Protection Act of 1988**, and issues publications of scientific research related to cave and karst systems they manage[89].

In 2022 the Southeast Climate Adaptation Science Center (SE CASC) initiated a two-year project to develop a **Cave Conservation Management Toolbox** to address the impacts of climate change by exploring the microclimates and biodiversity patterns of caves in nine states, including Virginia. One of the scientific objectives of the project is to determine how cave climates vary with full forest cover on the surrounding landscape and those where forests have been removed. Detailed information about the project can be found through SE CASC[90].

Bat Conservation International is an international organization with a mission to conserve bats through science-based conservation, development of new conservation tools and techniques, and the prioritization of conservation strategies and targets[91]. One of the current goals of the NGO is to protect and restore roosting and foraging habitat for bats, including in abandoned mines that provide roosting habitat. Their abandoned mines initiative collaborates with government partners to identify significant bat habitat and develop long-term protection and management plans. Guidance has been developed on the installation of bat-compatible gates at mine entrances and more than 5000 mines have been surveyed by the organization since 2008. Bat Conservation International also partners with federal agencies to develop spatial datasets of priority bat habitats and implement BMPs for bat conservation on public lands.

2.8.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

Volunteers can become involved in expanding the knowledge and conservation of cave and karst systems through the National Speleological Society, which engages cavers in tens of thousands of hours of service annually[92]. More than 250 local chapters of the National Speleological Society are active nationwide and internationally, including chapters in every state of the Northeast region except Maine, New Hampshire, and Rhode Island.

2.8.8 HABITAT INFORMATION, RESEARCH AND MONITORING NEEDS

There are several areas of needed research for Subterranean habitats in the Northeast:

- Comprehensive inventory of cave systems throughout the region, particularly in Pennsylvania, New York, and New England, and potentially using the dataset developed by Culver et al. (2015) for the former Appalachians LCC as a foundation for expansion
- Apply the model developed by Culver et al. (2015) for cave-dwelling species and the surrounding surface landscape for the central and southern Appalachians to the remaining area of the Northeast
- Identification of cave watersheds, the area of land that drains to a particular cave or cave spring, for significant cave and cavern systems for RSGCN that warrant protection
- Potential expansion and application of the Cave Conservation Management Toolbox under development by SE CASC to the Northeast region
- Incorporate mine site data from West Virginia into the National Minerals Information Center spatial dataset(s) to provide comprehensive coverage of the Northeast region
- Include West Virginia in the Horton and San Juan (2022) spatial dataset of mine-related features on the landscape of the Northeast to provide comprehensive coverage of the Northeast region
- Combine the Horton and San Juan (2022) spatial dataset for mine-related landscape features, the Culver et al. (2015) spatial dataset for cave and karst features in the central and southern Appalachians, and the Anderson et al. (2023) spatial dataset for protected lands in the region to determine the level of protection of Subterranean Areas habitat for Northeast RSGCN and Watchlist species

2.9 NON-TIDAL WETLANDS

Figure 2.9. 1 Non-Tidal Wetlands habitat support 262 Northeast RSGCN and Watchlist species. (Dolly Sods Fen, WV)

2.9.1 HABITAT DESCRIPTION

Wetlands are defined by the FGDC Wetlands Classification Standard according to Cowardin et al. (1979):

> WETLANDS *are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.* (FGDC 2013, pp. 6-7)

In the NEAFWA region, the 14 SWAPs of 2015 included 135 Key Habitats for SGCN that are within Non-Tidal Wetlands habitat (*Appendix 2A*, Table 2A.9). Non-Tidal Wetlands for RSGCN and Watchlist species include springs, seeps, vernal pools, fens, bogs, swamps, emergent marshes, peatlands, sedge meadows, artificial marshes, shrub / scrub wetlands, and forested wetlands.

Non-tidal Wetland habitat in the Northeast has the third highest number of RSGCN and Watchlist species (262) of any habitat type. There are 120 RSGCN, ten Proposed RSGCN, 92 Watchlist [Assessment Priority], and 13 Proposed Watchlist species across 17 taxonomic groups associated with Northeast Non-tidal Wetland habitat (*Supplementary Information 2*, Table 2.9.1, Figure 2.9.2). Another 27 species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. Regional priority species associated with Non-Tidal Wetlands are the most taxonomically diverse of all 24 habitat types, with 17 out of 20 taxonomic groups assessed represented. Seven RSGCN and Proposed RSGCN that are endemic to the Northeast are of Very High Concern – three moths and one each caddisfly, dragonfly, rabbit, and turtle.

Table 2.9. 1 The number of species in each RSGCN and Watchlist category associated with Non-Tidal Wetlands habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	120
Proposed RSGCN	10
Watchlist [Assessment Priority]	92
Proposed Watchlist [Assessment Priority]	12
Watchlist [Interdependent Species]	1
Watchlist [Deferral to adjacent region]	27
TOTAL	**262**

The Northeast RSGCN Database (version 1.0) contains data on habitat characteristics associations for Non-Tidal Wetlands-associated RSGCN and Watchlist species, such as substrate, hydroperiod, and vegetation densities; whether the Wetlands are or contain vernal pools, springs / seeps, peat; whether they've ditched and drained, or diked / impounded; or are artificial wetlands and drainage systems.

Numerous (31) Wetlands in the Northeast have been designated National Natural Landmarks, many of them exemplary sphagnum bogs and Atlantic White Cedar (*Chamaecyparis thyoides*) swamps of national significance. Non-tidal Wetlands that have been designated as **Ramsar Wetlands** of international importance include four habitat complexes in the Northeast[93]:

- Missisquoi Delta and Bay Wetlands, Vermont (Non-Tidal Wetlands, Rivers and Streams, Great Lakes)

- Niagara River Corridor, New York (Non-Tidal Wetlands, Rivers and Streams, Riparian and Floodplain, Beaches and Dunes, and Great Lakes)
- Edwin B. Forsythe National Wildlife Refuge, New Jersey (Non-tidal Wetlands, Tidal Wetlands, Beaches and Dunes, Estuaries)
- Chesapeake Bay Estuarine Complex, Maryland and Virginia (Tidal Wetlands, Estuaries, Beaches and Dunes, Lakes, Non-tidal Wetlands)

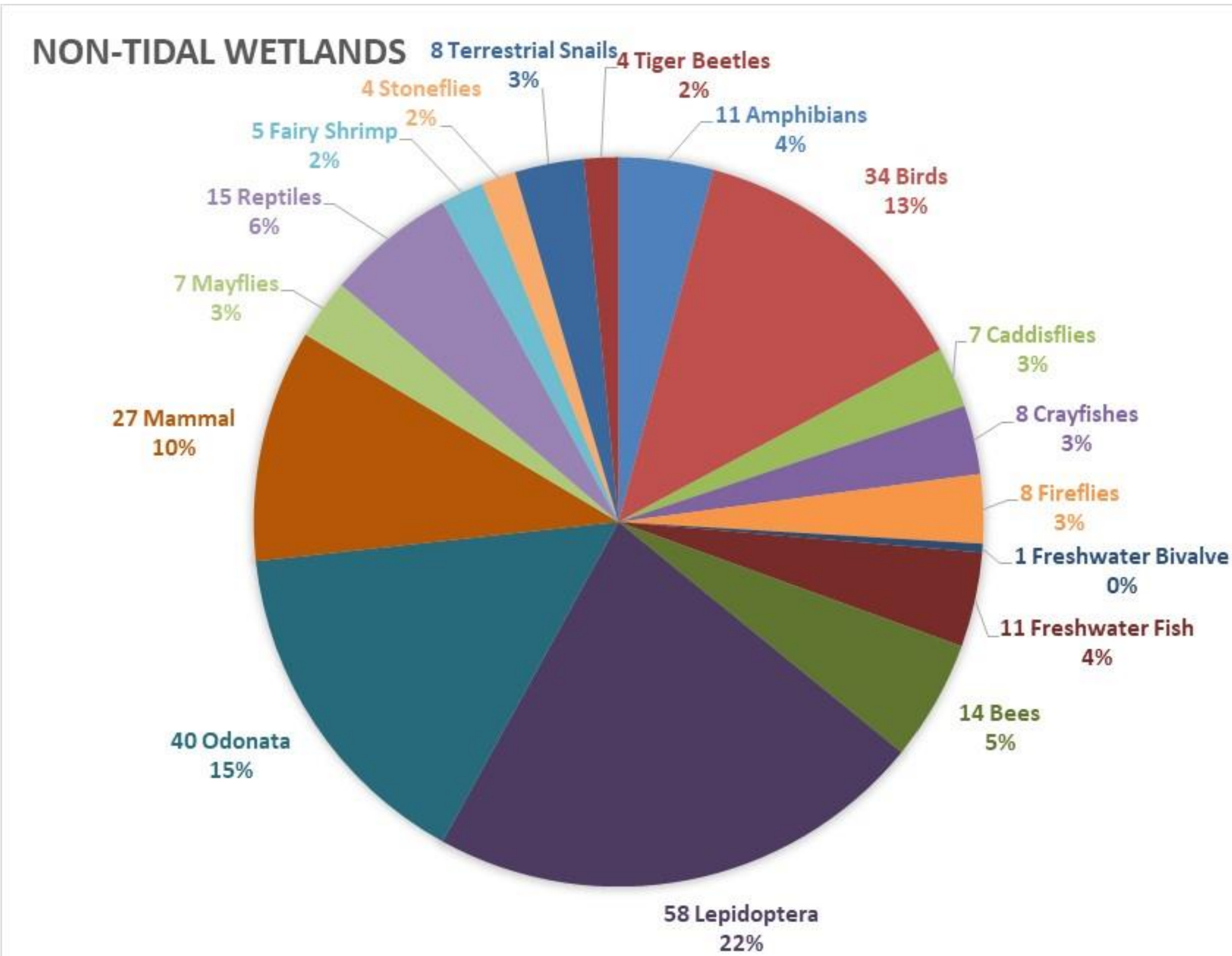

Figure 2.9. 1 Northeast RSGCN and Watchlist species associated with Non-Tidal Wetland habitats represent 17 taxonomic groups.

2.9.2 HABITAT DISTRIBUTION AND CONSERVATION

Non-Tidal Wetlands and Tidal Wetlands and Flats are found throughout the Northeast region, with nearly 700,000 wetland complexes identified in the region by Ferree and

Anderson (2008). The mean size of Northeast wetland complexes ranged from 6.7 to 27.8 acres depending on the geographic area (Ferree and Anderson 2008). The most recent land cover dataset from the Designing Sustainable Landscapes program (DSLland version 5.0, issued 2020) identified nearly 8 million acres of Non-Tidal Wetlands (excluding Floodplain wetlands, see Section 2.13) habitat in the Northeast as of 2011-2013 (Table 2.0.3). The updated habitat condition assessment from Anderson et al. (2023) identified over 11.6 million acres of all wetland types (Non-Tidal Wetlands, Tidal Wetlands and Flats, and Riparian and Floodplain wetlands) as of 2019. More than 8.3 million acres of these wetlands are Non-Tidal Wetlands.

Non-Tidal Wetlands are less conserved than Tidal Wetlands and Flats in the Northeast (Anderson et al. 2023). Anderson et al. (2023) provides an updated understanding of historical wetlands distribution and current conservation status for the region.

2.9.3 HABITAT CONDITION

Threats to the multiple finer scale habitat types within this coarse Northeast Non-tidal Wetlands habitat vary by location and type but include Development (Threat 1.0), Agriculture (Threat 2.0), Pollution (Threat 9.0), and multiple aspects of Climate Change (Threat 11.0). The USFWS National Wetlands Inventory Program periodically assesses the status and condition of Non-Tidal Wetlands. Dahl (1990) assessed **Wetland Losses in the United States 1780s to 1980s**. Stedman and Dahl (2008) summarized the **Status and Trends of Wetlands in the Coastal Watersheds of the Eastern United States 1998-2004**. Dahl and Stedman (2013) provides an assessment of the **Status and Trends of Wetlands in the Coastal Watersheds of the Conterminous United States 2004-2009**.

Anderson and Olivero-Sheldon (2011) assessed the status and condition of Non-Tidal Wetlands habitat in the Northeast as of the early 2000s. That assessment found that at least 2.8 million acres of wetlands (both Non-tidal Wetlands and Tidal Wetlands and Flats), one quarter of their historical extent, had been converted to development or drained for agriculture. Two-thirds of the region’s wetlands had development or agricultural land uses within 100 meters, which can impact the ecological condition of the wetlands. That conservation status assessment is updated in Anderson et al. (2023) with habitat status and condition information as of 2019 as well as trends over the past two decades.

Anderson et al. (2013b) predicted future habitat loss of Northeast habitats to development over the next 50 years. The most threatened Non-Tidal Wetlands habitat macrogroup for habitat loss was the North-Central Appalachian Acidic Swamp, which was predicted to lose 8% of its habitat to development over the next five decades. Peatlands appeared to be the least threatened by development habitat loss, with less than 1% loss predicted.

Anderson et al. (2013b) characterized the condition of Northeast habitats as of the early 2000s. Wetlands habitat was more fragmented and less connected to surrounding natural cover types than terrestrial habitats. The landscape context indices (the level of connectedness of the habitat patch to surrounding natural land cover types) of Non-Tidal Wetlands varied across macrogroup types, with the most connected macrogroups including Atlantic Coastal Plain Peatland Pocosin and Canebrake, Boreal-Laurentian Bog, Boreal-Laurentian-Acadian Acidic Basin Fen, Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp, and Acadian Maritime Bog. The most fragmented macrogroups included Central Interior Highlands and Appalachian Sinkhole and Depression Pond, North-Central Interior Wet Flatwoods, North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest, and North-Central Interior and Appalachian Rich Swamp.

Anderson et al. (2013b) assessed the landscape complexity, a measure of climate resilience, of Northeast habitats. Stream-related Non-Tidal Wetlands had the highest landscape diversity scores of all wetland types, as did very small northern fens. Boreal-Laurentian Bogs had the lowest landscape diversity, along with swamps and pocosins in the coastal plain.

Anderson et al. (2016a and 2016b) assessed the resiliency and connectedness of habitats of the eastern United States at the landscape scale, identifying resilient sites for conservation. Staudinger et al. (2023) summarizes the state of knowledge of Non-Tidal Wetlands habitat resiliency to climate change.

2.9.4 HABITAT MANAGEMENT

The Environmental Protection Agency (EPA) summarized **National Management Measures to Protect and Restore Wetlands and Riparian Areas for the Abatement of Nonpoint Source Pollution** in 2005 (EPA 2005). Specific guidance describes types of conservation measures that address nonpoint source pollution, measures that protect Non-Tidal Wetlands and Riparian habitats, measures that restore these habitats, and the practice of mitigation banking.

The **Best Management Practices for Wetland Butterflies** RCN project addressed the uncertain status and distribution of many wetland butterfly species in several Mid-Atlantic States, including SGCN and RSGCN species in the Northeast. Some species declines may be in part due to threats impacting groundwater wetlands, including outright destruction, habitat degradation and the succession of open wetland habitats to forest or dense shrubland. Climate change and habitat fragmentation may further impact these species and leave them vulnerability to local extirpations.

The primary objective of this effort was to enhance and expand populations of wetland butterfly SGCN through developing a greater understanding of the distribution and habitat requirements for these species, and by implementing habitat enhancement projects where needed. Project goals were (1) to update distribution data for 14 butterfly SGCN in the region, (2) model species distribution and climate conditions for each species; (3) identify and prioritize wetlands that support one or more of these 14 species, (4) implement wetland enhancement and improvement projects, and (5) develop Best Management Practices for species distribution and climate modeling and for wetland enhancement projects. Results can guide targeted survey work for these species as well as prioritize wetlands for enhancement projects, and in the long-term results may serve to improve habitats for these species, offering the potential to increase populations of butterfly SGCN and promote connectivity between populations through increased habitat availability.

Best Management Practices were developed, and habitat enhancement projects were initiated in Maryland and Pennsylvania. The report includes Life History Guides to the 14 species, the Pennsylvania Habitat Management Guide for Pollinators, Wetland Butterfly Habitat Enhancement BMPS, and additional resources including an example Wetland Restoration Report (see the NEFWDTC website for resources).

Another RCN project addressed RSGCN turtles associated with Non-Tidal Wetlands habitat. Over the last decade, significant advancements have been made in addressing the information and conservation needs of RSGCN turtles. Multiple partners and grants have resulted in robust conservation plans, protocols, and best management practices for these important RSGCN to be implemented regionally. The **Conservation Plan for Blanding's Turtle and Associated Wetland-Dependent SGCNs** project advances those efforts to additional species. The Blanding's Turtle (*Emydoidea blandingii*) is a Northeast RSGCN of Very High Concern, with habitat modifications one of several causes of decline.

In June 2014, the Northeast Blanding's Turtle Working Group completed the **Conservation Plan for Blanding's Turtle and Associated Wetland-Dependent Species of Greatest Conservation Need in the Northeastern United States**. This plan was updated in July 2021 after a second round of sampling and habitat management actions. Both efforts were multi-year collaborative projects funded by the U.S. Fish and Wildlife Service through its Competitive State Wildlife Grant program. See *Chapter 4* for additional information about the cooperative conservation efforts of this partnership. Conservation and management plans (including priority site management plans) for four RSGCN turtles – Blanding's, Spotted (*Clemmys guttata*), Wood (*Glyptemys insculpta*), and Eastern Box (*Terrapene carolina*) – are available online (see *Chapter 4* for more information)[94].

Staudinger et al. (2023) describes the state of knowledge of adaptive management of Non-Tidal Wetlands habitats to climate change.

2.9.5 HABITAT MONITORING

Wetlands habitat is included as a regional performance monitoring metric for the Northeast (NEAFWA 2008). Anderson and Olivero-Sheldon (2011) conducted a conservation status assessment for Wetlands in the Northeast as per this regional monitoring framework prior to the 2015 SWAPs. Anderson et al. (2023) updates the conservation status of Wetlands habitat in the Northeast for the 2025 SWAPs.

The EPA monitors the physical, chemical, and biological integrity of wetlands as part of the **National Wetlands Condition Assessment**[95].

The **National Wetlands Inventory (NWI)**, administered by the USFWS, monitors the status and trends of Non-Tidal Wetlands, Tidal Wetlands and Flats, and Riparian wetlands throughout the country. The NWI maintains maps and geospatial datasets on the location and distribution of all wetland types, using the classification system previously described (FGDC 2013, Cowardin et al. 1979). National and regional analyses on the status and trends of wetlands are periodically updated and are available through the USFWS[96].

2.9.6 PARTNERS

Regulatory partners for protecting Non-Tidal Wetlands, Tidal Wetlands and Flats, and Riparian wetlands include the U.S. Army Corps of Engineers, EPA, and USFWS. Projects such as development, infrastructure, transportation, and others that are anticipated to impact wetlands habitat are required to receive regulatory permits outlining measures to avoid, minimize, and mitigate those habitat impacts.

The **USGS Wetland and Aquatic Research Center**[97] is the agency's center for scientific research and product development for wetlands and aquatic resources in the United States. Established in 2015 with roots in the former Biological Research Division, the Center has a Strategic Science Plan that guides research priorities for the next five to ten years in support of partner agencies within the Department of the Interior (USFWS, NPS, BOEM), and other federal, state, and local partners (USGS 2017). The current scientific priorities are to:

- Provide actionable science needed to conserve and restore plant, fish, and wildlife populations and communities,
- Provide science needed to detect, understand, control, and mitigate the risks and impacts of nonindigenous species and pathogens,
- Improve the understanding of wetland and aquatic ecosystem structure, function, and services,
- Provide the science needed to better characterize, monitor, and prepare for the ecological effects of climate and land-use change,

- Apply interdisciplinary science to enhance strategies for management, conservation, and restoration of ecosystems, and
- Provide science to improve ecological understanding and enhance landscape- and seascape-scale strategies for ecological management, conservation, and restoration.

The Wetland and Aquatic Research Center has 13 priority landscapes for place-based research. Two of these priority landscapes are in the Northeast – the Great Lakes and Chesapeake Bay.

The mission of the **National Association of Wetland Managers**[98] is to build capacity for state and Tribal members, fostering collaboration within the wetland community of practice by encouraging the application of sound science to wetland management and policy, promoting the restoration and protection of wetlands and associated aquatic resources, and providing training and education for members and the public.

2.9.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of Non-Tidal Wetlands habitat through several ongoing citizen science projects. The World Wetland Network, Ramsar Section of the Society of Wetland Scientists, the Cobra Collective, and IUCN collaborated in 2017 and again in 2020 to engage citizen scientists in a global status assessment of wetlands[99]. Most other citizen science projects engaging the public in conserving Non-Tidal Wetlands are local or state scale efforts, such as **Vernal Pool Monitoring Programs** by the Connecticut Association of Wetland Scientists[100] or Maine Audubon Society[101].

Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

2.9.8 HABITAT INFORMATION, RESEARCH, AND MONITORING NEEDS

Habitat information, research, and monitoring needs for Non-Tidal Wetlands habitat (as opposed to wetland-obligate species) in the Northeast are addressed through the ongoing activities of the Northeast Climate Adaptation Science Center, USGS Wetlands and Aquatic Resources Center, and the National Wetlands Inventory program of the USFWS.

2.10 BIG RIVERS

Figure 2.10. 1 Big Rivers habitats support 43 Northeast RSGCN and Watchlist species. (Connecticut River photo credit: Mike Tessler)

2.10.1 HABITAT DESCRIPTION

Big Rivers are the major, mainstem rivers of the region with watersheds of at least 9653 square miles (10,000 square kilometers) in size, equivalent to the consolidated Large Rivers and Great Rivers size classes in the stream habitat classification systems developed for the Northeast region and the eastern United States (Olivero and Anderson 2008, Olivero-Sheldon et al. 2015, McManamay et al. 2018, Anderson et al. 2023). In the Northeast region, RSGCN and Watchlist species are associated with 17 Big Rivers:

- Allegheny
- Connecticut
- Delaware
- Hudson
- James
- Kanawha
- Kennebec
- Merrimack
- Monongahela
- Niagara
- Ohio
- Oswego
- Penobscot
- Potomac
- St. Croix
- St. Lawrence
- Susquehanna

In the NEAFWA region, the 14 SWAPs of 2015 included nine Key Habitats for SGCN that are within Big Rivers habitat (*Appendix 2A*, Table 2A.10). Big Rivers habitat is physically connected to upstream Rivers and Streams (Section 2.11) and downstream Tidal Rivers and Streams (Section 2.12).

There are 25 RSGCN, one Proposed RSGCN, 13 Watchlist [Assessment Priority] and two Proposed Watchlist species across ten taxonomic groups associated with Big Rivers habitat (*Supplementary Information 2*, Table 2.10.1, Figure 2.10.2). Another two species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. Three freshwater mussels, one freshwater fish and one diadromous fish RSGCN or Proposed RSGCN are of Very High Concern and at least 75% regional responsibility in the Northeast.

Table 2.10. 1 The number of species in each RSGCN and Watchlist category associated with Big Rivers habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	25
Proposed RSGCN	1
Watchlist [Assessment Priority]	13
Proposed Watchlist [Assessment Priority]	2
Watchlist [Deferral to adjacent region]	2
TOTAL	**43**

The Northeast RSGCN Database (version 1.0) contains data on habitat characteristics associations for Big Rivers-associated RSGCN and Watchlist species, such as major drainage basin (St. Lawrence, Gulf of Maine / Cape Cod Bay, Long Island Sound, Hudson / New York Bay, Delaware Bay, Chesapeake Bay, Great Lakes, Ohio / Mississippi), associated upland habitat, temperature, oxygen level, alkalinity, gradient, substrate, vegetation densities, and the presence of habitat features or formations, including slackwater, oxbows, gravel and sand bars, logs and woody debris, and artificial structures.

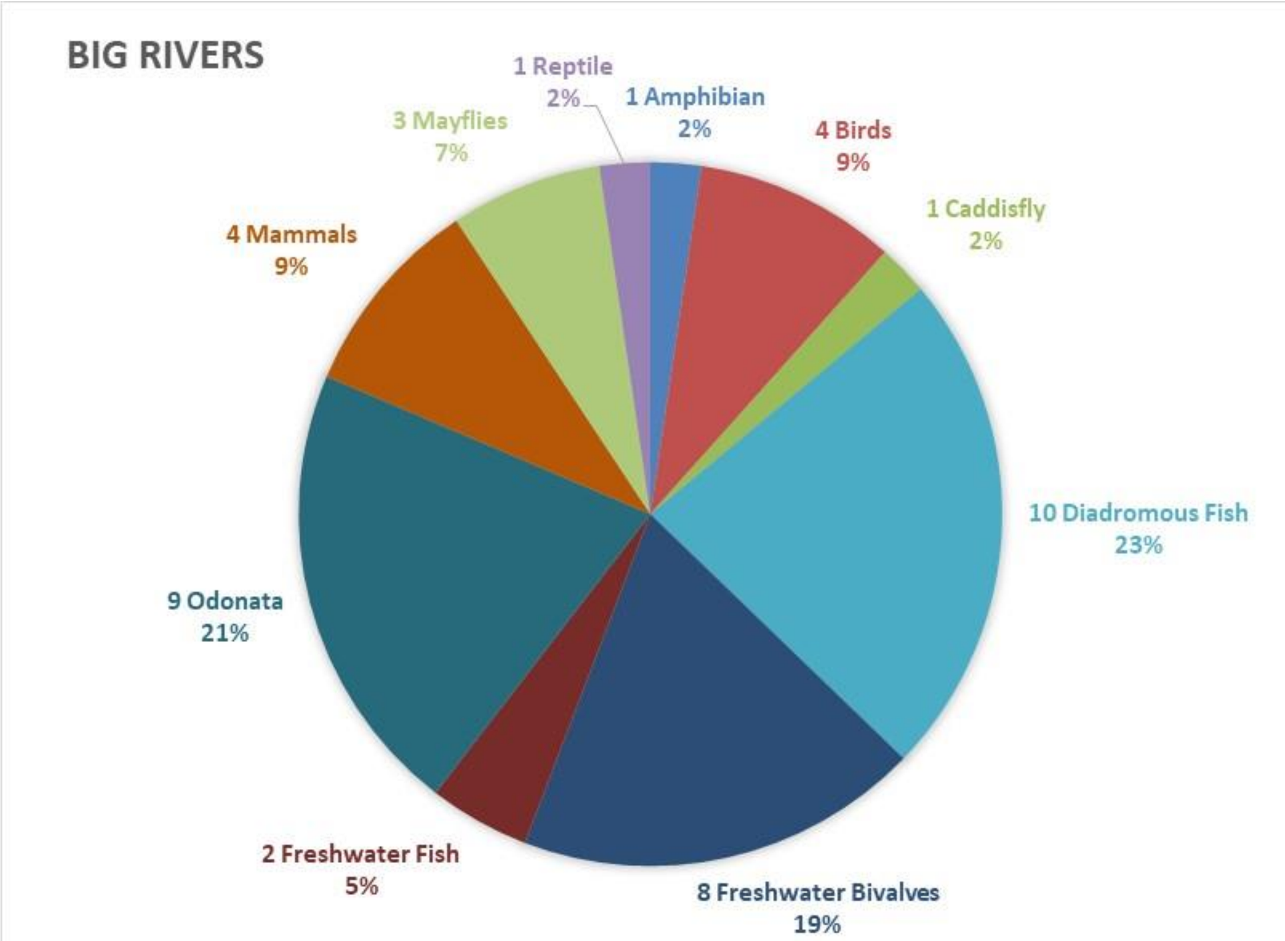

Figure 2.10. 2 Northeast RSGCN and Watchlist species associated with Big Rivers habitats represent ten taxonomic groups.

2.10.2 HABITAT DISTRIBUTION AND CONSERVATION

The most recent land cover dataset from the Designing Sustainable Landscapes program (DSLland version 5.0, issued 2020) identified more than 4.6 million acres of all freshwater Rivers and Streams habitat (including Big Rivers) in the Northeast as of 2011-2013 (Table 2.0.3). The updated habitat condition assessment from Anderson et al. (2023) identified nearly 2000 miles of freshwater Big Rivers in the Northeast as of 2019.

Anderson et al. (2023) provides an updated assessment on the conservation status of freshwater Big Rivers in the region as of 2022, which are generally less conserved than Tidal Rivers and Streams or freshwater Rivers and Streams.

2.10.3 HABITAT CONDITION

Threats to the multiple finer scale habitat types within this coarse Northeast Big Rivers habitat vary by location and type but include Pollution (Threat 9.0), Dams (Threat 7.2), Development in the associated watershed (Threat 1.0), and various Natural System Modifications (Threat 7.0).

Anderson and Olivero-Sheldon (2011) assessed the status and condition of Rivers and Streams habitat, including Big Rivers, in the Northeast as of the early 2000s. This assessment evaluated the level of development within a 100-meter wide Riparian and Floodplain buffer along the freshwater Big Rivers and Rivers and Streams in the region. Conditions in 2001 exhibited decreasing levels of natural cover in this riparian buffer zone with increasing stream size, with the largest rivers (Big Rivers) showing the highest level of development. The level of agricultural land uses in the riparian buffer zone was lowest along the Big Rivers, however, compared to headwater streams.

The 2011 conservation status assessment is updated in Anderson et al. (2023) with habitat status and condition information as of 2019 as well as trends over the past two decades. The level of impervious surface cover in associated upland habitats in the watersheds of Big Rivers is increasing, for example, and approximately two-thirds of the Big Rivers in the Northeast are considered highly altered in their hydrology.

Staudinger et al. (2023) summarizes the state of knowledge of Big Rivers habitat resiliency to climate change.

2.10.4 HABITAT MANAGEMENT

Many of the region's Big Rivers have management plans and/or programs that include Rivers and Streams, Tidal Rivers and Streams, Tidal Wetlands and Flats, and Estuaries in landscape level conservation efforts. The programs and initiatives addressing the management needs of these connected habitats typically include associated upland habitats as well, recognizing that activities in those terrestrial habitats impact water quality and environmental conditions in the aquatic habitats. *Chapters 5* and *7* describe the monitoring and management programs and partnerships actively conserving these connected systems in the Connecticut, Hudson, Delaware, and Chesapeake Bay river basins.

Staudinger et al. (2023) describes the state of knowledge of adaptive management of Big River habitats to climate change.

2.10.5 HABITAT MONITORING

Nationally, the EPA monitors the condition of water quality and ecological conditions of rivers and streams as part of the **National Rivers and Streams Assessment**[102]. The

EPA **StreamCat** database compiles monitoring data from many sources on the condition of Rivers and Streams across the country[103].

Regional monitoring programs and initiatives for Big Rivers habitat are a blend of those involved in freshwater Rivers and Streams (Section 2.11.5), Tidal Rivers and Streams, and Estuaries (Section 2.19.5). *Chapter 5* describes the monitoring programs and partnerships actively conserving Big Rivers in the Connecticut, Hudson, Delaware, and Chesapeake Bay river basins.

Most monitoring of Big Rivers habitat is conducted at the local and state level, through state water quality protection programs, regulatory permitting programs for discharges into tributary Rivers and Streams, and conservation programs of watershed associations, Riverkeepers, and other conservation partner organizations.

2.10.6 PARTNERS

Partners throughout the Northeast work to protect and conserve the region's Big Rivers. *Chapter 7* describes the partners working to conserve the Connecticut, Hudson, Delaware, and Susquehanna Rivers. The **Connecticut River Watershed Council** works to protect the watershed from source to sea[104]. The **Delaware River Basin Commission** is a partnership between the states of New York, New Jersey, Pennsylvania, and Delaware to protect the Delaware River watershed with both regulatory and non-regulatory programs and initiatives[105]. The **Interstate Commission on the Potomac River Basin** has developed a comprehensive plan for protecting the watershed of this Big River, works cooperatively to manage water supply operations on the river, and educational and communication resources about the watershed and its needs[106]. The **Susquehanna River Basin Commission (SRBC)** is a regulatory and non-regulatory partnership between the states of New York, Pennsylvania, and Maryland as per the 1961 Susquehanna River Basin Compact[107].

The **Connecting the Connecticut** project developed an interactive GIS based application to estimate continuous unimpacted daily streamflow at ungauged locations in the Connecticut River basin (see *Chapters 4* and *7* for further details). Work from this project allows users to identify a stream reach of interest in the Connecticut River basin and obtain estimated continuous daily, unregulated or "natural" streamflow at the selected location. The application spans the entire Connecticut River basin, including the states of Connecticut, Massachusetts, New Hampshire, and Vermont. This work expands on a method developed for Massachusetts to estimate daily streamflow at ungauged locations. The development of the multi-state software tool and user manual is available at their website[108].

Many of the Northeast's Big Rivers have dedicated Riverkeeper programs working to conserve these habitats and their fish and wildlife resources as part of the **Waterkeeper Alliance**[109]:

- Upper St. Lawrence Riverkeeper
- Buffalo Niagara Riverkeeper
- Connecticut Riverkeeper
- Hudson Riverkeeper
- Delaware Riverkeeper
- Middle Susquehanna Riverkeeper
- Lower Susquehanna Riverkeeper
- Upper Potomac Riverkeeper
- Potomac Riverkeeper
- James Riverkeeper

2.10.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of Big Rivers habitat through several ongoing citizen science projects sponsored by the partners described for each of the region's largest watersheds in *Chapters 5* and *7*.

The **GLOBE Program**, an international citizen science initiative sponsored by NASA, engages the public in numerous environmental monitoring projects[110]. The GLOBE Observer includes several monitoring protocols for students, teachers, and the public. Citizen scientists enter measurements and observations into a public database of water quality, hydrology, and aquatic macroinvertebrate data. Other GLOBE programs engage the public in monitoring agriculture, soils, weather, air quality, urban areas, oceans, and lakes.

Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

2.10.8 HABITAT INFORMATION, RESEARCH AND MONITORING NEEDS

Habitat information, research and monitoring needs for Big Rivers habitat in the Northeast are identified for each river basin in the assessments and management plans of the partner organizations listed above and in *Chapter 7*.

2.11 RIVERS & STREAMS

Figure 2.11. 1 River and Stream habitats support 349 Northeast RSGCN and Watchlist species.

2.11.1 HABITAT DESCRIPTION

Rivers and Streams habitat are characterized by the Northeast Aquatic Habitat Classification System and its expansion to the entire eastern United States (Olivero and Anderson 2008, Olivero-Sheldon et al. 2016, McManamay et al. 2018). The Northeast Aquatic Habitat Classification System defines rivers as having catchments or watersheds of at least 39 square miles and streams with smaller watersheds (Olivero and Anderson 2008). Rivers and Streams habitat is physically connected to surrounding Riparian and Floodplain habitat (Section 2.13) and may be connected to downstream Big Rivers (Section 2.10) or Tidal Rivers and Streams (Section 2.12) depending on size and location.

In the NEAFWA region, the fourteen 2015 SWAPs included 151 Key Habitats for SGCN that are within Rivers and Streams habitat (*Appendix 2A*, Table 2A.11). Most SWAP Key Habitats have applied the Northeast Aquatic Habitat Classification System to identify particular stream types with attributes for size, gradient, temperature, and alkalinity.

River and Stream habitat in the Northeast has the highest number of RSGCN and Watchlist species (349) of any habitat type. There are 167 RSGCN, 22 Proposed RSGCN, 84 Watchlist [Assessment Priority] and 27 Proposed Watchlist species across 12 taxonomic groups associated with Northeast Rivers and Streams habitat (*Supplementary Information 2*, Table 2.11.1, Figure 2.11.2). Another 49 species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. Twenty-seven (27) RSGCN and Proposed RSGCN in the Northeast are of Very

High Concern and of at least 75% regional responsibility: 11 freshwater fish, six stoneflies, three crayfish, three freshwater mussels, one turtle, one dragonfly, one caddisfly, and one diadromous fish. The Bluestone, Clinch and Checkered Sculpins (*Cottus* sp. 1, 4 and 7 respectively) are endemic to single watersheds in Virginia and West Virginia and are of Very High Concern due to their restricted ranges and resultant vulnerabilities.

Table 2.11. 1 The number of species in each RSGCN and Watchlist category associated with Rivers and Streams habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	167
Proposed RSGCN	22
Watchlist [Assessment Priority]	84
Proposed Watchlist [Assessment Priority]	27
Watchlist [Deferral to adjacent region]	49
TOTAL	**349**

The Northeast RSGCN Database (version 1.0) contains data on habitat characteristics associations for Rivers and Streams-associated RSGCN and Watchlist species, such as associated upland habitat, temperature, oxygen level, alkalinity, gradient, substrate, vegetation densities, and the presence of habitat features or formations, including slackwater, oxbows, gravel and sand bars, logs and woody debris, riffles, pools, headwaters, and artificial structures.

Olivero-Sheldon et al. (2016) identified, mapped, and classified Rivers and Streams habitat within the boundaries of the former Appalachian Landscape Conservation Cooperative, which includes much of the NEAFWA region. As part of those analyses, **Threshold Indicator Taxa Analysis (TITAN)** were completed to characterize patterns of species abundance with different River and Stream size classes, gradients, temperature, and alkalinity. Fish species abundance trends (increasing or decreasing) with increasing or decreasing size, gradient, temperature, and alkalinity are presented. Northeast RSGCN and Watchlist species included in these TITAN analyses include American Eel (*Anguilla rostrata*), American Shad (*Alosa sapidissima*), Blackside Darter (*Percina maculata*), Blueback Herring (*Alosa aestivalis*), Brook Trout (*Salvelinus fontinalis*), Dusky Darter (*Percina sciera*), Redfin Pickerel (*Esox americanus*), Redside Dace (*Clinostomus elongatus*), Sauger (Sander canadensis), Shield Darter (*Percina peltate*), Slimy Sculpin (*Cottus cognatus*), Striped Bass (*Morone saxatilis*), and

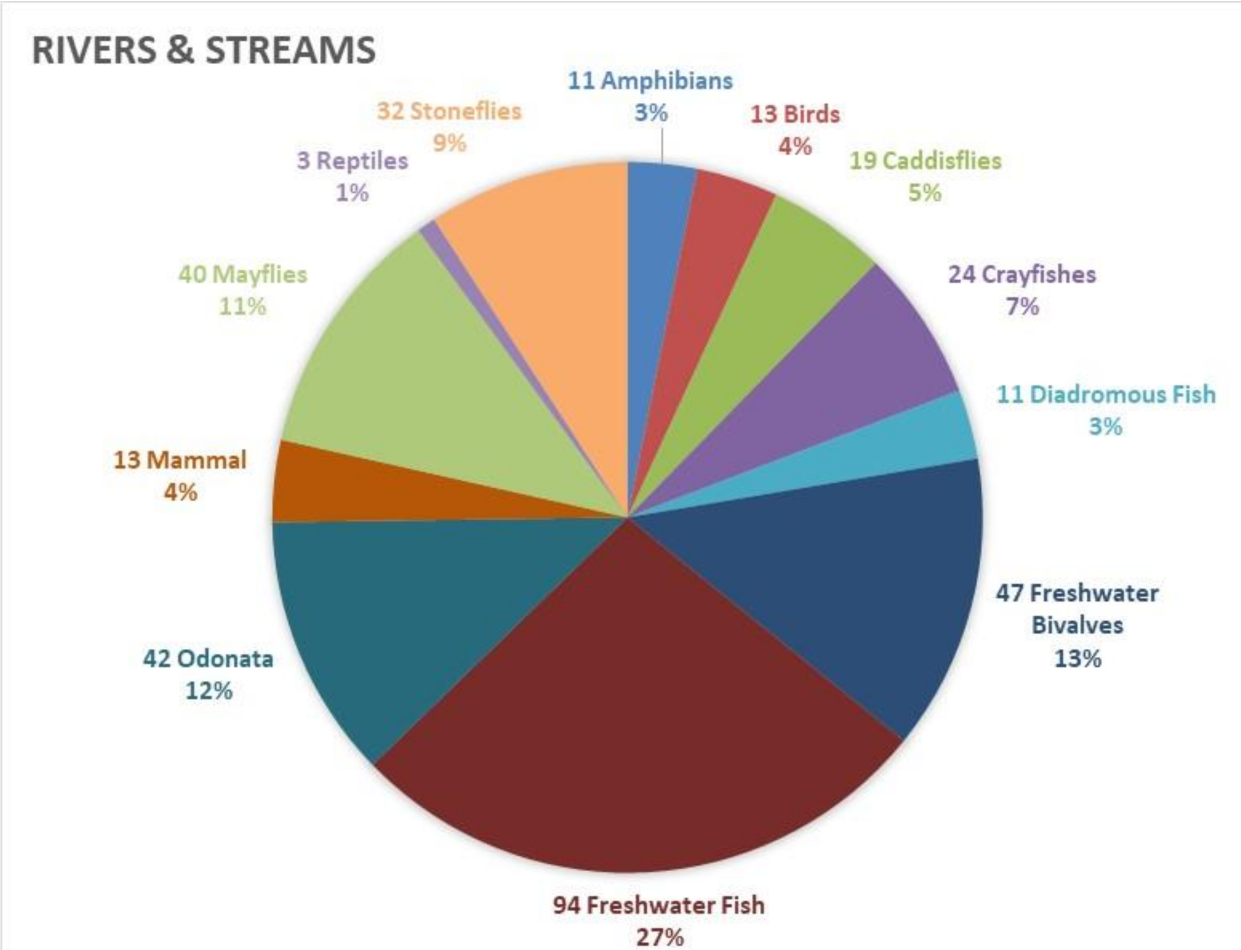

Figure 2.11. 2 Northeast RSGCN and Watchlist species associated with River and Stream habitats represent 12 taxonomic groups.

Swallowtail Shiner (*Notropis procne*). TITAN analyses were also conducted for at least 50 benthic species, including mayflies, stoneflies, and caddisflies. Appendix 3 of Olivero-Sheldon et al. (2016) provides individual results for each fish and invertebrate species, informing species habitat characteristics associations for key Rivers and Streams attributes.

2.11.2 HABITAT DISTRIBUTION AND CONSERVATION

The most recent land cover dataset from the Designing Sustainable Landscapes program (DSLland version 5.0, issued 2020) identified more than 4.6 million acres of all freshwater Rivers and Streams habitat (including Big Rivers) in the Northeast as of 2011-2013 (Table 2.0.3). Anderson and Olivero Sheldon (2011) assessed the status and condition of more than 202,000 miles of Rivers and Streams, Big Rivers, and Tidal Rivers and Streams, with 92,573 miles of headwaters, 75,228 miles of creeks, 19,421 miles of small rivers, 8975 miles of medium tributary rivers, and 3441 miles of medium mainstream rivers. Rivers and Streams in the Large and Great River size classes accounted for less than 2% of the stream and river miles.

The updated habitat condition assessment from Anderson et al. (2023) incorporated new techniques and spatial datasets, identifying approximately 202,000 miles of Rivers and Streams, Big Rivers, and Tidal Rivers and Streams as of 2019 (Table 2.11.2). Freshwater Rivers and Streams account for more than 190,000 of those total miles. Pennsylvania, New York, and Virginia have the highest number of River and Stream miles in the region, across all size classes.

Anderson et al. (2023) also assessed the current level of conservation of freshwater Rivers and Streams, which was defined as the proportion of land within the 100-meter wide Riparian and Floodplain zone that is secured against development. Approximately 16-18% of the associated Riparian and Floodplain habitat along the Rivers and Streams of the Northeast was conserved as of 2022, less than the level of conservation for Big Rivers and Tidal Rivers and Streams.

2.11.3 HABITAT CONDITION

Threats to the multiple finer scale habitat types within this coarse Northeast Rivers and Streams habitat vary by location and type but include Pollution (Threat 9.0), Dams and Culverts (Threat 7.2.1 and 7.2.3), conversion of their associated watersheds to Development (Threat 1.0) and Agriculture (Threat 2.0), and multiple aspects of Climate Change (Threat 11.0). Anderson and Olivero-Sheldon (2011) found the region's Rivers and Streams to be highly fragmented, with an average of seven dams and 106 road-stream crossings per 100 miles of stream in the Northeast.

Anderson et al. (2013b) predicted future habitat loss of Northeast habitats to development over the next 50 years. For aquatic habitats, the analysis assessed the level of development and agriculture in upstream watersheds. Cold water Rivers and Streams were predicted to remain the most intact, with only 5% to 21% habitat loss over the next five decades. Rivers and Streams habitat with the most predicted conversion to development in upstream watersheds were warm medium rivers, moderate gradient warm small rivers, warm large rivers, low gradient warm headwaters and creeks, and moderate gradient cool headwaters and creeks.

The Ramsar Convention identifies wetland and aquatic sites of global significance[93] and the Niagara River Complex connecting Lakes Erie and Ontario in New York has been identified for its high habitat value as a Ramsar site.

Anderson et al. (2013b) found that 47% of Rivers and Stream miles in the Northeast were disturbed by impervious surfaces in their upstream watersheds, with 5% highly impacted, 12% moderately impacted, and 30% minimally impacted. Highly impacted watersheds are concentrated in coastal areas and within the urban and suburban fringe of cities. The degree of impacts from impervious surfaces in upstream catchments decreases with river size, indicating that smaller headwaters and creeks are the most impacted although the fact that their watersheds are smaller with less capacity to offset the impacts with areas of natural cover. Freshwater Rivers and Streams are less impacted by impervious surface cover in their watersheds than Tidal Rivers and Streams, with the most undisturbed miles located in the more northern and higher elevation portions of the region.

Anderson et al. (2023) provides an updated assessment on the condition of freshwater Rivers and Streams in the Northeast, finding that more of the associated Riparian and Floodplain area to be converted than conserved but that the level of conserved lands has increased between 2012 and 2022. The degree of hydrologic alteration was also evaluated, with freshwater Rivers and Streams less hydrologically altered than Big Rivers and Tidal Rivers and Streams. The amount of impervious surface present in the watersheds of Rivers and Streams increased over the past decade.

The EPA **StreamCat** database provides data on the condition of more than 2.65 million stream segments across the country[103]. The StreamCat dataset currently contains over 600 metrics related to Rivers and Streams and their condition. Both natural and anthropogenic information is included. Anthropogenic condition variables include the percent urbanization within the watershed, dam reservoir volumes, the mean application rate of synthetic nitrogen fertilizer on agricultural lands, the erodibility of agricultural soils, the density of coal mines within the watershed, the mean pesticide use within the watershed, and many more that impact the condition of Rivers and Streams for fish and wildlife.

Martin et al. (2020) assessed Rivers and Streams and Tidal Rivers and Streams habitat for diadromous fish in the North Atlantic and Mid-Atlantic, including mapping and analyses of several environmental variables:

- Percentage of impervious surface in the upstream drainage area
- Point source pollution site density in catchment
- Non-point source pollution levels in catchment
- Riparian buffers (percentage of floodplain area with natural land cover)
- Potential for species access (presence of diadromous species and aquatic barrier connectivity)
- Flow alteration (volume of all upstream storage)
- Local fragmentation (density of road crossings and dams in catchment)
- Presence of ESA critical habitat for Atlantic Salmon and sturgeons

Detailed maps of Rivers and Streams and Tidal Rivers and Stream watersheds used by diadromous fish showing the distribution of each of these environmental variables are available in Martin et al. (2020) and on Data Basin[111], along with maps showing the cumulative results ranking areas for protection (**Areas of Excellent Fish Habitat**) and restoration (**Restoration Opportunity Areas**). In the NEAFWA region, tidal and freshwater Rivers and Streams in northeastern Maine had the highest density and abundance of Areas of Excellent Fish Habitat while urbanized eastern Massachusetts had the highest density and abundance of Restoration Opportunity Areas.

The **Northeast Aquatic Connectivity Project**, completed in 2012, created a regional inventory of dams, impassable waterfalls, and anadromous fish habitat across the Northeast to inform landscape level conservation efforts to restore aquatic connectivity in Rivers and Streams habitat. This RCN project led by The Nature Conservancy developed a regional network of conservation partners addressing aquatic connectivity and a tool to allow managers to re-rank dams at multiple scales (e.g., state, HUC) or use attribute filters (e.g., river size class, dam type) to evaluate 72 ecologically-relevant metrics linked to dam locations. Prioritization of future aquatic connectivity restoration projects is thus based on relative ecological benefits to anadromous and resident fish from barrier mitigation, informing restoration of River and Stream habitat at the dam or river network scale. The resulting NEAFWA Connectivity dam, waterfall, and anadromous fish database allows aquatic connectivity to be addressed at the landscape scale (Martin and Apse 2011). Results from this RCN project are now a part of the suite of management tools provided by the **North Atlantic Aquatic Connectivity Collaborative**, discussed below under Section 2.11.4.

Anderson et al. (2013b) characterized the condition of Northeast habitats as of the early 2000s. The landscape context indices (the level of connectedness of the habitat patch to surrounding natural land cover types) of Rivers and Streams varied across macrogroup types, with the most connected macrogroups including Low Gradient, Cold, Headwaters and Creeks and Cold, Medium Rivers. The most fragmented macrogroups were Moderate Gradient, Cool, Headwaters and Creeks and Low Gradient, Cool, Small Rivers.

Staudinger et al. (2023) summarizes the state of knowledge of Rivers and Streams habitat resiliency to climate change.

2.11.4 HABITAT MANAGEMENT

Many of the region's Rivers and Streams have management plans and/or programs that include Big Rivers, freshwater Rivers and Streams, Tidal Rivers and Streams, Tidal Wetlands and Flats, and Estuaries in landscape level conservation efforts. The programs and initiatives addressing the management needs of these connected habitats typically include associated upland habitats as well, recognizing that activities in those terrestrial habitats impact water quality and environmental conditions in the aquatic habitats.

Chapters 5 and *7* describe the monitoring and management programs and partnerships actively conserving these connected systems in the Connecticut, Hudson, Delaware, and Chesapeake Bay river basins.

Nationally, the **Atlantic Coast Fish Habitat Partnership (ACFHP)** has identified several conservation objectives for the North Atlantic and Mid-Atlantic regions for coastal fish habitat, including aquatic connectivity in Rivers and Streams for diadromous species, in their **Conservation Strategic Plan 2017-2021** and updated **Conservation Strategic Plan 2020-21** (ACFHP 2017, 2020).

Numerous guidelines, standards and best practices to address aquatic connectivity in Rivers and Streams have been developed. The New England District of the USACE provides a list of guidance and standards addressing stream connectivity for proposed projects in the region[112].

The New England District of the USACE also developed **BMPs for Stream Crossings** in 2015 for both tidal and non-tidal Streams in the Northeast (USACE 2015). Best practices are described for new and replacement crossings and culvert extensions to minimize impacts to Rivers and Streams and Riparian and Floodplain habitats. These BMPs incorporate the guidance of the USFS stream simulation manual to provide for aquatic habitat connectivity at road-stream crossings (USFS 2008).

The **North Atlantic Aquatic Connectivity Collaborative (NAACC)** includes is a network of individuals agencies and organizations from the 13 North Atlantic states from Maine to West Virginia focused on improving aquatic connectivity across the region[113]. The NAACC provides protocols for road-stream crossings (culverts and bridges) to assess and score crossings for fish and wildlife passability, as well as culvert condition and other data useful for evaluating risk of failure. The aquatic connectivity portal maintained by the North Atlantic Aquatic Connectivity Collaborative is a one-stop shop for tools and regional collaboratives focused on aquatic organism passage ("fish passage") and fragmentation of River and Stream ecosystems. It is a starting place for stakeholders, users, and tool developers looking to keep track of the latest initiatives and better identify opportunities for collaboration and action. Tools and examples on this site are described in *Chapter 4*.

The **Connecticut River Flow Restoration Study**, led by The Nature Conservancy, U.S. Army Corps of Engineers, and University of Massachusetts Amherst, developed a watershed-scale assessment of the potential to restore River and Stream flow in the Connecticut River basin through re-operation of dams (Kennedy et al. 2018). This project assessed the current alteration of River and Stream flows in the basin, assessed

Penobscot River

The **Penobscot River Restoration Project** is a collaboration between the Penobscot Indian Nation, seven conservation groups, hydropower companies PPL Corporation and Black Bear Hydro, LLC, and state and federal agencies, to restore 11 species of sea-run fish to the Penobscot River, while maintaining energy production[1]. This was accomplished by removing dams, installing fish lifts, installing bypasses, and replacing water intakes.

the ecological flow needs, developed hydrological models, assessed the impacts of high and low streamflows, and evaluated multiple management alternatives. Optimized flow management actions for operations at US Army Corps of Engineers dams were identified. The study concluded that additional flow management in the Connecticut River watershed beyond flow operations at U.S. Army Corps of Engineers operated facilities may be needed to fully restore river health and function in some locations.

Chapter 4 describes numerous other local and state conservation projects to improve water quality and restore aquatic connectivity at road crossings and dams.

Guidelines and best practices are also available to address the impacts of pollution on Rivers and Streams. The EPA maintains a **National Menu of BMPs for Stormwater** management to address potential impacts to aquatic habitats from pollution[114]. Best management practices have been developed for forestry practices to protect water quality in adjacent aquatic habitats and are available from the National Association of State Foresters[115] and from the US Forest Service[116]. Agricultural BMPs to protect water quality are provided by the EPA[117].

Staudinger et al. (2023) describes the state of knowledge of adaptive management of Rivers and Streams habitats to climate change.

2.11.5 HABITAT MONITORING

Rivers and Streams habitat is included as a regional performance monitoring metric for the Northeast (NEAFWA 2008). Anderson and Olivero-Sheldon (2011) conducted a conservation status assessment for Rivers and Streams in the Northeast as per this regional monitoring framework prior to the 2015 SWAPs. Anderson et al. (2023) updates the conservation status of Rivers and Streams habitat in the Northeast for the 2025 SWAPs.

The EPA monitors the condition of water quality and ecological conditions of rivers and streams as part of the **National Rivers and Streams Assessment**[102]. The EPA

StreamCat database collects monitoring data on the condition of Rivers and Streams habitat from multiple sources into one accessible resource[103].

The EPA uses monitoring data of stream temperatures as a climate change indicator in the Chesapeake Bay region[118]. Data from 1960 to 2014 from 129 stream gauges document warming temperatures at 79% of the sites and decreasing temperatures at 5% of the sites. The overall Chesapeake Bay region has increased stream water temperatures since 1960 by an average of 1.2 degrees Fahrenheit across all sites and by 2.2 degrees at sites where the long-term trends are statistically significant. The largest stream temperature increases are in the southern part of the region (e.g., Virginia).

The EPA also uses monitoring data of streamflow as a climate change indicator across the US[119]. Indicator Rivers and Streams data from 1940 to 2018 include the seven-day minimum annual streamflow, three-day annual high streamflow, annual average streamflow, timing of winter-spring runoff, and number of days with very low streamflow. In the Northeast, the seven-day low streamflows have generally increased, indicating on the days with the lowest streamflows the Rivers and Streams are carrying more water than previously. High streamflows have generally increased or not changed much in the Northeast since 1940. The average annual streamflow has increased at most sites in the Northeast. The timing of the winter-spring runoff is five to ten days earlier across most of the Northeast. And the number of days when streamflow is very low has decreased overall in the Northeast but increased in some streams of the Mid-Atlantic.

In the Connecticut River basin, the **Interactive, GIS-Based Application to Estimate Continuous, Unimpacted Daily Streamflow at Ungauged Locations in the Connecticut River Basin Project** developed an interactive map-based decision-support tool to estimate continuous unimpacted daily streamflow at ungagged locations in the Connecticut River basin (Archfield et al. 2013; see *Chapter 4* for further details). Work from this project allows users to identify a stream reach of interest in the Connecticut River basin and obtain estimated continuous daily, unregulated or "natural" streamflow at the selected location. The **Connecticut River UnImpacted Streamflow Estimator (CRUISE)** tool spans the entire Connecticut River basin, including the states of Connecticut, Massachusetts, New Hampshire, and Vermont. This work expands on a method developed for Massachusetts to estimate daily streamflow at ungagged locations. The CRUISE software tool and user manual are available through the USGS[120].

Chapter 5 describes the monitoring programs and partnerships actively conserving Rivers and Streams in the Connecticut, Hudson, Delaware, and Chesapeake Bay river basins.

2.11.6 PARTNERS

Chapter 7 describes the partnership programs and initiatives actively conserving Rivers and Streams in the Connecticut River, Hudson River, Delaware River, and Chesapeake Bay watersheds.

One of the eleven regional USFWS At-Risk teams focuses on proactive conservation of six freshwater mussel At-Risk Species. Habitat degradation, which includes water pollution and impoundments, is by far the leading cause of drastic declines in freshwater mussel populations. Non-native species also have outcompeted some of native species. Freshwater mussels also provide ecological and economic benefits to people and aquatic ecosystems. Like oysters, they filter millions of gallons of water and act as ecosystem engineers. They're crucial to a multi-billion-dollar pearl jewelry industry, and harvest of mussels is a reserved treaty right for some Native American tribes. Without intervention, freshwater mussels will continue to disappear within their range, and are at risk losing valuable ecosystem services. Using adaptive management and working at landscape scales in partnership with states and Tribes, the Freshwater Mussels Team aims to restore and conserve these At-Risk Species of mussels and proactively address threats so that they can avoid the need to list these species under the Endangered Species Act.

With input from partners, the Freshwater Mussels Team has been building a conservation plan called the **Northeast Region Conservation Strategy for Freshwater Mussels** that provides a framework and strategies for conserving and restoring at-risk species of freshwater mussels and their habitats from Maine to Virginia and West Virginia. Ultimately, the team wants to decide on feasible, cost-effective actions that USFWS programs can take with partner support over the next five years to increase representation, redundancy, and resiliency (3 Rs) of each species, and ensure their long-term viability.

In 2022, the Freshwater Mussels Team interviewed biologists from 12 States, the Partnership for Delaware Estuary, US Geological Survey, and representatives from the Penobscot Nation. The team developed a suite of questions aimed at identifying priority areas and management and science needs for conservation of mussels. They are synthesizing the information from these interviews into priority area maps and tables, which will highlight areas for conducting surveys, habitat restoration, land protection, propagation and stocking, and science needs. Discussions held in 2021 with the Rappahannock, the Chickahominy, and the Upper Mattaponi Indian Tribes are also informing priority areas for conservation of At-Risk mussels and their host fish in the Northeast Region Conservation Strategy for Freshwater Mussels.

In 2023, the Freshwater Mussels Team will complete interviews with partners to further identify priority areas for conducting conservation for mussels. The strategy will be distributed to State and Tribal partners and other USFWS offices for review, incorporate comments and edits, and complete the At-Risk Conservation Strategy. Also in 2023, the team will work to build local action plans within target watersheds and implement conservation projects.

In addition to the federal partners already discussed, there are several non-governmental organizations with conservation programs for Rivers and Streams habitat in the Northeast and beyond. The **Izaak Walton League Save Our Streams** program[121] is a national stream monitoring program with trained volunteers that has monitored water quality since 1969. Volunteers monitor water chemistry, salt pollution from road salt, and aquatic macroinvertebrates. Water quality monitoring data are available in the **Clean Water Hub**.

The **Waterkeeper Alliance** is a global network of more than 300 local Waterkeeper groups dedicated to protecting clean water[109]. The organization monitors water quality, identifies and litigates sources of pollution, advocates for local clean water protections, and conducts education and outreach. The Waterkeeper groups active in the Northeast are focused on Big Rivers and are listed in Section 2.10.6.

Many watershed conservation organizations are located throughout the Northeast and work to protect and conserve Rivers and Streams habitat at multiple scales. The Delaware River Basin Commission, Delaware River Restoration Program, Partnership for the Delaware Estuary, Delaware Riverkeeper Network, and Delaware River Watershed Initiative are focused on the broad Delaware River watershed, for example. Within the Delaware River watershed, the Schuylkill Action Network focuses on the largest tributary to the Delaware River, the Schuylkill River, from its confluence with the Delaware in Philadelphia to its headwaters in the Appalachian Mountains of eastern Pennsylvania. At the most local level, up to five watershed associations are active just in one county of southeastern Pennsylvania to monitor, protect, and conserve the Tulpehocken Creek, Maiden Creek, Angelica Creek, Hay Creek, and Perkiomen Creek, all of which drain into the Schuylkill River, which drains into the Delaware River. These nested organizations allow conservation of Rivers and Streams habitat at multiple geographic scales, from headwater creeks to Big Rivers.

The Nature Conservancy has numerous programs and initiatives related to Rivers and Streams habitat. Globally, TNC aims to protect 621,000 miles of Rivers and Streams and 74 million acres of Lakes and Wetlands. The Delaware River and Bay is one of TNC's priority landscapes. TNC scientists and partners have developed numerous conservation planning and practices tools, including for Rivers and Streams[122]. As a landowner and manager, TNC has protected more than 400 preserves across the country, managed by local and state chapters.

2.11.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of Rivers and Streams habitat through several ongoing citizen science projects. The **Chesapeake Bay Program** partnership coordinates citizen science and non-traditional monitoring of water quality and benthic macroinvertebrates in the Chesapeake watershed through the **Chesapeake Monitoring Cooperative**[123]. The program's **Chesapeake Data Explorer** allows citizen scientists to store and manage data they collect and the public an opportunity to access data collections. The Program provides technical assistance to interested organizations or members of the public who desire to start a monitoring program.

The **GLOBE Program**, an international citizen science initiative sponsored by the NASA, engages the public in numerous environmental monitoring projects[110]. The GLOBE Observer includes several monitoring protocols for students, teachers and the public. Citizen scientists enter measurements and observations into a public database of water quality, hydrology, and aquatic macroinvertebrate data. Other GLOBE programs engage the public in monitoring agriculture, soils, weather, air quality, urban areas, oceans, and lakes.

Many states offer **Master Watershed Stewards** programs through Cooperative Extension offices that train citizen scientists to monitor water quality in Rivers and Streams and conduct environmental education activities.

CrowdHydrology is a USGS public project that began in the Northeast and has since spread across the country to document stream levels[124]. Citizen scientists submit water level data from stream gaging staffs or stations to the CrowdHydrology database via text messages. The database is publicly available for researchers, students, resource managers and others to use.

Citizen science project directories are available at anecdata.org, citizenscience.gov and scistarter.org.

2.11.8 HABITAT INFORMATION, RESEARCH AND MONITORING NEEDS

Habitat information, research and monitoring needs exist for Rivers and Streams habitat in the Northeast, as outlined in the conservation and management plans of individual Rivers (see *Chapters 5* and *7* for examples from the region's largest watersheds). At the regional level:

- Restore decommissioned USGS Stream gauges to revitalize stream flow and temperature monitoring stations

2.12 TIDAL RIVERS & STREAMS

Figure 2.12. 1 Tidal Rivers and Streams habitats support 48 Northeast RSGCN and Watchlist species. (Cohansey River, NJ, photo credit: John Gattuso)

2.12.1 HABITAT DESCRIPTION

Tidal Rivers and Streams are Rivers and Streams that are influenced by the tides and may be freshwater at their upstream extent and brackish to marine salinities at their downstream extent. Tidal creeks within Tidal Wetlands and Flats (Section 2.18) may have no freshwater component. Tidal Rivers and Streams are physically connected to upstream freshwater Rivers and Streams (Section 2.11) or Big Rivers (Section 2.10) and to downstream Estuaries (Section 2.19) or Marine Nearshore (Section 2.20) habitats. In the NEAFWA region, the 14 SWAPs of 2015 included 17 Key Habitats for SGCN that are within Tidal Rivers and Streams habitat (*Appendix 2A*, Table 2A.12). Tidal Rivers and Streams have been identified as SGCN Key Habitats in Rhode Island, New York, Pennsylvania, Delaware, and Virginia.

There are 26 RSGCN and 16 Watchlist [Assessment Priority] species across eight taxonomic groups associated with Northeast Tidal Rivers and Streams habitat (*Supplementary Information 2*, Table 2.12.1, Figure 2.12.2). Another six species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. The Bridle Shiner (*Notropis bifrenatus*) and the Gulf of Maine population of Atlantic Salmon (*Salmo salar*) both are of Very High Concern and with at least 75% regional responsibility in the Northeast. Every diadromous fish RSGCN and Watchlist

Table 2.12. 1 The number of species in each RSGCN and Watchlist category associated with Tidal Rivers and Streams habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	26
Watchlist [Assessment Priority]	16
Watchlist [Deferral to adjacent region]	6
TOTAL	**48**

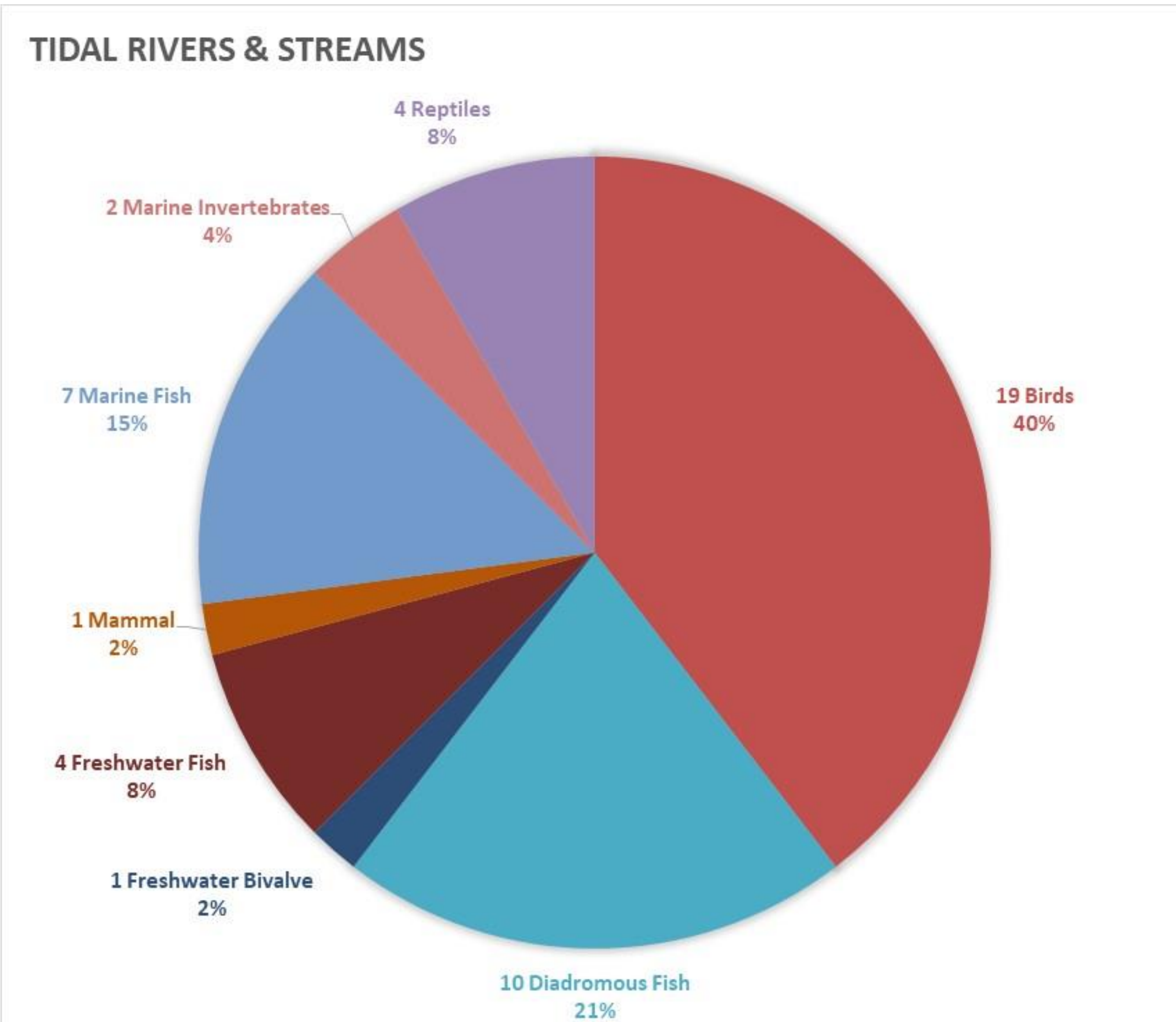

Figure 2.12. 2 Northeast RSGCN and Watchlist species associated with Tidal River and Stream habitats represent 13 taxonomic groups.

species uses Tidal Rivers and Streams as they migrate to inland spawning grounds from the ocean.

The Northeast RSGCN Database (version 1.0) contains data on habitat characteristics associations for Tidal Rivers and Streams-associated RSGCN and Watchlist species, such as associated upland habitat, temperature, oxygen level, alkalinity, gradient, substrate, vegetation densities, and the presence of habitat features or formations including slackwater, oxbows, gravel and sand bars, logs and woody debris, riffles, pools, and artificial structures.

2.12.2 HABITAT DISTRIBUTION AND CONSERVATION

The most recent land cover dataset from the Designing Sustainable Landscapes program (DSLland version 5.0, issued 2020) identified more than 181,000 acres of freshwater Tidal Rivers and Streams habitat in the Northeast as of 2011-2013, categorizing brackish Tidal Rivers and Streams as Estuaries (see Section 2.19) (Table 2.0.3). The updated habitat condition assessment from Anderson et al. (2023) identified over 6100 miles of Tidal Streams, more than 2200 miles of Tidal Rivers, and more than 650 miles of Tidal Big Rivers in the Northeast.

Roman et al. (2000) describes the characteristics of Tidal Rivers in New England, from Hudson Bay to Maine. Anderson et al. (2023) provides an updated assessment on the conservation status of Tidal Rivers in the region, which are generally more conserved than Big Rivers or freshwater Rivers and Streams.

2.12.3 HABITAT CONDITION

Threats to the multiple finer scale habitat types within this coarse Tidal Rivers and Streams habitat in the Northeast vary by location and type but include Development (Threat 1.0), Transportation infrastructure (Threat 4.1 and 4.2), Pollution (Threat 9.0), Climate Change (Threat 11.0), Dredging of navigation channels (Threat 4.3.2), and Natural System Modifications like Channelization (Threat 7.3.7), Tidal Water Restrictions (Threat 7.2.9), and Shoreline Stabilization (Threat 7.3.1).

The extent of Tidal Rivers and Streams habitat in the Northeast is advancing inland with sea level rise that push ocean tides farther upstream (Ensign and Noe 2018). Expansion of Tidal Rivers and Streams upstream with sea level rise and saltwater intrusion also will lead to conversion of Non-tidal Wetlands and Riparian and Floodplains habitat to freshwater Tidal Wetlands (Ensign and Noe 2018). Ensign and Noe (2018, p. 38) note that “In any river with a barrier to tidal extension [dams, weirs, natural fall lines], loss of tidal freshwater ecosystem function due to saltwater intrusion will be a net loss of function because no migration can occur upstream.”

Anderson et al. (2013b) predicted future habitat loss of Northeast habitats to development over the next 50 years. For aquatic habitats, the analysis assessed the level of development and agriculture in upstream watersheds. Tidal Rivers and Streams are more threatened by development in their upstream watersheds than freshwater Rivers and Streams, with large Tidal Rivers the most threatened with more than 60% watershed habitat loss to development predicted. Small and medium Tidal Rivers were predicted to face more than 55% watershed habitat conversion to development and Tidal headwaters and creeks approximately 50%. Anderson et al. (2023) updates the assessment of historical and predicted habitat loss of Tidal Rivers and Streams in the Northeast.

Anderson et al. (2013b) found that Tidal Rivers and Streams in the Northeast were disturbed by impervious surfaces in their upstream watersheds, with nearly 60% of Tidal small and medium river miles highly or moderately impacted, over 40% of Tidal headwaters and creeks, and more than 30% of Tidal large rivers. Highly impacted watersheds are concentrated in coastal areas and within the urban and suburban fringe of cities. The degree of impacts from impervious surfaces in upstream catchments decreases with river size, indicating that smaller headwaters and creeks are the most impacted although the fact that their watersheds are smaller with less capacity to offset the impacts with areas of natural cover. Tidal Rivers and Streams are more impacted by impervious surface cover in their watersheds than freshwater Rivers and Streams. Anderson et al. (2023) updates this analysis for conditions as of 2019.

Martin et al. (2020) assessed Rivers and Streams and Tidal Rivers and Streams habitat for diadromous fish in the North Atlantic and Mid-Atlantic, including mapping and analyses of several environmental variables:

- Percentage of impervious surface in the upstream drainage area
- Point source pollution site density in catchment
- Non-point source pollution levels in catchment
- Riparian buffers (percentage of floodplain area with natural land cover)
- Potential for species access (presence of diadromous species and aquatic barrier connectivity)
- Flow alteration (volume of all upstream storage)
- Local fragmentation (density of road crossings and dams in catchment)
- Presence of ESA critical habitat for Atlantic Salmon and sturgeons

Detailed maps of Rivers and Streams and Tidal Rivers and Stream watersheds used by diadromous fish showing the distribution of each of these environmental variables are available in Martin et al. (2020), along with maps showing the cumulative results ranking areas for protection (Areas of Excellent Fish Habitat) and restoration (Restoration Opportunity Areas). In the NEAFWA region, tidal and freshwater Rivers and Streams in northeastern Maine had the highest density and abundance of Areas of Excellent Fish Habitat while urbanized eastern Massachusetts had the highest density and abundance of Restoration Opportunity Areas.

Anderson et al. (2013b) characterized the condition of Northeast habitats as of the early 2000s. The landscape context indices (the level of connectedness of the habitat patch to surrounding natural land cover types) of Tidal Rivers and Streams varied across macrogroup types, with the most connected macrogroup being Tidal Large Rivers, although it was only moderately connected to the surrounding natural landscape. The most fragmented macrogroup was Tidal Headwaters and Creeks.

Anderson et al. (2016a and 2016b) assessed the resiliency and connectedness of habitats of the eastern United States at the landscape scale, identifying resilient sites for conservation.

Staudinger et al. (2023) summarizes the state of knowledge of Tidal Rivers and Streams habitat resiliency to climate change.

2.12.4 HABITAT MANAGEMENT

Many of the region's Tidal Rivers and Streams have management plans and/or programs that include Big Rivers, Rivers and Streams, Tidal Rivers and Streams, Tidal Wetlands and Flats, and Estuaries in landscape level conservation efforts. The programs and initiatives addressing the management needs of these connected habitats typically include associated upland habitats as well, recognizing that activities in those terrestrial habitats impact water quality and environmental conditions in the aquatic habitats. *Chapters 5* and *7* describe the monitoring and management programs and partnerships actively conserving these connected systems in the Connecticut, Hudson, Delaware, and Chesapeake Bay river basins.

Staudinger et al. (2023) describes the state of knowledge of adaptive management of Tidal River and Stream habitats to climate change.

2.12.5 HABITAT MONITORING

Monitoring programs and initiatives for Tidal Rivers and Streams habitat are a blend of those involved in freshwater Rivers and Streams (Section 2.11.5) and Estuaries (Section 2.19.5). *Chapter 5* describes the monitoring programs and partnerships actively conserving Tidal Rivers and Streams in the Connecticut River, Hudson River, Delaware River, and Chesapeake Bay watersheds.

2.12.6 PARTNERS

Conservation partners involved in protecting and conserving Tidal Rivers and Streams habitat are a blend of those involved in freshwater Rivers and Streams (Section 2.11.6) and Estuaries (Section 2.19.6). *Chapter 7* describes the partnership programs and initiatives actively conserving Tidal Rivers and Streams in the Connecticut River, Hudson River, Delaware River, and Chesapeake Bay watersheds.

2.12.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of Tidal Rivers and Streams habitat through several ongoing citizen science projects sponsored by the partners described for each of the region's largest watersheds in *Chapters 5* and *7*.

Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

2.12.8 HABITAT INFORMATION, RESEARCH AND MONITORING NEEDS

The following habitat information, research and monitoring needs exist for Tidal Rivers and Streams habitat in the Northeast as identified by Ensign and Noe (2018):

- Install long-term sensor networks on Tidal Rivers and Streams to detect tidal extension
- Recommission stream gages that have been decommissioned to assess changes in river hydrology
- Conduct experiments to manipulate hydrology to determine how rates of ecosystem functions change with tides
- Investigate the cumulative impacts of tidal extension, climate change, and anthropogenic disturbances to watersheds on ecosystem functions
- Identify areas where land and river conservation efforts will generate the largest landscape level benefits using improved predictions on the consequences of sea level rise to preserve ecosystem functions

2.13 RIPARIAN & FLOODPLAINS

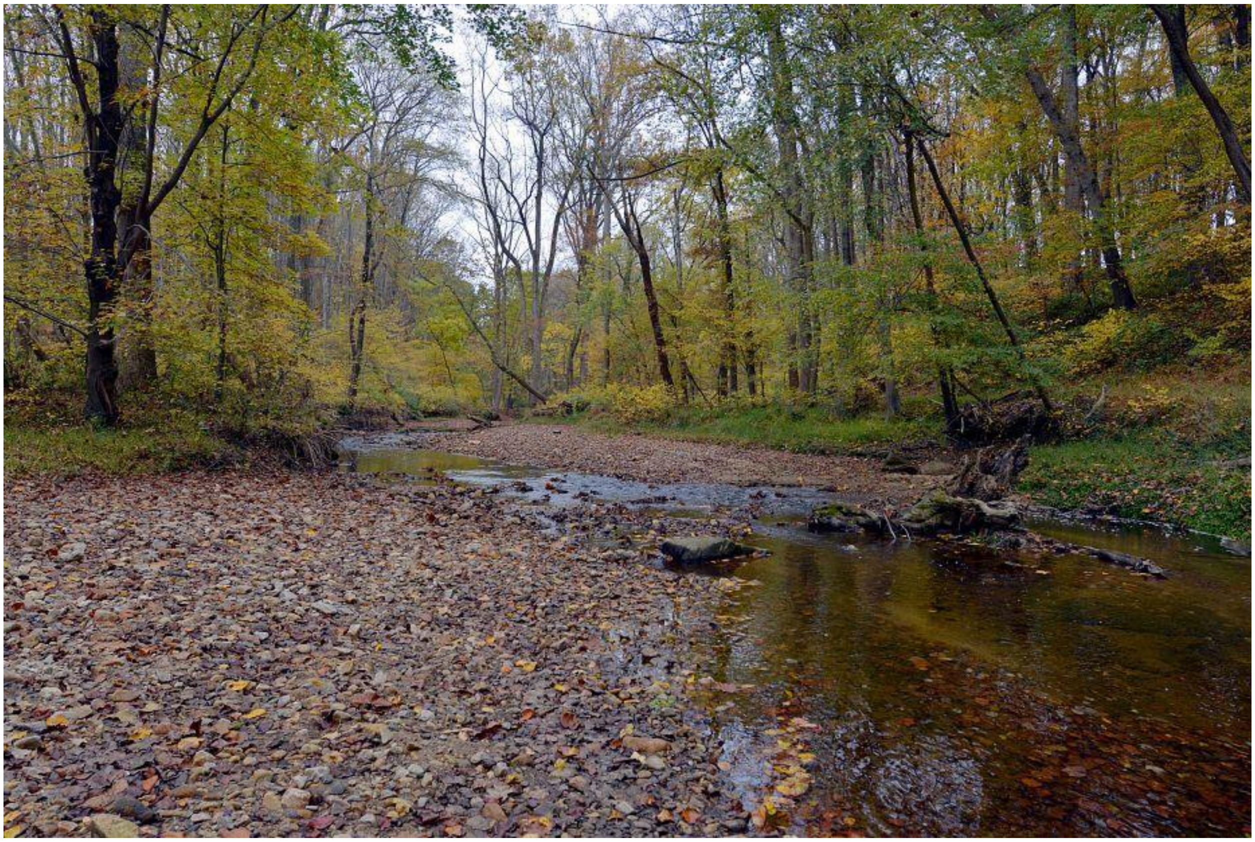

Figure 2.13. 1 Riparian and Floodplain habitats support 301 Northeast RSGCN and Watchlist species. (Montgomery County, MD, photo credit: University of Maryland Extension)

2.13.1 HABITAT DESCRIPTION

Riparian and Floodplain habitat for Northeast is defined as the 100-year floodplain for Big Rivers, Rivers and Streams, and Tidal Rivers and Streams. Riparian and Floodplain habitat includes Forests and Woodlands, Non-Tidal Wetlands, and other terrestrial natural habitat types present within the 100-year floodplain. Note that the habitat condition assessment of Anderson et al. (2023) defines the Riparian zone as a 100-meter-wide strip on either side of a River or Stream, which may or may not match the 100-year floodplain boundary. In the NEAFWA region, the 14 SWAPs of 2015 included 23 Key Habitats for SGCN that are within Riparian and Floodplain habitat (*Appendix 2A*, Table 2A.13). SWAP Key Habitats include floodplain forests and riparian areas adjacent to rivers and streams.

Riparian and Floodplain habitat in the Northeast has the second highest number of RSGCN and Watchlist species (301) of any habitat type. There are 132 RSGCN, 22 Proposed RSGCN, 99 Watchlist [Assessment Priority] and 16 Proposed Watchlist species across 15 taxonomic groups associated with Northeast Riparian and Floodplain habitat (*Supplementary Information 2*, Table 2.13.1, Figure 2.13.2). Another 32 species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. Sixteen of the RSGCN and Proposed RSGCN associated with Riparian and Floodplain habitat are of Very High Concern and at least 75% regional responsibility – six stoneflies, three terrestrial snails, two freshwater mussels, one moth, one dragonfly, one turtle, one firefly, and one caddisfly.

The Northeast RSGCN Database (version 1.0) contains data on habitat characteristics associations for Riparian and Floodplain-associated RSGCN and Watchlist species, such as salinity, substrate, vegetation densities, artificial structures, and snags.

Table 2.13. 1 The number of species in each RSGCN and Watchlist category associated with Riparian and Floodplains habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	132
Proposed RSGCN	22
Watchlist [Assessment Priority]	99
Proposed Watchlist [Assessment Priority]	16
Watchlist [Deferral to adjacent region]	32
TOTAL	**301**

2.13.2 HABITAT DISTRIBUTION AND CONSERVATION

The most recent land cover dataset from the Designing Sustainable Landscapes program (DSLland version 5.0, issued 2020) identified more than 1.1 million acres of Riparian and Floodplains habitat in the Northeast as of 2011-2013 (Table 2.0.3). The updated habitat condition assessment from Anderson et al. (2023) identified over 11.6 million acres of all wetland types (Non-Tidal Wetlands, Tidal Wetlands and Flats, and Riparian and Floodplain wetlands) as of 2019. More than 2 million acres of these wetlands are Floodplain wetlands. Anderson and Olivero-Sheldon (2011) found that only 6% of Floodplain wetlands were conserved, or secured from conversion to development or agriculture.

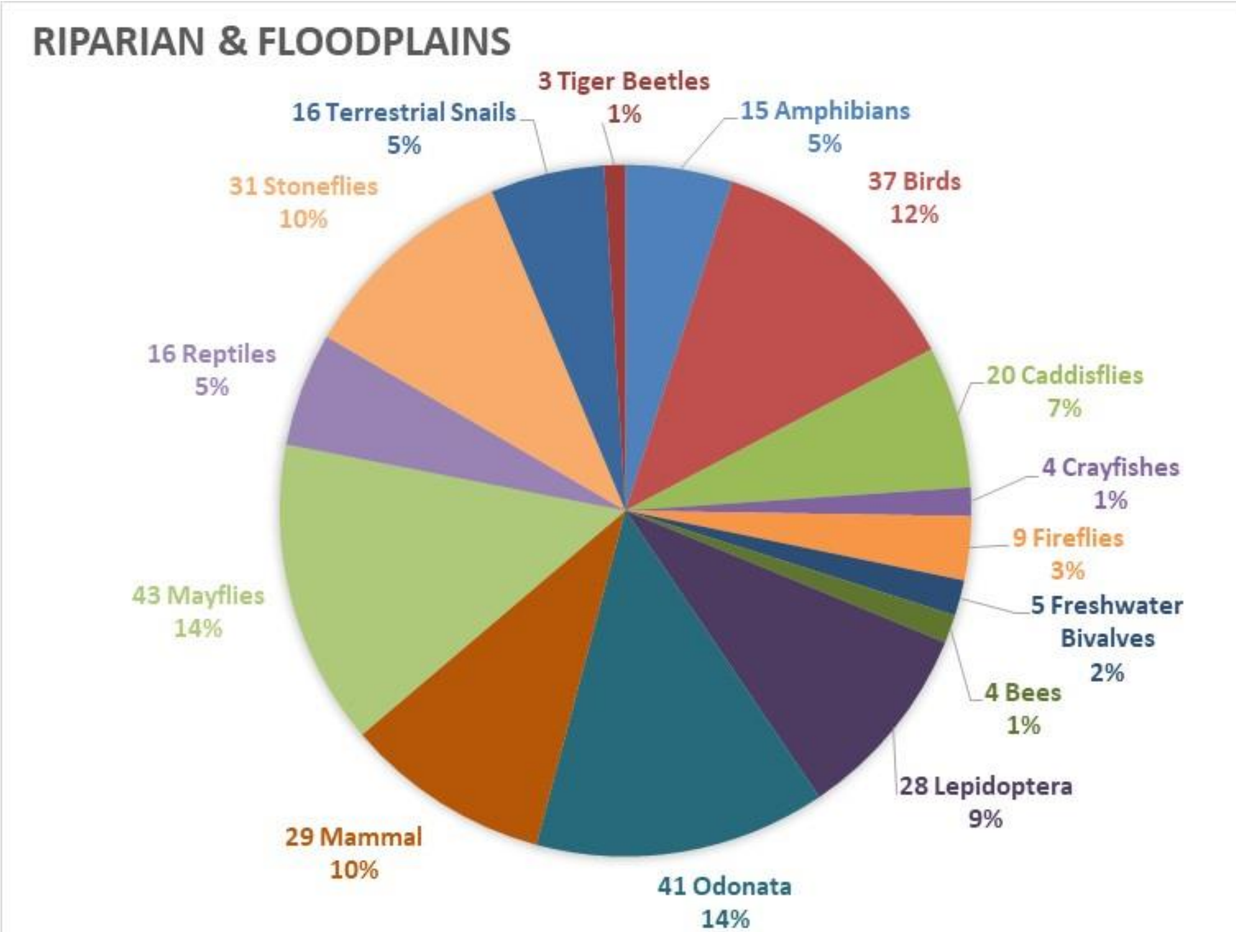

Figure 2.13. 2 Northeast RSGCN and Watchlist species associated with Riparian and Floodplain habitats represent 15 taxonomic groups.

In 2020, the USGS released the **Floodplain Ecosystem Service Mapper**[125], a tool that displays field site data and LIDAR-derived floodplain and stream channel geomorphic metrics within the Delaware River and Chesapeake Bay watersheds. The first release of this tool includes field site data for 68 sites in the Chesapeake and Delaware Floodplain network (including site photographs), stream reach estimates of channel geometry derived from the **Floodplain and Channel Evaluation Tool (FACET)**[126], and the active two-year floodplain extent as derived from FACET. Additional datasets are added to the Floodplain Ecosystem Service Mapper as they become available[127].

The Nature Conservancy has developed an **Active River Area Conservation Framework** to protect Rivers and Streams (Smith et al. 2008). This Framework links components of Rivers and Streams to their associated Riparian and Floodplain habitats and describes the ecosystem services and habitat values of functioning Active River

Areas. Delineation methods are described, with a case study of the Connecticut River. A framework for assessing the Active River Area to inform conservation planning and River and Stream restoration is presented. TNC has applied this framework to delineate the Active River Area of Rivers and Streams across the Eastern United States with spatial datasets available at either the 10-meter (Southern Appalachians) or 30-meter scale (Northeast and Mid-Atlantic area) on the Conservation Gateway website[128].

Anderson et al. (2023) provides an updated assessment on the conservation status of Riparian and Floodplain habitat in the region. This assessment found that a greater proportion of the Riparian and Floodplain habitat within 100-meters of Rivers and Streams has been converted to development or agriculture than has been conserved against those land uses, with the Riparian and Floodplain zone along Big Rivers the least conserved and along Tidal Rivers and Streams the most conserved.

2.13.3 HABITAT CONDITION

Threats to the multiple finer scale habitat types within this coarse Riparian and Floodplains habitat vary by location and type but include Development (Threat 1.0), Agriculture (Threat 2.0), Invasive Species (Threat 8.0), Pollution (Threat 9.0), and Natural System Modifications (Threat 7.0), the latter including Dams (Threat 7.2).

Anderson et al. (2013b) assessed the land cover condition of Riparian and Floodplain habitat within 100 meters of mapped Rivers and Streams in the Northeast (Figure 2.13.3). This condition assessment calculated the proportion of the 100-meter Riparian buffer zone that was developed or in agricultural land use as of 2006, with medium and high-density development weighted to have more impact. Overall 73% of the Northeast's 100-meter Riparian zone was in natural cover in 2006, with the majority of that (56%) forested. Fourteen percent of the measured Riparian zone was wetlands, with very large proportions along Tidal Rivers and Streams. Of the converted Riparian area, 16% was in agricultural use and 12% developed. The highest levels of agriculture were in the Riparian zones of medium and small freshwater Rivers and Streams, and the most development was in the Riparian zones of large Rivers, both Tidal and freshwater. Anderson et al. (2023) updates this assessment to 2019 conditions. The updated assessment found that at least 27% of Floodplain Wetlands have been converted to development or drained for agriculture.

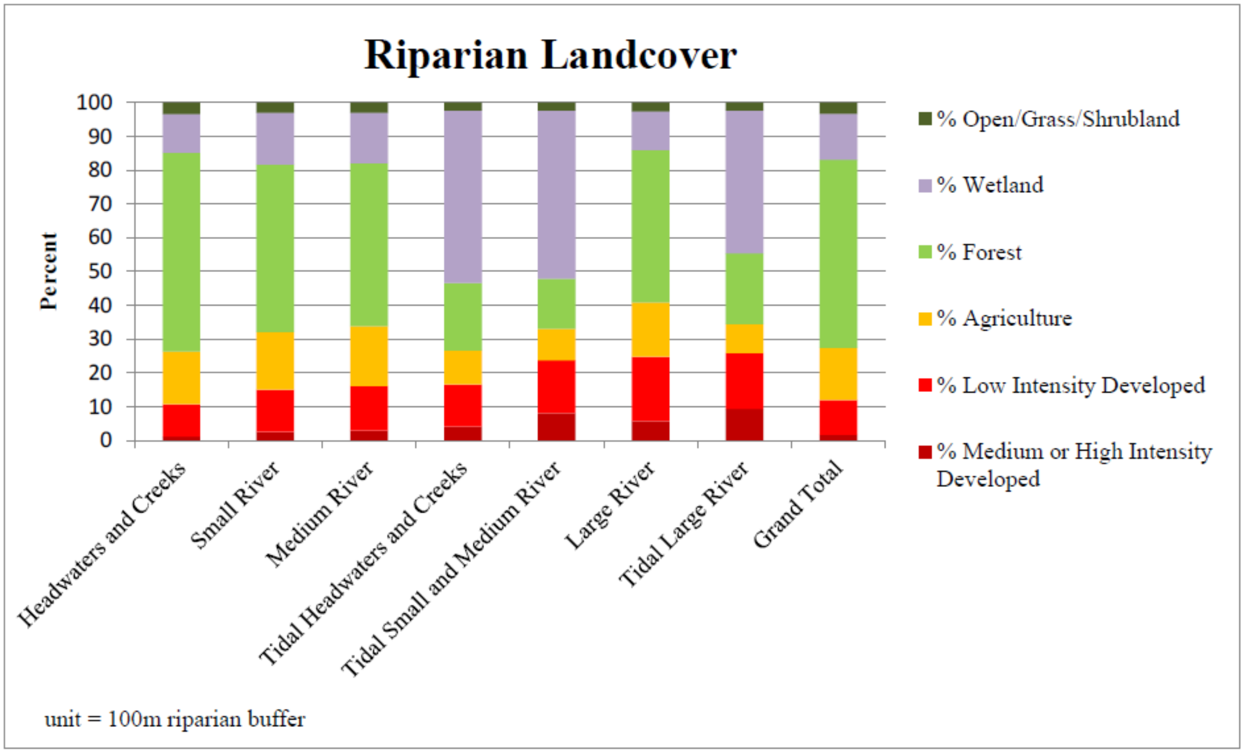

Figure 2.13. 3 Land cover types within the 100-meter Riparian area along Rivers and Streams and Tidal Rivers and Streams of the Northeast as of 2006, from Anderson et al. (2013b).

Anderson et al. (2013b) characterized the condition of Northeast habitats as of the early 2000s. Patches of Riparian and Floodplain habitats varied in their level of connectedness depending on the macrogroup. Laurentian-Acadian Large River Floodplains were the most connected while North-Central Appalachian Large River Floodplains were the least connected.

Anderson et al. (2013b) assessed the landscape complexity, a measure of climate resilience, of Northeast habitats. Riparian and Floodplain forested wetlands showed high landscape diversity and resiliency, except for Floodplain wetlands in the coastal plain which scored among the lowest among all wetlands for landscape complexity.

Staudinger et al. (2023) summarizes the state of knowledge of Riparian and Floodplain habitat resiliency to climate change.

2.13.4 HABITAT MANAGEMENT

A variety of BMPs are available for Riparian and Floodplain habitats. The EPA provides BMPs for stormwater management in forested Riparian areas as part of its National

Menu of BMPs for Stormwater[114]. Phillips et al. (2000) describes BMPs for Riparian areas from forestry activities.

The Environmental Protection Agency (EPA) summarized **National Management Measures to Protect and Restore Wetlands and Riparian Areas for the Abatement of Nonpoint Source Pollution** in 2005 (EPA 2005). Specific guidance describes types of conservation measures that address nonpoint source pollution, measures that protect Non-Tidal Wetlands and Riparian habitats, measures that restore these habitats, and the practice of mitigation banking.

Riparian Management Practices: A Summary of State Guidelines describes state guidelines to protect and manage Riparian forest habitats for 49 states (Blinn and Kilgore 2001). The most commonly recommended Riparian zone to protect Rivers and Streams and Lakes and Ponds is 50-feet wide with a 50 to 75% canopy closure, but specific guidelines vary widely among states. Understanding site-specific conditions is critical to implement Riparian management effectively, as a one-size-fits-all buffer width does not protect all Riparian functions across all sites.

Managing Grasslands, Shrublands, and Young Forest Habitats for Wildlife: A Guide for the Northeast includes recommendations on improving wildlife habitat condition in Riparian areas (Oehler et al. 2006). Chapter 9 of this guide, "Riparian Zones: Managing Early-Successional Habitats Near the Water's Edge," describes the ecological values of Northeast Riparian areas to wildlife and adjacent Rivers and Streams. Management practices are recommended for Riparian habitat to enhance adjacent aquatic ecosystems and protect water quality, with specific guidelines for riparian buffer strips.

Staudinger et al. (2023) describes the state of knowledge of adaptive management of Riparian and Floodplain habitats to climate change.

2.13.5 HABITAT MONITORING

The distribution and extent of Riparian and Floodplains habitat are monitored through several remote sensing land cover assessment programs. LANDFIRE includes multiple Floodplain ecological systems (e.g., Central Appalachian River Floodplain, Laurentian-Acadian Floodplain Forest) within their spatial land cover datasets, which have been updated every two to three years but will be updated annually starting in 2022. Regionally, the Designing Sustainable Landscapes program at the University of Massachusetts monitors the extent of multiple Floodplain macrogroups (based on the LANDFIRE ecological systems) as land cover classes in the Northeast.

The Federal Emergency Management Agency (FEMA) monitors the extent and distribution of Floodplains as part of the **National Flood Insurance Program**[129].

FEMA Floodplain maps include the 100- and 500-year Floodplains, which are updated periodically.

2.13.6 PARTNERS

Many partners addressing the conservation needs of Riparian and Floodplain habitat do so through programs and initiatives to improve water quality in aquatic habitats through conservation measures to reduce nonpoint source pollution. One of the conservation targets of the **Keystone Ten Million Trees Partnership**, for example, is to restore forested streamside buffers in the Riparian zones of Rivers and Streams in the Chesapeake watershed to filter pollution runoff, provide habitat, and stabilize streambanks. Multiple conservation programs of the **Natural Resources Conservation Service** improve Riparian habitat on agricultural lands (see Section 2.22.4). Maintenance or enhancement of Riparian and Floodplain habitat is a major conservation tool advised by the **Environmental Protection Agency** to mitigate stormwater runoff.

2.13.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of Riparian and Floodplains habitat through several ongoing citizen science projects. The **Migratory Dragonfly Partnership**[130] is a citizen-science project supported by the Xerces Society and US Forest Service to engage the public in documenting observations of migratory dragonflies in the US, Canada, and Mexico. A data collection protocol, standardized datasheet, and field guide are provided to interested participants. Countless citizen scientists and public volunteers are involved in watershed based conservation initiatives in the major watersheds of the Northeast, which often involves Riparian and Floodplain restoration projects (see *Chapter 7*).

Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

2.13.8 HABITAT INFORMATION, RESEARCH AND MONITORING NEEDS

Habitat information, research and monitoring needs exist for Riparian and Floodplain habitat in the Northeast:

- Integration of the Active River Area Conservation Framework and its associated spatial datasets[128] with the habitat condition assessments of Anderson et al. (2023) to more accurately assess the condition of the full Floodplain of the region's Rivers and Streams (as opposed to a uniform 100-meter buffer)

2.14 GREAT LAKES

Figure 2.14. 1 Great Lakes habitats support 36 Northeast RSGCN and Watchlist species. (Lake Erie, PA)

2.14.1 HABITAT DESCRIPTION

Great Lakes habitat for RSGCN and Watchlist species are one size class larger than the largest size class (Very Large Lakes of 10,000+ acres) in the Northeast Lake and Pond Classification System (Olivero-Sheldon and Anderson 2016), with areas of 100,000 acres or more. In the Northeast region, there are three Great Lakes: Lake Erie, Lake Ontario, and Lake Champlain.

There are five Great Lakes in the US, with Lakes Erie and Ontario partially or completely within the NEAFWA region. For the purposes of Northeast RSGCN, Lake Champlain, surrounded by Vermont, New York and Quebec, is also categorized as a Great Lake for RSGCN habitat due to its large size (278,400 acres). Lake Erie is the smallest Great Lake by water volume and also the shallowest lake with the warmest surface water temperatures in the summer. Lake Ontario is the fourth-largest lake by water volume and is characterized by a steeply sloping lakebed, creating deeper and colder nearshore waters than the other Great Lakes. Water flows from Lake Erie to Lake Ontario through the Niagara River and its famous Niagara Falls, then from Lake Ontario through the St. Lawrence Seaway to the Atlantic Ocean. Lake Champlain is approximately 120 miles in length, 12 miles at its widest, and reaches over 400 ft deep, although the average lake depth is 64 ft. Lake Champlain drains north into the St. Lawrence River via the Richelieu River in Quebec.

In the NEAFWA region, the 14 SWAPs of 2015 included four Key Habitats for SGCN that are within Great Lakes habitat in Vermont, New York, and Pennsylvania (*Appendix 2A*, Table 2A.14). There are 16 RSGCN, one Proposed RSGCN, 16 Watchlist [Assessment Priority] and one Proposed Watchlist species across nine taxonomic groups associated with Northeast Great Lakes habitat (*Supplementary Information 2*, Table 2.14.1, Figure 2.14.2). Another two species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. Only one RSGCN, the freshwater fish Bridle Shiner, associated with the Great Lakes is of Very High Concern and at least 75% regional responsibility.

The Northeast RSGCN Database (version 1.0) contains data on habitat characteristics associations for Great Lakes-associated RSGCN and Watchlist species, such as which Great Lake, temperature, substrate, vegetation densities, and habitat features and formations including logs and woody debris, low fetch, deep water, reefs and live rock, and artificial structures.

Table 2.14. 1 The number of species in each RSGCN and Watchlist category associated with Great Lakes habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	16
Proposed RSGCN	1
Watchlist [Assessment Priority]	16
Proposed Watchlist [Assessment Priority]	1
Watchlist [Deferral to adjacent region]	2
TOTAL	**36**

2.14.2 HABITAT DISTRIBUTION AND CONSERVATION

The most recent land cover dataset from the Designing Sustainable Landscapes program (DSLland version 5.0, issued 2020) identified more than 458,000 acres of Great Lakes aquatic habitat in the Northeast as of 2011-2013, although it is uncertain how far offshore this analysis extends (Table 2.0.3). The updated habitat condition assessment from Anderson et al. (2023) identified more than 11.3 million acres of this habitat as of 2019.

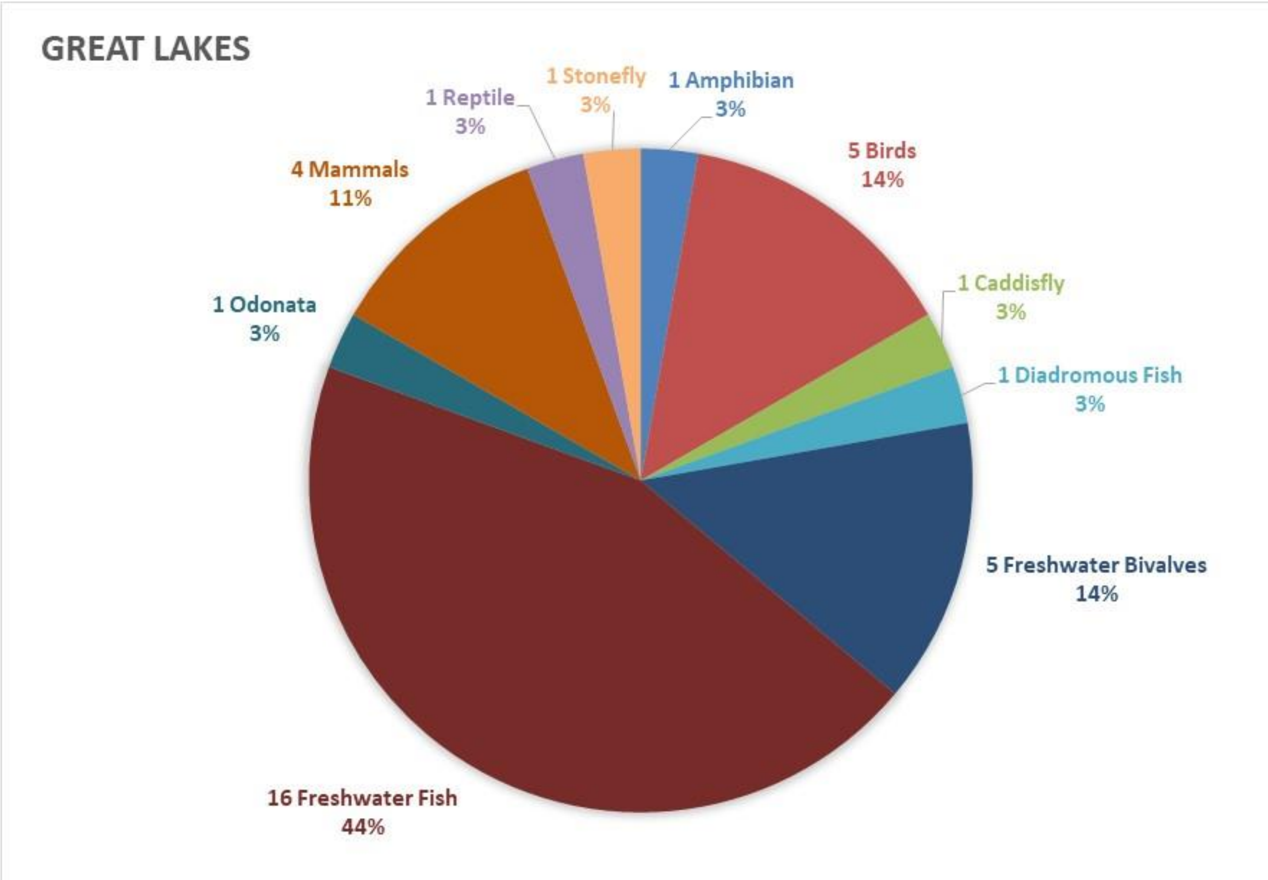

Figure 2.14. 2 Northeast RSGCN and Watchlist species associated with Great Lakes habitat represent ten taxonomic groups.

In all of the Great Lakes of the Midwest and Northeast regions, 11.6% of the waters are protected in some way within Marine Protected Areas (Wenzel et al. 2020). In the Northeast, NOAA proposed the designation of **Lake Ontario National Marine Sanctuary**[131] in 2019. The new National Marine Sanctuary would encompass 1724 square miles of eastern Lake Ontario waters and bottomlands offshore New York, extending to the Canadian border. The designation of the Lake Ontario National Marine Sanctuary is expected to be finalized in 2023.

2.14.3 HABITAT CONDITION

Threats to the Great Lakes vary by location and finer scale habitat type but include Invasive Species (Threat 8.1), Pollution (Threat 9.0), and multiple types of Natural System Modifications (Threats 7.2 and 7.3). The **Great Lakes Fishery Commission** conducts periodic assessments of Lakes Erie and Ontario, issuing **State of the Lake** reports on their status[132]. The **Great Lakes Restoration Initiative[133]** and its conservation partners also conduct ecological assessments of the Great Lakes (see *Chapter 5* for a full description).

The 2015 **National Coastal Condition Assessment (NCCA)** found that nationally 31% of Great Lakes nearshore waters (within 5 kilometers of shore and less than 30 m water depth) were rated in good biological condition, partly due to the inability to accurately sample one-third of the survey locations due to the presence of invasive zebra and quagga mussel colonies or hard lake bottoms. Good sediment quality was found at 62% of surveyed waters, but data are limited due to the same sampling issues as for biological condition. Eutrophication is persistent in the Great Lakes, with 54% of Great Lakes waters in good condition; Lake Erie in particular is impacted by eutrophication, with only 23% of the lake rated good. Contamination of fish tissue was rated good in only 17% and rated poor in 47%. Nearly two-thirds (65%) had good condition for mercury in fish tissue. At least 99% of the waters surveyed were in good condition for microcystins toxicity and Enterococci. Of the 152 fish tissue samples taken in the 2015 assessment, 100% had detectable levels of mercury, PFAS (per- and polyfluoroalkyl substances) and PCBs (polychlorinated biphenyls), with PCB levels exceeding the EPA cancer risk benchmark in most samples (EPA 2021).

Regionally, Lakes Erie and Ontario are partially or completely within the NEAFWA region. The NCCA surveyed 1042 square miles of Lake Erie nearshore waters and 532 of Lake Ontario nearshore waters. Lake Ontario had the lowest proportion of nearshore waters with a good rating for biological condition in 2015 (10%) and Lake Erie the second lowest (13%), both considerably less than Lake Michigan (45%) and Lake Superior (40%). Lake Erie had the highest proportion of poor biological condition (42%) of all the lakes, while Lake Ontario had 11%. More than two-thirds (69%) of the nearshore waters of Lake Ontario were unable to be sampled due to the presence of invasive species and hardbottom substrates, however. Long-term trends indicate Lake Erie with increasing levels of good biological condition waters (10% to 13% from 2010 to 2015) while Lake Ontario had a declining trend (19% to 10%; EPA 2021).

Lake Erie has the highest proportion of waters impacted by eutrophication of all the Great Lakes with 60% of its nearshore waters in poor condition; elevated turbidity and total phosphorous are the leading drivers for the lake's poor water quality, where harmful algal blooms have become widespread and relatively common. The eastern portion of Lake Erie, the portion within the NEAFWA region, has generally better water quality than the central and western portions. Lake Ontario is less impacted than the national total (61% versus 54% in good condition for eutrophication). Long-term trends show eutrophication decreasing in Lake Erie but increasing in Lake Ontario. The ecological effects of fish contamination are better in Lake Erie, however, than all the other lakes with 38% of the nearshore waters in good condition (the highest) and 28% in poor condition (the lowest). Lake Ontario nearshore waters are tied for the lowest – only 7% rated in good condition for fish contamination. Fish contamination levels in Lake Erie improved from 2010 to 2015 with a 23% point decrease in the nearshore area rated poor with an increase in area rated good or fair, although some of the change may be due to a decline in the area that was not assessed between surveys. In Lake Ontario the proportion of nearshore waters with good condition for fish contamination declined from 2010 to 2015 from 15% to 7%, but the area of waters not assessed jumped from 14% to 35%. The level of fish contaminated with mercury is highest in Lake Ontario of all the Great Lakes, with 9% exceeding the human health benchmark compared to Lake Erie's 4% and the Great Lakes as a whole 6% (EPA 2021).

The **Lake Champlain Basin Atlas**[134] includes information on the environmental condition of Lake Champlain, including water quality, invasive species, and climate change impacts.

2.14.4 HABITAT MANAGEMENT

Management of Great Lakes habitat, both aquatic habitat within the lakes themselves and associated upland and Rivers and Streams habitat within the Great Lakes watersheds, takes place through multiple landscape scale partners. *Chapter 7* describes these partners and their management programs and initiatives, which include:

- Great Lakes Restoration Initiative
- Great Lakes Commission
- Great Lakes – St. Lawrence River Basin Water Resources Council
- Great Lakes Fishery Commission
- Great Lakes Indian Fish and Wildlife Commission
- EPA Great Lakes National Program Office
- NOAA Great Lakes Environmental Research Lab
- Invasive Carp Regional Coordinating Committee
- Lake Champlain Basin Program

The **Great Lakes Water Quality Agreement** is a joint agreement between the United States and Canada to protect and restore the waters of the Great Lakes initially signed in 1972 and updated in 2012 (US and Canada 2012). In the US, the EPA coordinates activities under the agreement.

2.14.5 HABITAT MONITORING

The extensive habitat monitoring programs and projects in the Great Lakes are described in detail in *Chapter 5*.

2.14.6 PARTNERS

In addition to the partners listed above, the Great Lakes Sea Grant Network, the Waterkeeper Alliance, and The Nature Conservancy also are active in Great Lakes conservation (see *Chapter 7* for detailed descriptions). The Nature Conservancy, for example, has numerous programs and initiatives related to Great Lakes habitat. Globally, TNC aims to protect 74 million acres of Lakes and Wetlands and 621,000 miles of Rivers and Streams. The Great Lakes is one of TNC's priority landscapes. TNC scientists and partners have developed numerous conservation planning and practices tools, including for Great Lakes[135]. As a landowner and manager, TNC has protected more than 400 preserves across the country, managed by local and state chapters.

2.14.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of Great Lakes habitat through several ongoing citizen science projects sponsored by the partners described for the Great Lakes watershed in *Chapters 5* and *7*.

Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

2.14.8 HABITAT INFORMATION, RESEARCH, AND MONITORING NEEDS

Habitat information, research and monitoring needs for Great Lakes habitat in the Northeast are described and updated in the management plans of the conservation partnerships active in the Great Lakes, such as the Great Lakes Restoration Initiative.

2.15 LAKES & PONDS

Figure 2.15. 1 Lake and Pond habitats support 126 Northeast RSGCN and Watchlist species. (Moosehead Lake, ME).

2.15.1 HABITAT DESCRIPTION

The Northeast Lake and Pond Classification System defines ponds as waterbodies less than 10 acres in size and lakes as those greater than 10 acres (Olivero-Sheldon and Anderson 2016). For the purposes of characterizing RSGCN and Watchlist species habitat, artificial impoundments and reservoirs are considered Lakes and Ponds habitat.

In the NEAFWA region, the 14 SWAPs of 2015 included 54 Key Habitats for SGCN that are within Lakes and Ponds habitat (*Appendix 2A*, Table 2A.15). Most SWAPs classify Lakes and Ponds into the Northeast Lake and Pond Classification System to identify particular Lake and Pond types with attributes for size, trophic state, and alkalinity.

There are 63 RSGCN, three Proposed RSGCN, 46 Watchlist [Assessment Priority] and two Proposed Watchlist species across 12 taxonomic groups associated with Northeast Lakes and Ponds habitat (*Supplementary Information 2*, Table 2.15.1, Figure 2.15.2). Another 12 species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. Five RSGCN and Proposed RSGCN associated with Lakes and Ponds are of Very High Concern and at least 75% regional responsibility – three fish, one dragonfly and one stonefly.

The Northeast RSGCN Database (version 1.0) contains data on habitat characteristics associations for Lakes and Ponds-associated RSGCN and Watchlist species, such as temperature, substrate, vegetation densities, and habitat features and formations, including logs and woody debris, low fetch, deep water, reefs and live rock, and artificial structures.

Table 2.15. 1 The number of species in each RSGCN and Watchlist category associated with Lakes and Ponds habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	63
Proposed RSGCN	3
Watchlist [Assessment Priority]	45
Proposed Watchlist [Assessment Priority]	2
Watchlist [Deferral to adjacent region]	12
TOTAL	**126**

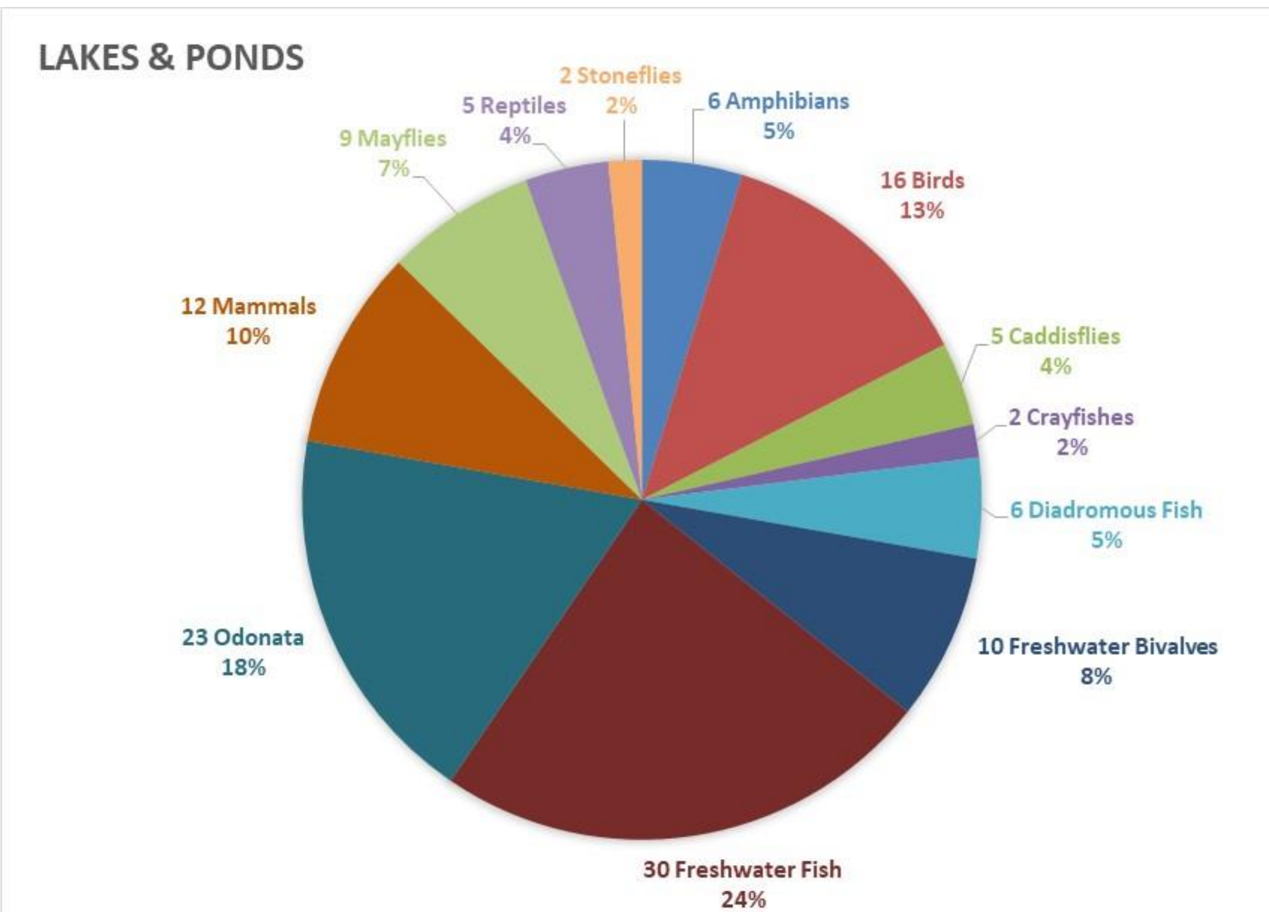

Figure 2.15. 2 Northeast RSGCN and Watchlist species associated with Lake and Pond habitats represent 12 taxonomic groups.

2.15.2 HABITAT DISTRIBUTION AND CONSERVATION

The Northeast region had 36,675 Lakes and Ponds of all sizes identified, mapped, and classified into one of 36 waterbody types by Olivero-Sheldon and Anderson (2016). The most recent land cover dataset from the Designing Sustainable Landscapes program (DSLland version 5.0, issued 2020) identified more than 3 million acres of Lakes and Ponds habitat in the Northeast as of 2011-2013 (Table 2.0.3). The updated habitat condition assessment from Anderson et al. (2023) identified more than 2.7 million acres of this habitat as of 2019, excluding the Great Lakes (Section 2.14). The majority of the 36,000+ Lakes and Ponds of the region are Small Ponds (44%) and Large Ponds (34%), but because of their small size they represent less than one-quarter of the total surface area of all Lakes and Ponds. The conservation status of Lakes and Ponds habitat is described in Anderson et al. (2023).

2.15.3 HABITAT CONDITION

Threats to the multiple finer scale habitat types within Northeast Lakes and Ponds habitat vary by location and type but include Pollution (Threat 9.0), Invasive Species (Threat 7.0), and anthropogenic land uses within their watersheds that affect water quality (Threats 1.0, 2.0, 3.0, and 4.0).

Anderson and Olivero-Sheldon (2011) assessed the status and condition of Lakes and Ponds habitat in the Northeast as of the early 2000s. Anderson et al. (2023) provides a detailed assessment of habitat condition, loss, fragmentation, and resilience of Northeast Lakes and Ponds habitat as of 2019 as well as trends over the past two decades. Staudinger et al. (2023) summarizes the state of knowledge of Lakes and Ponds habitat resiliency to climate change.

Olivero-Sheldon and Anderson (2016) calculated 315 habitat attributes for more than 36,000 Lakes and Ponds in the Northeast to use in predictive models to classify unsampled waterbodies.

Hintz et al. (2022) found that freshwater Lakes are increasingly threatened by salinization from road deicing salts, mining operations, agricultural practices, and climate change. This study tested how salinization affects Lake food webs, finding that current water quality standards in Canada, the United States, and Europe are not sufficient to prevent substantial mortality of zooplankton. Two of the 16 lakes in this international study were located in the Northeast – Dartmouth Lake and Lake George. "The loss of zooplankton triggered a cascading effect causing an increase in phytoplankton biomass by 47% at study sites…[which] could alter nutrient cycling and water clarity and trigger declines in fish production" (Hintz et al. 2022, p. 1). The test results indicated that current water quality guidelines for chloride are not sufficient to protect Lake food webs and that toxicity thresholds for zooplankton remain unknown.

The EPA **LakeCat** database[136] provides data on the condition of more than 378,000 Lakes and Ponds across the country. The LakeCat dataset currently contains over 300 metrics related to Lakes and Ponds and their condition. Both natural and anthropogenic information is included. Anthropogenic condition variables include the percent urbanization and agriculture within the watershed, dam reservoir volumes, the mean application rate of synthetic nitrogen fertilizer on agricultural lands, the erodibility of agricultural soils, the density of coal mines within the watershed, the mean pesticide use within the watershed, and many more that impact the condition of Lakes and Ponds for fish and wildlife.

2.15.4 HABITAT MANAGEMENT

There are no national or regional habitat management plans for Lakes and Ponds outside of the Great Lakes. Individual Lakes and Ponds may have watershed management plans, however. The **North American Lake Management Society** provides guidance on the development of Lake and watershed management plans[137].

Staudinger et al. (2023) describes the state of knowledge of adaptive management of Lake and Pond habitats to climate change.

2.15.5 HABITAT MONITORING

Lakes and Ponds habitat is included as a regional performance monitoring metric for the Northeast (NEAFWA 2008). Anderson and Olivero-Sheldon (2011) conducted a conservation status assessment for Lakes and Ponds in the Northeast as per this regional monitoring framework prior to the 2015 SWAPs. Anderson et al. (2023) updates the conservation status of Lakes and Ponds habitat in the Northeast for the 2025 SWAPs.

The EPA monitors the condition of water quality and ecological conditions of lakes as part of the **National Lakes Assessment**[138].

The EPA uses monitoring data for lake ice for nine lakes in the US as a climate change indicator[139]. Monitoring data are available from 1850 to 2019. The lake ice indicator shows that lakes generally are freezing later in the year than in the past (at a rate of approximately 0.5 – 1.5 days per decade) and thawing earlier in the spring (at a rate of 0.8 days per decade), shortening the period when the lakes are covered in ice annually by several weeks. The EPA also uses lake temperature monitoring data[140] as a climate change indicator, with data available from 1985 to 2009. Data from 34 lakes across the US and Canada for the average July to September surface temperatures document an increase in average temperature for 32 of the 34 lakes, with 24 lakes warming by more than 1 degree Fahrenheit and 15 by more than 2 degrees.

The **Global Lake and River Ice Phenology Database**, which is maintained by the National Snow and Ice Data Center, collects monitoring data on ice cover, freeze dates, and breakup dates for 865 Lakes and Rivers across the Northern Hemisphere, with 66 water bodies having more than 100 years of records[141]. Other data included in this database provide information on power plant discharges, shoreline length, water depths, watershed size, conductivity, secchi depth, surface area, and other physical features. The database includes habitat information on one lake in Connecticut, three in Massachusetts, 24 in Maine, four in New Hampshire, and 28 in New York.

2.15.6 PARTNERS

The **North American Lake Management Society[142]** is a partnership organization with a mission to protect and manage Lakes and Ponds throughout North America. The organization was founded in Maine in 1980 and has now spread to three countries. A certification program is available to recognize lake managers and professionals who have completed specialized training and management experience. International symposia are held annually at various locations in the United States and Canada. The organization publishes a peer-reviewed journal, *Lake and Reservoir Management*, to share relevant research. Other education initiatives include publication of the *LakeLine* and *NALMS Notes and Lake News* newsletters. Since 2004, the organization has supported an **Inland Harmful Algal Blooms** program[143] that provides a number of online resources addressing the threat to Lakes and Ponds habitat.

2.15.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of Lakes and Ponds habitat through several ongoing citizen science projects. The **Lake Observations by Citizen Scientists and Satellites (LOCSS)** project[144] asks citizen scientists to submit lake water level measurements to ground-truth satellite measurements, allowing for a better understanding of how the quantity of water in lakes changes over time. Monitored lakes include several in Massachusetts (2), New Hampshire (19) and New York (15).

The **Global Lake Ecological Observatory Network (GLEON)** monitors the water quality of Lakes worldwide as well as the Rivers and Streams connected to them[145]. Using the Lake Observer mobile app, citizen scientists record geo-referenced data on weather, water quality, ice cover and aquatic vegetation. More than 1200 Lake Observer observations were collected in the Northeast region during 2022.

The North American Lake Management Society conducts an annual **Secchi Dip-In** event when volunteers can gather data on Lake water quality and submit it to the **Secchi Dip-In Online Database[146]**. The EPA is one of many partners in this citizen science project.

Fish Watchers is a public project[147] by the **International Game Fish Association** to create a national fish biodiversity database for the United States (called **FishBase**) by allowing the public to submit records of fish that have been seen or caught.

Most citizen science projects related to Lakes and Ponds are state-based, such as the **University of Rhode Island's Watershed Watch** program for monitoring water quality throughout Rhode Island or Vermont's **LoonWatch Day** to annually count Common Loon populations on assigned lakes. Many states offer **Master Watershed Stewards** programs through Cooperative Extension offices that train citizen scientists to monitor water quality and conduct environmental education activities.

Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

2.15.8 HABITAT INFORMATION, RESEARCH, AND MONITORING NEEDS

A few habitat information, research and monitoring needs exist for Lakes and Ponds habitat in the Northeast:

- Determine chloride thresholds that protect zooplankton food webs (Hintz et al. 2022)
- Improved water quality guidelines for saline pollution (Hintz et al. 2022)

2.16 SHORELINES

Figure 2.16. 1 Shoreline habitat support 64 Northeast RSGCN and Watchlist species. (Maine coast photo credit: Maine Sea Grant).

2.16.1 HABITAT DESCRIPTION

Shorelines habitat for Northeast RSGCN and Watchlist species includes Shorelines on Lakes and Ponds, Estuaries and the Marine Nearshore but excludes Beaches and Dunes, Non-Tidal Wetlands and Tidal Wetlands and Flats. Because those habitats are considered separately (Section 2.17), these Shorelines tend to be rocky. In the NEAFWA region, the 14 SWAPs of 2015 included 21 Key Habitats for SGCN that are within Shorelines habitat (*Appendix 2A*, Table 2A.16). SWAP Key Habitats include intertidal bedrock or rocky shores of Estuaries or the Atlantic Ocean, maritime bluffs and headlands, or lakeshores without Beaches.

There are 29 RSGCN, three Proposed RSGCN, 25 Watchlist [Assessment Priority], and three Proposed Watchlist species across 12 taxonomic groups associated with Northeast Shorelines habitat (*Supplementary Information 2*, Table 2.16.1, Figure 2.16.2). Another four species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. The stonefly Presidential Springfly (*Diura washingtoniana*), dragonfly Pine Barrens Bluet (*Enallagma recurvatum*), and Puritan Tiger Beetle (*Ellipsoptera puritana*) are RSGCN of Very High Concern that are endemic to the Northeast and associated with Shorelines habitat.

The Northeast RSGCN Database (version 1.0) contains data on habitat characteristics associations for Shorelines-associated RSGCN and Watchlist species, such as tidal zone, substrate, salinity, vegetation densities, tidal pools, rocky shores, cliffs or bluffs, wrack, and artificial structures.

Table 2.16. 1 The number of species in each RSGCN and Watchlist category associated with Shorelines habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	29
Proposed RSGCN	3
Watchlist [Assessment Priority]	25
Proposed Watchlist [Assessment Priority]	2
Watchlist [Deferral to adjacent region]	4
TOTAL	**64**

2.16.2 HABITAT DISTRIBUTION AND CONSERVATION

The most recent land cover dataset from the Designing Sustainable Landscapes program (DSLland version 5.0, issued 2020) identified nearly 24,000 acres of rocky Shorelines habitat in the Northeast as of 2011-2013 (Table 2.0.3). The updated habitat condition assessment from Anderson et al. (2023) provides an assessment of the Shoreline 100-meter buffer zone around Lakes and Ponds as of 2019. No comprehensive delineation of the region's rocky Shorelines is available.

Roman et al. (2000) describes the characteristics of rocky Shorelines in the Estuaries of the Northeast, observing that due to the glacial history and geomorphology of the region rocky, estuarine Shoreline habitat is quite unique, being virtually absent from the Mid-Atlantic, Southeast, and Gulf of Mexico coasts of the US.

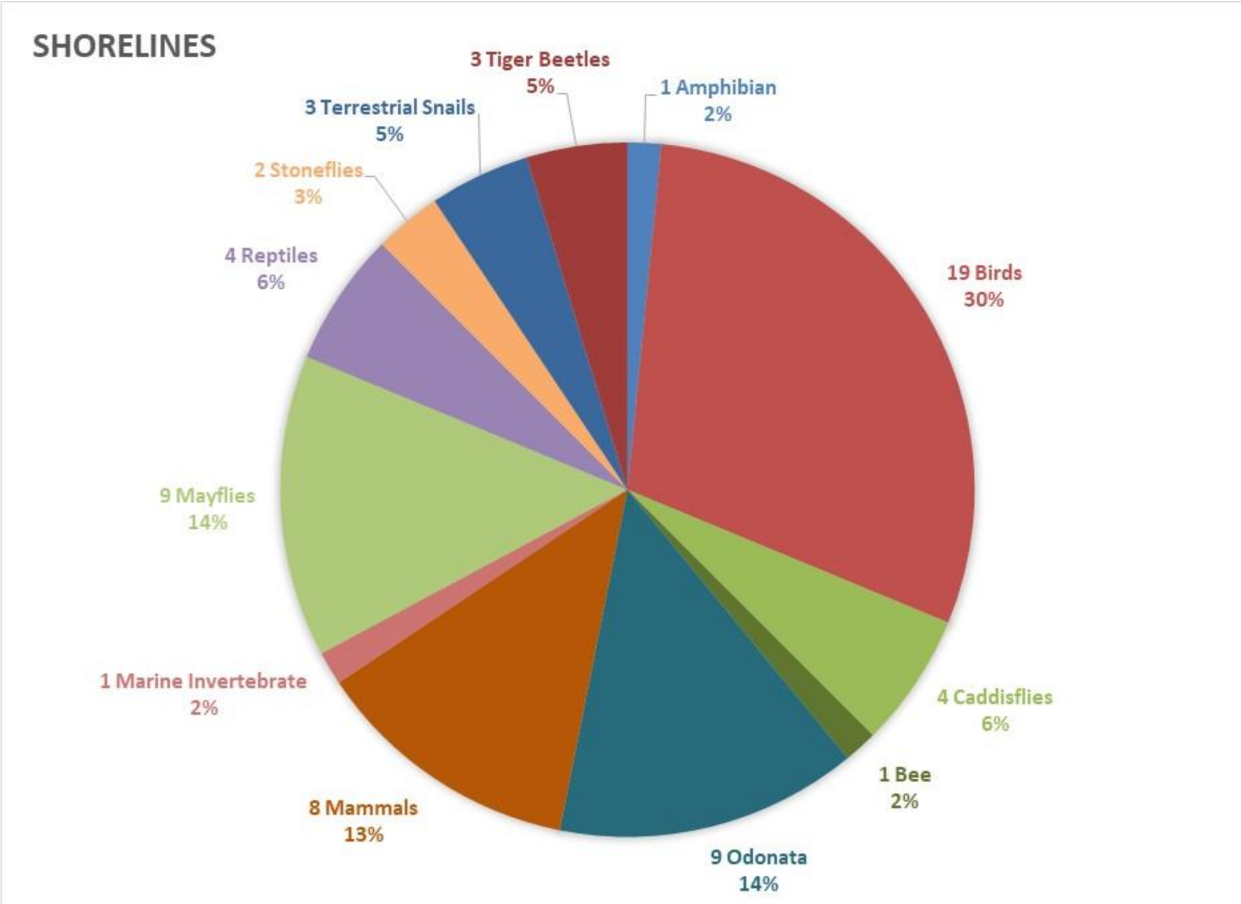

Figure 2.16. 2 Northeast RSGCN and Watchlist species associated with Shorelines habitat represent 12 taxonomic groups.

The Shorelines buffer around the region's Lakes and Ponds are more conserved surrounding Large Lakes (1000-10,000 acres), Very Large Lakes (10,000+ acres), and Medium Lakes (100-1000 acres) than Small (2-10 acres) and Large Ponds (10+ acres) and Small Lakes (2-100 acres; Anderson et al. 2023).

2.16.3 HABITAT CONDITION

Threats to the multiple finer scale habitat types within this Northeast Shorelines habitat vary by location and type but include Shoreline Alteration (Threat 7.3.1), Development (Threat 1.0), Human Disturbance from Recreational Activities (Threat 6.1), Invasive Species (Threat 8.0), Pollution (Threat 9.0), and Climate Change (Threat 11.0).

Anderson et al. (2013b) predicted future habitat loss of Northeast habitats to development over the next 50 years. The Acadian-North Atlantic Rocky Coast macrogroup was predicted to lose 13.6% of its habitat to development over the next five decades.

Estuarine rocky Shorelines of the Northeast are threatened by non-native and invasive species (Threat 8.1.3), particularly Green Crab (*Carcinus maenus*) and Common Periwinkle (*Littorina littorea*) (Roman et al. 2000). The Common Periwinkle has become the dominant herbivore for intertidal algae on New England rocky shorelines since its introduction in the mid-1800s, controlling the structure of rocky intertidal communities. The Green Crab is a predator on both rocky Shoreline and soft-substrate estuarine Shorelines, significantly altering the structure and function of native communities in the Northeast.

Anderson and Olivero-Sheldon (2011) assessed the status and condition of some Shorelines habitat in the Northeast as of the early 2000s. That conservation status assessment is updated in Anderson et al. (2023) with habitat status and condition information as of 2019 as well as trends over the past two decades. The Shoreline zone (100-meters) around all Lakes and Ponds of the Northeast have less land in developed or agricultural land uses than conserved against those land uses, with the Shoreline zone of the Great Lakes and Small Ponds more converted than conserved while the Shoreline zone around Large Ponds and Small Lakes are the reverse. More than 40% of the Shoreline zone of the Great Lakes has been converted to development or agriculture. Over the past decade the trend has been to conserve more Shoreline lands than has been lost to development or agriculture.

Staudinger et al. (2023) summarizes the state of knowledge of Shorelines habitat resiliency to climate change.

2.16.4 HABITAT MANAGEMENT

Rocky coastal Shorelines habitat is generally managed at the state or local level, through state coastal zone management programs along the Atlantic coast. The **Massachusetts Climate Action Tool**[148] describes the ecology and vulnerability of rocky coastal Shorelines in New England and associated resources, such as a Climate Change Vulnerability Assessment for the coastal islands and rocky shores of New Hampshire and Maine. Staudinger et al. (2023) describes the state of knowledge of adaptive management of Shorelines habitats to climate change.

2.16.5 HABITAT MONITORING

No regional scale monitoring programs are known to exist in the Northeast for Shorelines habitat, along lakeshores or the rocky New England coastline. The US Department of the Interior Minerals Management Service, now known as the Bureau of Ocean Energy Management (BOEM), developed **Methods for Performing Monitoring, Impact, and Ecological Studies on Rocky Shores** in 2001 (Murray et al. 2002). These methods address shoreline classification, habitat types, and site selection recommendations for impact and monitoring studies. Sampling designs and species-level sampling techniques are described.

2.16.6 PARTNERS

State coastal zone management programs have regulatory authority over projects proposed to modify Shoreline habitat along the marine, estuarine, and Great Lakes coastlines. The **Sea Grant Program**, with operations in every Northeast state except West Virginia and the District of Columbia, offer extensive education and outreach programs relating to Shoreline habitat (see *Chapter 7*). In 2021, NOAA established a regional collaboration to address marine debris in the Gulf of Maine, running through at least September 2023, by conducting more than 100 Shoreline clean-up projects[149]. Other partners conserving Shoreline habitat are more localized, such as the **Maine Coast Heritage Trust**[150] that has protected more than 150 preserves open to the public over the past five decades.

2.16.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of Shorelines habitat through several ongoing citizen science projects. The **Big Microplastic Survey** is a global project[151] to gather information on plastic pollution along the Shorelines of lakes, rivers and coastal areas. Citizen scientists use standardized methods to document the presence and abundance of plastic within five small sample sites within one 25-meter length of shoreline.

Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

2.16.8 HABITAT INFORMATION, RESEARCH AND MONITORING NEEDS

Several habitat information, research and monitoring needs exist for Shorelines habitat in the Northeast:

- A comprehensive delineation of the rocky Shoreline length of the entire Northeast region, including marine, estuarine, and freshwater Shorelines
- A comprehensive ecological assessment of the rocky Shoreline of the region

2.17 BEACHES & DUNES

Figure 2.17. 1 Beach and Dune habitats support 53 Northeast RSGCN and Watchlist species. (Gateway National Recreation Area on Long Island, NY)

2.17.1 HABITAT DESCRIPTION

Beach and Dune ecosystems in the Northeast are highly dynamic habitats at the land-water interface, ranging from small pocket marine beaches of New England to the long barrier islands of Long Island and the Delmarva peninsula. In the Northeast, sandy Beach and Dune habitats are of three types: marine, estuarine, and freshwater. Marine Beach and Dune habitats are found on the margins of the Atlantic Ocean from southern Maine to Virginia. Estuarine Beach and Dune habitats are similarly found from Maine to Virginia along the margins of the region's estuaries, most notably Chesapeake Bay, Delaware Bay, and the numerous large estuaries of Long Island. Freshwater Beach and Dune habitats are located along the margins of the Great Lakes, in Pennsylvania, New York and Vermont along the edges of Lakes Erie, Ontario, and Champlain. The sandy Beach and Dune habitats of the Northeast, particularly in New England, may be interspersed with rocky sections of coastline, which are discussed under the Shorelines habitat (Section 2.16), or salt marsh habitat, which is discussed under the Tidal Wetlands and Flats habitat (Section 2.18). The submerged portion of the beach, called the shoreface, is addressed under the Marine Nearshore (Section 2.20), Estuaries (Section 2.19), or Great Lakes (Section 2.14) habitat types depending on the water body. Thirty-three key habitats from 2015 Northeast SWAPs are associated with Beach and Dune habitat regionally (*Appendix 2A*, Table 2A.17).

Beach and Dune habitats typically have sparse or no vegetation, with a sand or gravel substrate that continuously moves with the winds, waves, tides, lake levels, storms, and ice. This habitat is intrinsically linked to both terrestrial and aquatic elements, transitioning on the landward side to terrestrial habitats that are fully vegetated and on the water side to submerged aquatic habitats. Beaches are storm-driven ecosystems that shift in space and time with storms depositing overwash deposits of sand, shells and/or gravel on the landward side of the beach and within the dunes, raising the elevation of the habitat and removing or burying vegetation. In the absence of anthropogenic habitat modifications, beaches and dunes in the Northeast would persist in a natural equilibrium with rising sea level and storm events but would shift in space over time.

Beach and Dune habitats support an array of wildlife, with 27 RSGCN, 19 Watchlist [Assessment Priority] and two Proposed Watchlist [Assessment Priority] species in eight taxonomic groups associated with this habitat type in the Northeast (*Supplementary Information 2*, Table 2.17.1, Figure 2.17.1). Another five species are Watchlist [Deferral] species to another AFWA region. Three RSGCN associated with Beach and Dune habitats are of Very High Concern and endemic to the Northeast – the Bethany Beach Firefly (*Photuris bethaniensis*), Puritan Tiger Beetle, and Eastern Beach Tiger Beetle (*Habroscelimorpha dorsalis dorsalis*).

Table 2.17. 1 The number of species in each RSGCN and Watchlist category associated with Beaches and Dunes habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	27
Watchlist [Assessment Priority]	19
Proposed Watchlist [Assessment Priority]	2
Watchlist [Deferral to adjacent region]	5
TOTAL	**53**

Shorebirds and colonial waterbirds rely on sandy Beach and Dune habitats for nesting on the sparsely vegetated to bare ground and forage on or near the beaches and adjacent waters. Shorebird populations have declined 33% since 1970 according to the **2022 State of the Birds** report, second only to Grassland birds in rate of decline (NABCI 2022). Ten shorebird species and three waterbirds that occur in the Northeast are identified as Tipping Point species in the 2022 State of the Birds report with cumulative population losses over 70% since 1980 and a future trajectory to lose another half of their remnant populations in the next five decades without intervention (NABCI 2022). Four of these Tipping Point shorebirds and waterbirds are RSGCN or Watchlist species: Least Tern (*Sternula antillarum*), Ruddy Turnstone (*Arenaria interpres*), Semipalmated Sandpiper (*Calidris pusilla*) and Whimbrel (*Numenius phaeopus*).

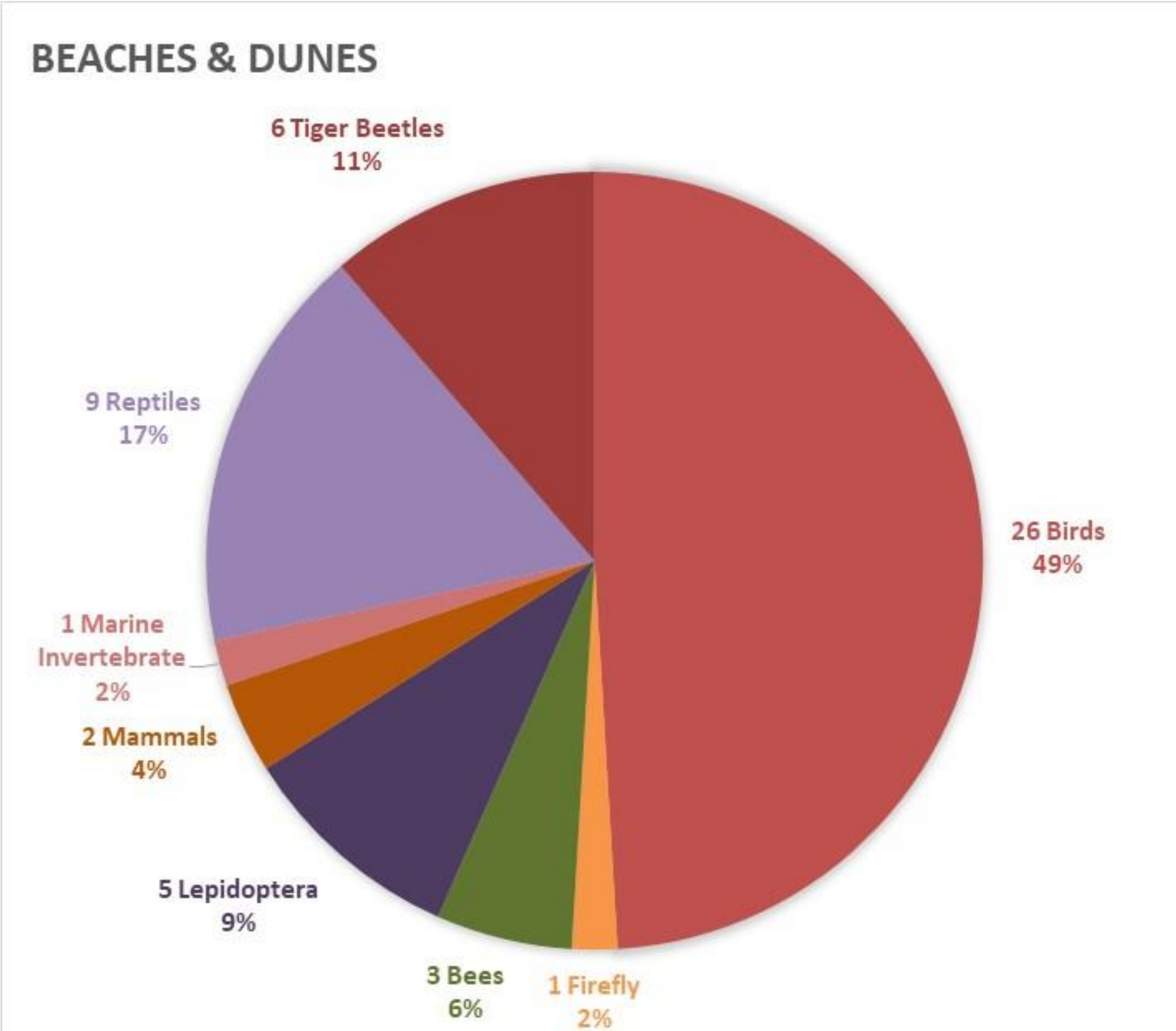

Figure 2.17. 2 Northeast RSGCN and Watchlist species associated with Beach and Dune habitats represent eight taxonomic groups.

Piping Plovers (*Charadrius melodus*), a federally-listed RSGCN, nests on both the Atlantic Coast and Great Lakes beaches of the region, with distinct breeding populations.

Estuarine beaches provide nesting or spawning habitat for Northern Diamondback Terrapin (*Malaclemys terrapin terrapin*) and Horseshoe Crab (*Limulus polyphemus*), both RSGCN. Small numbers of federally-listed RSGCN marine sea turtles nest on the Atlantic Coast beaches of Virginia and Maryland in the southern portion of the region. Great Lakes beaches also provide nesting and foraging habitat for RSGCN and Watchlist shorebirds and waterbirds. Several invertebrate RSGCN and Watchlist species are associated with Beach and Dune habitat, from the Bethany Beach Firefly (*Photuris* *bethaniensis*) and Similar Carder Bee (*Dianthidium simile*) to several species of tiger beetles.

Beach and Dune habitats of the Northeast provide key migratory and wintering areas for several RSGCN and Watchlist birds. The estuarine beaches of Delaware Bay are a major migratory stopover for the Northeast RSGCN Red Knot (*Calidris canutus rufa*) every spring, with 75-100% Regional Responsibility for migration of the federally-listed species. The Northeast provides more than 75% of the migration season Regional Responsibility and 100% of the wintering season Regional Responsibility for the RSGCN Purple Sandpiper (*Calidris maritima*). More than 50% of the migratory range of the Whimbrel is within the NEAFWA region. Countless shorebirds, waterbirds and landbirds migrate through the region's beaches and dunes annually.

2.17.2 HABITAT DISTRIBUTION AND CONSERVATION

Beach and Dune habitat occurs within every NEAFWA state or District except West Virginia (Table 2.17.2). All 11 coastal Northeast states where Beach and Dune habitat occurs have designated it as a Key Habitat for SGCN within their 2015 SWAPs (*Appendix 2A*, Table 2A.17).

Sandy beach habitat along the North Atlantic Coast, from Maine to North Carolina, was mapped and inventoried in a project supported by the North Atlantic LCC following Hurricane Sandy, which struck the mid-Atlantic coast in October 2012. The availability and distribution of marine sandy beach habitat was assessed before Hurricane Sandy (Rice 2015a, 2015b and 2015c), immediately following the hurricane's landfall in New Jersey (Rice 2015d), and three years after the storm (Rice 2017), capturing habitat changes to this storm-driven ecosystem. The estuarine beaches of the North Shore and Peconic Estuary of Long Island, NY, were also assessed. Habitat availability for sandy beaches is typically measured in linear length of shoreline rather than acres due to their continually shifting nature (Table 2.17.2).

There are no known comprehensive regional assessments of estuarine Beach and Dune habitat availability in the Northeast. The sandy beach habitat along the Long Island Sound and Peconic Estuary shorelines of Long Island, New York, were assessed alongside the marine sandy beach habitat in Rice (2017) and provide a partial assessment. The Peconic Estuary shoreline of Long Island had 37.05 miles of sandy Beach and Dune habitat in 2015 and the North Shore of Long Island on the Long Island Sound estuarine shoreline had 38.96 miles (Table 2.17.2). Anderson et al. (2013a) identified 96,690 acres of Atlantic Coastal Plain Beach and Dune habitat in the Northeast as of 2001 as part of the Map of Terrestrial Habitats of the Northeastern United States (Ferree and Anderson 2013). These nearly 100,000 acres of habitat include both marine and estuarine beach and dune habitat, covering Long Island Sound, the Peconic Estuary of New York, Delaware Bay, and the lower Chesapeake Bay. Some estuarine beaches on the bayside or adjacent mainland landward of barrier islands were not included.

The availability of Beach and Dune habitat on the Great Lakes shorelines of Pennsylvania, New York and Vermont was included as a dune habitat (Great Lakes Dune & Swale) in the *Map of Terrestrial Habitats of the Northeastern United States* (Ferree and Anderson 2013). As of 2001, Anderson et al. (2013a) identified 1,805 acres of Great Lakes Dune and Swale habitat along the shorelines of Lake Erie, Lake Ontario, and Lake Champlain.

Rice (2017) identified at least 828 miles of Beach and Dune habitat in the Northeast that was owned and/or managed by public entities or NGOs, although no distinction was made between areas protected for conservation versus recreation (Table 2.17.3). New

Table 2.17. 2 The length of sandy beach habitat present and lost due to coastal engineering structures within each state of the NEAFWA region as of 2015 (Rice 2017).

State / District	Length of Sandy Beach in 2015 (miles)	Length of Sandy Beach Habitat Loss as of 2015 (miles)
Connecticut	88	18.12
Delaware	25	0
Maine	48	1.68
Maryland	31	0
Massachusetts	458	47.86
New Hampshire	10	0.83
New Jersey	125	2.29
New York:		
Atlantic Ocean	123	3.12
North Shore	124	4.32
Peconic Estuary	144	10.02
Rhode Island	46	1.90
Virginia	105	0
TOTAL	**1651**	**90.88**

Hampshire, Massachusetts, New York (Atlantic Ocean), Delaware, Maryland and Virginia all had at least half of their Beach and Dune habitat in public and/or NGO ownership as of 2015. Along the estuarine sandy beach shoreline of Long Island, where data are available, 43% of the sandy Beach and Dune habitat was in public or NGO ownership in 2015 on the Peconic Estuary and 39% on the North Shore (Rice 2017). Anderson et al. (2013a) identified 37.5% of the Atlantic Coastal Plain Beach and Dune habitat as conserved, including both marine and estuarine Beaches and Dunes, and 62.5% of the Great Lakes Dune and Swale habitat as conserved.

Table 2.17. 3 The length and proportion of marine sandy beach habitat in each state that is in public and/or NGO ownership along the Atlantic coast of NEAFWA (Rice 2017).

State / District	Length of Sandy Beach in Public and/or NGO Ownership as of 2015 (miles)	Proportion of Sandy Beach in Public and/or NGO Ownership as of 2015 (miles)
Connecticut	40	44%
Delaware	14	58%
Maine	14	28%
Maryland	22	71%
Massachusetts	242	53%
New Hampshire	5	55%
New Jersey	32	26%
New York:		
Atlantic Ocean	62	50%
North Shore	36	29%
Peconic Estuary	63	43%
Rhode Island	26	56%
Virginia	94†	89%
TOTAL	**828**	**48%**

† An unknown portion of Cedar Island is privately owned but undeveloped. The Chincoteague NWR owns a number of island parcels. The total island length is included here.

Several conservation partners own, manage and protect marine and estuarine sandy Beach and Dune habitat in the Northeast. The National Park Service (NPS) is one of the largest landowners, conserving ~102 miles of sandy beach habitat at Cape Cod NS in Massachusetts, Fire Island NS in New York, Gateway National Recreation Area in New York and New Jersey, and Assateague Island NS in Maryland. The USFWS also manages over 80 miles of sandy Beach and Dune habitat as part of the National Wildlife Refuge System, which includes 21 refuges in the region where sandy beach habitat was present in 2015 (Rice 2017).

The states of the Northeast own and/or manage more than 141 miles of marine and estuarine Beach and Dune habitat, presenting opportunities in every coastal state for collaboration between sister agencies. Partnership opportunities for the conservation of Beach and Dune habitat also abound at the local level, where municipalities and local communities own and/or manage nearly 143 miles of marine and estuarine Beach and Dune habitat in the Northeast, although often for recreational purposes. A number of counties own beachfront lands as well. At the local level, the Northeast region has a large number of land trusts that have conserved coastal habitats and actively manage Beach and Dune habitat (Rice 2017).

2.17.3 HABITAT CONDITION

Beach and Dune habitat is threatened by Development (Threat 1.0), Natural System Modifications (Threat 7.0), Human Disturbance (Threat 6.1), and Climate Change (Threat 11.0) at the regional level (Rice 2017), national level (Gittman et al. 2015), and global level (Brown and McLachlan 2002).

As of 2015, at least 76 miles of marine Beach and Dune habitat in the NEAFWA region had been lost due to beach armoring or coastal engineering structures, some of which have been in place for 100 years, and another 14 miles lost on the estuarine shorelines of the North Shore and Peconic Estuary of Long Island, NY (Table 2.17.2). The highest amounts of habitat loss have been in Massachusetts and Connecticut (Rice 2017).

Of the nearly 97,000 acres of Atlantic Coastal Plain Beach and Dune habitat inventoried by Anderson et al. (2013a), the average rate of habitat loss to development was 165 acres per year with 8,263 acres projected to be lost by 2060. Of the 1,805 acres of Great Lakes Dune and Swale habitat inventoried by Anderson et al. (2013a), the average rate of habitat loss to development was 2 acres per year with 77 acres projected to be lost by 2060.

The condition of Beach and Dune habitat in the Northeast is impacted by shoreline stabilization with both beach armor and sediment placement (both beach nourishment and dredged material placement), development, beach driving with off-road vehicles (ORV), beach scraping and sand fencing. Habitat suitability for RSGCN and Watchlist species is also affected by oftentimes intense human disturbance due to the high recreational use of the habitat. Rice (2017) summarizes the ecological impacts of these types of habitat modifications of sandy Beach and Dune habitat.

The condition of sandy beach habitat was assessed as of 2015 by Rice (2017), including the location and extent of several habitat modifications: development, beach armor or coastal engineering structures, sediment placement (either beach nourishment or dredged material disposal), beach scraping, and sand fencing. Rice (2017) provides detailed information on these habitat modifications, along with Google Earth data layers, for each Atlantic coastal state (at the municipal level) in the NEAFWA region (Table 2.17.4). A companion assessment for tidal inlet habitat contains detailed information on the number, location and condition of tidal inlets that often separate sandy beaches along the Atlantic Coast (Rice 2016). This series of habitat assessments and associated data sources are available through Data Basin[152].

The Northeast states had 1,060 miles of marine Beach and Dune habitat in 2015, 40% (423 miles) of which had been developed on the landward side (Table 2.17.4). Virginia had the least developed Atlantic beachfront proportionally while New Hampshire had the most developed (15% and 86%, respectively). Four of the ten NEAFWA coastal states had at least half of their marine Beach and Dune habitat modified by development – Maine, New Hampshire, Connecticut and New Jersey. The level of beachfront development has increased in every Northeast coastal state but one (RI) since the 1970s, with the largest increases in Connecticut and New Hampshire (27% and 23%, respectively) (Rice 2017).

Up to 3,481 groins and 160 jetties have been constructed and remained in place as of 2015 in the Northeast on marine beaches, along with at least 77 breakwaters and 2,144 seawalls, bulkheads, and revetments. Massachusetts, Connecticut and New Jersey have the highest number of coastal engineering structures along marine sandy beach habitat (Rice 2017).

Sediment placement projects include beach nourishment, storm damage reduction projects, artificial dune construction, the closure of tidal inlets, and dredge disposal placement projects. More than 27%, or nearly 400 miles, of the marine sandy Beach and Dune habitat in the Northeast has been modified by sediment placement as of 2015 (Table 2.17.4). The marine sandy Beach and Dune habitat of Maryland, New Jersey and New York are the most modified by sediment placement projects in the Northeast with more than 60% of each modified in this way (Rice 2017). As sea level continues to rise with climate change, and storms become more frequent and severe, sediment placement projects are likely to become more frequent in the Northeast, modifying increasing amounts of marine and estuarine sandy Beach and Dune habitat. As of 2015, an additional ~76 miles of marine sandy beach habitat were proposed to be modified by new sediment placement projects (Rice 2017).

Beach scraping most often occurs immediately following storm events and is intended to artificially rebuild dunes on sandy beaches, using heavy equipment to push or create mounds of sand that may have been eroded or lost during the storm. Beach scraping projects tend to be localized and sponsored by local municipalities. In the three years following Hurricane Sandy (2012-2015), nearly 63 miles, or 6%, of the marine sandy Beach and Dune habitat was modified by beach scraping activities. The marine sandy Beach and Dune habitats of New Jersey (20%) and the Atlantic Coast of New York (18%) were the most modified by beach scraping between 2012 and 2015 (Table 2.17.4; Rice 2017).

Sand fencing is installed on beaches to create new dunes in a designated spot by trapping windblown sediment, typically to protect adjacent development and infrastructure. Between 2012 and 2015 at least 15% of the Beach and Dune habitat along the Atlantic Ocean, Long Island Sound and Peconic Estuary shorelines of the Northeast were modified with sand fencing (Rice 2017).

The cumulative impacts of these habitat modifications to the Atlantic sandy beachfront of the Northeast are significant and long-term. Of the 322 communities surveyed in Rice (2017) from Maine to North Carolina, 122 (43%) of the municipalities have no sandy Beach and Dune habitat remaining that has not been modified in at least one way. Regionally, only 32% (344 miles) had not been modified in at least one way as of 2015. Of these ~344 miles, over 32 miles were disturbed by ORV use and ~44 miles were indirectly modified by the presence of roadways within 500 ft. New Hampshire had the least amount of unmodified marine Beach and Dune habitat at 3%, while Virginia had the highest at 78% due to the number of undeveloped and preserved barrier islands on the Eastern Shore. The longest lengths of marine Beach and Dune habitat in the Northeast that were not modified as of 2015, when excluding historical sediment placement projects that have not occurred in the preceding 20 years, are at Assateague Island National Seashore in Maryland (12 miles), Chincoteague NWR in Virginia (12 miles), on Nantucket in Massachusetts (11 miles) and at Cape Cod National Seashore and Monomoy NWR in Massachusetts (9 miles); all of these beaches are in public or NGO ownership.

Estuarine Beach and Dune habitat is impacted by the same threats as along the oceanfront. The condition of sandy beach habitat along the Long Island Sound and Peconic Estuary shorelines of Long Island, New York, were assessed alongside the marine sandy beach habitat in Rice (2017). These estuarine beach habitats have been impacted by the same habitat modifications as the Atlantic coast sandy beaches, with 40% of the Peconic Estuary sandy beaches and 62% of the North Shore of Long Island modified by development. Both sandy shorelines have been significantly modified by beach armor, with 30% of the Peconic Estuary and 34% of the North Shore of Long Island impacted by coastal engineering structures, including a known 1,410 structures in place as of 2015 along the sandy beach shoreline of the Peconic Estuary and 899 structures along the North Shore of Long Island. More than 14 miles of sandy beach habitat has been lost along these two estuarine shorelines (Rice 2017).

At least 5% of the Peconic Estuary sandy beach habitat and at least 5% of the North Shore of Long Island sandy beach habitat had been modified by sediment placement as of 2015 (Table 2.17.5). Both estuarine sandy shorelines had approximately 2 miles of Beach and Dune habitat proposed for additional sediment placement projects as of 2015 (Rice 2017).

Table 2.17. 4 Habitat modifications by coastal state in the NEAFWA region as of 2015 for marine sandy beach habitat (Rice 2017). Note that the proportion of marine sandy shoreline modified by beach armor includes the length of armored shoreline where sandy beach habitat has been lost (Table 2.17.2). The proportion of habitat modified by sediment placement activities is a minimum due to a lack of accurate historical records in many locations.

State	Proportion of Marine Sandy Beach Modified by Development as of 2015	Proportion of Marine Sandy Shoreline Modified by Armor as of 2015	Proportion of Marine Sandy Beach Modified by Sediment Placement as of 2015	Proportion of Marine Sandy Beach Modified by Beach Scraping 2012-2015	Proportion of Marine Sandy Beach Modified by Sand Fencing 2012-2015
ME	65%	33%	> 13%	0.2%	2%
NH	86%	72%	> 14%	2%	2%
MA	41%	31%	> 4%	0.1%	4%
RI	34%	13%	> 15%	7%	18%
CT	55%	54%	> 15%	3%	4%
NY	44%	28%	62%	18%	46%
NJ	65%	62%	63%	20%	47%
DE	45%	15%	49%	6%	60%
MD	29%	5%	100%	12%	32%
VA	15%	11%	39%	3%	8%
TOTAL	**40%**	**28%**	**> 27%**	**6%**	**17%**

Table 2.17. 5 Habitat modifications by coastal state in the NEAFWA region as of 2015 for estuarine sandy beach habitat (Rice 2017). Note that the proportion of estuarine sandy shoreline modified by beach armor includes the length of armored shoreline where sandy beach habitat has been lost (Table 2.17.2). The proportion of habitat modified by sediment placement activities is a minimum due to a lack of accurate historical records in many locations.

State	Proportion of Estuarine Sandy Beach Modified by Development as of 2015	Proportion of Estuarine Sandy Shoreline Modified by Armor as of 2015	Proportion of Estuarine Sandy Beach Modified by Sediment Placement as of 2015	Proportion of Estuarine Sandy Beach Modified by Beach Scraping 2012-2015	Proportion of Estuarine Sandy Beach Modified by Sand Fencing 2012-2015
NY North Shore	62%	34%	> 5%	1%	0.50%
NY Peconic Estuary	60%	30%	> 5%	0.01%	0.60%

As of 2015, only 36% of the Peconic Estuary sandy beach habitat and 14% of the North Shore of Long Island estuarine beach habitat had not been modified in at least one way, for a total of 73 miles of unmodified sandy Beach and Dune habitat. Twenty-four communities along these two estuarine shorelines of Long Island had no unmodified sandy Beach and Dune habitat as of 2015.

The condition of freshwater Beach and Dune habitat along the Great Lakes shorelines of Lakes Erie, Ontario, and Champlain has not been assessed regionally.

Beach and Dune habitat is naturally fragmented and typically connected along the coastline or shoreline via tidal inlets that naturally separate linear sections of Beaches and Dunes. Sediment is shared across tidal inlets by longshore currents that carry sediment from one beach to another. As of 2015 there were 392 tidal inlets connecting Beach and Dune habitat long the marine Atlantic coast from Maine to Virginia and the North Shore and Peconic Estuary estuarine shorelines of Long Island. More than two-thirds (68%) of those inlets had been modified in at least one way as of 2015, with more than 90% of the tidal inlets modified in New Hampshire, the Atlantic coast of New York, New Jersey, Delaware and Maryland (Rice 2016). These inlet modifications fragment adjacent beaches that would otherwise be connected via sediment transport processes.

Beach and Dune habitat in the Northeast also can be fragmented by development (Threat 1.0) and coastal engineering structures or shoreline armor (Threat 7.0). Anderson et al. (2013b) found the Atlantic Coastal Plain Beach and Dune habitat in the Northeast to be highly fragmented. For Great Lakes Dune and Swale habitat, Anderson et al. (2013a) found a higher degree of connectedness than along the Atlantic Coast. Rice (2017) identified only 93 segments of Beach and Dune habitat at least one mile in length on the Atlantic, Long Island Sound and Peconic Estuary shorelines of the Northeast region that were not fragmented by natural system modifications (Threat 7.3.1, 7.3.4, and 4.1.1). The longest contiguous Beach and Dune habitat was on Assateague Island National Seashore (MD), Nantucket (MA), Chincoteague NWR (VA) and the Cape Cod National Seashore – Monomoy NWR coastline in Chatham (MA). Shorter pocket beaches are more common in New England and are naturally fragmented by intervening sections of rocky shoreline.

Beach and Dune habitat is a storm-driven system that shifts in space over time and is adapted to changes in sea level in a self-sustaining suite of interconnected physical processes. Tidal inlets separating many beaches open, close and migrate alongshore over time.

Recognition of the functions of beach and dune habitat for coastal resilience and reduction of risk for adjacent coastal development has increased over the last decade. Beneficial use of dredged material is a focus of the **USACE Regional Sediment Management (RSM) Program**[153] as well as the **Engineering with Nature (EWN) Program**[154], strategically placing dredged material to restore multiple coastal habitats, including eroded beaches. The EWN Program "is the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through collaboration" and provides several on-line resources, including nature-based solutions guidance and an atlas of more than 100 Engineering with Nature projects from across the world[154]. A list of nature-based solutions guidance for multiple water and infrastructure management topics, including coastal resilience, from numerous federal agencies, international partners and others can be found on the program's website[155].

Bridges et al. (2015), **Use of Natural and Nature-based Features for Coastal Resilience**, provides an example framework for mimicking the natural features of beach and dune habitat to improve the resilience of developed coastlines. **Coastal Risk Reduction and Resilience: Using the Full Array of Measures** provides a summary of the potential resilient processes and environmental outcomes of natural, nature-based, nonstructural, and structural coastal risk reduction measures, including for beaches and dunes (USACE 2013, see Appendix A). Widrig (2021) provides a guide for the use of native plants to reestablish Beach and Dune as well as Shoreline habitats on New York's Great Lakes shorelines.

The USGS and partners have been modeling the long-term vulnerability and sustainability of coastal beach and dune habitat in the Northeast region, predicting the availability of beach and dune habitat with sea level rise and future storm scenarios associated with climate change. Gutierrez et al. (2015) describes the development and application of the predictive model at Assateague Island in Maryland and Virginia. In the near future, Gutierrez et al. (2015, p. 2452) state that "With increased potential for future sea level rise and for increased frequency of storm-related overwash, many barrier islands are expected to evolve at a faster pace than what has been observed … historically."

2.17.4 HABITAT MANAGEMENT

Numerous landscape scale management plans exist that address the conservation of species associated with Beach and Dune habitat in the Northeast. The goals of the **US Shorebird Conservation Plan** include the restoration or maintenance of high-quality shorebird habitat in the US and beyond (Brown et al. 2001). The **US Shorebird Conservation Partnership Council** implements the goals and objectives of the plan and maintains a website of regional plans and resources[156]. The **Northern Atlantic Regional Shorebird Plan** is the regional implementation plan for the NEAFWA region and has identified 11 habitat objectives for shorebird habitat, including the identification, management, and protection of beachfront breeding habitat for RSGCN Piping Plover and American Oystercatcher (*Haematopus palliatus*) (Clark et al. 2004). Detailed conservation action recommendations to monitor, manage and research shorebird habitats and threats are provided for each state. The **North American Waterbird Conservation Plan** (Kushlan et al. 2002) similarly identifies conservation needs and priority conservation actions for colonial waterbirds and their associated habitats, including Beach and Dune habitat.

Natural systems modifications and development inhibit the natural resilience of beach and dune habitats to respond to storms and rising sea level. Rice (2009) identified BMPs for coastal engineering and sediment placement projects to avoid and minimize adverse ecological impacts from natural system modifications of beach and dune habitat. These BMPs were incorporated into the **Comprehensive Conservation Strategy for the Piping Plover (*Charadrius melodus*) in its Coastal Migration and Wintering Range in the Continental United States** (USFWS 2012) and USACE technical guidance, **Developing Best Management Practices for Coastal Engineering Projects that Benefit Atlantic Coast Shoreline-dependent Species** (Guilfoyle et al. 2019).

The **Great Lakes Restoration Initiative** updates an Action Plans[157] every five years that includes terrestrial shoreline habitat as well as aquatic habitats. The Great Lakes Restoration Initiative Action Plan III for fiscal years 2020-2024 includes a long-term goal of protecting and restoring habitat to sustain healthy ecosystem functions and native species (GLRI 2019). Conservation measures the Action Plan uses for tracking progress include the acres of habitat restored, protected, or enhanced and the number of species benefiting from implemented projects. The return of breeding Piping Plovers to beaches in Pennsylvania and New York is considered a success story towards this goal. Northeast RSGCN and Watchlist species identified as potential target species for conservation activities include Piping Plover, Mitchell's Satyr (*Neonympha mitchellii mitchellii*), Moose (*Alces alces*) and Rusty-patched Bumble Bee (*Bombus affinis*).

The USGS and partners have been modeling the long-term vulnerability and sustainability of coastal beach and dune habitat in the Northeast region, predicting the availability of beach and dune habitat with sea level rise and future storm scenarios associated with climate change. Gutierrez et al. (2015) describes the development and application of the predictive model at Assateague Island in Maryland and Virginia. Gutierrez et al. (2015, p. 2452) state that "With increased potential for future sea level rise and for increased frequency of storm-related overwash, many barrier islands are expected to evolve at a faster pace than what has been observed … historically." Several potentially competing objectives challenge decision-making for mitigation or adaptive management of Beach and Dune habitat. Gutierrez et al. (2015) found that beach and dune habitat with anthropogenic modifications are more likely to have narrower island widths, lower dune heights and wider beaches and that beach erosion rates are higher within 10 kilometers of tidal inlets. Their probabilistic model incorporates the inherent uncertainty of coastal processes with climate change factors, allowing evaluation of potential management decisions for future conditions related to adaptive habitat management, such as the continued existence of overwash areas that are often attractive for breeding and foraging shorebirds and waterbirds.

In a natural, unmodified system, barrier islands and spits will migrate landward over time during a period of rising sea level. In this way the Beach and Dune habitat is self-sustaining as it adapts to climate change and rising seas. Lentz et al. (2016) found that nearly 70% of the coastal landscape in the Northeast has some degree of capacity to adapt to sea level rise, with the remaining nearly 30% predicted to be inundated. Where development and infrastructure has modified the natural system, this natural adaptive process is interrupted or blocked. Nordstrom et al. (2016) inventoried the feasibility of removing shore protection structures or allowing them to deteriorate at 12 national parks in the Northeast to facilitate landform and habitat adaptation to climate change; case examples where shoreline retreat, removal of structures inherited by past practices and the use of more flexible construction methods for new development have been incorporated into park management are presented.

Adaptive management of Beach and Dune habitat in the Northeast and beyond can address several, often competing, objectives. The habitat can be managed adaptively to

New Jersey Beaches

Two adaptive management projects have recently been constructed in New Jersey to enhance nesting and foraging habitat for shorebirds and waterbirds. Three small platforms were created in 2015 at the southern end of Stone Harbor adjacent to Hereford Inlet, raising the beach elevation above spring high tide levels to prevent storm flooding of nests in a project funded by NFWF and sponsored by multiple state and NGO partners. In 2020 federal, state and Rutgers University partners enhanced shorebird and waterbird habitat at Barnegat Light State Park by removing vegetation, grading dunes to enhance nesting habitat and creating ephemeral pools for foraging sites.

maintain, or sustain species populations such as breeding, foraging, migrating or wintering shorebirds and waterbirds. In developed areas, communities often manage beaches and dunes for human recreational use, including public access, ORV, surf fishing, swimming, dog-walking, and other recreational activities. Beach and dune habitat can be managed with coastal engineering structures and sediment placement projects to increase resiliency to protect adjacent development. Communities and private landowners may plant vegetation or install sand fencing to create and maintain dunes by trapping windblown sand. Dunes may be artificially created or "restored" with sediment placement or beach scraping. These management practices seek to mimic the natural services that Beach and Dune habitat provides to adjacent development and to the public by enhancing or replacing the dynamic habitat that is trying to migrate with rising sea level in a position that protects existing development and infrastructure.

The NPS has developed the **Coastal Adaptation Strategies Handbook** (Beavers et al. 2016) and its accompanying **Coastal Adaptation Strategies: Case Studies** (Schupp et al. 2015) with recommendations and examples of adaptive management of coastal habitats and resources threatened by climate change. One case example has been the adaptive management of beach and dune habitat at Assateague Island National Seashore (ASIS) in Maryland using a number of techniques to restore natural processes that have been modified by coastal engineering and inlet dredging projects for nearly a century. Dual jetties and dredging at Ocean City Inlet have led to long-term, severe erosion of ASIS beach and dune habitat. The NPS and the USACE initiated a program to adaptively manage the placement of dredged sediment in the nearshore to partially restore sediment losses and have notched dunes to facilitate overwash, restoring nesting and foraging habitat for nesting shorebirds and waterbirds (Schupp et al. 2013).

2.17.5 HABITAT MONITORING

Monitoring of Beach and Dune habitat typically consists of species-based monitoring of shorebird, waterbird, or turtle populations. Individual NWR, National Seashores or parks, state parks, and other protected landholdings often have habitat management plans that monitor Beach and Dune habitat associated with species-based monitoring programs. Many states and academic partners monitor shoreline change or erosion rates, particularly in developed areas and along sections of beach with coastal engineering structures or sediment placement projects, many of which may be permit requirements. State coastal zone management programs typically monitor erosion rates as part of their authorized programs under the federal **Coastal Zone Management Act (CZMA)**, administered by NOAA to manage coastal resources, including the Great Lakes. Protection of natural resources is one of the goals of the CZMA and coastal habitat is one of the five performance measures of the **National Coastal Zone Management Program** in evaluating state programs[158]. A directory of state coastal zone management programs approved by NOAA and their state authorities is available through the program website[159].

The USGS has mapped shoreline changes in New England and the Mid-Atlantic over the past 150 years in the **National Assessment of Shoreline Change** using a standardized method (Hapke et al. 2011). Available data allowed the USGS to measure beach erosion rates for 78% of the New England and Mid-Atlantic coasts, determining a long-term shoreline change rate of -0.5 meters per year ± 0.09 meters per year for the region as a whole, with a widespread increase in the proportion of shoreline experiencing extreme erosion rates (greater than 1.0 meters per year). The short- and long-term shoreline change trends for the region are erosional, with 65% of the shoreline transects measured eroding and long-term rates generally higher in the Mid-Atlantic than in New England due to the presence of more dynamic barrier islands and spits in the former than the latter. The overall percentage of shoreline eroding was higher in New England, however. Data layers for the National Assessment of Shoreline Change in the NEAFWA region are available online from the USGS (Himmelstoss et al. 2010).

The **Virginia Coast Reserve Long-term Ecological Research (LTER)** site is developing a predictable understanding of coastal landscapes, monitoring long-term change as well as short-term disturbances to dynamic barrier islands as part of the national **LTER Network** supported by the National Science Foundation. Approximately 110 kilometers (68 miles) of the Delmarva Peninsula coastline has been monitored in this project since 1987. At least seven universities and TNC collaborate on multiple habitat research and monitoring projects, including shoreline change, land cover, waterbirds, mammals and linked aquatic habitats in adjacent tidal wetlands and estuaries. Data products and reports are available on the Virginia Coast Reserve LTER website maintained by the University of Virginia Department of Environmental Sciences[160].

2.17.6 PARTNERS

There are a number of landscape-level initiatives, programs and partners addressing the research, management, and conservation needs of Beach and Dune habitat in the Northeast. The **Atlantic Flyway Shorebird Initiative (AFSI),** a cooperative partnership[161], has developed a **Business Plan** (AFSI 2015) identifying the research, monitoring and conservation needs of coastal habitats and focal species along the Atlantic coast of the United States (and beyond) and regularly funds projects that meet the goals of the Business Plan through the National Fish and Wildlife Foundation (NFWF). State agencies are eligible to apply for these NFWF grants with a 1:1 non-Federal match of cash and/or in-kind services. Two **AFSI Focal Habitats** are within the NEAFWA region – Maritime Canada and the Northeastern U.S. and the Mid-Atlantic and Southeastern US. Seven of the **AFSI Focal Species** are Northeast RSGCN or Watchlist species, presenting opportunities for collaboration: American Oystercatcher, Piping Plover, Whimbrel, Ruddy Turnstone, Red Knot, Purple Sandpiper (*Calidris maritima*) and Semipalmated Sandpiper. AFSI has several Working Groups focused on collaborative conservation efforts and issues such as habitat (with four subgroups focused on coastal engineering, human activities, predation, and incompatible management), flyway engagement, resources / funding, communications, monitoring and hunting. A collection of outreach materials is available in a searchable online resource for agencies and individuals involved in conserving and managing shorebird habitats, including several signs developed and used by the states of Maine and Massachusetts[162].

The USFWS conducts regional programs for migratory birds and federally-listed species reliant upon Beach and Dune habitat in the Northeast. As part of the AFSI Initiative, Virginia Tech and the USFWS developed **Guidance and Best Practices for Addressing Human Disturbance to Shorebirds at Fall Migratory Stopover Sites** in the Northeast (Mengak et al. 2019). A **Guide to Applying Science and Management Insights and Human Behavior Change Strategies to Address Beach Walking and Dog Disturbance Along the Atlantic Flyway** (Comer et al. 2021) has also been developed, with pilot projects to implement the strategies underway at several Northeast beaches. Both Guides and associated resources for implementation are available on the AFSI website.

The USFWS Beach and Shorebirds Team focuses on three At-Risk Species (American Oystercatcher, Whimbrel, and Ruddy Turnstone) that represent a cross-section of shorebird life histories, seasonal habitat use, and management needs in the region. Each is listed as a USFWS Bird of Conservation Concern and SGCN in most coastal states in the region. To date, the team has focused on identifying their role in supporting existing conservation planning, such as the **American Oystercatcher Hemispheric Conservation Plan**, the **Whimbrel Conservation Plan**, and the **Atlantic Flyway**

Shorebird Initiative. They have also prioritized increased engagement between USFWS staff from five programs and collaborative conservation entities such as the **American Oystercatcher Working Group** and groups of external partners with specific expertise in the three species (e.g., NGOs, state wildlife agencies, and universities). Lastly, the Team has initiated efforts to improve internal coordination across programs in the region. Although implementation is just getting underway, specific 2023 priorities include:

- Initiating actions to address human disturbance at priority regional refuges
- Planning and pursuing opportunities for habitat acquisition, restoration, and enhancement
- Increasing efficacy and stability of predation management at locations experiencing poor outcomes
- Initiating research to identify priority stopovers (Ruddy Turnstone and Whimbrel) and understand the relative importance of marsh habitat for breeding American Oystercatchers
- Helping initiate the first conservation plan for Ruddy Turnstone, a poorly understood species
- Engaging with partners outside our region to support priority conservation activities in other areas

The **National Audubon Society** and numerous state and local Audubon organizations undertake countless activities related to the conservation, management and monitoring of bird species that rely upon sandy Beach and Dune habitat. These organizations own several nature preserves in the Northeast. The National Audubon Society is a key partner in AFSI and the **Atlantic Coast Joint Venture (ACJV)**. Partnering with the Cornell Lab or Ornithology and others, Audubon launched a **Bird Migration Explorer**[163] resource in 2022 that aggregates millions of bird observation data into an interactive map to illustrate the migratory paths and stopover sites for hundreds of bird species, including shorebirds and waterbirds using Beach and Dune habitat in the Northeast. The migratory pathways illustrated on the Bird Migration Explorer for shorebirds and waterbirds clearly highlight the importance of the NEAFWA region as a migration corridor.

The **Great Lakes Restoration Initiative** has funded more than 285 projects related to beaches throughout the Great Lakes, with at least 34 of them within the NEAFWA region. Four of these projects have been implemented in PA, including habitat restoration for the federally-endangered and RSGCN Piping Plover and other beach/dune specialists at Presque Isle State Park. Thirty projects have been implemented in NY, ranging from dune protection and restoration activities to removing invasive species, addressing non-point source pollution, and hiring beach and dune stewards for public lands. A searchable database of GLRI funded projects is available through the Initiative's website[164].

2.17.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

Several state agency and NGO partners collaborate with the public to monitor and protect RSGCN and Watchlist species associated with Beach and Dune habitats. Citizen scientists and others can serve as beach stewards during periods of high recreational use to conduct education and outreach to the public to address threats to species and habitat from human disturbance. Some shorebirds and waterbirds have been banded and the public can report sighted bands to monitoring programs; Audubon New York maintains a website with a guide for citizens to identify shorebird bands with links for the various reporting organizations[165]. Other citizen science projects in Northeast Beach and Dune habitat include horseshoe crab surveys on Delaware Bay beaches, seabirds in New England and the Mid-Atlantic, beach profiles in southern Maine, and the **Coastal Research Volunteer Program** in New Hampshire.

Mobile apps have been developed for citizen scientists to contribute to monitoring Beach and Dune habitat and their associated species. **CoastSnap** is a global citizen science project to capture changing coastlines over time, from storms, sea level rise, human activities and other factors using repeat photos of the same location in a community beach monitoring app[166]. Citizen scientists who have contributed to CoastSnap are documenting changing conditions on beaches in the Northeast through regional projects in Delaware (co-sponsored by Sea Grant Delaware)[167] and Massachusetts (co-sponsored by Woods Hole Sea Grant)[168].

The EPA released a mobile app in 2021 called the **Sanitary Survey App for Marine and Fresh Waters** to help communities track beach water quality with the assistance of citizen scientists[169]. The USGS developed the **iPlover** mobile app[170] that collects information about Beach and Dune habitat and their surrounding environments. A citizen science project with a mobile app called **Nurdle Patrol** has been developed by NOAA and several partners to monitor plastic pellet pollution (called nurdles) on beaches[171].

The RCN 3.0 **Coordinated Assessment of Northeastern Diamond-backed Terrapin Populations** project will incorporate a citizen science component to gather data with annual terrapin surveys in each state to identify state and regionally important conservation areas for terrapins, including estuarine Beaches, Tidal Wetlands and Flats, and Estuaries.

Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

2.17.8 HABITAT INFORMATION, RESEARCH, AND MONITORING NEEDS

Several habitat information, research and monitoring needs exist for Beach and Dune habitat in the Northeast:

- Location, distribution and condition of Beach and Dune habitat on all estuarine shorelines, including the full extent of Chesapeake Bay and backbarrier estuaries
- Linear extent and condition of Beach and Dune habitat on Great Lakes shorelines, updating the spatial analysis of Anderson et al. (2013a) for direct comparison to the habitat assessments of Rice (2017)
- Research and monitoring needs itemized in Guilfoyle et al. (2019) to further develop and test BMPs for coastal engineering projects
- Inventory of public and NGO protected Beach and Dune habitat on Great Lakes and estuarine shorelines
- Periodic condition assessment updates given the rapid pace of coastal development and shoreline stabilization modifying Beach and Dune habitat

2.18 TIDAL WETLANDS & FLATS

Figure 2.18. 1 Tidal Wetlands and Flats habitats support 85 Northeast RSGCN and Watchlist species. (Peconic Estuary, NY, photo credit: Peconic Estuary Partnership)

2.18.1 HABITAT DESCRIPTION

Tidal Wetlands and Flats can be classified in the **Wetlands and Deepwater Habitats Classification** system (Cowardin et al. 1979, FGDC 2013). This classification system is used by the National Wetlands Inventory[172] to map and monitor Non-Tidal Wetlands, Tidal Wetlands and Flats, and Estuaries across the US. Tidal Wetlands can be freshwater, brackish, and salt subtypes. Tidal Flats are unvegetated substrate exposed at low tide and can consist of mud or sand (Greene et al. 2010).

Greene et al. (2010) summarizes the Tidal Wetlands of the Northeast and their role in the estuarine food web, fish productivity, water quality, and other ecosystem services. Tidal Flats are foraging grounds both when exposed and submerged for many shorebirds, crustaceans, fish, and invertebrate species like the RSGCN Horseshoe Crab, Watchlist Blue Crab (*Callinectes sapidus*) and Watchlist Fiddler crabs (*Uca* spp.). Common prey inhabiting Tidal Flats include the three Watchlist species Eastern Oyster (*Crassostrea virginica*), Hard Clam or Northern Quahog (*Mercenaria mercenaria*), and Soft Shell Clam (*Mya arenaria*).

In the NEAFWA region, the 14 SWAPs of 2015 included 51 Key Habitats for SGCN that are within Tidal Wetlands and Flats habitat (*Appendix 2A*, Table 2A.18). Tidal Wetlands and Flats for RSGCN and Watchlist species include salt marshes, brackish marshes, freshwater tidal marshes, tidal swamps, tidal shrub / scrub wetlands, tidal forested wetlands, salt pannes, and intertidal sand and mud flats.

There are 38 RSGCN, 35 Watchlist [Assessment Priority], and one Proposed Watchlist species across 13 taxonomic groups associated with Northeast Tidal Wetlands and Flats habitat (*Supplementary Information 2*, Table 2.18.1, Figure 2.18.2). Another 11 species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. Seven RSGCN associated with Tidal Wetlands and Flats are of Very High

Table 2.18. 1 The number of species in each RSGCN and Watchlist category associated with Tidal Wetlands and Flats habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	38
Watchlist [Assessment Priority]	35
Proposed Watchlist [Assessment Priority]	1
Watchlist [Deferral to adjacent region]	11
TOTAL	**85**

Great Marsh, MA

The Great Marsh of Massachusetts has been designated a Western Hemisphere Shorebird Reserve of regional importance and a globally significant Important Bird Area. More than 300 species of birds frequent the Tidal Wetlands and Flats complex and its connected Estuaries, Beaches, and Dunes. Concentrations of up to 25,000 ducks and 6000 Canada geese occur during spring and fall migration.

With more than 10,000 acres of salt marsh, Great Marsh is the largest salt marsh system north of Long Island, New York. Much of the complex has been protected within the Parker River NWR, Crane Reservation, Crane Wildlife Refuge, and Sandy Point State Reservation. The area is one of the oldest sites of human habitat in Massachusetts, with archaeological resources dating back 10,000 years old.

Concern – one diadromous fish, four birds and two mammals. The Tuckahoe Masked Shrew (*Sorex cinereus nigriculus*) is endemic to the Northeast and of Very High Concern.

The Northeast RSGCN Database (version 1.0) contains data on habitat characteristics associations for Tidal Wetlands and Flats-associated RSGCN and Watchlist species, such as vegetation densities and the presence of tidal freshwater marsh, wrack, surface litter, shellfish beds, shoals, artificial structures, dikes, or ditching and draining.

Roman et al. (2000) describes the habitat characteristics of Tidal Wetlands and Flats in the region from Hudson Bay to Maine. Tidal Wetlands and Flats of New England are diverse due to the complex bedrock geology and glacial history of the region.

Numerous (31) Wetlands in the Northeast have been designated **National Natural Landmarks**, many of them exemplary sphagnum bogs and Atlantic White Cedar swamps of national significance. Tidal Wetlands that have been designated as **Ramsar Wetlands** of international importance[93] include:

- Connecticut River Estuary and Tidal Wetlands Complex, Connecticut
- Edwin B. Forsythe NWR, New Jersey
- Delaware Bay Estuary, Delaware and New Jersey
- Chesapeake Bay Estuarine Complex, Maryland and Virginia

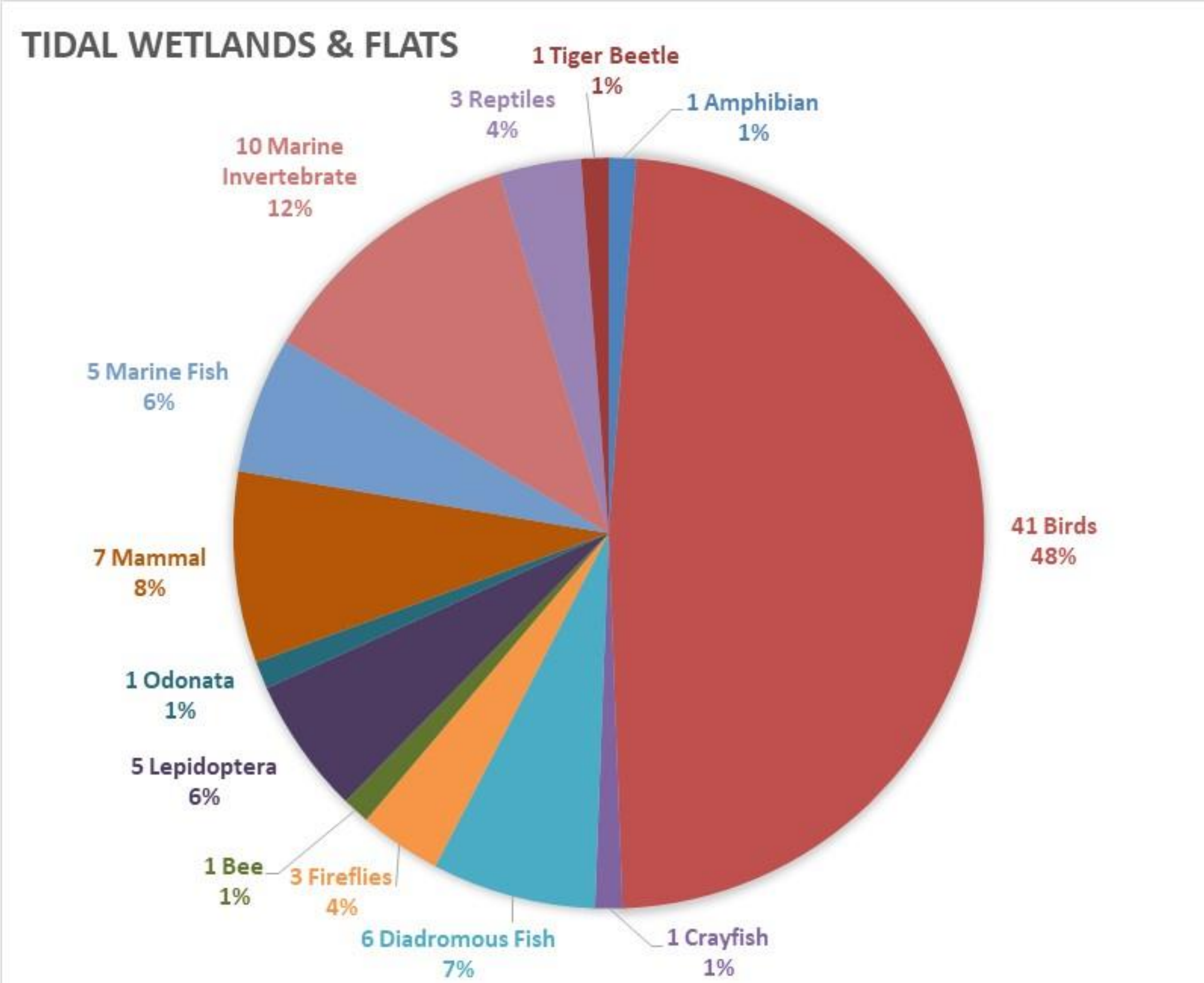

Figure 2.18. 2 Northeast RSGCN and Watchlist species associated with Tidal Wetland habitats represent 13 taxonomic groups.

2.18.2 HABITAT DISTRIBUTION AND CONSERVATION

Nationally, Gittman et al. (2015) found 48% of the marine and estuarine shoreline consists of brackish and tidal marsh. Regionally, Tidal Wetlands and Flats of the Northeast are orders of magnitude smaller than those along the Mid-Atlantic, South Atlantic, and Gulf of Mexico coastlines (Greene et al. 2010, Roman et al. 2000). Tidal Wetlands and Flats are limited by a lack of a broad and relatively coastal plain in New England, which tends to create narrow, fringing marshes. Salt marshes associated with barrier island or spit systems may reach notable size, such as those at Scarborough Marsh in Maine, Great Marsh in Massachusetts, or Barnstable Marsh in Massachusetts (Roman et al. 2000).

Intertidal Flats, on the other hand, are a common and extensive estuarine habitat type across the Northeast. The proportion of estuarine habitats that are intertidal Tidal Flats ranges from 75% in the vicinity of Mount Desert Island in Maine to 10% in Delaware Bay, with a general decrease in extent from north to south across the Northeast region (Roman et al. 2000).

The most recent land cover dataset from the Designing Sustainable Landscapes program (DSLland version 5.0, issued 2020) identified nearly 1.2 million acres of Tidal Wetlands and Flats habitat in the Northeast as of 2011-2013 (Table 2.0.3). The updated habitat condition assessment from Anderson et al. (2023) identified over 11.6 million acres of all wetland types (Non-Tidal Wetlands, Tidal Wetlands and Flats, and Riparian and Floodplain wetlands) as of 2019. More than one million acres of these wetlands are Tidal Wetlands and Flats.

Tidal Wetlands and Flats are more conserved than Non-Tidal Wetlands in the Northeast (Anderson et al. 2023). Anderson et al. (2023) provides an updated understanding of historical wetlands distribution and current conservation status for the region.

2.18.3 HABITAT CONDITION

ACFHP (2017) identified the top priority threats to marsh habitat in the Mid-Atlantic as Dredging (Threat 4.3.2 and 4.3.3), Shoreline Stabilization (Threat 7.3.1), Sedimentation (Threat 9.3.2), Invasive Species (Threat 8.1), Vessel Impacts (Threat 4.3.1) and water quality degradation and eutrophication (Threat 9.0).

National threats to salt marsh birds along the East Coast identified as very high or high threats in the **Salt Marsh Bird Conservation Plan** (Atlantic Coast Joint Venture 2019) include habitat loss to sea level rise (Threat 11.1.1), historical natural system modifications (Threat 7.3.1 and 7.2), transportation infrastructure that restricts tidal flow (Threat 4.1.1), reduced sediment supply from upstream dams (Threat 7.2), and limited capacity to migrate with sea level rise due to incompatible upland land uses (Threat 1.1).

The USFWS National Wetlands Inventory Program periodically assesses the status and condition of Non-Tidal Wetlands. Dahl (1990) assessed **Wetland Losses in the United States 1780s to 1980s**. Stedman and Dahl (2008) summarized the **Status and Trends of Wetlands in the Coastal Watersheds of the Eastern United States 1998-2004**. Dahl and Stedman (2013) provides an assessment of the **Status and Trends of Wetlands in the Coastal Watersheds of the Conterminous United States 2004-2009**.

Over the past century as much as half of the salt marsh has been lost nationally, mostly due to human activities. Along the Atlantic coast, 60% of the land less than one meter above current sea level is expected to be developed or hardened with shoreline armoring in the future as sea level rises and squeezes Tidal Wetlands and Flats habitat at the landscape scale (Gittman et al. 2015).

Greene et al. (2010) estimated that the area of salt marsh in Rhode Island has been reduced by 53% since 1832 and that 40% of Massachusetts' salt marsh has been lost since 1777. Basso et al. (2015) found that in Long Island Sound, Tidal Wetland losses over the previous 130 years were 27% in Connecticut and 48% in New York, with New York continuing to lose Tidal Wetlands habitat since the 1970s (a decrease of 19%) while Connecticut has had a slight gain (an increase of 8%).

Anderson et al. (2013b) predicted future habitat loss of Northeast habitats to development over the next 50 years. The most threatened Tidal Wetlands habitat was the along the south shore of the James River in Virginia, which was predicted to lose 17% of its habitat to development over the next five decades.

In addition to these habitat losses of Tidal Wetlands and Flats in the Northeast, this habitat type has been fragmented by roads and the digging of mosquito ditches to drain marshes. An estimated 90% of the marshes from Maine to Virginia have been modified by mosquito ditches (Roman et al. 2000). These natural system modifications began during Colonial times, when draining of marshes facilitated opportunities for salt hay farming. By the 1930s this practice was more prevalent in an effort to systematically drain mosquito breeding areas.

Gittman et al. (2015) found that 1% of the tidal marsh shoreline in the US has been modified by hardened shoreline stabilization structures, which are typically constructed landward of the marsh. Connecticut (4%), Rhode Island (6%) and New Hampshire (7%) had the most hardened marsh shorelines on the US Atlantic coast.

Anderson et al. (2013b) characterized the condition of Northeast habitats as of the early 2000s. Wetlands habitat was more fragmented and less connected to surrounding natural cover types than terrestrial habitats. The landscape context indices (the level of connectedness of the habitat patch to surrounding natural land cover types) of Tidal Wetlands varied across macrogroup types, with the most connected macrogroup Atlantic Coastal Plain Embayed Region Tidal Freshwater / Brackish Marsh. The most fragmented macrogroup was North Atlantic Coastal Plain Brackish / Fresh and Oligohaline Tidal Marsh. Anderson et al. (2013b) also assessed the landscape complexity, a measure of climate resilience, of Northeast habitats. In general, tidal marshes (a dozen macrogroups) exhibited low landscape diversity and resiliency.

Greene et al. (2010) assessed the ecological resilience of coastal habitats in the Northeast to rising sea level, identifying habitat features and stressors that influence the vulnerability and resiliency of Tidal Wetlands and Flats. Salt marshes grow both horizontally and vertically to adapt to sea level rise, and barriers to that growth (migration) into adjacent upland areas affect the ecological resilience of the Tidal Wetlands. As sea level rises, the extent of saltwater up Tidal Rivers and Streams will move upstream, altering the salinity of Estuaries and potentially converting freshwater and brackish marshes into salt marshes. Greene et al. (2010) also note that over the last century the sediment accretion rate of salt marshes generally are lower than the rate of sea level rise, potentially leading to their inundation and loss.

Coastal Risk Reduction and Resilience: Using the Full Array of Measures provides a summary of the potential resilient processes and environmental outcomes of natural, nature-based, nonstructural and structural coastal risk reduction measures, including for salt marshes (USACE 2013, see Appendix A). Staudinger et al. (2023) summarizes the state of knowledge of Tidal Wetlands and Flats habitat resiliency to climate change.

TNC led a partnership with NOAA, EPA, USFWS, the University of Massachusetts, and the states of Maine, Delaware, Connecticut, Rhode Island, Massachusetts, and Maryland in a RCN project to identify **Resilient Coastal Sites for Conservation in the Northeast and Mid-Atlantic**[173]. More than 10,000 sites across the region were evaluated for their capacity to sustain biodiversity and natural ecosystem services with increasing inundation from sea level rise. Resilience scores were identified based on the likelihood that the coastal habitats can and will migrate to adjacent lowlands. Datasets were created that include results for different sea level rise scenarios and an online tool allows users to explore the results for any coastal site[174]. The project found that with no action, the region could lose an estimated 83% of tidal habitats to sea level rise inundation, but those losses could be offset by habitat expansions at thousands of sites that have the capacity for landward migration. With appropriate management, as much as 50% of the tidal habitat loss could be offset by these gains.

2.18.4 HABITAT MANAGEMENT

The Atlantic Coast Joint Venture developed a **Salt Marsh Bird Conservation Plan**, which describes a number of detailed conservation objectives for Tidal Wetlands habitat (ACJV 2019). Habitat-related conservation strategies include:

- Restore and enhance degraded salt marsh
- Prioritize land acquisition in the marsh transition zone
- Develop and implement BMPs to facilitate marsh migration and offset marsh losses
- Increase the use of dredged material to benefit salt marsh habitat
- Integrate conservation of salt marshes into programs of the Natural Resources Conservation Service

- Engage transportation agencies to improve infrastructure impacts
- Alleviate impacts from spills and contaminants

The Salt Marsh Bird Conservation Plan includes an objective to implement experimental projects in at least one quarter of priority migration corridors to identify management methods that are effective to facilitate marsh migration, institute monitoring protocols to measure effectiveness, and ensure that private landowners have access to BMP resources and tools.

Other management plans addressing the conservation needs of Tidal Wetlands and Flats habitat are localized to particular estuaries, such as those that are part of the National Estuary Program that are required to have comprehensive conservation and management plans (see Estuaries in Section 2.19).

Kritzer et al. (2016) found that salt marshes are more valuable in the Mid-Atlantic than in New England portion of the Northeast to accommodate the northward shift in many fish species along the Atlantic Coast due to warming waters from climate change. The importance of New England salt marshes may increase as marsh-dependent fish species that are currently absent or rare increase with continued northward range shifts from the Mid-Atlantic. Greene et al. (2010) describe a number of conservation actions and strategies to enhance the resilience of coastal systems. Staudinger et al. (2023) describes the state of knowledge of adaptive management of Tidal Wetlands and Flats habitats to climate change.

The Northeast Climate Adaptation Science Center has developed several resources to inform management of Tidal Wetlands and Flats (see the NE CASC website[175] for project details and products):

- **Science to Support Marsh Conservation and Management Decisions in the Northeastern United States.** A synthesis of science and socio-economic understanding about changing coastal systems is urgently needed. This project will develop a region-wide strategic capacity to provide timely science support for decision-makers dealing with climate-induced changes in coastal resilience and vulnerability.
- **Effects of Urban Coastal "Armoring" on Salt Marsh Sediment Supplies and Resilience to Climate Change.** Along exposed coasts, humans have built seawalls and other structures to protect homes and infrastructure from erosion. It is believed that reduced erosion as a result of this “coastal armoring” has made it harder for salt marshes to thrive along urbanizing, armored shorelines.
- **Refugia are Important but are they Connected? Mapping Well-Connected Climate Refugia for Species of Conservation Concern in the Northeastern U.S.** As the climate continues to change, vulnerable wildlife

species will need management strategies to help them adapt to these changes. One specific management strategy is based on the idea that in certain locations, climate conditions will remain suitable for species to continue to inhabit into the. future. The main objective of this project was to provide a map of projected refugia networks at the end of the century for each of 10 Species in Greatest Conservation Need in the northeastern US. This information will support efforts of the USFWS Northeast Region to assess habitat needs for several species under federal consideration for listing as well as other Species of Greatest Conservation Need. Maps of refugia connectivity will also support the prioritization of on-the-ground habitat management in the region.

Awareness of and implementation of adaptive management of Tidal Wetlands and Flats has increased in the Northeast in recent years. Two recent Competitive State Wildlife Grant (CSWG) and USFWS Science Applications projects also inform management of the region's Tidal Wetlands and Flats:

The **Testing Salt Marsh Restoration Practices for Saltmarsh Sparrow Conservation Project (2020) (CSWG and SA)** will inform best practices for habitat restoration. The Saltmarsh Sparrow (*Ammospica caudacuta*) has experienced dramatic population loss caused by nest and deteriorating conditions in tidal marshes throughout the North Atlantic coast. The purpose of this project is to test a variety of management techniques designed to protect and restore salt marsh habitat. This project will identify the best strategies to be employed in salt marsh habitat restoration, and advance efforts to conserve the imperiled saltmarsh sparrow and other salt marsh dependent birds.

Additionally, a project to create and **Restore Eastern Black Rail Habitat Project (2020) (CSWG)** at six non-tidal freshwater wetlands on Maryland's Eastern Shore was funded through CSWG. Following recommendations from the conservation plan, this project aimed to shift the population to non-tidal habitats that are safe from the threat of sea level rise in order to help stabilize and grow the population. These efforts continue to create ideal conditions to attract and retain Eastern Black Rails in two different settings, creating a complex of wetlands in an area that has historically supported Black Rails.

The US Army Corps of Engineers and National Park Service completed a Tidal Wetlands restoration project in **Jamaica Bay**, New York, to address the predicted loss of all remaining island marsh habitat by 2025 (Bridges et al. 2015, Schupp et al. 2015). Between 1924 and 1974, approximately 25% (205 hectares) of tidal salt marsh was lost in Jamaica Bay near New York City, and another 304 hectares was lost between 1974 and 1999. The US Army Corps of Engineers and National Park Service used dredged material from nearby navigational channels to restore more than 71 hectares of Tidal Wetlands and Flats habitat at three salt marsh islands in Jamaica Bay.

2.18.5 HABITAT MONITORING

The EPA monitors the physical, chemical, and biological integrity of wetlands as part of the **National Wetlands Condition Assessment**[95]. The **National Wetlands Inventory (NWI)**, administered by the USFWS, monitors the status and trends of Non-Tidal Wetlands, Tidal Wetlands and Flats, and Riparian wetlands throughout the country. The NWI maintains maps and geospatial datasets on the location and distribution of all wetland types, using the classification system previously described (FGDC 2013, Cowardin et al. 1979). National and regional analyses on the status and trends of wetlands are periodically updated and are available through the program's website[96].

The **Coastal Marsh Inventory** is a catalog of salt marsh restoration, enhancement, and management projects along the Atlantic Coast that is maintained by the Atlantic Coast Joint Venture[176]. Project submissions are welcomed to add to this database monitoring conservation projects in Tidal Wetlands.

The **Virginia Coast Reserve Long-term Ecological Research** site is developing a predictable understanding of coastal landscapes, monitoring long-term change as well as short-term disturbances to dynamic barrier islands as part of the national LTER Network supported by the National Science Foundation. Approximately 110 kilometers (68 miles) of the Delmarva Peninsula coastline has been monitored in this project since 1987. At least seven universities and TNC collaborate on multiple habitat research and monitoring projects, including salt marshes and sea level rise. Data products and reports are available on the Virginia Coast Reserve LTER website maintained by the University of Virginia Department of Environmental Sciences[160].

2.18.6 PARTNERS

NOAA maintains a **Digital Coast** resource that provides data, tools, and training resources for addressing coastal issues, including data and maps for land cover, sea level rise, elevation, hurricanes, coastal flooding, imagery, socioeconomics, weather and climate, marine habitat and species, ocean uses and planning areas, water quality, infrastructure, oceanography and more[177].

The **Atlantic Coast Joint Venture** provides a number of resources and tools related to the conservation of Tidal Wetlands habitat on the Atlantic Coast[178]. The Coastal Marsh Inventory and **Saltmarsh Sparrow Project Inventory** track conservation projects throughout the region and the adjacent Southeast. Spatial datasets are available for impoundments, tidal marsh vegetation, and priority areas for salt marsh restoration and marsh migration projects. Landscape prioritization tools are available for Eastern Black Rail (*Laterallus jamaicensis jamaicensis*) and Saltmarsh Sparrow (*Ammospiza caudacuta*), two Northeast RSGCN.

The **USGS Wetland and Aquatic Research Center**, described in Section 2.9.6 for Non-Tidal Wetlands, conducts numerous scientific research studies in Tidal Wetlands and Flats along the Atlantic and Gulf Coasts. One recent project studied the impacts of coastal and watershed changes on upper Estuaries, with causes and implications for Tidal Wetland transitions with sea level rise. The study used 'ghost forests' as an indicator of rapid conversion of freshwater Tidal Wetlands to brackish or marine Tidal Wetlands[179]. In 2022, the USGS completed a topographic and bathymetric survey along the Chincoteague Living Shoreline project area in Virginia, a project that constructed oyster reefs and mud Tidal Flats to enhance habitat and protect the adjacent shoreline[180]. Also in 2022, the USGS released an analysis of potential landward migration of Tidal Wetlands in response to sea level rise throughout the conterminous United States, using 2016 data from the **Coastal Change Analysis Program** with a 1.5-meter sea level rise scenario[181]. An associated geospatial dataset to define the boundaries of estuarine drainage areas was created for 65 Estuaries along the Atlantic Coast[182].

Another key partner in conserving Tidal Wetlands and Flats habitat in the Northeast is the **Saltmarsh Habitat and Avian Research Program (SHARP)[183]**. The SHARP partnership collaborates to support the science needed to inform tidal marsh bird conservation. The program has developed **Tidal Marsh Survey Protocols**, **Avian Demographic Study Protocols**, and protocols for saltmarsh safety, tide heights, and photographs. In 2015, SHARP completed **The Conservation Status of Tidal-Marsh Birds** report, with state-by-state summaries. One of the other products developed by partners in 2017 with SHARP is a marsh habitat zonation map for the Northeast at 3-meter resolution. More than 50 peer-reviewed publications have been published using SHARP data between 2014 and 2021.

2.18.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of Tidal Wetlands and Flats habitat through several ongoing citizen science projects. The **eBlueCarbon** project monitors the health of tidal marshes and submerged aquatic vegetation (SAV) to capture broad trends on blue carbon ecosystem health anywhere in the world. Citizen scientists use the **eOceans** app to submit observations to the project[184].

The RCN 3.0 **Coordinated Assessment of Northeastern Diamond-backed Terrapin Populations** project will incorporate a citizen science component to gather data with annual terrapin surveys in each state to identify state and regionally important conservation areas for terrapins, including estuarine Beaches, Tidal Wetlands and Flats, and Estuaries.

Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

2.18.8 HABITAT INFORMATION, RESEARCH, AND MONITORING NEEDS

Habitat information, research, and monitoring needs for Tidal Wetlands and Flats habitat in the Northeast include:

- A comprehensive inventory of Tidal Wetlands and Flats loss due to shoreline armoring

2.19 ESTUARIES

Figure 2.19. 1 Estuaries habitat support 82 Northeast RSGCN and Watchlist species. (Oyster reef in Chesapeake Bay photo credit: NOAA)

2.19.1 HABITAT DESCRIPTION

Estuaries are complex systems that occur at the intersection between water bodies where fresh and saltwater mix and are influenced by tides and currents, such as bays, mouths of rivers, and lagoons (EPA 2021). For the purposes of characterizing RSGCN habitat in the Northeast, Estuaries include only the open water and subtidal portions of these systems, with Tidal Wetlands and Flats (Section 2.18), Tidal Rivers and Streams (Section 2.12), Beaches and Dunes (Section 2.17), and other Shorelines (Section 2.16) separate but connected habitats.

Estuarine systems can be classified in the **Wetlands and Deepwater Habitats Classification** system, including both subtidal and intertidal areas (Cowardin et al. 1979, FGDC 2013). This classification system is used by the National Wetlands Inventory to map and monitor Non-Tidal Wetlands, Tidal Wetlands and Flats, and Estuaries across the US[96]. Open water Estuaries and a portion of the Marine Nearshore are classified and mapped as "deepwater" systems that remain subtidal at all times by Cowardin et al. (1979) and FGDC (2013).

In the NEAFWA region, the 14 SWAPs of 2015 included 76 Key Habitats for SGCN that are within open water and subtidal Estuaries habitat (*Appendix 2A*, Table 2A.19). There are 43 RSGCN, 28 Watchlist [Assessment Priority] and two Watchlist [Interdependent Species] species across seven taxonomic groups associated with Northeast Estuaries habitat (*Supplementary Information 2,* Table 2.19.1, Figure 2.19.2). Another nine species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. Eight RSGCN and Proposed RSGCN associated with Estuaries are of Very High Concern in the Northeast – three fish, four sea turtles and one waterbird.

Table 2.19. 1 The number of species in each RSGCN and Watchlist category associated with Estuaries habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	43
Watchlist [Assessment Priority]	28
Watchlist [Interdependent Species]	2
Watchlist [Deferral to adjacent region]	9
TOTAL	**82**

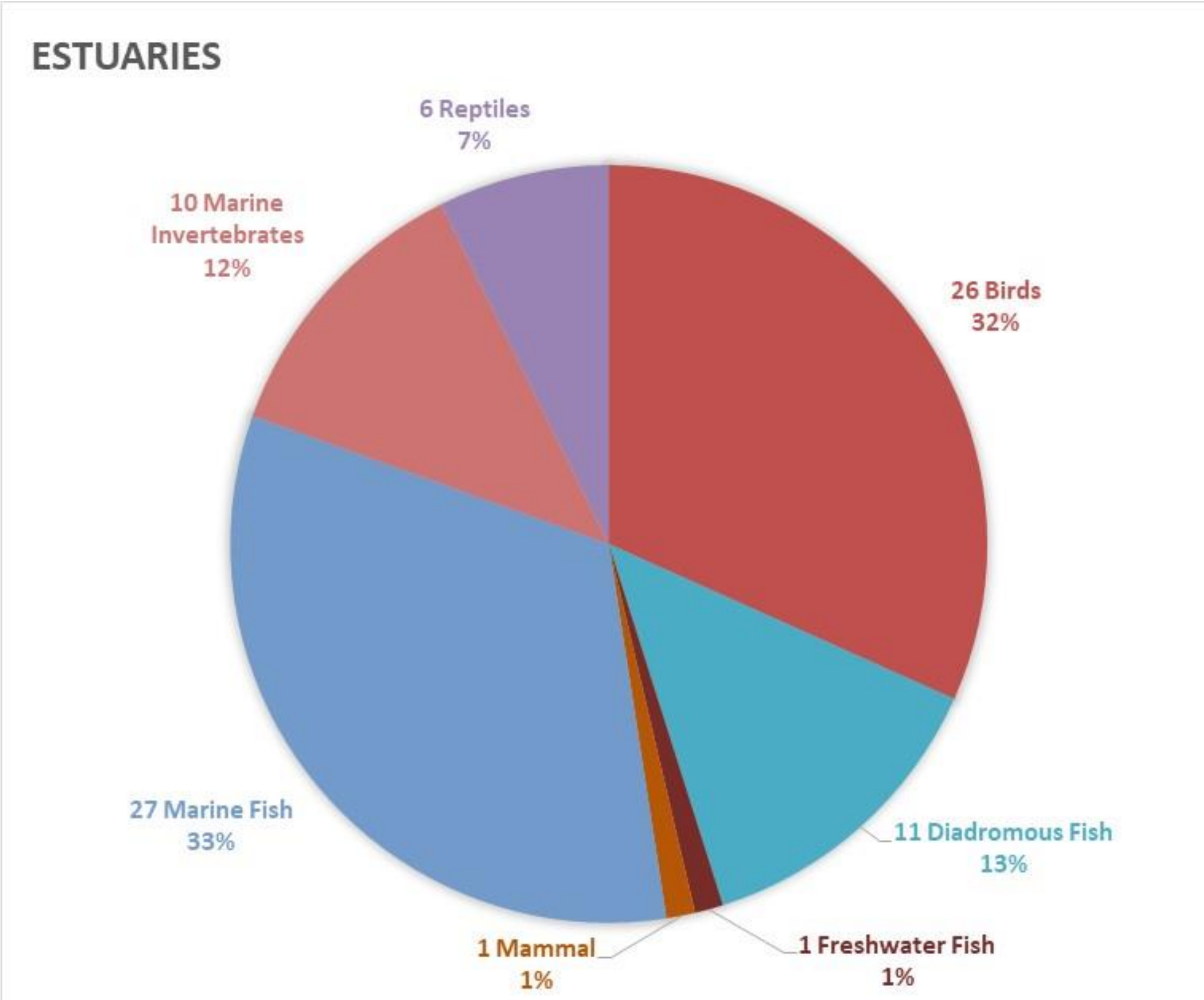

Figure 2.19. 2 Northeast RSGCN and Watchlist species associated with Estuaries habitat represent seven taxonomic groups.

Because Estuaries are interconnected with several other habitat, such as Tidal Rivers and Streams, all of the RSGCN and Watchlist diadromous fish migrate through and/or use Estuaries as nursery areas. A number of marine fish similarly use Estuaries seasonally and for larval and/or juvenile life stages. Northern and American Sand Lances (*Ammodytes dubius* and *Ammodytes americanus* respectively) are Watchlist [Interdependent Species] associated with Northeast Estuaries, both of which are integral pieces of the estuarine and marine food web with multiple RSGCN. Four of the five RSGCN and federally-listed sea turtles forage in Estuaries in the warmer months. Other RSGCN and Watchlist species are residents primarily of Estuaries, including Northern Diamond-backed Terrapin (*Malaclemys terrapin terrapin*) and several invertebrates like Eastern Oyster (*Crassostrea virginica*), Northern Quahog (*Mercenaria mercenaria*), Bay Scallop (*Argopecten irradians*), Soft Shell Clam (*Mya *arenaria*) and Blue Crab (*Callinectes sapidus*). Twenty-one RSGCN and Watchlist birds are associated with Estuaries, primarily for foraging but the five waterfowl also breed or winter in Northeast Estuaries.

Habitat features and formations of Estuaries associated with RSGCN and Watchlist species include reefs and live rock, artificial structures, gravel and sand bars, shoals, sand and mud flats, shellfish beds, SAV, kelp beds, floating algae, and benthic and aerial use. Estuarine shellfish beds can be composed of oyster reefs, scallop beds, hard clam beds or accumulations of dead shells and the habitat characteristics of each are described in Kritzer et al. (2016), with these shellfish identified as Northeast RSGCN or Watchlist species that create habitat features and formations valuable to a number of other RSGCN or Watchlist species. Eelgrass (*Zostera marina*) is the dominant seagrass in the Northeast, forming SAV meadows within Estuaries that are another important habitat formation for foraging, spawning and refuge for fish and invertebrates. Eelgrass beds also trap nutrients and sediments, filter pollution, protect estuarine shorelines from erosion and provide attachment site for the planktonic life stages of some shellfish like Bay Scallop (Greene et al. 2010).

2.19.2 HABITAT DISTRIBUTION AND CONSERVATION

Estuaries are present in every coastal NEAFWA state, from Maine to Virginia. Chesapeake Bay (approx. 4480 square miles of open water and Tidal Wetlands and Flats) is the largest Estuary in the US, with seven Northeast states part of its watershed and more than 300 fish and wildlife species associated with the bay. The Gulf of St. Lawrence along the Northeast's border with Canada is the largest Estuary in North America with roughly 60,000 square miles of area (Malmquist 2009). Long Island Sound is the second largest Estuary in the Northeast, spanning approximately 1268 square miles (Van Patten et al. 2009). Altogether the region has an estimated 9,086,687 acres (14,198 square miles) of Estuaries habitat according to the National Wetlands Inventory, with data from 2007 to 2017 depending on the state (Table 2.19.2). Connecticut has the largest area of Estuaries habitat due to Long Island Sound, with Virginia and Maryland the next highest as they share Chesapeake Bay.

Within Estuaries, some benthic habitat features and formations have been inventoried in portions of the Northeast. Significant areas of SAV in the region were identified in Greene et al. (2010), with Chesapeake Bay (24,848 hectares), Long Island South Shore (9861 hectares), Nantucket Sound (6462 hectares) and Casco Bay (3331 hectares) the largest. Shellfish beds occur throughout the region's Estuaries, with roughly 2900 discrete shellfish areas identified from Maine to North Carolina by Greene et al. (2010). Roman et al. (2000) reported that as much as 20% of the Hudson River Estuary river bottom with suitable depth and light supports SAV. More recently, Martin et al. (2020) mapped the location and distribution of SAV and shellfish beds in the North Atlantic

Table 2.19. 2 The availability and distribution of Estuaries habitat present and lost within each state of the NEAFWA region according to the NWI. Note that NWI mapping of deepwater Estuaries habitat dates from 2007 to 2017 across the Northeast states, the most recent data available. The area of protected Estuaries and adjacent Marine Nearshore waters is from the NOAA MPA Inventory, which does not distinguish between estuarine and marine waters.

State / District	Area of Estuaries (acres)	Area of Protected Estuaries and adjacent Marine Nearshore waters as of 2020 (acres)
Connecticut	2,783,060	1378
Delaware	173,908	4781
Maine	87,109	2638
Maryland	1,714,292	13,634
Massachusetts	145,423	22,284
New Hampshire	9,728	6986
New Jersey	1,488,274	77,140
New York	848,196	37,851
Pennsylvania	37	74
Rhode Island	107,194	2078
Virginia	1,729,467	49,545†
TOTAL	**9,086,688**	**218,388**

†Includes the waters of Assateague Island NS in both Maryland and Virginia.

and Mid-Atlantic regions, two priority habitats of the **Atlantic Coast Fish Habitat Partnership (ACFHP)**. Spatial datasets of the location and distribution of SAV and oyster reefs for the entire Northeast are available on Data Basin[185].

Nearly one-third of the nation's 30 **National Estuarine Research Reserves (NERR)** are located in the Northeast. The Northeast has nine NERR that have protected 85,255 acres of open water Estuary habitat: Wells NERR (ME), Great Bay NERR (NH), Waquoit Bay NERR (MA), Narragansett Bay NERR (RI), Hudson River NERR (NY), Jacques Cousteau NERR (NJ), Delaware NERR (DE), Chesapeake Bay NERR - Maryland (MD), and Chesapeake Bay NERR – Virginia (VA). Details about the

NERR System, which is administered by NOAA, can be found through the Program's website[186].

The **NOAA Marine Protected Area (MPA) Inventory** identified protected areas of Estuaries, Marine Nearshore and Marine Offshore and Oceanic habitats in the US in 2020 that meet the IUCN definition for international protected areas. An interactive map viewer of the MPA Inventory is available online through NOAA[187]. Protected waters include NERR, National Marine Sanctuaries and waters within the boundaries of state and federal parks, wildlife management areas, refuges and preserves. In the Northeast, 218,388 acres of Estuaries and connected Marine Nearshore waters were protected as of 2020, including the nine NERR (Table 2.19.1).

There are 28 Estuaries in the US within the **National Estuary Program**, 12 of which are in the Northeast region: Barnegat Bay (NJ), Buzzards Bay (MA), Casco Bay (ME), Delaware Center for the Inland Bays (DE), Long Island Sound (NY and CT), Maryland Coastal Bays Program (MD), Massachusetts Bay (MA), Narragansett Bay (RI), New York-New Jersey Harbor (NY and NJ), Partnership for the Delaware Estuary (DE), Peconic Estuary (NY), and Piscataqua Region Estuaries (ME and NH). The National Estuary Program is managed by the EPA and Estuaries in the program are designated as nationally significant[188]. The Program does not protect the Estuaries physically but provides technical assistance and grants to states and their partners to develop comprehensive management plans to restore and protect the Estuaries. Conservation projects that have been conducted within the 12 Estuaries in the Northeast as part of the National Estuary Program, along with the areas in which each partnership works, are inventoried and described in an online map viewer[189].

The National Marine Fisheries Service (NMFS) designates **Essential Fish Habitat (EFH)** and **Habitat Areas of Particular Concern (HAPC)** in Estuaries and Marine Nearshore and Marine Offshore and Oceanic habitats. EFH and HAPC are a regulatory protection that requires consultation with NMFS for proposed projects that would modify those areas with potential impacts to their fish and wildlife resources. In the Northeast region, EFH and/or HAPC have been designated within virtually all of the region's Estuaries for at least one species, typically for multiple. Long Island Sound, for example, is designated HAPC and EFH for more than three dozen species. NOAA maintains an online map viewer of designated EFH and HAPC[190].

2.19.3 HABITAT CONDITION

Coastal habitats are highly connected, physically and ecologically, systems in a state of dynamic change with sea level rise and saltwater intrusion that converts one habitat type to another, leading to gains in some and losses in others. Freshwater Rivers and Streams are converting to Tidal River and Streams with saltwater intrusion and changes in freshwater flow, Tidal Rivers and Streams may be converting to open water Estuaries with sea level rise, Estuaries may be converting to Marine Nearshore, and Tidal Wetlands are converting to Tidal Flats, Estuaries and Marine Nearshore (Dahl and Stedman 2013, Ensign and Noe 2018). The surface area of open water and subtidal Estuaries in the Northeast appear to be experiencing a net gain in recent years due to sea level rise and habitat modifications to Tidal Wetlands and Flats. As sea level rises, Tidal Wetlands and Flats may become inundated and convert to open water.

Nationally 124,290 acres (2.4%) of estuarine vegetated wetlands were lost between 2004 and 2009, converting from vegetated Tidal Wetlands to unvegetated Tidal Flats, open water Estuaries or Marine Nearshore habitats. Estuarine (unvegetated) Tidal Flats increased by 20,854 acres nationally and 2211 acres along the Atlantic coast during the same time period (Dahl and Stedman 2013). Dahl and Stedman (2013) cite conversion of saltwater wetlands to open water Estuaries and Marine Nearshore habitat as the cause for the vast majority of coastal wetland loss from 1998 to 2009 nationally, with more than 96% of coastal wetland losses on the Atlantic and Gulf of Mexico coasts from 1998 to 2004 due to conversion to open water (Stedman and Dahl 2008). The highest rates of wetland loss to open water habitats are along the Gulf of Mexico coast, with the Atlantic coast experiencing much lower rates and the majority of the Atlantic coast habitat conversion occurring between Rhode Island Sound and the mouth of the Chesapeake Bay between 1998 and 2004 and in Delaware Bay between 2004 and 2009 (Dahl and Stedman 2013). This indicates that the surface area of Estuaries has increased between 1998 and 2009 in several major Estuaries of the Northeast.

Stedman and Dahl (2008) state that the New England coast is much less vulnerable to habitat conversion of coastal wetlands to open water Estuaries than the Mid-Atlantic, with Chesapeake Bay the most vulnerable to sea level rise habitat conversion.

Saltwater intrusion and sea level rise are extending Tidal Rivers and Streams upstream with conversion of freshwater Rivers and Streams to tidally-influenced waters (Ensign and Noe 2018), which could also convert the downstream portions of the Tidal Rivers and Streams to Estuaries. At the same time, portions of the seaward side of Estuaries and estuarine wetlands may convert to Marine Nearshore habitat as the entire coastal system tries to migrate landward and upwards with rising seas. Between 2004 and 2009, 8437 acres of coastal wetlands were converted to Marine Nearshore intertidal habitat nationally and 1084 acres along the Atlantic coast (Dahl and Stedman 2013).

Historically some Estuaries habitat (along with Tidal Wetlands and Flats) was converted to upland areas through artificial fill to facilitate development but the amount of historic loss in the Northeast is generally lacking. As these activities became regulated under the federal Clean Water Act, habitat conversion slowed considerably (Dahl and Stedman 2013).

Although the overall change in surface area of Estuaries may be experiencing a period of net gain in the Northeast, there are downward trends in the loss of particular features and formations within Estuaries, such as mollusk reefs and seagrass beds. Global losses of seagrass beds were 29% as of 2009 and of oyster beds were 85% as of 2011 (Kritzer et al. 2016).

Greene et al. (2010) describe the historical trends of oyster reefs and populations in the Northwest Atlantic, noting that the Estuaries of Chesapeake Bay historically produced the most oysters. Native shellfish beds in many Estuaries globally are functionally extinct, with intact oyster reefs or shellfish beds difficult to find in the northern hemisphere (Greene et al. 2010). Comprehensive estimates of oyster loss in the Northeast have not been developed, but estimates are available for some individual Estuaries. Most of the remaining oyster reefs in the Northeast are located from Delaware Bay south.

Roman et al. (2000) describe historical trends in SAV in the Northeast, stating that "it is likely that eelgrass disappeared in the 19th century from many systems of the northeast as a result of land clearing, deforestation, and industrial development," with losses being localized and due to human activities. In the 1930s an epidemic disease (wasting disease) eliminated 90% of the eelgrass in the North Atlantic, which slowly recovered in most Estuaries until a recurrence of the wasting disease in the 1980s caused localized die-offs in Casco Bay (ME), Great Bay (NH), Stage Harbor (MA), and the Niantic River (CT) (Greene et al. 2010, Roman et al. 2000). Since then many eelgrass beds have recovered but recovery has been minimized in some areas due to rapidly increased nutrient and sediment loads which has led "to the eventual loss of thousands of hectares of eelgrass beds that had briefly returned following the disease outbreak" (Greene et al. 2010, p. 2-6). Cumulatively, more than half of the historic eelgrass beds in Chesapeake Bay, the region's largest Estuary, were lost by the 1970s (Greene et al. 2010).

Most recently, Schumchenia (2021) updated an inventory of eelgrass meadows in the five New England states that partner in the Northeast Regional Ocean Council (NROC), listing the spatial datasets available for each of the five states.

Halpern et al. (2019) provides a detailed analysis of the global threats and impacts to multiple estuarine and marine habitat types, from salt marsh to coral reefs, rocky intertidal shorelines to kelp forests. The 2015 **National Coastal Condition Assessment (NCCA)** found that nationally 71% of estuarine waters were rated in good biological condition and 76% had good sediment quality. Eutrophication is widespread, with only 33% of estuarine waters in good condition. Contamination of fish tissue was rated good in only 15% and rated poor in 55%. Slightly more than half (55%) had good condition for mercury in fish tissue. All (100%) of the waters surveyed were in good condition for microcystins toxicity and 99% for Enterococci (EPA 2021).

Roman et al. (2000) describes the threats and condition of Northeast Estuaries and their associated Tidal Wetlands and Flats and rocky Shorelines, particularly coastal development (Threat 1.0) and nutrient loading (Threat 9.3.1). Greene et al. (2010) provides an assessment of overall eutrophic conditions in Estuaries of the Northeast with projections for the future based on human influence of adjacent terrestrial land.

In the Northeast region, the National Coastal Condition Assessment surveyed 9956 square miles at 252 sites in 2015. Overall, the region fared better than the nation as a whole, with 71% in good biological condition, increasing from 65% in 2010 and 51% in 2005. The Northeast also had more estuarine waters in good condition for eutrophication in 2015 than the nation (48% versus 33%) and with only 7% rated in poor condition (half the national total of 15%). Eutrophication conditions have improved over time, from 33% in good condition in 2005 to 44% in 2010 and 48% in 2015. Sediment quality in Northeast Estuaries was the same as the national total of 76% in good condition, with only 1% in poor condition in 2015. Long-term trends in sediment quality for contaminants vary in the Northeast, from 68% in good condition in 2005 to 55% in 2010 then 76% in 2015. The ecological effects of fish contamination in Estuaries of the Northeast were slightly better than the national total in 2015, with 18% of the estuarine waters in good condition compared to 15% nationally. More than half (51%) were in poor condition, however. While the proportion of Estuaries with good fish contamination ratings was unchanged between 2010 and 2015, the proportion in poor condition increased significantly from 35% to 51%. The degree of decline in this ecological indicator is uncertain due to improved sampling techniques between the two sample periods. The condition of Northeast Estuaries for Enterococci and microcystin levels were the same as the national totals. Mercury levels in fish tissue were generally good, with 60% of the Northeast Estuaries in good condition and less than 1% above health benchmarks; the remaining 40% of estuarine waters were not assessed due to fish being caught not meeting minimum size requirements, not of species consumed by humans, or no fish caught at all.

"Although [2015] NARS [**National Aquatic Resource Survey**] reports for lakes and for rivers and streams indicate increased nutrient concentrations since previous surveys [2005 and 2010], eutrophication condition in estuaries did not reflect these increases, perhaps due to the influence of open waters and associated tidal flushing. The combined results, however, support the need to continue and expand efforts to address sources of nutrient pollution" (EPA 2021, p. 7). EPA monitoring identified estuarine waters with the most area in good condition in 2015 at 71%, compared to 48% for wetlands and roughly one-third for lakes, Great Lakes nearshore waters, and river and stream miles (EPA 2021).

The ACFHP compiled an **Assessment of Existing Information on Atlantic Coastal Fish Habitat** on priority threats to Atlantic coastal habitats in 2009, including Estuaries, with more than 500 data sources[191]. Priority national threats to Atlantic coastal fish and their habitats include obstructions to fish passage and habitat connectivity (Threat 7.2), Dredging (Threats 4.3.2 and 4.3.3), Shoreline Stabilization and Sediment Placement (Threat 7.3.1), water quality degradation and eutrophication (Threat 9.0), consumptive Water Withdrawal (Threats 7.2.6 and 7.2.7), Sedimentation (Threat 9.3.2), Vessel Impacts (Threat 4.3.1), contamination of water and sediments (Threats 9.2, 9.3 and 9.4), and Invasive Species (Threat 8.1). ACFHP (2017, p. 17) describes the detailed threats to priority habitats in the North Atlantic and Mid-Atlantic regions.

Martin et al. (2020) assessed the Estuaries and Tidal Wetlands and Flats of the Northeast and Mid-Atlantic regions, including mapping and analyses of several environmental variables:

- Seagrass and oyster reef habitat
- Tidal wetland habitat
- Length of estuarine marsh – water edge habitat
- Proximity to protected habitat
- Proximity to development
- Water quality (the number of EPA 303(d) listed waters)
- Length of hardened shoreline
- Linear feet of causeway fragmenting habitat

Detailed maps of Estuaries and Tidal Wetlands and Flats showing the distribution of each of these environmental variables are available in Martin et al. (2020) and on Data Basin[111], along with maps showing the cumulative results ranking areas for protection (**Areas of Excellent Fish Habitat**) and restoration (**Restoration Opportunity Areas**). In the NEAFWA region, Estuaries and Tidal Wetlands and Flats were highly localized with the eastern shore of Virginia (both within Chesapeake Bay and on the Atlantic coast) having the highest density and abundance of Areas of Excellent Fish Habitat while the urbanized areas of the New York City area had the highest density and abundance of Restoration Opportunity Areas.

The condition of specific benthic habitat features and formations within Estuaries have been assessed at different scales in the Northeast. Greene et al. (2010) identified five priority regional threats to nearshore shellfish in the Northwest Atlantic: overharvest (Threat 5.4), Pollution (Threat 9.0), altered freshwater regimes (Threat 7.2), Climate Change (Threat 11.0), and parasites, diseases and Invasive Species (Threat 8.0). "Threats which characteristically impact the [SAV] key ecological attributes [in the Northeast] include eutrophication, algal blooms, alterations to water temperature regime, benthic organism harvest methods, boating activities, shoreline armoring and impediments to natural sediment movements, barrier island and inlet stabilization approaches, invasive species (especially green crabs), toxins, excessive macroalgae, altered seed predation regime, dredging, decreased abundance of native shellfish, disease, and herbivory" (Greene et al. 2010, p. 2-42).

The **Northeast Regional Marine Fish Habitat Assessment** was completed in 2022 by NOAA, the New England Fishery Management Council, Mid-Atlantic Fishery Management Council and other conservation partners. This regional habitat assessment describes and characterizes estuarine, nearshore, and offshore fish habitat distribution, abundance, and quality in the Northeast region. The **Northeast Regional Habitat Assessment Data Explorer Tool**[192] provides an interactive, publicly available resource to explore trends data in fish species distribution at both the state and regional scales and to access the data collected and reports prepared as part of the assessment.

The **Ramsar Convention**[93] identifies wetland and estuarine sites of global significance and four Estuaries in the Northeast have been identified for their high habitat value as Ramsar sites: the Connecticut River Estuary and Tidal Wetlands Complex, Edwin B. Forsythe NWR in NJ, Delaware Bay Estuary, and the Chesapeake Bay Estuarine Complex.

Coastal zones are a matrix of shifting ecosystems, with dynamic connections between Estuaries and Tidal Rivers and Streams, Tidal Wetlands and Flats, Beaches and Dunes, other Shorelines, and the Marine Nearshore. The boundaries between these connected habitats are dynamic, shifting with the winds and tides, freshwater inflows from river systems, marine inflows from coastal storms, and sea level rise. Kritzer et al. (2016) describes the need to manage distinct marine and estuarine systems as an interconnected mosaic rather than distinct habitats.

Estuaries can be fragmented by roads and causeways, bridges, tide gates and other artificial structures. Estuarine benthic habitats like oyster reefs, shellfish beds and SAV can be fragmented by dredging and artificial structures like jetties, groins, docks and piers. The extent of habitat fragmentation of Estuaries and their benthic habitat formations at the regional scale in the Northeast is not well known.

Greene et al. (2010, see Chapter 2) describes the inherent resiliency of Estuaries and associated coastal ecosystems, stating that although severe losses and condition declines have occurred historically, most functional groups and species persist (in significantly reduced numbers) and recovery has occurred where protection and restoration has taken place, although that recovery can have a significant lag time. Juvenile fish communities appear to be more resilient to the potentially damaging impacts of coastal storms like hurricanes with greater integrity of SAV ecosystems in Estuaries, but the long-term resilience of estuarine fishes to acute storm impacts with chronic degradation of the estuarine environment and predicted increases in the frequency and intensity of storms is unknown (Zhang et al. 2022). **Coastal Risk Reduction and Resilience:**

Using the Full Array of Measures provides a summary of the potential resilient processes and environmental outcomes of natural, nature-based, nonstructural and structural coastal risk reduction measures, including for seagrass beds and oyster reefs (see Appendix A of USACE 2013).

2.19.4 HABITAT MANAGEMENT

Numerous landscape and seascape level management plans exist for the Estuaries of the Northeast US. Each of the Estuaries that participates in the **National Estuary Program** develops a **Comprehensive Conservation and Management Plan (CCMP)**. CCMPs are implemented through Implementation Actions, which are prioritized by each program and share some similarities to SWAP conservation actions. The Long Island Sound CCMP was revised in 2015 and the **Long Island Sound Study**, the regional partnership managing the National Estuary Program in Long Island Sound, issued a list of Implementation Actions[193] for 2020-2024. Example Implementation Actions include the projects that restore or maintain habitat connectivity, development of a habitat connectivity model, identification of which sites are likely to be impacted by sea level rise and which are ideal for habitat migration, and the development and application of standardized habitat quality metrics and assessment methodologies for targeted habitat types.

The **Chesapeake Bay Program**, the largest Estuary in the region, is a regional partnership[194] implementing the goals of the **Chesapeake Bay Watershed Agreement**. The Chesapeake Bay Watershed Agreement is a multi-state and federal agreement that includes all the states within the Bay's watershed. The 2014 Agreement, as amended in August 2022, has ten goals and 31 outcomes (conservation targets) guiding the restoration of Chesapeake Bay and its watershed[195]. The **Clean Water Blueprint for the Chesapeake Bay and its Rivers and Streams** sets state specific plans with pollution reduction goals for 2025 to address EPA pollution limits for the Estuary set in 2010. The EPA issues two-year milestones on implementation of the Blueprint; the October 2022 evaluation found that there were new significant successes in 2022, most of the watershed's states are not on track to meet the 2025 water quality restoration goals. Only West Virginia and the District of Columbia are on track to meet their cleanup goals of the Estuary.

Chapter 7 describes similar landscape level management programs for Long Island Sound, the Hudson River / New York Harbor, and Delaware Bay Estuaries.

The **Atlantic Coast Fish Habitat Partnership** is the regional Fish Habitat Partnership and has identified several conservation objectives for the North Atlantic and Mid-Atlantic regions for coastal fish habitat in their **Conservation Strategic Plan**

2017-2021 and updated **Conservation Strategic Plan 2020-21** (ACFHP 2017, 2020).

Greene et al. (2010) and Staudinger et al. (2023) describe a number of conservation actions and strategies to enhance the resilience of coastal systems to climate change.

2.19.5 HABITAT MONITORING

Individual **National Estuary Programs** may monitor individual Estuaries for water quality and habitat status and condition, but regional or national scale monitoring efforts are few. The EPA monitors water quality and ecological conditions in estuarine waters along the coasts and the freshwater of the Great Lakes in the **National Coastal Condition Assessment** (EPA 2021). The NCCA is conducted every five years and uses standardized sampling procedures and quality assurance protocols to assess coastal conditions at the regional and national scale. The most recent NCCA is from 2015, with the 2020 assessment not available at the time of this writing. Ecological indicators monitored as part of the NCCA include: biological condition of benthic invertebrates including mollusks, worms and crustaceans; eutrophication; sediment contaminant levels; fish tissue contamination; Enterococci bacteria levels; and microcystin toxin levels. The 2020 NCCA expanded to include new indicators of total alkalinity and the level of microplastics and nitrogen isotopes in sediments (EPA 2021). Detailed results of the NCCA monitoring are available on the **NCCA Dashboard**[196].

The National Centers for Coastal Ocean Science at NOAA monitors eutrophication levels in the nation's estuaries as part of the periodic **National Estuarine Eutrophication Assessment**, but the frequency of the assessment is dependent on the availability of funding[197]. NOAA and the National Marine Fisheries Service (NMFS) conduct species-based monitoring in coastal waters, but comprehensive regional monitoring of Estuary habitat features like SAV, shellfish beds or oyster reefs are lacking.

The **Virginia Coast Reserve Long-term Ecological Research (LTER)** site is developing a predictable understanding of coastal landscapes, monitoring long-term change as well as short-term disturbances to dynamic barrier islands as part of the national LTER Network supported by the National Science Foundation. Approximately 110 kilometers (68 miles) of the Delmarva Peninsula coastline has been monitored in this project since 1987. At least seven universities and TNC collaborate on multiple habitat research and monitoring projects, including seagrass restoration, oyster restoration and bottom dwelling fish and wildlife. Data products and reports are available on the Virginia Coast Reserve LTER website maintained by the University of Virginia Department of Environmental Sciences[160].

2.19.6 PARTNERS

There are 12 Estuary partnerships within the National Estuary Program in the Northeast, each with a collaborative partnership to manage and improve the condition of those Estuaries. Conservation projects that have been conducted within the 12 Estuaries in the Northeast as part of the National Estuary Program, along with the areas in which each partnership works, are inventoried and described in a map viewer maintained by the EPA[198]. The strategic priorities and programs of each National Estuary Program is described in its own Comprehensive Conservation and Management Plan. Many partners and collaborative programs to conserve Estuaries of the Northeast involve conservation activities within the Estuary's watershed to address stressors and threats to habitat quality of the Estuaries.

Partners involved in the protection of the region's largest Estuaries – Chesapeake Bay, Long Island Sound, New York – New Jersey Harbor and Estuary, and Delaware Bay are described in *Chapter 7*. Other Estuaries with conservation partnerships include the Peconic Estuary Partnership[199], Narragansett Bay Estuary Program[200], and the Casco Bay Estuary Partnership[201].

Federal partners involved with the protection and conservation of Estuaries in the Northeast include the EPA and NOAA. The roles of the EPA and NOAA were discussed in preceding sections. NOAA also maintains a **Digital Coast** resource that provides data, tools and training resources for addressing coastal issues, including data and maps for land cover, sea level rise, elevation, hurricanes, coastal flooding, imagery, socioeconomics, weather and climate, marine habitat and species, ocean uses and planning areas, water quality, infrastructure, oceanography and more[177].

Fisheries partners that work in Northeast Estuaries include the NMFS, Atlantic Coast Fish Habitat Partnership[202], the **New England Fishery Management Council[203]**, the **Mid-Atlantic Fishery Management Council[204]**, and the **Atlantic States Marine Fisheries Commission[205]**. Although the latter three focus primarily on marine fish, they also manage diadromous fish and some marine invertebrates (e.g., the RSGCN Horseshoe Crab). Several species of management concern to these organizations are also associated with the region's Estuaries.

The ACFHP conducts conservation actions throughout the Northeast, from restoring aquatic connectivity on Rivers and Streams habitat to restoring oyster reefs, salt marsh and SAV beds. In Estuaries, ACFHP priority habitats include shellfish beds, live hardbottoms, unvegetated substrates, SAV, macroalgae and associated Tidal Wetlands. In the North Atlantic region the three priority habitats for ACFHP conservation efforts are riverine bottoms (for diadromous fish), SAV and marine and estuarine shellfish beds. In the Mid-Atlantic priority conservation habitats include the same three plus Tidal Wetlands (ACFHP 2017).

Other partners are collaborating to conserve specific features and formations of Estuaries like SAV and oyster reefs. The Nature Conservancy and partners are conducting a landscape scale restoration project to restore SAV to the lagoons of Virginia's eastern shore. The project involves not only planting eelgrass beds but reintroduction of eelgrass-dependent Bay Scallop and settlement substrate for oysters (Greene et al. 2010). The **Delaware Bay Oyster Restoration Task Force** has been conducting similar work in Delaware Bay, strategically placing millions of bushels of shell material at historic oyster reef sites throughout the Bay (Greene et al. 2010). The **Oyster Recovery Partnership** has restored approximately 3000 acres of oyster reefs in Chesapeake Bay and manages the **Shell Recycling Alliance**, a shell recycling network throughout the Mid-Atlantic region[206].

2.19.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of Estuaries habitat through several ongoing citizen science projects. Individual National Estuary Programs involve the public in their conservation, education and outreach activities. The Long Island Sound Study, for example, supports **Sound Stewardship** volunteer projects that involve the public in activities that address the priorities of the Long Island Sound Estuary Program. Other monitoring programs involving citizen scientists and volunteers in the region's Estuaries are described in *Chapter 5*. For example, the **Chesapeake Monitoring Cooperative**, established by the Chesapeake Bay Program Partnership in 2015, unites groups and individuals involved in monitoring a variety of environmental metrics in Chesapeake Bay, provides technical assistance, and maintains a user-friendly database to gather citizen science monitoring data for use by agency partners[207].

The **GoPro Aquaculture Project** was established by NOAA in 2019 to involve citizen scientists and shellfish growers to document how oyster cages used in shellfish aquaculture provide habitat in Long Island Sound[208]. The project uses GoPro camera footage to understand the interactions between fish communities and shellfish aquaculture gear. The **Delaware Bay Horseshoe Crab Survey** was founded in 1990 and involves citizen scientists to conduct beach surveys on spawning Horseshoe Crabs[209]. The RCN 3.0 **Coordinated Assessment of Northeastern Diamond-backed Terrapin Populations** project will incorporate a citizen science component to gather data with annual terrapin surveys in each state to identify state and regionally important conservation areas for terrapins, including estuarine Beaches, Tidal Wetlands and Flats, and Estuaries.

Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

2.19.8 HABITAT INFORMATION, RESEARCH AND MONITORING NEEDS

Martin et al. (2020) identified several research needs for Estuaries along the Atlantic coast:

- Improved understanding of the relationship of fish presence and habitat presence and health
- Estuarine mixing and hydrodynamic models to better inform the effects of point and non-point source pollution
- Consistent map inventories of oyster reef and SAV habitat
- Evidence-based quantified thresholds for environmental variables used to assess habitat condition
- Weighted analyses of environmental variables to assess habitat condition

2.20 MARINE NEARSHORE

Figure 2.20. 1 Marine Nearshore habitats support 93 Northeast RSGCN and Watchlist species. (Monomoy NWR, MA, photo credit: Spencer Kennard)

2.20.1 HABITAT DESCRIPTION

Marine Nearshore habitat extends from the intertidal zone along the coastlines of the Northeast seaward to the water depth where light no longer reaches the seafloor in a level that supports photosynthesis. NOAA defines this zone as the “sunlight”, or euphotic, zone and it generally extends to 200 meters of water depth. Photosynthesis is not possible at deeper depths, within the “twilight” zone (200 to 1000 meters depth) or the aphotic zone (deeper than 1000 meters)[210]. Generally speaking, the Marine Nearshore habitat for RSGCN in the Northeast extends seaward to a 200-meter water depth and the Marine Offshore and Oceanic habitat extends seaward of the 200-meter water depth. For the purposes of characterizing RSGCN habitat in the Northeast, the Marine Offshore and Oceanic habitat extends to the federal Exclusive Economic Zone (EEZ), located 200 nautical miles offshore. Marine Nearshore habitat includes both the pelagic water column and the benthic seafloor. Habitat features and formations important to Northeast RSGCN in the Marine Nearshore and Marine Offshore and Oceanic habitats include SAV, kelp forests, artificial structures such as artificial reefs, the Sargasso Sea, floating algae, benthic, deep water, reefs and live rock, shellfish beds, shoals, aerial (for seabirds), and Banks (e.g., Georges Bank). RSGCN and Watchlist species known to be associated with these habitat features and formations can be found in the Northeast RSGCN Database (version 1.0).

Greene et al. (2010, p. 4-1) describes the physical oceanography of the Northwest Atlantic’s Marine Nearshore and Marine Offshore and Oceanic habitats, which “are important predictors of marine species distribution and abundance, from phytoplankton to predatory pelagic fish to whales.”

Marine habitats can be classified with the **Coastal and Marine Ecological Classification Standard**, which characterizes habitats into Biotopes using their biogeographical component, aquatic setting, geoform component, substrate component and biotic component (FGDC 2012). The CMECS also includes a series of seven types of modifiers to further describe CMECS units, such as anthropogenic impacts and physicochemical metrics. The **National Ocean Service (NOS)** of NOAA maintains a database of projects where CMECS has been applied to classify marine and estuarine areas, with an interactive map[211]. In the Northeast, at least 12 projects have applied the CMECS to classify marine and estuarine habitats.

Spalding et al. (2007) identified 232 marine ecoregions of the world in the Marine Nearshore, of which there are 19 in the US (Wenzel et al. 2020). Marine ecoregions are defined as areas with relatively homogeneous species composition that are distinct from adjacent areas, with the species composition likely based on a distinct suite of topographic or oceanographic features and/or a small number of ecosystems (Spalding et al. 2007). There are three marine ecoregions in the Marine Nearshore of the Northwest Atlantic, from north to south:

- Scotian Shelf
- Gulf of Maine / Bay of Fundy
- Virginian

"The Northwest Atlantic region is known for its cold, nutrient-rich, and highly productive waters that have sustained regional economies for centuries. With its strong tidal flows, complex circulation patterns, and varied seafloor topography the region supports large diverse populations of bottom dwelling fish and an array of benthic communities. The deep basins and shallow banks of the Gulf of Maine, with seasonal concentrations of plankton and forage fish, attract an impressive number of marine mammals. Farther south, the broad continental margin, large estuaries, and deep submarine canyons function as nursery areas for estuary dependent fishes, critical stopover sites for millions of seabirds, migratory pathways for large pelagic species, and key habitat for coldwater corals" (Greene et al. 2010, p. 1-2).

The 14 Northeast SWAPs of 2015 include 49 Key Habitats for SGCN that are in the Marine Nearshore (*Appendix 2A*, Table 2A.20). Some of these Key Habitats are specific features and formations like kelp beds, SAV, mollusc reefs, artificial reefs or wrecks, and live hardbottom. Others are broader and include the water column or various substrate types like bedrock, gravel or sand.

There are 54 RSGCN, two Proposed RSGCN, 29 Watchlist [Assessment Priority], two Watchlist [Interdependent Species] and one Proposed Watchlist species across seven taxonomic groups associated with Northeast Marine Nearshore habitat (*Supplementary Information 2*, Table 2.20.1, Figure 2.20.2). Another five species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. RSGCN and Watchlist species associated with the Marine Nearshore include 22 birds, 16 marine fish, 13 sharks, 11 diadromous fish, nine marine invertebrates, five skates and rays, four federally-listed sea turtles, four bats, and three whales (two of which are federally-listed) (Figure 2.20.2). Twelve RSGCN and Proposed RSGCN associated with the Marine Nearshore are of Very High Concern in the Northeast region, all but one of which are federally-listed species.

Several benthic marine habitats are valuable to coastal fishes and invertebrates. More than 2000 marine invertebrate species are known to inhabit the seafloor of the Northwest Atlantic (Greene et al. 2010). Kritzer et al. (2016) found that soft sediments and diadromous riverine systems are of higher value in the Northeast Atlantic while

Table 2.20. 1 The number of species in each RSGCN and Watchlist category associated with Marine Nearshore habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	54
Proposed RSGCN	2
Watchlist [Assessment Priority]	29
Proposed Watchlist [Assessment Priority]	1
Watchlist [Interdependent Species]	2
Watchlist [Deferral to adjacent region]	5
TOTAL	**93**

marshes and coral reefs are of higher value in the Southeast. Soft sediment substrates were found to be more valuable ecologically than previously thought. SAV is a key nursery habitat along the entire Atlantic coast (Kritzer et al. 2016) and is present in the Marine Nearshore as well as Estuaries.

In 2013 the New York Department of State (NY DOS) completed a study of the continental shelf offshore New York, from the coastline to the edge of the continental shelf (NY DOS 203). Numerous spatial data sets were created as part of the project characterizing the Marine Nearshore from Rhode Island to New Jersey. They characterize this central portion of the region as:

> *The continental shelf within the [Offshore NY] study area has relatively simple topography and slopes gradually from the shore to the shelf edge. The seafloor on the continental shelf is generally composed of sand which grades to finer sediments such as silt and clay as water depth increases. The relatively homogeneous seafloor has sporadic relic sand and gravel ridges from past glacial periods, exposed sandstone and bedrock, dumping sites and other infrastructure …, scuttled vessels, artificial reefs (including subway cars submerged through a New Jersey reuse program), shipwrecks, and lost cargo. The most pronounced topographic features in the offshore planning area are the Hudson Shelf Valley, which crosses the entire shelf at the southern end of the offshore planning area, and the Hudson Canyon, which connects to the Hudson Shelf. The shelf Valley and is the largest submarine canyon on the U.S. Atlantic continental margin. edge also features numerous submarine canyons spanning the offshore planning area.* (NY DOS 2013, p. 19)

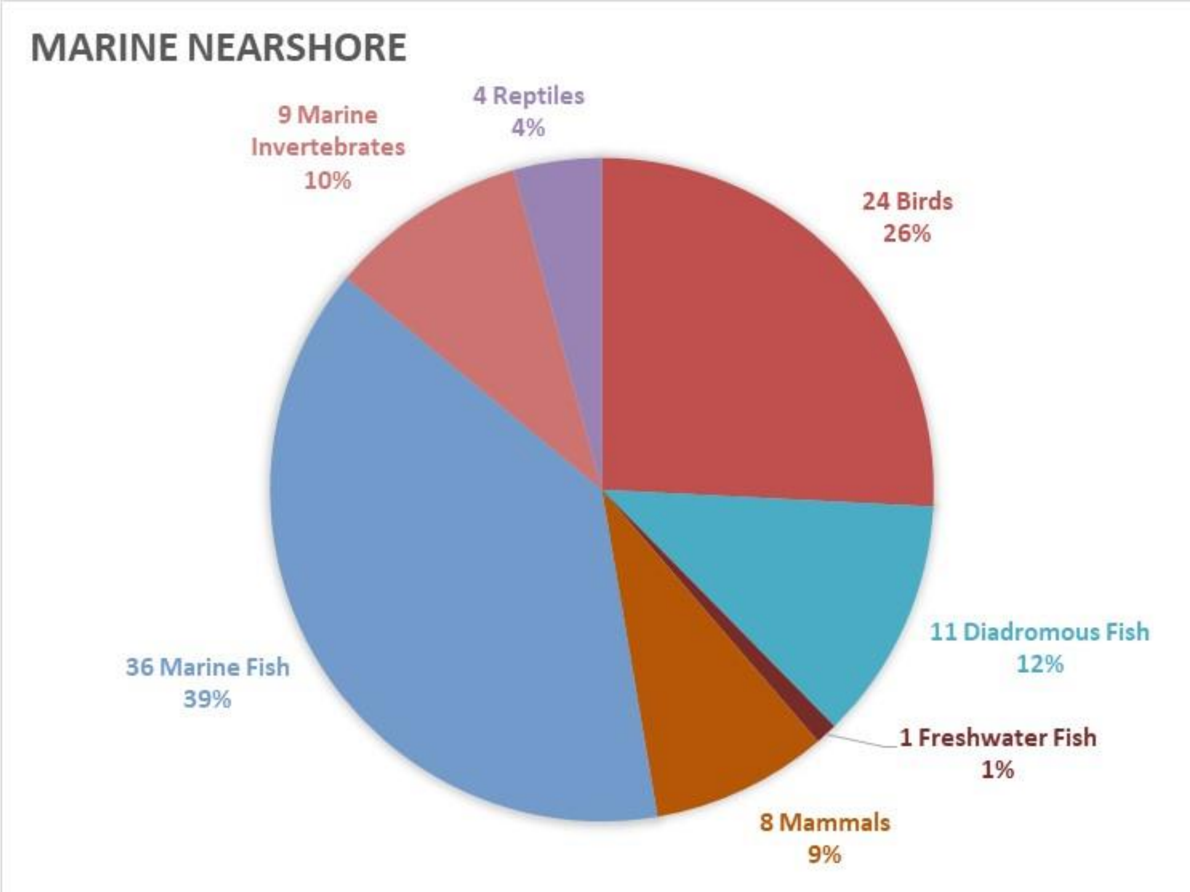

Figure 2.20. 2 Northeast RSGCN and Watchlist species associated with Marine Nearshore habitats represent seven taxonomic groups.

2.20.2 HABITAT DISTRIBUTION AND CONSERVATION

There are more than 4.8 million acres of marine waters in the US, with 3% of those waters located in the Northeast region and 1% in the Great Lakes (Wenzel et al. 2020). The Marine Nearshore is divided into state waters (out to 3 nautical miles) and federal waters (between 3 and 200 nautical miles), although state and federal partners collaborate in both areas.

The **Northwest Atlantic Marine Ecoregional Assessment** (Greene et al. 2010) compiled a baseline of the scientific information available on the status and distribution of key species and habitats in the Marine Nearshore and Marine Offshore and Oceanic habitats of the Northeast. From the northern limits of the Gulf of Maine in Canadian waters just north of Maine to Cape Hatteras in North Carolina, from the mean high-water line to a water depth of 2500 m at the foot of the continental slope, there are 138,937 square miles of Marine Nearshore and Marine Offshore and Oceanic habitat. Green et al. (2010) describes the biogeographical characteristics of three subregions within this area – the Gulf of Maine, southern New England, and the Mid-Atlantic Bight (from north to south).

The Northwest Atlantic Marine Ecoregional Assessment also assessed the abundance and distribution of marine fishes in the Northeast (Table 2.20.2), identifying distinctive fish habitats for 11 diadromous (Greene et al. 2010, Chapter 6), 32 demersal (Chapter 7), eight small pelagic (Chapter 8) and 14 large pelagic species (Chapter 9). Twelve marine RSGCN and Watchlist fish species and their marine habitats were assessed in this project (Table 2.20.1). Ten diadromous fish assessed by Greene et al. (2010) are Northeast RSGCN and Watchlist species. Three small pelagic fish and ten large pelagic fish that are Northeast RSGCN or Watchlist species were also assessed. The importance of various habitat types, features and locations in the Northeast for each diadromous fish species are summarized in Chapter 6, demersal fish in Chapter 7, and pelagic fish in Chapters 8 and 9 of Greene et al. (2010), with maps showing the present and historic distribution of each species within freshwater Rivers and Streams, Tidal Rivers and Streams, Estuaries, Marine Nearshore and Marine Offshore and Oceanic habitats of the Northeast. Important marine areas in the region are identified for each fish species where sufficient data were available.

Regional Marine Nearshore areas that were identified as important habitat for all large pelagic species include the area along the 50 m isobath south of Block Island Sound. For pelagic neonates, the most species rich area was in southern New England from the coast to beyond the 50 m isobath south of Block Island Sound to along the Hudson canyon, plus a small strip along the coastline by Delaware Bay and Chesapeake Bay. Juvenile pelagic fish are most abundant in the same areas as the neonates plus in the Marine Offshore and Oceanic habitat along the shelf-slope break between 200 and 1000 m water depths. Several pelagic species also regularly can be found in adjacent Estuaries and Marine Offshore and Oceanic areas (Greene et al. 2010).

Much remains not well known about many marine species and their habitat requirements, with some new information about the Northeast region's importance to many species seasonally and for different life stages. The RSGCN Atlantic Bluefin Tuna, for example, was known to spawn only in the Gulf of Mexico and the Mediterranean Sea for a long time, until a recent discovery of a new spawning area was discovered in the Marine Offshore and Oceanic area from Cape Cod (MA) to Cape Hatteras (NC) where water depths are at least 2000 m (Richardson et al. 2016, Hernandez et al. 2022). This discovery expanded the region's responsibility for this highly migratory species from summer foraging grounds to spawning grounds as well. Recent research has also gathered more support to identify a young-of-the-year nursery area for the RSGCN White Shark (*Carcharodon carcharias*) in the Marine Nearshore offshore Long Island, New York (Curtis et al. 2018).

Table 2.20. 2 The Northwest Atlantic Marine Ecoregional Assessment evaluated the status, distribution, and habitats for numerous Northeast RSGCN and Watchlist species in Greene et al. (2010).

Species Group	RSGCN and Watchlist Species Evaluated in Greene et al. (2010)
Diadromous fish **(Chapter 6)**	Alewife (Alosa pseudoharengus), American Eel (*Anguilla rostrata*), American Shad (*Alosa sapidissima*), Atlantic Salmon (*Acipenser oxyrinchus oxyrinchus*), Atlantic Tomcod (*Microgadus tomcod*), Blueback Herring (*Alosa aestivalis*), Hickory Shad (*Alosa mediocris*), Rainbow Smelt (*Osmerus mordax*), Sea-run Brook Trout (*Salvelinus fontinalis*) and Shortnose Sturgeon (*Acipenser brevirostrum*)
Demersal fish **(Chapter 7)**	Atlantic Cod (*Gadus morhua*), Atlantic Croaker (*Micropogonias undulatus*), Atlantic Halibut (*Hippoglossus hippoglossus*), Barndoor Skate (*Dipturus laevis*), Black Sea Bass (*Centropristis striata*), Golden Tilefish (*Lopholatilus chamaeleonticeps*), Rosette Skate (*Leucoraja garmani*), Tautog (*Tautoga onitis*), Thorny Skate (Amblyraja radiata), Weakfish (Cynoscion regalis), Winter Flounder (*Pseudopleuronectes americanus*) and Yellowtail Flounder (*Limanda ferruginea*)
Small pelagic fish **(Chapter 8)**	Atlantic Herring (*Clupea harengus*), American Sand Lance (*Ammodytes americanus*) and Northern Sand Lance (*Ammodytes dubius*)
Large pelagic fish **(Chapter 9)**	Atlantic Bluefin Tuna (*Thunnus thynnus*), Dusky Shark (*Carcharhinus obscurus*), Great Hammerhead (*Sphyrna mokarran*), Porbeagle (*Lamna nasus*), Sand Tiger (*Carcharias taurus*), Sandbar Shark (*Carcharhinus plumbeus*), Scalloped Hammerhead (*Sphyrna lewini*), Shorfin Mako (*Isurus oxyrinchus*), Thresher Shark (*Alopias vulpinus*) and White Marlin (*Kajikia albida*)
Cetaceans **(Chapter 10)**	Fin Whale (*Balaenoptera physalus*), Harbor Porpoise (*Phocoena phocoena phocoena*), Humpback Whale (*Megaptera novaeangliae*), North Atlantic Right Whale (*Eubalaena glacialis*), Sei Whale (*Balaenoptera borealis*) and Sperm Whale (*Physeter macrocephalus*)
Sea Turtles **(Chapter 11)**	Green Sea Turtle (*Chelonia mydas*), Leatherback Sea Turtle (*Dermochelys coriacea*) and Loggerhead Sea Turtle (*Caretta caretta*)

Species Group	RSGCN and Watchlist Species Evaluated in Greene et al. (2010)
Birds **(Chapter 12)**	Barrow's Goldeneye (*Bucephala islandica*), Harlequin Duck (*Histrionicus histrionicus*), Least Tern (*Sternula antillarum*), Piping Plover (*Charadrius melodus*), Red Knot (*Calidris canutus rufa*) and Roseate Tern (*Sterna dougallii dougallii*)

The Northwest Atlantic Marine Ecoregional Assessment evaluated the status, distribution and importance of Marine Nearshore and Marine Offshore and Oceanic areas to several cetaceans, sea turtles and coastal and marine birds which are Northeast RSGCN or Watchlist species (Table 2.20.1). Six RSGCN and Watchlist marine mammals were evaluated by Greene et al. (2010, Chapter 10). Important marine areas in the region to these cetaceans are located within several areas of the Gulf of Maine such as Cape Cod Bay, Massachusetts Bay, Jeffreys Ledge, Stellwagen Bank, Georges Bank and Great South Channel.

Three of the four RSGCN sea turtle species were evaluated by Greene et al. (2010, Chapter 11), with important habitat areas vary by species and season. Green Sea Turtles are located in the estuarine and marine waters surrounding Long Island, Chesapeake Bay, and the eastern shore of Virginia during summer months and have nested on the beaches of Virginia. Loggerhead Sea Turtles have recently nested on ocean beaches in Maryland (since 2017) and Delaware (2018) and in the Marine Nearshore and Estuaries are present in Chesapeake Bay and as far north as Cape Cod in the summer months. Leatherback Sea Turtles are typically concentrated farther offshore during the warmer months in the Marine Nearshore out to the inner continental shelf from southern Long Island to Maryland and along the shelf break for the entire region.

Six coastal and marine bird RSGCN and Watchlist species were assessed (Greene et al. 2010, Chapter 12). Marine areas found to be important nationally or hemispherically to these birds include the Marine Nearshore of the Delmarva Peninsula, Cape Cod region and northeast coastal Maine and the Estuaries of Chesapeake Bay, Delaware Bay and Great Marsh (MA). Eighty percent of Roseate Terns nest on two islands in the Northeast, Great Gull Island in New York and Bird Island in Massachusetts. Nearly the entire population of rufa Red Knot migrate through the region in the spring, with hemispherically important migratory stopover sites on Delaware Bay and the eastern shore of Virginia. Regionally important areas to coastal and marine birds include the Marine Nearshore of Maine and New Hampshire and the Estuaries of Long Island, New Jersey and Delaware. Barrow's Goldeneye, for example, winters in the shallow marine waters along the coast of Maine and maritime Canada. Harlequin Ducks winter along the rocky coasts and islands of Maine and maritime Canada (Greene et al. 2010). As more research is being conducted related to offshore wind energy development, more information about the use of the Marine Nearshore by migratory birds is becoming available, including documentation of migratory flight paths across the Marine Nearshore area from Cape Cod and Long Island to New Jersey and points south.

More than 2000 species of invertebrates live on the seafloor of the Marine Nearshore and Marine Offshore and Oceanic habitats of the Northeast, from marine worms to scallops, corals to crab. Each of these benthic invertebrates is adapted to particular habitat characteristics such as sediment type and grain size, water depth and topography. Greene et al. (2010) identified and mapped 72 of the most common benthic habitat communities in the region.

Deep-sea or cold-water corals are those that live in waters at least 50 meters deep. In the Northeast, deep-sea corals are present in the canyons south of Georges Bank and on the surrounding sea mounts and continental slope. Smaller areas of soft coral and sea pens, which do not need hardbottoms, occur in some areas of the Gulf of Maine both close to shore and farther offshore (NEFMC 2020). Deep-sea corals are managed by the New England Fishery Management Council, with the ecological importance and vulnerability of coral habitats described in NEFMC (2020). The USGS developed the **Cold-Water Coral Geographic Database** with records of coral in the Northwest Atlantic and Gulf of Mexico from 1880 to 2008, which is available online through the USGS[212]. NY DOS (2013) identified 5619 records of known deep-sea coral and sponge locations, adding other records to the USGS database for the region between Rhode Island and New Jersey.

While hardbottom areas occur throughout the Northeast Marine Nearshore and Marine Offshore and Oceanic habitats, they are most widespread in the Marine Nearshore of New England, particularly the near coastline of Maine (Greene et al. 2010, see Figure 3-7). Farther away from the coastline, hardbottom areas are somewhat correlated with areas of gravel substrate, which are concentrated in large patches around the Hudson Canyon, the eastern edge of Nantucket Shoals and the tip of Georges Bank. Elsewhere gravel patches are patchy (Greene et al. 2010). Otherwise the seafloor of the Northeast is dominated by fine to coarse sand with large patches of silt substrate in southern New England, in deep regions of the Gulf of Maine, and along the continental slope.

Greene et al. (2010, p. 3-26) developed a **Benthic Habitat** map for the Northwest Atlantic that includes the Marine Nearshore and Marine Offshore and Oceanic habitats of Northeast RSGCN, with descriptions of the characteristic water depth, seafloor topography, sediment type and benthic invertebrate species assemblages for each benthic habitat.

The **Northeast Ocean Data Portal[213]**, created by the **Northeast Regional Ocean Council (NROC)[214]**, provides a repository of datasets and reports related to estuarine and marine resources of New England and sometimes beyond, depending on the dataset. One resource is a story map of **Habitat Mapping and Classification in the Northeast USA**, which reviews over 20 active habitat characterization projects in the region and identified the CMECS as the preferred unified marine habitat classification scheme[215].

Habitat-related data available on the Northeast Ocean Data Portal fall within three categories:

- *Marine Life*: datasets on marine mammals, sea turtles, birds, fish, and habitat (28 datasets)
- *Environment*: datasets on bathymetry, physical oceanography, water quality, and habitat restoration
- *Human Dimensions*: datasets on aquaculture, commercial fishing, culture, demography and economy, energy and infrastructure, marine transportation, national security, recreation, sand resources, and administrative boundaries

Datasets hosted by both the NROC and external hosts are included in the Northeast Ocean Data Portal. The Portal also includes announcements of offshore wind development proposals, USACE Public Notices and proposed actions by the US Coast Guard. A list of offshore wind development projects and their current status and location are available on the Portal[216]. The Portal also includes a Data Explorer where users can create custom maps of interest for a particular area and range of data layers, such as the benthic habitats of the Marine Nearshore of New Jersey or the shellfish habitat of the Gulf of Maine.

The **Mid-Atlantic Regional Council on the Ocean (MARCO)[217]** has developed a similar **Mid-Atlantic Ocean Data Portal[218]** for the southern portion of the NEAFWA region. One notable MARCO project, in partnership with NOAA, was a recent effort to map and identify priority deepwater canyons from Virginia to Maine. MARCO also collaborated with the Woods Hole Oceanographic Institute in Massachusetts to add species level data on coral from seep sea canyons in the region to the Mid-Atlantic Ocean Data Portal. To increase awareness and appreciation of the biodiversity of the region's deep-sea canyons, MARCO and partners have developed a multiple webinar series and educational materials that showcase research about and imagery of these remote habitats[219].

NY DOS (2013) surveyed 16,740 square miles (12,650 square kilometers) off the south shore of New York City and Long Island, including both state (0 – 3 nautical miles) and federal (3 – 200 nautical miles) waters. One of the goals of the assessment was to provide information on the status and distribution of ecological resources and habitats to aid in future offshore wind energy regulatory reviews. Datasets related to habitat availability include predicted locations of existing natural resources (e.g., corals, sponges, fish, whales, sea turtles, seabirds) and modeled physiographic information (e.g., seafloor features, depth, current, temperature, wind speeds).

More than 1000 **Marine Protected Areas (MPA)**[189] exist throughout the US, with five located exclusively in the Marine Nearshore of the Northeast region and numerous others protecting both Marine Nearshore and connected Estuary habitats (Table 2.19.1). Nationally, 26% of US waters (including the Great Lakes) were protected within some sort of MPA as of 2020, although the most highly protected category of MPAs are located in the Pacific Ocean. Wenzel et al. (2020) found that many of the most ecologically significant taxa, ecosystems, habitats and processes have been protected by federal and state MPAs, including 83% of mangroves, 80% of shallow tropical corals, 63% of seagrasses and 54% of deep corals. In the Northeast region, 5.1% of the marine and estuarine waters are in MPAs (Wenzel et al. 2020). Massachusetts has designated five Ocean Sanctuaries in the Marine Nearshore, totaling 1,340,590 acres of Marine Nearshore open water.

Essential Fish Habitat (EFH) has been designated in the Marine Nearshore for a number of RSGCN and Watchlist species that are managed by NOAA Fisheries under the Magnuson-Stevens Fishery Conservation and Management Act, but the presence of EFH does not confer any physical protection only regulatory authority for proposed activities in those areas. The **EFH Mapper** is an interactive online viewer[190] showing the location and details of EFH in the US. Virtually the entire Marine Nearshore and Marine Offshore and Oceanic areas of the Northeast have been designated as EFH for at least one species at some life stage, with the area with the highest density of all EFH in the Marine Nearshore located from approximately Delaware Bay south to Cape Hatteras in North Carolina; for neonate pelagic fish, EFH hotspots occurs just offshore Long Island and offshore the mouth of Delaware Bay (Greene et al. 2010, see Figure 9-18).

2.20.3 HABITAT CONDITION

Marine Nearshore habitat is within the global ocean system, which changes in spatial extent on a geologic timescale. During a period of rising sea level such as the one that is currently occurring, there is a potential for an increase in Marine Nearshore habitat as coastal lands are inundated. Detailed summary information about rising sea level in the US is available in the **US Climate Resilience Toolkit**[220].

Specific marine habitat features such as shellfish beds, live hardbottoms, SAV and coral have been lost due to human impacts. Data on the regional extent of loss of these habitat features is uncertain however because the full distribution of these habitat features is generally lacking.

The Northwest Atlantic Marine Ecoregional Assessment (Greene et al. 2010) compiled a baseline of the scientific information available on the status and distribution of key species and habitats in the Marine Nearshore and Marine Offshore and Oceanic habitats of the Northeast. Top regional threats to the marine seascape as a whole include Pollution and nutrient runoff (Threat 9.0), coastal Development (Threat 1.0), Sea Level Rise (Threat 11.1.1), and fisheries (Threat 5.4). Regional threats to the habitats of several marine species groups are listed in Table 2.20.3.

Globally, coral reef, seagrass and mangrove ecosystems in the Marine Nearshore "are the most vulnerable to rapid human impact compared to larger and deeper ecosystem types" with the highest average cumulative impacts and the fastest rate of increase in cumulative impacts (Halpern et al. 2019, p. 2). Subtidal soft bottom and deep-water ecosystems have the least cumulative human impact as of 2013 and the lowest rates of increase in impacts. Climate stressors are the dominant drivers of change in the Marine Nearshore, but shipping and land-based pressures are also increasing (Halpern et al. 2019). Regionally, New England and maritime Canada have relatively high cumulative impacts from human activities in marine habitats compared to the Mid-Atlantic and Southeast regions (Halpern et al. 2019). Halpern et al. (2019) provides a detailed analysis of the global threats and impacts to multiple estuarine and marine habitat types, from salt marsh to coral reefs, rocky intertidal shorelines to kelp forests.

Halpern et al. (2019, p. 5) state that "if current trajectories of change persist, the global cumulative impact of humans on the ocean will be profound and may rapidly push many ocean regions past critical tipping points of sustainability. … Coordinated, comprehensive management that accounts for multiple stressors can leverage decreases in single stressors to accommodate potential increases in others when making strategic development and conservation decisions. Results also highlight that spatial variability in the local manifestation of climate change may offer local refugia that can be targeted for protection and management to 'buy time' in efforts to mitigate and adapt to a changing climate."

Halpern et al. (2019, p. 6) argue that "To help support the global human population and mitigate the impacts we are having on our landscapes, we are shifting our impacts into the sea. How much more change can these ecosystems endure?"

Nationally coastal habitats are increasingly threatened by Sea Level Rise (Threat 11.1.1), coastal Flooding (Threat 11.4), water Pollution (Threat 9.0), Harmful Algal Blooms (Threat 8.2.9) and other hazards (NCCOS 2022). Detailed information about the impacts of climate change and sea level rise on marine systems can be found in the US Climate Resilience Toolkit[220] and regionally in Staudinger et al. (2023).

Table 2.20. 3 The Northwest Atlantic Marine Ecoregional Assessment evaluated the regional threats for numerous Northeast RSGCN and Watchlist species in Greene et al. (2010).

Species Group	Regional Threats to Marine RSGCN and Watchlist Species Habitat
Diadromous fish (Chapter 6)	Fishing (Threat 5.4) Dams and their operation (Threat 7.2.1) Pollution (Threat 9.0) Entrainment and impingement at power plants (Threat 7.2.6) Invasive species (Threat 8.1) Climate change (Threat 11.0)
Demersal fish (Chapter 7)	Fishing (Threat 5.4) Climate change (Threat 11.0) Offshore energy development (Threat 3.1 and 3.3) Changes in water temperature and entrainment mortality at power plants (Threat 9.6.2 and 7.2.6) Coastal development (Threat 1.0) Pollution (Threat 9.0) Natural system modifications (Threat 7.3 and 4.3) Invasive species (Threat 8.1)
Small pelagic fish (Chapter 8)	Pollution (Threat 9.0) Climate change (Threat 11.0) Fishing impacts (Threat 5.4) Entrainment at power plants (Threat 7.2.6)
Large pelagic fish (Chapter 9)	Fishing (Threat 5.4.2) Bycatch (Threat 5.4.2) Multiple aspects of climate change (Threat 11.0)
Cetaceans (Chapter 10)	Bycatch (Threat 5.4.2) Fishing gear entanglement (9.4.4) Vessel collisions (Threat 4.3.1) Depletion of prey resources Noise pollution (Threat 9.6.3) High levels of marine contaminants (Threat 9.2 and 9.4)

Species Group	Regional Threats to Marine RSGCN and Watchlist Species Habitat
Sea Turtles **(Chapter 11)**	Bycatch (Threat 5.4) Natural system modifications (Threat 7.3) Coastal development (Threat 1.0) Multiple types of pollution (Threat 9.2, 9.3, 9.4 and 9.6.1) Fishing gear entanglement (9.4.4) Vessel collisions (Threat 4.3.1)
Birds **(Chapter 12)**	Human disturbance (Threat 6.1) Shoreline stabilization (Threat 7.3.1 and 7.3.4) Dredging (Threat 4.3.2) Bycatch (Threat 5.4.2)

The **Northeast Regional Marine Fish Habitat Assessment** was completed in 2022 by NOAA, the New England Fishery Management Council, Mid-Atlantic Fishery Management Council and other conservation partners[221]. This regional habitat assessment describes and characterizes estuarine, nearshore, and offshore fish habitat distribution, abundance, and quality in the Northeast region. The **Northeast Regional Habitat Assessment Data Explorer Tool**[222] provides an interactive, publicly available resource to explore trends data in fish species distribution at both the state and regional scales and to access the data collected and reports prepared as part of the assessment.

The New England and Mid-Atlantic Fishery Management Councils monitor the status of the Northeast marine ecosystems, collaborating with NOAA to issue annual **State of the Ecosystem Reports** on the New England and Mid-Atlantic shelf systems (NOAA 2022a, 2022b). These monitoring reports assess the trends and status of several indicators related to seascape scale fishery management objectives. Monitoring indicators are described in *Chapter 5*.

The ACFHP compiled an **Assessment of Existing Information on Atlantic Coastal Fish Habitat** on priority threats to Atlantic coastal habitats in 2009, including the Marine Nearshore, with more than 500 data sources[223]. The Atlantic States Marine Fisheries Commission published a comprehensive review of habitat information for diadromous fish under its management authority called the **Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs**, which found that the top threats are barriers to migration between habitats, water withdrawal facilities, toxic and thermal discharges, channelization and dredging, land use change that causes pollution, atmospheric deposition (acid rain), reduced dissolved oxygen and climate change (Greene et al. 2009). SWAP information from the Northeast coastal states was incorporated into this review.

Kritzer et al. (2016) ranked the importance of 25 freshwater, estuarine and Marine Nearshore habitat types for 131 species of fish and motile invertebrates along the Atlantic coast of the US, dividing the coast into four regions from the Canadian border to south Florida. In the North Atlantic region (Canadian border to Cape Cod) 34 species were evaluated and in the Mid-Atlantic region (Cape Cod to Cape Hatteras) 53 were evaluated. In the North Atlantic and Mid-Atlantic regions, the most valuable habitat type was coastal inert substrate, or soft bottom substrates, followed by Rivers and Streams diadromous fish habitat. SAV, marine and estuarine shellfish beds and other live hardbottom habitats were also of high value to fish and motile invertebrate species. Kritzer et al. (2016, p. 279) refers to soft sediment substrates (with and without structure) as “unsung habitat heroes” along the Atlantic coast and particularly in the North Atlantic and Mid-Atlantic regions and caution against assessing them as less valuable than other estuarine and marine habitat types when siting offshore energy and development projects.

NY DOS (2013) developed several datasets for the Marine Nearshore and Marine Offshore and Oceanic areas for the area between Rhode Island and New Jersey. Datasets related to habitat condition include the location and characteristics of human uses (e.g., commercial and recreational fishing, recreational boating, commercial shipping lanes, nature viewing) and infrastructure and regulated areas (e.g., unexploded ordnance, navigation lanes, turning basins, dump sites, fiber-optic cables, electric transmission cables, pipelines).

Marine ecosystems are ecologically connected through processes such as larval transport and post-recruitment spillover and the movement of marine mammals, fish, whales, seabirds and other species between biological hotspots. Diadromous fish in particular illustrate the connectivity between freshwater, estuarine and marine systems, migrating between the systems for different life stages. Some marine RSGCN and Watchlist species such as Tautog (*Tautoga onitis*), Weakfish (*Cynoscion regalis*), and Atlantic Croaker (*Micropogonias undulatus*) use Estuaries for spawning, larval development, juvenile nursery habitat or seasonal summer use as adults. Kritzer et al. (2016) describes the need to manage distinct marine and estuarine systems as an interconnected mosaic rather than distinct habitats because of the movement of marine and estuarine species between habitat types, features or formations seasonally or for different life stages. “A systematic literature review of evidence for movement across habitats from juvenile to adult stages illustrates that most species of economically important fish in the United States and Australia move among different habitats throughout their lives" (Kritzer et al. 2016, p. 281). As fish and wildlife move between coastal habitats, they facilitate the transfer of nutrients and carbon between food webs (Greene et al. 2010).

Wenzel et al. (2020) defines connectivity within the Marine Nearshore in two ways. Habitat connectivity is the link between geographically separated habitats of the same type such as larval dispersal among coral reefs. Seascape connectivity is the link between different types of habitats within the same ecosystem, such as diadromous fish migrating from the Marine Nearshore to Tidal Rivers and Streams for spawning. Both types of connectivity are important to protect marine fish and wildlife resources.

NOAA has identified ways that MPA can be connected in networks of protected areas, as defined by IUCN[224]. Wenzel et al. (2020) provides recommendations on conservation actions that would improve MPA connectivity, including 'other effective conservation measures' that are not designation of additional MPAs such as military exclusion zones or fishery closures. Although a comprehensive inventory of these 'other effective conservation measures,' as defined by IUCN, has not been developed for the Northeast region, the National MPA Center identified approximately 3% of US waters in such areas as of 2008 (Wenzel et al. 2020).

No comprehensive assessments have been completed for resiliency of Marine Nearshore habitat in the Northeast. The Smithsonian's **Tennenbaum Marine Observatories Network (TMON) Marine Global Earth Observatory (MarineGEO)** program has a number of research projects underway to address this data need by increasing understanding of the Marine Nearshore and Marine Offshore and Oceanic habitats and how biodiversity strengthens resiliency. One study involves research into the ability of the marine ecosystem to withstand the introduction of non-native species such as the invasive Lionfish (*Pterois miles* and *Pterois volitans*) that is moving north into the Northeast, a project that involves standardized field experiments to test the interaction between native predators and non-native species. Detailed information about MarineGEO and its projects can be found through the program's website[225].

The **US Climate Resilience Toolkit** provides numerous detailed resources to improve coastal and marine habitat resiliency with climate change[220]. **Coastal Risk Reduction and Resilience: Using the Full Array of Measures** provides a summary of the potential resilient processes and environmental outcomes of natural, nature-based, nonstructural and structural coastal risk reduction measures, including for coral reefs (USACE 2013, see Appendix A).

2.20.5 HABITAT MANAGEMENT

The federal **Ocean Policy Committee (OPC)** was established by Congress in 2021 as a secretary-level interagency body co-chaired by the Council on Environmental Quality (CEQ) and Office of Science and Technology Policy[226]. The OPC has two subcommittees – the Ocean Resource Management Subcommittee to coordinate policy across the federal government and the Ocean Science and Technology Subcommittee to coordinate science and technology, plus oversee a National Ocean Mapping, Exploration and Characterization Council. An Ocean Research Advisory Panel advises the OPC with non-federal expertise from academia, tribes, states, industry and the National Academies. The OPC **2022-23 Action Plan**[227] was released in July 2022 with three goals:

- Maximize the environmental, economic, and social benefits that the ocean provides to all Americans
- Develop an ocean-based climate plan to coordinate Federal agency actions on ocean-based climate solutions
- Strengthen the US ocean science and technology enterprise by advancing ocean science, technology, innovation, and partnerships to address societal needs

As of the fall of 2022, the OPC is developing a **US Ocean Climate Action Plan** and a **National Strategy for a Sustainable Ocean Economy**, both guided by the Ocean Resource Management Subcommittee. The **National Oceanographic Partnership Program (NOPP)**[228] now operates under the Ocean Science and Technology Subcommittee of the OPC, led by Secretary of Navy in coordination with NOAA. The NOPP is a partnership to facilitate ocean science research and education between federal agencies, states, tribes, academia and industry.

The Atlantic Coastal Fish Habitat Partnership (ACFHP) **Conservation Strategic Plan 2017-2021 and its accompanying Conservation Strategic Plan 2020-2021** identify priority habitats, threats and conservation actions for diadromous, estuarine-dependent and marine fish (ACFHP 2017, 2020). The ACFHP has developed a number of decision-making tools addressing the conservation needs of fish and their habitats along the Atlantic coast, including a species-habitat matrix tool to evaluate the relative importance of specific habitat types for a given life history stage of an individual species (Kritzer et al. 2016) and the estuarine and diadromous sections of the **Fish Habitat Decision Support Tool** that visualizes and ranks fish habitat[229].

MA Ocean Management

Massachusetts has an Ocean Management Plan, updated in 2021, that outlines a management framework for Habitat, Fisheries, Transportation and Navigation, Cultural Heritage and Recreational Uses, and Sediment and Geology in the state's Marine Nearshore.

Priority management recommendations include identifying habitat maps for numerous species and species groups, ensuring that corridors for whale movement between core areas be considered in ocean planning and permitting, developing a framework for identifying classes of ocean construction that are incompatible with vulnerable, structure-forming seafloor organisms, developing a framework for protecting sea turtles during ocean development activities, possibly establishing protection for sand lance, and updating siting and performance standards for ocean activities in core habitat areas for sea ducks.

Numerous RSGCN and Watchlist species are managed by the NOAA Fisheries, New England Fishery Management Council[203], Mid-Atlantic Fishery Management Council[204], and Atlantic States Marine Fisheries Commission[205], with management plans that address habitat as well as species populations. A group of highly migratory species (HMS) of marine fish are managed jointly by NOAA Fisheries under the **Atlantic HMS Fishery Management Plan[230]**. RSGCN and Watchlist marine fish managed as HMS in this management plan include Bluefin Tuna (*Thunnus thynnus*), Common Thresher Shark (*Alopias vulpinus*), Scalloped Hammerhead (*Sphyrna lewini*), Shortfin Mako (*Isurus oxyrinchus*), and White Shark (*Carcharodon carcharias*). Internationally HMS are managed by the **International Commission for the Conservation of Atlantic Tunas (ICCAT)[231]** and include RSGCN Bluefin Tuna and White Marlin (*Kajikia albida*), although several pelagic oceanic sharks are also of interest like Watchlist Blue Shark (*Prionace glauca*) and RSGCN Shortfin Mako.

Ocean and marine planning has increased in recent years, with national efforts by the Ocean Policy Committee and Bureau of Ocean Energy Management, regional efforts by Northeast Regional Ocean Council and Mid-Atlantic Regional Council on the Ocean, and state efforts by Massachusetts and New York. Increasing proposals to develop offshore wind energy is driving new scientific research and conservation efforts in the Marine Nearshore of the Northeast, with conservation measures to avoid, minimize and mitigate adverse impacts to fish and wildlife resources and their habitats under development. Greene et al. (2010) recommend several management techniques to reduce human impacts and enhance recovery of marine benthic habitats.

Staudinger et al. (2023) describes the state of knowledge of adaptive management of Marine Nearshore habitats to climate change. Many fish species are shifting northward with warming waters along the US Atlantic Coast due to climate change. Kritzer et al. (2016, p. 282) observes that the North Atlantic region is experiencing more rapid changes in species distributions than the rest of the country and predicts that “marsh-dependent [fish] species that are currently absent or rare in the North Atlantic [will] become more prominent because of these observed range shifts from the Mid-Atlantic region.” Staudinger et al. (2023) summarizes the current understanding of range shifts for marine RSGCN species in the Northeast.

2.20.5 HABITAT MONITORING

The North Atlantic Ocean is home to numerous regional monitoring partnerships and programs. The Tennenbaum Marine Observatories Network and its MarineGEO program[225] is a collaborative global network of coastal research partners who are cataloging the coastal marine life of the world, seeking to understand how and why it is changing and what the consequences of that change are for people. Administered by the Smithsonian, TMON directs and coordinates research efforts, collecting long-term data with standard protocols across multiple scientific disciplines. The partnership network is filling a critical data need by creating a comprehensive database of standardized information on the biological diversity of the Marine Nearshore.

The **Atlantic Deepwater Ecosystem Observatory Network (ADEON)**, hosted by the University of New Hampshire, was deployed in 2017 along the outer continental shelf of the Mid- and South Atlantic between 100- and 1000-meters water depth[232]. The long-term monitoring project measures a number of natural and human factors to inform the ecology and soundscape of the outer continental shelf. The network monitors marine sound, the presence of vocalizing marine life (fish and marine mammals), the presence of non-vocalizing marine life (zooplankton, fish, marine mammals), a biodiversity indicator, presence of vessels, and a number of oceanographic variables. The study area includes the southern portion of the NEAFWA region, from the mouth of Delaware Bay south through Virginia.

Multiple programs and projects within NOAA monitor aspects of the Marine Nearshore and Marine Offshore and Oceanic habitats of the Northeast. NOAA Fisheries monitors recreational and commercial fishing in the Marine Nearshore, including for several species that are RSGCN or Watchlist species in the Northeast. The **NOAA Northeast Fisheries Science Center (NEFSC)** conducts several ecosystem surveys in the Marine Nearshore of the region, including a database of biannual fisheries-independent bottom trawl surveys, from the 1960s to present. Data from NEFSC surveys are available online through NOAA[233]. The NEFCS **Marine Resources Monitoring, Assessment and Prediction Program (MARMAP)** conducted periodic standardized surveys of the Northeast Marine Nearshore and Marine Offshore and Oceanic areas at 193 stations from Cape Sable, Nova Scotia, to Cape Hatteras, North Carolina from 1977 to 1988.

Since 1992 portions of the MARMAP survey design were continued with the **Ecosystem Monitoring Program (EcoMon)** for long-term monitoring at 120 stations[234]. NOAA and collaborators have developed a monitoring tool and database of ocean acidification data in marine waters of the US[235].

The **Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS)[236]** collects ocean information with a regional network, consolidating information in one place and supporting long-term ecosystem monitoring projects. Ongoing projects relevant to Marine Nearshore habitat include the following, with detailed information on each at http://neracoos.org/projects/:

- Northeast Integrated Ocean Observing Network (IOOS)
- New England Coastal Acidification Network (NECAN)
- Integrated Sentinel Monitoring Network for Change (ISMN)
- Marine Biodiversity Observation Network (MBON)
- Ocean Acidification Information Exchange (OAIE)
- Coastal Ocean Model Testbed (COMT)
- NOAA Physical Oceanographic Real Time System (PORTS)
- Harmful Algal Bloom Observing Network for New England (HABON-NE)

Woods Hole Sea Grant conducts annual surveys of kelp forests in New England at 15 sites from Rhode Island to Maine as part of the global **Kelp Ecosystem Ecology Network (KEEN)**, which indicate that kelp forests have been declining in the Gulf of Maine since the late 1970s. KEEN-New England[237] offers training for researchers, technicians and students for survey protocols and species identification.

The EPA uses ecological monitoring data from the Northeast to track shifting ranges of marine species as climate change indicators[238]. The Marine range shifts of RSGCN American Lobster (*Homarus americanus*) and Black Sea Bass (*Centropristis striata*) are two of the indicator species, with maps available that illustrate the northward shifts from 1973 to 2019.

The **Integrated Sentinel Monitoring Network[239]** is supported by numerous Northeast conservation partners, including the Northeast Regional Ocean Council, Marine Biodiversity Observation Network (MBON), Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS), Bureau of Ocean Energy Management, Environmental Protection Agency, National Oceanic and Atmospheric Administration, the states of Connecticut and New Hampshire, and numerous academic and non-governmental organizations. Established in 2019, this “network of networks” aims to convene the Northeast region’s ocean monitoring projects into one resource with three objectives:

- Find and fill gaps in present ecosystem observation activities,
- Facilitate data sharing, integration, and communication among existing monitoring efforts, and
- Synthesize results to make individual project results more impactful

An inventory of regional monitoring projects in the marine seascape of the Northeast is available online[240].

The **Marine Biodiversity Observer Network[241]** is a national network of monitoring programs, with the NERACOOS program through the Integrated Sentinel Monitoring Network, administering the MBON project in the Gulf of Maine ecosystem. The goal of this monitoring effort is to identify and understand long-term changes in the Gulf of Maine ecosystem, with a focus on plankton biodiversity. The copepod *Calanus finmarchicus* serves as the primary indicator species because of its important role in the marine food web, serving as a dominant food source for RSGCN herring and North Atlantic Right Whale (*Eubalaena glacialis*) plus the Watchlist [Interdependent] Sand Lances (*Ammodytes americanus* and A. *dubius*).

Partners in the Integrated Sentinel Monitoring Network periodically convene **Centers for Analysis, Prediction and Evaluation (CAPE)** to conduct expert analysis and interpretation of monitoring data. The scope, scale, and duration of a thematic CAPE varies, as does membership among the expert partners. One current CAPE is currently analyzing monitoring datasets on the abundance of zooplankton to develop spatial maps and predictions of change for key marine species, thus informing foraging habitat for marine fish and whales. Analysis results from CAPE assessments are available online[242].

The Northeast Regional Ocean Council recently supported a monitoring assessment of the Marine Nearshore and Marine Offshore and Oceanic areas of the Northeast, from the Canada Maritime Provinces to Long Island Sound, the results of which are described in Montgomery et al. (2021). This seascape level monitoring effort is discussed in *Chapter 5*.

Other seascape level monitoring programs address particular threats or species. For example, NOAA maintains the **Invasive Lionfish Web Portal** to monitor the spread of invasive Lionfish in the Atlantic and Gulf of Mexico[243]. The ICCAT Regional Observer Program for Bluefin Tuna monitors the harvest and bycatch of Bluefin Tuna in the Atlantic, a Northeast RSGCN of High Concern and increasing regional responsibility with the recent discovery of a spawning area in the region. NOAA also maintains a **Deep-sea Coral National Observation Database for the Northeast Region[244]**.

2.20.6 PARTNERS

Conservation partners collaborating to protect Marine habitats in the region are described in *Chapter 7*, including the:

- Northeast Regional Ocean Council
- Mid-Atlantic Regional Council on the Ocean
- NOAA Fisheries
- Atlantic Coast Fish Habitat Partnership
- New England Fishery Management Council
- Mid-Atlantic Fishery Management Council
- Atlantic States Marine Fisheries Commission

In addition to these partners, NOAA's **National Centers for Coastal Ocean Science (NCCOS)**[245] also conducts a number of research projects in the Marine Nearshore and Marine Offshore and Oceanic areas and provides funding opportunities through the Competitive Research Program and the RESTORE Science Program. The National Centers for Coastal Ocean Science **Strategic Plan for Fiscal Years 2022-2026** has six priority science goals which could help inform SWAPs understand the condition and threats to coastal habitats (NCCOS 2022, p. 2):

- Advancing ecosystem science for conservation and sustainable use
- Developing and implementing advanced observation technologies and ecological forecasts
- Facilitating resilience and adaptation to inundation and climate impacts
- Detecting, monitoring, and mitigating impacts of chemical and biological stressors
- Advancing social, economic, and behavioral approaches to coastal stewardship
- Investing in our people and achieving organizational excellence

The NCCOS ecosystem science priority has four sub-priority focal areas to inform decision-making: marine spatial mapping, habitat mapping, biogeographic / ecological assessments and research, and monitoring and research in coral reef ecosystems. Ecological forecast products include pathogens, hypoxia, harmful algal blooms and coastal habitats. The three sub-priorities for scientific projects facilitating resilience and climate change adaptation address ecosystem change, community and ecosystem vulnerability, and evaluation of habitat restoration and NNBF projects. NCCOS research on chemical stressors includes quantifying bioaccumulation and establishing acute and chronic effects thresholds for several marine and estuarine species and taxa (NCCOS 2022). One of NCCOS research facilities are located in the Northeast region – the Cooperative Oxford Laboratory on Chesapeake Bay in Maryland, providing an opportunity for regional collaboration. Detailed information about NCCOS projects, data, reports and funding opportunities can be found through the program's website[246].

The **National Oceanographic Partnership Program[228]** is a partnership to facilitate ocean science research and education between federal agencies, states, tribes, academia and industry. Since 1997 the NOPP has funded more than 200 projects, including environmental monitoring, ocean exploration and marine resource management. Each project must have at least one federal and one non-federal partner. A list of NOPP funded projects can be found at https://nopp.org/projects/nopp-project-table/. One NOPP project is the **Atlantic Deepwater Ecosystem Observatory Network**[232], deployed in 2017.

The federal **Bureau of Ocean Energy Management (BOEM)[247]** manages resources in federal waters of the Marine Nearshore and Marine Offshore and Oceanic habitats of the Northeast, including marine minerals, oil and gas, and wind energy development. As part of their leasing activities, the BOEM Environmental Studies Program develops, funds and manages a variety of scientific research projects on marine fish and wildlife resources and their habitats in potential lease areas. The Atlantic **Marine Assessment Program of Protected Species (AMAPPS)[248]**, for example, is supported by BOEM along with partners USFWS and the US Navy to develop models on the seasonal distribution and abundance of marine protected species including sea turtles, whales and dolphins. Data from ongoing and completed BOEM environmental studies is available through the agency's Marine Cadastre website[249]. Maps produced by BOEM and its programs, including an atlas of large submarine canyons (including nine in the Northeast region), are also available[250].

Current federal leases for offshore wind energy development issued by BOEM stretch from Massachusetts to Virginia. In 2019 the BOEM established a **Gulf of Maine Task Force** as an intergovernmental panel of federal, tribal, state and local officials from Maine, New Hampshire and Massachusetts to guide the planning of offshore leases for wind energy development in the Gulf of Maine. Information about the Task Force and BOEM planning for new offshore wind energy leases in this area of the region can be found through the agency's online platform[251].

The **North Atlantic Coast Cooperative Ecosystems Studies Unit (CESU)** is part of a national network of CESUs, each a collaborative partnership of federal, university, NGO, museum and other entities[252]. The North Atlantic Coast CESU is hosted by the University of Rhode Island and has nine federal partners, one tribal partner (the Narragansett Indian Tribe), and 35 colleges, universities, research institutions, conservation organizations and marine aquarium partners. The Unit supports research, education and technical assistance to inform decision-making within a number of natural and cultural resources areas, including Estuaries, Tidal Wetlands and Flats, Beaches and Dunes, other Shorelines, and the Marine Nearshore. Detailed information about North Atlantic Coast CESU projects can be found on their website[253].

The **Atlantic Marine Birds Cooperative[254]** is a collaborative partnership of agencies, organizations and scientists working on the conservation of marine birds. Active Working Groups address the topics of bycatch, citizen science and disease, forage fish, marine spatial planning, and seabird colonies and adjacent waters.

The Ocean Conservancy is a conservation NGO with a mission to protect the world's ocean and its wildlife[255]. Key program areas at the Ocean Conservancy include ocean justice, climate change, smart ocean planning, government relations, sustainable fisheries, trash free seas, and geographic focus areas on Florida and the Arctic. New Jersey's promotion of blue carbon in coastal areas as part of the **Regional Greenhouse Gas Initiative** is highlighted by the Ocean Conservancy as a state success story for addressing climate change in oceanic habitats.

Chapter 7 describes additional partners in seascape conservation in the Northeast region.

2.20.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of Marine Nearshore habitat through several ongoing citizen science projects. NOAA Fisheries manages a network of volunteer marine mammal stranding and entanglement organizations that enhance the surveillance capabilities of state, tribal and federal agencies[256]. The federal agency also administers the **Right Whale Sighting Advisory System** that accepts public observations, among other surveys, to identify the presence of RSGCN and federally-endangered North Atlantic Right Whale in marine waters to reduce collisions with ships[257]. **Whale Alert** is a smartphone app that allows the public and mariners to report all whale observations to lower the risk of ship strikes and at the same time helps the public identify whales they see[258].

Several citizen science projects for **National Marine Sanctuaries** can be found through NOAA[259]. In the Northeast, one such project is the Stellwagen Seabird Stewards Program that collects seabird sightings from experienced birders. Multiple other programs include volunteers to increase awareness and support for the Stellwagen Bank National Marine Sanctuary in a variety of ways. The Stellwagen Bank National Marine Sanctuary also is a Sister Sanctuary Program with marine mammal sanctuaries in the Caribbean, sharing citizen science efforts from the **CARIB Tails** project[260] to capture tail photographs of RSGCN Humpback Whale (*Megaptera novaeangliae*) in their Caribbean breeding grounds and North Atlantic summer feeding grounds, documenting migratory connections.

The **Seabird Ecological Assessment Network (SEANET)** is a citizen science program initiated by the Tufts Center for Conservation Medicine and the Lloyd Center for Environmental Studies in Massachusetts to identify and mitigate threats to marine birds[261].

Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

2.20.8 HABITAT INFORMATION, RESEARCH AND MONITORING NEEDS

Greene et al. (2009, see Chapter 12) identified habitat research information needs for seven RSGCN diadromous fish managed by the ASMFC. Information needs for diadromous fish in the Marine Nearshore include:

- Model the effects of climate change by determining the impacts of changes in pH and temperature on all life stages
- Determine which contaminants have an impact on various life stages and at what concentrations
- Identify unknown optimal and tolerance ranges for depth, temperature, salinity, dissolved oxygen, pH, substrate, current velocity and suspended sediments
- Determine the impacts of channel dredging, shoreline filling and overboard spoil disposal
- Define necessary restrictions for implementation of energy projects in diadromous fish habitat areas and develop policies on limiting the spatiality or seasonality of development projects

2.21 MARINE OFFSHORE & OCEANIC

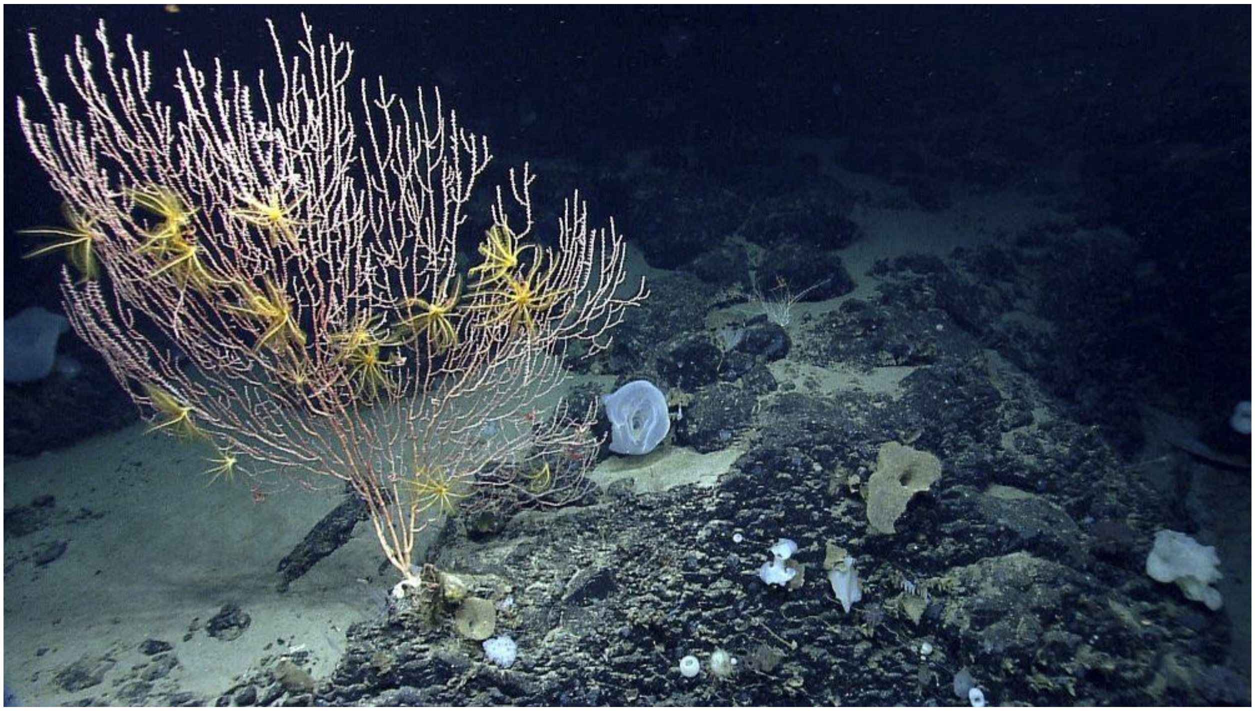

Figure 2.21. 1 Marine Offshore and Oceanic habitats support 75 Northeast RSGCN and Watchlist species. (Canyons and Seamounts National Marine Monument photo credit: NOAA).

2.21.1 HABITAT DESCRIPTION

Marine Offshore and Oceanic habitat includes both the seafloor and benthic habitat as well as the pelagic water column and is located seaward of Marine Nearshore habitat, which extends to approximately 200 meters of water depth and is generally located on the continental shelf break or slope. The Marine Offshore and Oceanic area of the Northeast region includes a number of submarine canyons, deep-sea coral ecosystems, and in some areas the edge of the abyssal plain.

Marine habitats can be classified with the Coastal and Marine Ecological Classification Standard, which characterizes habitats into Biotopes using their biogeographical component, aquatic setting, geoform component, substrate component and biotic component (FGDC 2012). The CMECS also includes a series of seven types of modifiers to further describe CMECS units, such as anthropogenic impacts and physicochemical metrics. The National Ocean Service of NOAA maintains a database of projects where CMECS has been applied to classify marine and estuarine areas, with an interactive map available[211].

The 14 Northeast SWAPs of 2015 include 21 Key Habitats for SGCN in the Marine Offshore and Oceanic area of the region (*Appendix 2A*, Table 2A.21). Some of these Key Habitats are specific features and formations like rocky reefs. Others are broader and include the water column, upwelling zones or substrate types like bedrock, gravel, or soft sediment.

There are 48 RSGCN, three Proposed RSGCN, 15 Watchlist [Assessment Priority], two Watchlist [Interdependent Species] and one Proposed Watchlist species across six taxonomic groups associated with Northeast Marine Offshore and Oceanic habitat (*Supplementary Information 2*, Table 2.21.1, Figure 2.21.2). Another six species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. RSGCN and Watchlist species associated with the Marine Offshore and Oceanic habitat include 14 sharks, seven diadromous fish, seven birds, four federally-listed sea turtles, five skates and rays, five marine invertebrates, and six whales (five of which are federally-listed) (Figure 2.21.2). Twelve RSGCN and Proposed RSGCN associated with the Marine Offshore and Oceanic habitat of the Northeast are of Very High Concern.

2.21.2 HABITAT DISTRIBUTION AND CONSERVATION

There are 13 major submarine canyons between the Gulf of Maine and Cape Hatteras, plus abundant minor canyons (Ross and Brooke 2012). The Hudson Shelf Valley and Hudson Canyon complex extending offshore from the Hudson River in New York is the largest submarine canyon on the US Atlantic Coast (NY DOS 2013).

Table 2.21. 1 The number of species in each RSGCN and Watchlist category associated with Marine Offshore and Oceanic habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	48
Proposed RSGCN	3
Watchlist [Assessment Priority]	15
Proposed Watchlist [Assessment Priority]	1
Watchlist [Interdependent Species]	2
Watchlist [Deferral to adjacent region]	6
TOTAL	**75**

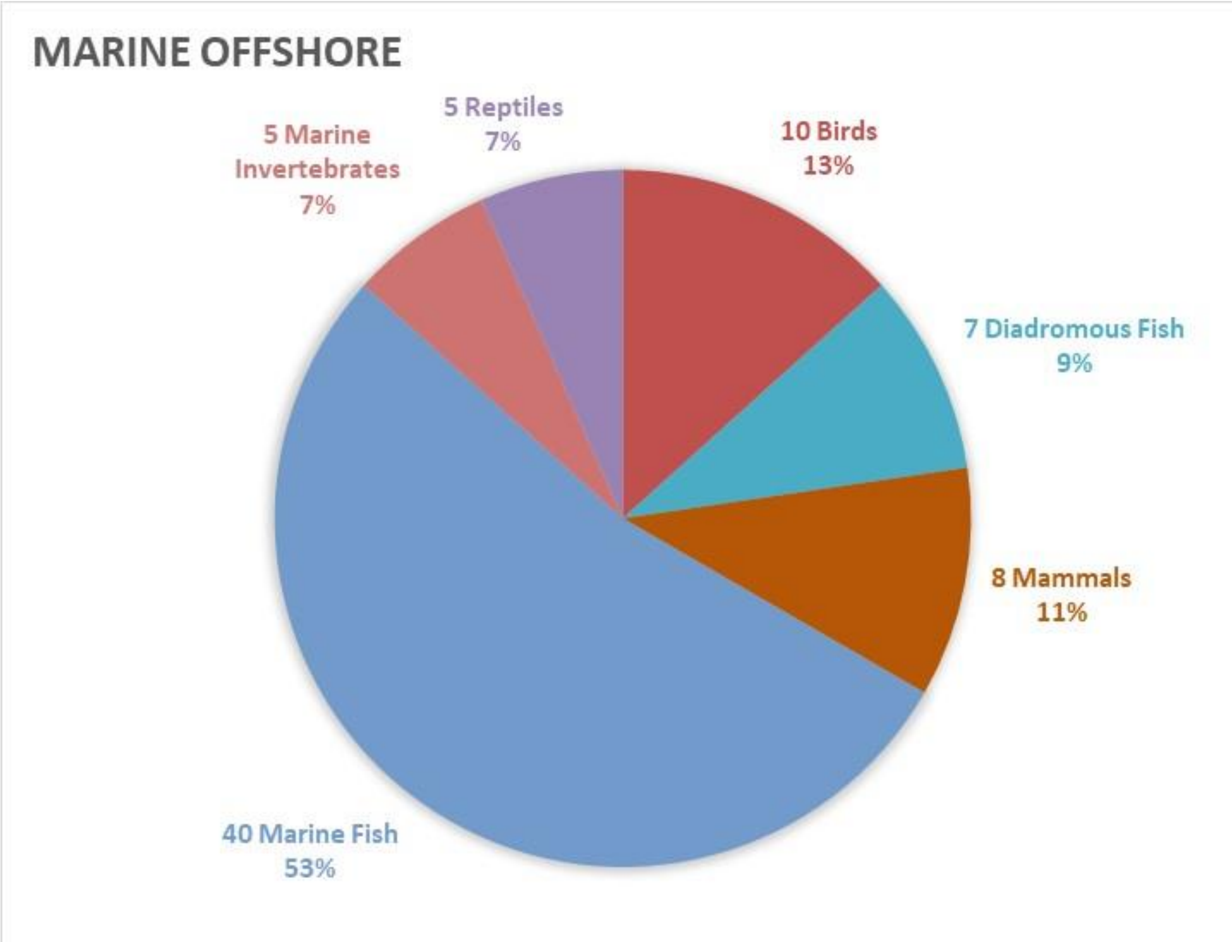

Figure 2.21. 2 Northeast RSGCN and Watchlist species associated with Marine Offshore and Oceanic habitats represent six taxonomic groups.

The Northwest Atlantic Marine Ecoregional Assessment (Greene et al. 2010) compiled a baseline of the scientific information available on the status and distribution of key species and habitats in the Marine Nearshore and Marine Offshore and Oceanic habitats of the Northeast, as described in Section 2.20.2. Regional Marine Offshore and Oceanic areas that were identified as important habitat for large pelagic species in the Northwest Atlantic Marine Ecoregional Assessment include the shelf-slope break (200-1000 m water depth) for the entire Northeast and the area between Washington and Norfolk canyons, particularly for adult large pelagic fish (Greene et al. 2010).

Three of the four RSGCN sea turtle species were evaluated by Greene et al. (2010, see Chapter 11), with important habitat areas vary by species and season. Leatherback Sea Turtles are the only species known to range into the Marine Offshore and Oceanic habitat of the region, typically concentrated farther offshore than other sea turtles during the warmer months in the Marine Nearshore out to the inner continental shelf from southern Long Island to Maryland and along the shelf break for the entire region.

More than 2000 species of invertebrates live on the seafloor of the Marine Nearshore and Marine Offshore and Oceanic habitats of the Northeast, from marine worms to scallops, corals to crab. Each of these benthic invertebrates is adapted to particular habitat characteristics such as sediment type and grain size, water depth and topography. Greene et al. (2010) identified and mapped more than 70 of the most common benthic habitat communities in the region.

Deep-sea or cold-water corals are those that live in waters at least 50 meters deep, occurring in both Marine Nearshore and Marine Offshore and Oceanic habitats. In the Northeast, deep-sea corals are present in the canyons south of Georges Bank and on the surrounding sea mounts and continental slope. Smaller areas of soft coral and sea pens, which do not need hardbottoms, occur in some areas of the Gulf of Maine both close to shore and farther offshore (NEFMC 2020).

In the Mid-Atlantic, a recent project supported by MARCO surveyed the submarine canyons and deep-sea coral of the continental shelf break. **Deep-water Coral and Fish of the U.S. Mid-Atlantic Canyons: Implications for Management and Conservation**, published in 2020, found that:

> *Submarine canyons like those found off the Northeast and Mid-Atlantic U.S. coast are some of the most productive deep-sea habitats, hosting remarkably high biological abundance and diversity. Animals living in these hotspots are vulnerable to human disturbance and rapidly changing oceanic conditions. Despite their high potential for containing undiscovered new species and as-yet unknown natural resources, more than 90 canyons along the U.S. East Coast remain largely unexplored.* (Shank and Heyl_2020, p. 1)

This study included 28 surveys of eight submarine canyons in the Mid-Atlantic region between 2013 and 2014, finding that 13 major types of deep-sea corals dominate the marine seascape in the canyons. The highest coral diversity and abundance was documented between 800 and 1600 m water depth (2624 and 5250 ft). Deep-sea coral ecosystems support more than 3500 invertebrate species globally plus many commercially important fish and provide biomedical resources for at least 20 human diseases. In this Mid-Atlantic study, 45 species of marine fish were identified in the coral areas (Shank and Heyl 2020).

Deep-sea corals are managed by the NEFMC and MAFMC, with the ecological importance and vulnerability of coral habitats described in NEFMC (2020) and MAFMC and NMFS (2016). The MAFMC has designated 15 discrete protection zones of deep-sea coral between 450 and 500 m water depth offshore New York, New Jersey, Delaware, Maryland and Virginia. The NEFMC, MAFMC and South Atlantic Fishery Management Council have developed a Memorandum of Understanding to jointly conserve deep-sea coral across their three management areas in the Atlantic Marine Offshore and Oceanic (MAFMC and NFMS 2016).

The USGS developed the **Cold-Water Coral Geographic Database**[212] with records of coral in the Northwest Atlantic and Gulf of Mexico from 1880 to 2008. NOAA maintains the **National Deep-Sea Corals and Sponges Database**[244], with a digital map of deep-sea coral and sponge locations, site characterization reports, and habitat suitability models. NY DOS (2013) identified 5619 records of known deep-sea coral and sponge locations, adding other records to the USGS database for the region between Rhode Island and New Jersey.

Greene et al. (2010, p. 3-26) developed a Benthic Habitat map for the Northwest Atlantic that includes the Marine Nearshore and Marine Offshore and Oceanic habitats of Northeast RSGCN, with descriptions of the characteristic water depth, seafloor topography, sediment type and benthic invertebrate species assemblages for each benthic habitat. This Benthic Habitat map is available through the Northeast Ocean Data Portal[216].

Much remains not well known about many marine species and their habitat requirements, with some new information about the Northeast region's importance to many species seasonally and for different life stages. The RSGCN Atlantic Bluefin Tuna, for example, was known to spawn only in the Gulf of Mexico and the Mediterranean Sea for a long time, until a recent discovery of a new spawning area was discovered in the Marine Offshore and Oceanic area from Cape Cod (MA) to Cape Hatteras (NC) where water depths are at least 2000 m (Richardson et al. 2016, Hernandez et al. 2022). This discovery expanded the region's responsibility for this highly migratory species from summer foraging grounds to spawning grounds as well.

There are two MPA in the Marine Offshore and Oceanic habitat of the Northeast. The **Northeast Canyons and Seamounts Marine National Monument** includes 12,699 square miles of Marine Offshore and Oceanic habitat located approximately 130 miles east-southeast of Cape Cod in federal waters off New York and New Jersey. The Marine National Monument is approximately the size of the state of Connecticut in two disjunct but adjacent areas, one protecting three submarine canyons and one protecting four seamounts. The **Gerry E. Studds / Stellwagen Bank National Marine Sanctuary** protects approximately 847 square miles of Marine Offshore and Oceanic habitat and is located east of Boston between Cape Ann and Cape Cod, Massachusetts. Both MPA are managed by NOAA. In June 2022, NOAA proposed a new National Marine Sanctuary to protect the **Hudson Canyon** offshore New York.

Other protection measures are regulatory in nature in Marine Offshore and Oceanic habitat. These include the designation of EFH and HAPC by NOAA Fisheries and designated coral protection areas from fisheries impacts by the regional Fishery Management Councils. Virtually the entire Marine Offshore and Oceanic area of the Northeast has been designated EFH for at least one species at one life stage or another, including Atlantic HMS and multiple other managed species[190].

2.21.3 HABITAT CONDITION

Marine Offshore and Oceanic habitat is within the global ocean system, which changes in spatial extent on a geologic timescale. Specific marine habitat features such as shellfish beds, live hardbottoms, SAV, and coral have been lost due to human impacts. Data on the regional extent of loss of these habitat features is uncertain however because the full distribution of these habitat features is generally lacking.

Data on the condition of deep-sea habitat is lacking globally, with assessments recommended at the habitat and ecosystem level over large spatial scales rather than the species level. Long-term data are deficient to understand both natural variability within this habitat type and human impacts on the habitat Technological advancements over the last few decades are enabling exploration of the deep-sea (i.e., areas below 200 m water depth), leading to the discovery of biodiversity hotspots like cold-water coral reefs and deep-sea sponge aggregations (Kazanidis et al. 2020).

Global threats to deep-sea ecosystems include bottom Trawling (Threat 7.3.6), deep-sea Mining (Threat 3.2.6), the operation of Oil and Gas Infrastructure (Threat 3.1), and Climate Change (Threat 11.0) (Kazanidis et al. 2020). Most of the world's oceans (59%) are impacted by cumulative impacts that are increasing significantly, with climate change having the largest impact but also fishing, land-based pollution and shipping contributing to cumulative impacts (Halpern et al. 2019). Halpern et al. (2019) found that globally the majority of the world's oceans have increasing rates of Ocean Acidification (Threat 11.2.1), Shipping (Threat 4.3), Light Pollution (Threat 9.6.1), organic chemical and nutrient Pollution from land-based uses (Threat 9.0) and direct human impacts. Between 2003 and 2013 the forms of commercial demersal fishing with the most impacts and high bycatch declined but impacts from pelagic fishing (both high and low bycatch) increased (Halpern et al. 2019). Halpern et al. (2019) provides a detailed analysis of the global threats and impacts to multiple estuarine and marine habitat types, from salt marsh to coral reefs, rocky intertidal shorelines to kelp forests.

Information on the resilience of deep-sea habitats is very limited (Kazanidis et al. 2020). Ecological impacts can be severe and long-term since vulnerable deep-sea ecosystems are formed by long-lived, slow-growing organisms that can take decades to centuries to recover fully from human disturbance (Kazanidis et al. 2020, Shank and Heyl 2020).

The Northwest Atlantic Marine Ecoregional Assessment (Greene et al. 2010) compiled a baseline of the scientific information available on the status and distribution of key species and habitats in the Marine Nearshore and Marine Offshore and Oceanic habitats of the Northeast. Top regional threats to the marine system include Pollution and nutrient runoff (Threat 9.0), coastal Development (Threat 1.0), Sea Level Rise (Threat 11.1.1), and fisheries (Threat 5.4).

2.21.5 HABITAT MANAGEMENT

See Section 2.20.5 for a discussion of current management resources for Marine Offshore and Oceanic habitat, which is typically managed in conjunction with the Marine Nearshore. *Chapter 7* also includes a discussion of the management programs and initiatives of regional partnerships in the Marine seascape of the Northeast.

2.21.5 HABITAT MONITORING

Monitoring of Marine Offshore and Oceanic habitat in the Northeast is generally included in the programs and projects described in Section 2.23.5 for the Marine Nearshore and in *Chapter 5*. Although they do not conduct regular monitoring, both the USGS and NOAA national databases of deep-sea coral and sponges are updated frequently with new records, site characterizations, and research findings.

2.21.6 PARTNERS

The NOAA **Deep Sea Coral Research and Technology Program** maintains a **Deep-Sea Coral Data Portal**[262] with links to the national database as well as status reports, an inventory of past and current fieldwork and other studies, a library of resources, and a photo gallery of imagery taken from deep-sea coral sites. The resources are sortable or filterable on location or regional Fishery Management Council.

Fisheries partners that work in Northeast Marine Offshore and Oceanic area include NOAA Fisheries, Atlantic Coast Fish Habitat Partnership, the New England Fishery Management Council, the Mid-Atlantic Fishery Management Council, the Atlantic States Marine Fisheries Commission, and the International Commission for the Conservation of Atlantic Tunas. These partner organizations manage fish populations but also have habitat conservation missions. See Section 2.20.6 for the Marine Nearshore for detailed information about each of these partner organizations.

2.21.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The citizen science programs and projects described in Section 2.20.7 for the Marine Nearshore also apply to the Marine Offshore and Oceanic.

2.21.8 HABITAT INFORMATION, RESEARCH AND MONITORING NEEDS

The Deep-water Coral and Fish of the U.S. Mid-Atlantic Canyons: Implications for Management and Conservation identified several information needs for Marine Offshore and Oceanic habitat in the region (Shank and Heyl 2020):

- Systematically identify deep-sea coral distributions in unexplored submarine canyons
- Survey biological diversity, habitat and environmental conditions of submarine canyons
- Identify interdependent relationships between deep-sea corals and the animals living on them, which may be life-long

ANTHROPOGENIC HABITATS

With historical habitat loss and fragmentation, anthropogenic habitat types have replaced natural habitat types throughout the Northeast region. More than 21.8 million acres of land consists of roads, railroads, dams, culverts, bridges, buildings, and landscaping (Table 2.0.3). Another 27.1 million acres are in agricultural land uses. Nearly one-third of the terrestrial, freshwater, and estuarine landscapes of the Northeast region are anthropogenic land uses. While suboptimal to natural habitats, these anthropogenic areas are utilized by a number of RSGCN and Watchlist species. The growing field of urban ecology addresses the need to understand the type and nature of human-wildlife interactions in urban environments in order to assist in the management, mitigation, or even promotion of these interactions (Soulsbury and White 2015). The benefits of human and wildlife interactions in Developed Areas are increasingly recognized, with the USFWS establishing an **Urban Wildlife Conservation Program**[263] in 2013 and the **One Health Initiative**[264] spreading around the world (see *Chapter 8*). "In an increasingly urbanized and resource-constrained world, we need to learn how to manage the risks from wildlife in new ways, and to understand how to maximize the diverse benefits that living with wildlife can bring" (Soulsbury and White 2015, p. 541).

2.22 AGRICULTURE: CROPLANDS & PASTURES

Figure 2.22. 1 Agricultural Croplands and Pastures habitats support 75 Northeast RSGCN and Watchlist species. (Lancaster County, PA, photo credit: Pennsylvania Department of Agriculture)

2.22.1 HABITAT DESCRIPTION

Agriculture: Croplands and Pasture habitat includes non-woody crops and pastures managed for agricultural purposes. NatureServe defines Croplands as cultivated fields and field borders that are not adjacent Forest edges (NatureServe 2022). This anthropogenic habitat can mimic natural Grasslands and early-successional habitats, providing suboptimal habitat to a variety of wildlife.

In the NEAFWA region, the 14 SWAPs of 2015 included 16 Key Habitats for SGCN that are within Agricultural Croplands and Pastures habitat (*Appendix 2A*, Table 2A.22). SWAP Key Habitats across eight states include pastures, hayfields, row crops, cultivated crops, buffer strips and fallow pastures.

There are 28 RSGCN, one Proposed RSGCN, 35 Watchlist [Assessment Priority] and three Proposed Watchlist species across eight taxonomic groups associated with Northeast Shorelines habitat (*Supplementary Information 2*, Table 2.22.1, Figure 2.22.2). Another eight species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. Five RSGCN associated with Agricultural Plantations and Orchards are of Very High Concern – Golden-winged Warbler

Table 2.22. 1 The number of species in each RSGCN and Watchlist category associated with Agricultural Croplands and Pastures habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	28
Proposed RSGCN	1
Watchlist [Assessment Priority]	35
Proposed Watchlist [Assessment Priority]	3
Watchlist [Deferral to adjacent region]	8
TOTAL	**75**

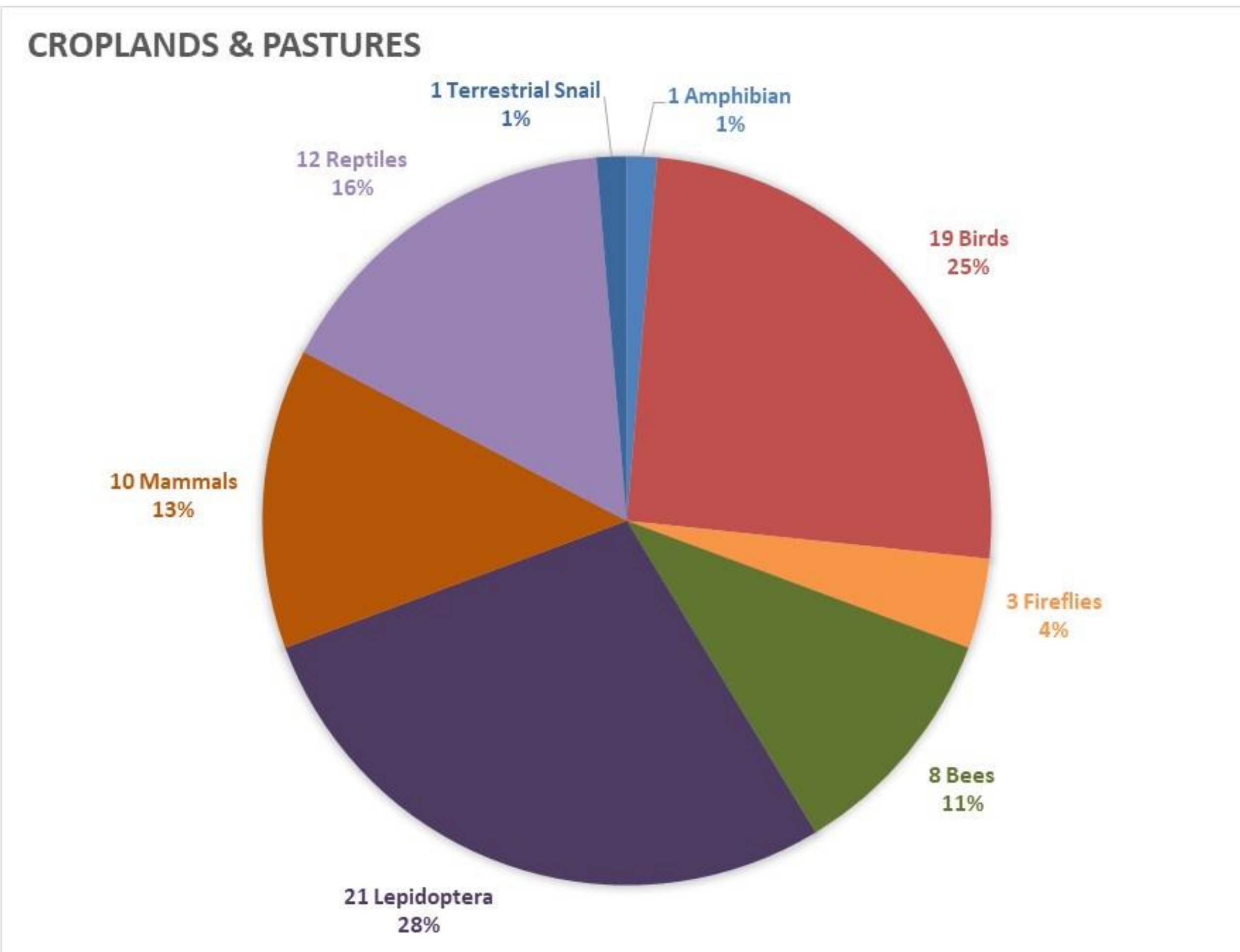

Figure 2.22. 2 Northeast RSGCN and Watchlist species associated with Agriculture: Croplands and Pasture habitats represent eight taxonomic groups.

(*Vermivora chrysoptera*), Blanding's Turtle (*Emydoidea blandingii*), Little Brown Myotis (*Myotis lucifugus*), Northern Long-eared Bat, and Tricolored Bat.

Habitat features, formations and other habitat characteristics preferred by RSGCN and Watchlist species within Agricultural Plantations and Orchards in the Northeast RSGCN Database (version 1.0) include till agriculture, no till agriculture, artificial structures, occupied buildings and abandoned buildings.

2.22.2 HABITAT DISTRIBUTION

Habitat distribution data for the Northeast from the DSL program (DSLland version 5.0) found 23,375,270 acres of Agricultural Croplands and Pasture in 2011. This total area is consistent with the acreage of Croplands and Pastures inventoried by the USDA in the 2017 Census of Agriculture (USDA 2019, Table 2.22.2). Virginia, Pennsylvania, and New York each have more than double the acreage of Agricultural Croplands and Pasture of any other Northeast state, each with more than five million acres in 2017.

Table 2.22. 2 The area of Agriculture: Croplands and Pastures within each state of the NEAFWA region as of 2017 according to the USDA 2017 Census of Agriculture (USDA 2019).

State / District	Area of Croplands & Pastures in 2017 (acres)
Connecticut	195,972
Delaware	466,482
District of Columbia	0
Maine	560,403
Maryland	1,598,623
Massachusetts	234,765
New Hampshire	146,964
New Jersey	539,602
New York	5,040,245
Pennsylvania	5,575,878
Rhode Island	24,789
Vermont	631,531
Virginia	5,650,872
West Virginia	2,410,857
TOTAL	**23,076,983**

2.22.3 HABITAT CONDITION

Special Issue 8 of the *Northeastern Naturalist*, published in 2017, presents a series of papers on the natural history of agricultural landscapes in the region, including articles on the effects of grazing on Grassland communities and wildlife[265].

The USDA offers numerous conservation programs for agricultural lands (see Section 2.22.4 Habitat Management below). Best practices for managing agricultural lands for conservation as part of these federal programs are available through the USDA[266]. This library of resources includes best practices for creating and maintaining:

- Shallow water areas for wildlife
- Permanent wildlife habitat
- Tree planting
- Contour grass strips
- Prairie strips
- Shelterbelt establishment
- Living snow fences
- Establishment of permanent vegetation to reduce salinity
- Establishment of permanent native grasses
- Riparian buffers
- Wetland restoration on floodplains and non-floodplains
- Marginal pastureland wildlife buffers
- Marginal pastureland wetland buffers
- Habitat buffers for upland birds
- Rare and declining habitat
- Duck nesting habitat
- Pollinator habitat
- Improving soil health
- Protecting water quality
- Enhancing wildlife
- Restoring wildlife habitat

2.22.4 HABITAT MANAGEMENT

The USDA offers several voluntary conservation-related management programs for agricultural landowners of croplands and marginal pastureland[267]. The **Conservation Reserve Program** compensates farmers to remove environmentally sensitive land such as wetlands from agricultural production and to plant species to improve habitat quality. One of the largest conservation programs in the country for private lands, the Conservation Reserve Program has created more than 3 million acres of restored wetlands, 175,000 stream miles of riparian forest and grass buffers, reduced nutrient runoff, and prevented more than 9 billion tons of soil erosion.

The Conservation Reserve Program currently offers three initiatives that benefit fish and wildlife resources and their habitats. The **State Acres for Wildlife Enhancement (SAFE) Initiative** restores important habitat to meet high priority state wildlife conservation goals, such as wetlands, trees, grass, longleaf pine, and buffers. The **CLEAR30 Initiative (Clean Lakes, Estuaries, And Rivers)** pilot began in 2020 focusing on 12 states in the Great Lakes and Chesapeake Bay watersheds but has now expanded nationwide. The Initiative enrolls agricultural lands in BMPs to reduce sediment loads, nutrient loads, and harmful algal blooms. The Climate Change Mitigation Assessment Initiative is studying how key program practices for perennial grasses, tree plantings and wetlands impact soil carbon.

The **Conservation Reserve Enhancement Program** targets conservation issues of high priority identified by government and NGOs, removing lands from production to address these issues or installing BMPs (e.g., avoiding haying and grazing during the primary nesting season). The **Farmable Wetlands Program** restores wetlands and wetland buffer zones on agricultural lands. The **Wetlands Reserve Program** purchases easements from agricultural landowners to protect, restore and enhance wetlands which were previously used for agricultural purposes. The **Grassland Reserve Program** prevents the conversion of grazing and pastureland to other land uses. The **Source Water Protection Program** addresses water quality by protecting surface and ground water that are drinking water supplies in rural areas. In 2017, more than 11,000 farms in the Northeast region were enrolled in the Conservation Reserve Program, Wetlands Reserve Program, Farmable Wetlands Program, or Conservation Reserve Enhancement Program, improving habitat condition for more than 317,000 acres of agricultural lands (Table 2.22.3).

The **Environmental Quality Incentives Program** of the USDA Natural Resources Conservation Service assists farmers, ranchers and forest landowners to integrate conservation management into working lands through technical and financial assistance to improve air and water quality, conserve water, reduce soil erosion and sedimentation, increase soil health, improve or create wildlife habitat, and mitigate against drought and increasing water volatility.

Funding is available from the **Voluntary Public Access and Habitat Incentive Program** for state and tribal government agencies to encourage private landowners to allow public access to their lands for fishing, hunting, and other wildlife-dependent recreation. Competitive grants are available for projects up to three years in duration, with up to 25% of the funding allowed for incentives to improve wildlife habitat. Maximum awards are $3 million.

The **Regional Conservation Partnership Program** leverages the collective resources of multiple partners collaborating on common conservation goals. Two types of projects are supported by this program. Classic projects are implemented with Natural Resources Conservation Service contracts and easements with landowners, producers, and communities. Grants projects are led by partner organizations who work with agricultural producers to develop new conservation structures and approaches not otherwise available.

Projects funded by the Regional Conservation Partnership Program in 2022 include several conservation projects in the Northeast. In Pennsylvania, the Department of Agriculture received a $7.85 million award for the **Farmland Preservation and Climate Change Mitigation** project, to leverage state and county funds to improve soil health, transition producers to organic production, model greenhouse gas benefits, and more. In Virginia, the Alliance for Shenandoah Valley and partners received more than $4.6 million for a project to increase landscape resiliency through modeling to identify target parcels for conservation easements with the highest conservation value. The **New Jersey COASTAL Aquaculture Project**, led by the Ocean County Soil Conservation District, will leverage nearly $1 million to enhance the aquatic habitat on shellfish leases and improve the water quality of the coastal bays of New Jersey by constructing oyster reefs. The Chesapeake Conservancy and 13 partners received nearly $10 million to implement conservation practices and systems to improve water quality and wildlife habitat on 18 streams listed as impaired in central Pennsylvania, with the goal of delisting the streams. In western Maine, the New England Forestry Foundation and partners received $1.5 million for the **Working Forests for Wildlife and Climate in Western Maine** project, which will restore and enhance fish, bird and wildlife habitats (including for RSGCN Atlantic Salmon and Watchlist [Assessment Priority] Moose), increase the resiliency of forests for climate change, and improve forest productivity through the use of best practices and the Forestry for Maine Birds habitat assessment tool developed by Maine Audubon.

The **Agricultural Management Assistance Program** provides assistance to agricultural producers for a variety of purposes, including the implementation of natural resource conservation practices. Eligible projects include planting of trees to improve water quality or create windbreaks, soil erosion control, integrated pest management, and transitioning to organic practices. This program is limited to 16 states where participation in federal crop insurance programs is historically low, 12 of which are in the Northeast (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia).

The **Conservation Innovation Grants** program is also competitive, supporting the development of new tools, practices, approaches and technologies for conservation on private lands. There are three types of grant opportunities – national, state, and on-farm trials. Since 2004 this program has funded nearly 800 projects, which are available in an online searchable database[268]. More than 150 of these projects are in the Northeast, with 21 projects worth $5.6 million directly related to habitat conservation on agricultural lands. Regional habitat conservation benefits include integrating native wildlflowers into grazing systems, forest carbon sequestration in the Appalachian mountains, improving pollinator habitat in pastures, measures to improve water quality in Chesapeake Bay, harvesting nuisance macroalgae to mitigate eutrophication on oyster farms, improve bat habitat, invasive terrestrial plant species management, enhancing bird nesting habitat on hayfields, and many addressing air and water pollution from agricultural practices.

The **Conservation Stewardship Program** provides technical and financial assistance to develop wildlife habitat conservation plans, improve the condition of grazing lands, and improve crop resiliency. The **Wetland Mitigation Banking Program** is a competitive grants program to develop and establish wetland mitigation banks to offset wetlands impacts agricultural lands either on-site or off-site.

The Natural Resources Conservation Service **RCA Data Viewer** provides a tool to graph, map, and download customizable datasets based on the best practices applied to private agricultural and forestry lands throughout all their programs[269]. The RCA Data Viewer includes data on best practices, acres in conservation, easement programs, financial assistance programs, and land use trends at the state and county level. As of 2022, for example, the Natural Resources Conservation Service had 483,860 acres of agricultural and forestry land in the Northeast in permanent conservation easements across all their programs and another 10,577 acres in 30-year easements, although these totals include easements to preserve agricultural and forestry lands from development and are not limited to those that enhance wildlife habitat. Agricultural and forestry lands enrolled in the Conservation Reserve Program, Wetlands Reserve Program, Farmable Wetland Program and Conservation Reserve Enhancement Program that can benefit Northeast fish and wildlife totaled 317,663 acres in 2017 (Table 2.22.3).

The USDA released an **Action Plan for Climate Adaptation and Resilience** in 2021 outlining how the federal agency will integrate climate adaptation into its mission, programs and operations. The Farm Service Agency of the USDA finalized an agency-specific Climate Change Adaptation Plan in 2022 that identifies and prioritizes climate vulnerabilities and actions to integrate climate change into the agency's operations, programs and decision-making. Both plans are available on the agency's website[270].

Table 2.22. 3 The area within each state enrolled in the USDA Conservation Reserve Program, Wetlands Reserve Program, Farmable Wetlands Program and Conservation Reserve Enhancement Program in 2017 (USDA 2019).

State / District	Area enrolled in USDA Conservation Programs in 2017 (acres)	Number of Farms enrolled in USDA Conservation Programs in 2017
Connecticut	44	6
Delaware	3,851	161
Maine	7,652	155
Maryland	55,463	1,939
Massachusetts	18	3
New Hampshire	Not reported	1
New Jersey	2,040	137
New York	35,619	1,117
Pennsylvania	153,755	5,073
Rhode Island	Not reported	1
Vermont	2,723	166
Virginia	46,815	1,929
West Virginia	9,683	330
TOTAL	**317,663**	**11,018**

2.22.5 HABITAT MONITORING

The USDA maintains a **Satellite Imagery Archive** and aerial photography of agricultural lands in the US, which generally includes non-agricultural land areas as well. Historical aerial photography is available dating back to 1955, and in some areas even older. An interactive online map shows the availability of historical imagery at the county level. The map and imagery catalogs searchable by state or county are available[271].

The National Agricultural Statistics Service of the USDA monitors agricultural lands with **CropScape**, an interactive online mapping tool and associated data layer of cropland across the country[272]. Datasets are available for every year starting from 1997 and distinguishes Croplands by type (e.g., corn, cotton, rice, soybeans), Pasture, wetlands, forest, developed, and other land cover types.

The distribution and extent of Agricultural Croplands and Pasture is monitored through other remote sensing land cover assessment programs as well. The National Land Cover Dataset maps the extent of Pasture / Hay and Cultivated Crops every three years. LANDFIRE includes row crops, fallow or idle cropland, pasture, hayland, wheat, and bush fruit and berries as vegetation types within their spatial land cover datasets, which have been updated every two to three years but will be updated annually starting in 2022. Regionally, the Designing Sustainable Landscapes program at the University of Massachusetts monitors the extent of Pasture / Hay and Cultivated Crops in the Northeast by combining multiple spatial datasets.

The USDA National Statistics Service conducts a **Census of Agriculture**[273] every five years that is a complete count of all farms and ranches in the country, with the most recent census underway in 2022. A series of atlas maps illustrate the data from the Census of Agriculture and are publicly available. Census of Agriculture data are available by state, county, tribal reservation, watershed and zip code.

The USDA conducts regular monitoring assessments and evaluations of the agency's programs and initiatives, such as bird conservation benefits from the Conservation Reserve Program, the benefits of prairie strips and saturated buffers, Chesapeake Bay benefits from Conservation Reserve Enhancement Program, water quality and quantity studies, pollinator studies, and other wildlife studies (e.g., Northern Bobwhite, grassland birds, amphibians). Monitoring, assessment and evaluation reports related to wildlife benefits are available[274].

2.22.6 PARTNERS

The Natural Resources Conservation Service of the USDA has multiple **Landscape Conservation Initiatives**[275] that can improve habitat condition for fish and wildlife on agricultural lands in the Northeast:

- *Great Lakes Restoration Initiative* – as partners with the EPA and other federal agencies, the initiative targets conservation efforts on private lands in priority

PA Farmland Preservation

Pennsylvania leads the nation in farmland preservation, conserving nearly 620,000 acres of agricultural lands from development (in perpetuity) between 1988 and 2022. More than 6100 farms across 58 counties have agricultural conservation easements through the Pennsylvania Agricultural Conservation Easement Purchase Program. Eligible farms must have at least 50% of the tract in cropland, pasture, or grazing uses and meet stewardship criteria for conservation practices and BMPs for nutrient management, soil erosion, and sedimentation.

watersheds to improve water quality in the Great Lakes

- *National Water Quality Initiative* – in 2022 there were at least 26 watersheds in the Northeast approved for this initiative to focus water quality monitoring, assessment and investments where they can generate the highest benefits for clean water
- *Working Lands for Wildlife* – provides technical and financial assistance in partnership with regulatory predictability from the USFWS for listed or potentially listed species where appropriate for conservation efforts on working agricultural and forestry lands; targeted species for 2022 include Northern Bobwhite, American Black Duck, Bog Turtle, Northeast Turtles, Eastern Hellbender, Monarch, and Golden-winged Warbler

In the Northeast, native bumble bee species are experiencing habitat loss, climate related threats, and competition form non-native species. One of the eleven Northeast USFWS At-Risk teams focuses on six At-Risk Species that are Farmland Pollinators in need of proactive conservation. All six species are also RSGCN or Watchlist species: Monarch butterfly, Ashton Cuckoo Bumble Bee (*Bombus ashtonii*), Lemon Cuckoo Bumble Bee (*Bombus citrinus*), American Bumble Bee (*Bombus pensylvanicus*), Yellow-banded Bumble Bee (*Bombus terricola*), and Variable Cuckoo Bumble Bee (Bombus variabilis). These species, collectively referred to as “farmland pollinators” are in need of region-wide habitat restoration and management. Additionally, little is known on the population status and distribution for many of these rare species. The USFWS provided funding to the Native Bee Inventory and Monitoring Lab for a multi-part project that includes surveys, floral resource research, public outreach, and developing a regional conservation strategy for bumble bees. Additional projects supported by the farmland pollinator team include bumble bee surveys on National Wildlife Refuges across the Region, native thistle seed collection and propagation, and continued support for the New England Pollinator Partnership[58].

2.22.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of Agricultural Croplands and Pastures habitat through fewer citizen science projects than for other habitats, with most focused on detecting and monitoring invasive plant and animal species. Citizen science project directories are available at citizenscience.gov and scistarter.org.

2.23 AGRICULTURE: PLANTATIONS & ORCHARDS

Figure 2.23. 1 Agricultural Plantations and Orchards habitats support 40 Northeast RSGCN and Watchlist species. (Apple orchard in NH, photo credit: Stone Brook Hill Farm)

2.23.1 HABITAT DESCRIPTION

The Agriculture: Plantations and Orchards habitat type includes ruderal forests, plantations, orchards and vineyards. Anderson et al. (2023) assessed the status and condition of ruderal and plantation forests in the Northeast, defined as early-successional trees on land reverting from clearing, plowing or grazing and plantations with intentionally planted trees. Less than 5% of the region's forests were composed of ruderal and plantation forests in 2019 (Anderson et al. 2023).

In the NEAFWA region, the 14 SWAPs of 2015 included 15 Key Habitats for SGCN that are within Agricultural Plantations and Orchards habitat (*Appendix 2A*, Table 2A.23). SWAP Key Habitats in seven states include ruderal forests, tree plantations of various types, managed forests, orchards, and vineyards.

There are 17 RSGCN, one Proposed RSGCN, 15 Watchlist [Assessment Priority] and one Proposed Watchlist species across six taxonomic groups associated with Northeast Agriculture: Plantations / Orchards habitat (*Supplementary Information 2*, Table 2.23.1, Figure 2.23.2). Another six species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. Ten of the RSGCN and Proposed RSGCN associated with Agricultural Croplands and Pastures are of Very High Concern, including the endemic New England Cottontail and Bog Turtle.

Table 2.23. 1 The number of species in each RSGCN and Watchlist category associated with Agricultural Plantations and Orchards habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	17
Proposed RSGCN	1
Watchlist [Assessment Priority]	15
Proposed Watchlist [Assessment Priority]	1
Watchlist [Deferral to adjacent region]	6
TOTAL	**40**

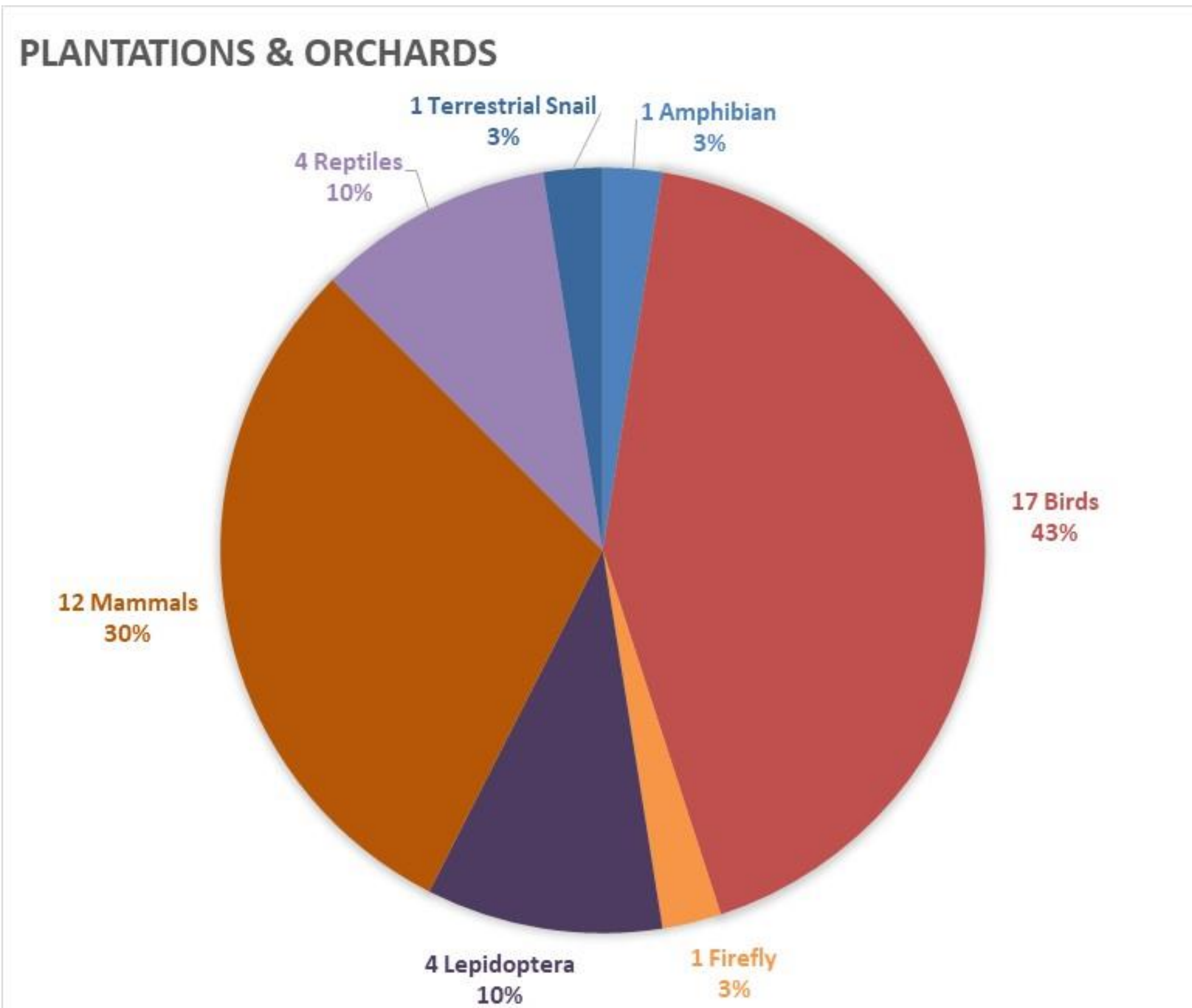

Figure 2.23. 2 Northeast RSGCN and Watchlist species associated with Agriculture: Plantation and Orchard habitats represent seven taxonomic groups.

Habitat features, formations and other habitat characteristics preferred by RSGCN and Watchlist species within Agricultural Plantations and Orchards included in the Northeast RSGCN Database (version 1.0) are the same as those for Forest and Woodland habitats (Section 2.1).

2.23.2 HABITAT DISTRIBUTION

Habitat distribution data for the Northeast from the DSL program (DSLland version 5.0) found 1,816,311 acres of Agricultural Plantations and Orchards in 2011, but this figure was derived from remote sensing imagery. The 2017 Census of Agriculture from the USDA, in comparison, inventoried 20,573,979 acres of Agricultural Plantations and Orchards (USDA 2019). The USDA census figures include maple syrup trees, Christmas trees, fruit and nut orchards, vineyards, and trees grown for pulp, paper or engineered wood but not for lumber. Due to the exclusion of tree plantations for lumber, the 20.57-million-acre total for the region is a minimum. Vermont had the largest total area in the Northeast due to nearly 5.9 million acres of maple syrup trees, the highest in the nation (Table 2.23.2). Eighty-four percent of the nation's acres of agricultural land in maple syrup production are in the Northeast, with four out of the top five states (VT, NY, ME and PA). There were more than 6000 Christmas tree farms in the Northeast in 2017, including three of the top five states in the country (PA, NY and NJ). Pennsylvania has the second highest number of Christmas tree farms in the country, with nearly 1300, and the fourth highest acreage (>30,000). The Northeast region had more than 11,200 fruit and nut orchards in 2017. Two Northeast states rank in the top five nationally for the number of acres of vineyards in 2017 (NY and PA).

2.23.3 HABITAT CONDITION

The condition of Agricultural Plantations and Orchards in the Northeast at the regional scale is not known.

2.23.4 HABITAT MANAGEMENT

In addition to the numerous conservation management programs offered by the Natural Resources Conservation Service and USDA described in Section 2.22.4 for Agricultural Croplands and Pastures, the USDA Emergency Forest Restoration Program provides funding to restore privately owned forests that have been damaged by natural disasters.

Managing Grasslands, Shrublands, and Young Forest Habitats for Wildlife: A Guide for the Northeast includes recommendations on improving wildlife habitat condition in old Orchards (Oehler et al. 2006). Chapter 7 of this guide, "Managing Abandoned Orchards and Apple Trees," describes the ecological values of Northeast apple Orchards to wildlife

Table 2.23. 2 The area of Agriculture: Plantations and Orchards within each state of the NEAFWA region as of 2017 according to the USDA 2017 Census of Agriculture (USDA 2019).

State / District	Area of Plantations & Orchards in 2017 (acres)
Connecticut	185,412
Delaware	41,874
District of Columbia	0
Maine	2,603,787
Maryland	326,499
Massachusetts	500,367
New Hampshire	837,587
New Jersey	159,225
New York	4,172,546
Pennsylvania	2,269,686
Rhode Island	31,759
Vermont	6,404,457
Virginia	1,868,583
West Virginia	1,172,197
TOTAL	**20,573,979**

and the early successional habitat provided by old, abandoned Orchards. Management practices are recommended to maintain and enhance wildlife habitat in abandoned Orchards, including mowing schedules, pruning, brush piling, and planting new trees to increase food resources and improve pollination.

The People's Trust for Endangered Species organization has developed a **Traditional Orchards: A Guide to Wildlife and Management** that although developed for the United Kingdom includes recommendations applicable to all Orchards for improving wildlife habitat conditions[276]. Recommended best practices include planting new trees, retaining dead and decaying wood within trees, creating log piles, leaving windfall and excess fruit for wildlife food, creating hedgerows and areas of scrub, and several conservation measures to enhance habitat value on the Orchard floor.

The North Carolina State University Cooperative Extension provides recommendations on how to improve habitat for pollinators on Christmas tree farms[277]. Recommendations include management tips for suppressing undesirable groundcovers, allowing field borders to grow, allowing field roads to grow during the summer months, managing cut-over fields for flowering groundcovers, and protecting bees from pesticides.

The North Carolina State University Cooperative Extension also has recommendations for developing wildlife-friendly pine plantations (Moorman and Hamilton 2019). Wildlife-friendly recommendations include creating a management plan which addresses where wildlife management ranks in the list of objectives for the property, how completely the property can serve as a wildlife resource, which wildlife species are targets, and cost. Management practices to improve habitat conditions for wildlife include thinning, burning, maintaining multiple stand ages, leaving woody debris and snags, using banded applications for herbicides (applying chemical controls only to planted rows of trees), planting trees at wider spacings, maintaining 1- to 5-acre openings within stands, installing and maintaining wide firebreaks around the plantation, and leaving some non-pine plant species on the site. Specific management practices are listed for early-, mid- and late-rotation periods, harvesting, and plantation edges. Considerations for managing the pine plantations in the context of the local landscape is recommended.

2.23.5 HABITAT MONITORING

Monitoring programs and projects for Agricultural Plantations and Orchards are the same as those for Croplands and Pastures (Section 2.22.5).

The distribution and extent of Agricultural Croplands and Pasture is monitored through other remote sensing land cover assessment programs as well. LANDFIRE includes orchards, vineyards, and ruderal forests as vegetation types within their spatial land cover datasets, which have been updated every two to three years but will be updated annually starting in 2022. Regionally, the Designing Sustainable Landscapes program at the University of Massachusetts monitors the extent of Pine Plantations / Horticultural Pines in the Northeast by combining multiple spatial datasets.

2.23.6 PARTNERS

The primary partner for improving habitat condition for fish and wildlife resources on Agricultural Plantations and Orchards is the US Department of Agriculture, which offers numerous conservation programs, technical and financial assistance, and best practices. The Natural Resources Conservation Service of the USDA operates offices in most counties of the US, offering localized assistance to agricultural landowners and conservation partners.

The **Working Woodlands Program** of The Nature Conservancy assists private Forest and Woodland landowners to improve the health and value of their land[278].

Initial states enrolled in the program include Pennsylvania, West Virginia, and New York. Landowners and TNC assess the potential wildlife habitat value of the property and for addressing climate change. Customized ten-year forest management plans are developed, conservation easements may be utilized, and the forests are certified by the Forest Stewardship Council, allowing forest products to be sold with that certification label. Enrolled lands have the option of selling carbon credits for their sustainably managed Forests and Woodlands. Landowners must own a minimum of 2000 acres of Forest and Woodland to participate in the Working Woodlands Program.

The **North East *State* Foresters Association** is a partnership of the state foresters of Maine, New Hampshire, Vermont, and New York alongside the US Forest Service, state and private forestry[279]. The mission of the association is to maintain the region's forests, assure forest health and productivity, and support the businesses and forest landowners who rely on forests. Their **About My Woods** is a smartphone app to assist woodland owners in Maine, New Hampshire, Vermont, and New York learn about their Forests and Woodlands. The **Northeast Silviculture Institute for Foresters**, with support from the North East *State* Foresters Association, provides training sessions and videos related to graduate level silviculture to share knowledge and inform decision-making with the best science[280].

The **Securing Northeast Forest Carbon Program**[281], funded by a US Forest Service Landscape Scale Restoration grant with seven states as partners, started in 2021 and will end in 2024. The North East State Foresters Association is the program coordinator and the Vermont Department of Forests, Parks and Recreation is the lead educator. The program intends to facilitate carbon sequestration in the region's privately owned forests through special management practices, carbon sales, and voluntary conservation easements with the goal of securing as much of the private forest carbon in the region as possible over the three-year period.

The **Forest Landowners Association** provides shared resources and advocacy for private working forest owners[282]. The organization's Forest Landowner Foundation provides scholarships and training for forestry careers, graduate school fellowships, and conducts education and outreach through webinar series to share information with landowners. Their **Conservation Forward** program addresses protection of listed species in working forests, hosting Timber Talks to demonstrate the co-existence of forestry practices with wildlife habitat conservation for stakeholders and Forest Forums to have round-table discussions to find common solutions.

2.23.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

The public is engaged in the conservation of Agricultural Plantations and Orchards habitat through fewer citizen science projects than for other habitats, with most focused on detecting and monitoring invasive plant and animal species. Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

2.24 DEVELOPED AREAS

Figure 2.24. 1 Developed Areas habitats support 37 Northeast RSGCN and Watchlist species. (Baltimore County, MD, photo credit: Shutterstock)

2.24.1 HABITAT DESCRIPTION

Development is one of the top regional threats (Threat 1.0) to Northeast RSGCN and Watchlist species and their habitats, leading to habitat loss, fragmentation and degradation as summarized in *Chapter 3*. Nevertheless, Developed Areas can and are utilized by some RSGCN and Watchlist species. While not critical to any one species, Developed Areas do provide suboptimal alternate habitats for several RSGCN and Watchlist birds, bats, pollinators, reptiles, and amphibians. Developed Areas include parks, airports, airfields, athletic fields, urban and suburban gardens, buildings, roads, bridges and railroads. Bridges and road culverts may provide roosting habitat for bats, as can buildings. Airports and airfields with their maintained grassy areas may substitute for natural Grasslands for birds. The gravel rooftops of big box stores and warehouses may provide nesting habitat for colonial waterbirds like the RSGCN Least Tern. Peregrine Falcon, a Watchlist [Assessment Priority] species, nests on the ledges of high rises and skyscrapers, substituting for natural Cliff nesting habitat. Six RSGCN and Watchlist bee species use gardens in Developed Areas, as does the RSGCN Monarch butterfly. In densely urbanized areas, city parks and gardens may be the only exposure residents have to wildlife.

The USFWS Urban Wildlife Conservation Program seeks to improve access to nature for human residents of Developed Areas, with more than 100 NWR located in or near cities, 32 Urban Wildlife Refuge Partnership cities, and 30 Urban Bird Treaty cities. Human interactions with urban wildlife can influence public perceptions and thus the future of wildlife and habitat conservation, placing increasing importance on urban wildlife management (McCance et al. 2017).

Altogether there are 12 RSGCN, two Proposed RSGCN and 15 Watchlist [Assessment Priority] species across eight taxonomic groups associated with Northeast Developed Areas habitat (*Supplementary Information 2*, Table 2.24.1, Figure 2.24.2). Another eight species associated with this habitat are Watchlist [Deferral] species deferred to adjacent AFWA regions. The 14 Northeast SWAPs of 2015 include 30 Key Habitats for SGCN that are Developed Areas (*Appendix 2A*, Table 2A.24). These Key Habitats include urban and recreational grasses, building structures, and other man-made features that are utilized by SGCN.

This section will focus on management and partnership information to improve the condition of Developed Areas for Northeast RSGCN and Watchlist species.

2.24.2 HABIBAT DISTRIBUTION

More than 14.6 million acres of the Northeast landscape has been developed, with an increasing trend over time (Anderson and Olivero-Sheldon 2011, Anderson et al. 2023). The New England states of Massachusetts, Rhode Island and Connecticut are the most developed. Anderson et al. (2023) provides a detailed summary of the degree of several natural habitat types have been converted to Developed Areas in the Northeast historically and in recent decades.

Table 2.24. 1 The number of species in each RSGCN and Watchlist category associated with Developed Areas habitat in the Northeast as of 2023.

Category	Number of Species
RSGCN	12
Proposed RSGCN	2
Watchlist [Assessment Priority]	15
Watchlist [Deferral to adjacent region]	8
TOTAL	**37**

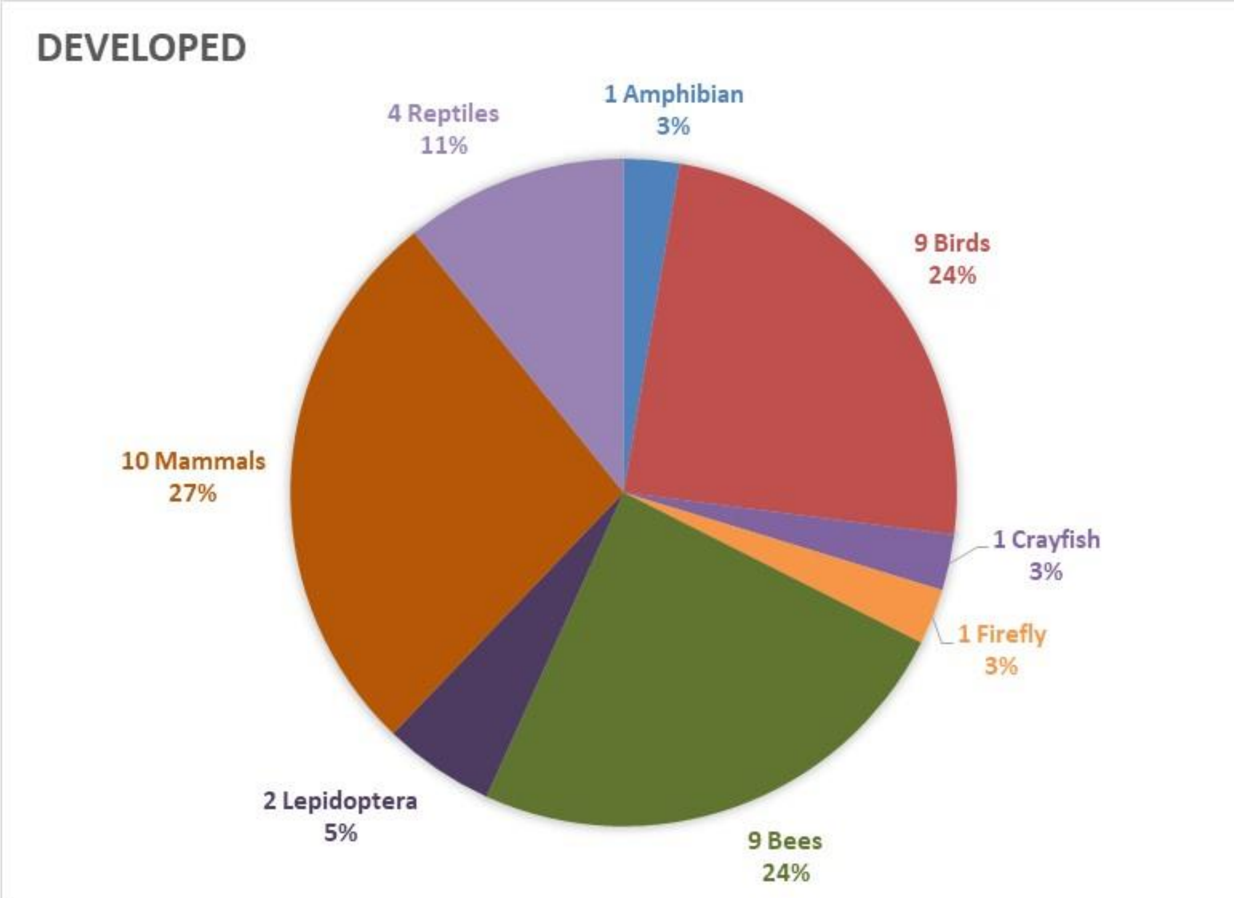

Figure 2.24. 2 Northeast RSGCN and Watchlist species associated with Developed Areas habitats represent eight taxonomic groups.

The Designing Sustainable Landscapes project[10] has developed a series of spatial datasets for the Northeast region, including a SPRAWL urban growth model for landscape planning (McGarigal et al. 2018), publishing (as of October 2022) an updated prediction of the distribution and extent of Developed Areas for 2040 and 2080. The most recent DSL land cover map and dataset (DSLland Version 5.0) was published in 2020 and includes multiple Developed Area land cover types. Altogether DSL has classified 21,809,856 acres of Developed Areas in the Northeast, including buildings, roadways, bridges, dams, and railways.

2.24.3 HABITAT CONDITION

Numerous techniques and programs are available to improve the condition of Developed Areas for wildlife. Urban wildlife management is of increasing importance and takes many forms (McCance et al. 2017). Multiple partner organizations offer guidance and certification of developed spaces as improved habitats for birds and pollinators. Others offer programs for urban forestry and canopy trees. Some address specific hazards such as light pollution, collisions with glass, aircraft or vehicles, and the use of transportation infrastructure by bats.

The National Wildlife Federation (NWF) **Certify Wildlife Habitat** program offers guidance and certification of improving suburban and urban yards, gardens, schoolyards, commercial spaces and roadside greenspaces for wildlife[283]. Certification requirements including providing wildlife food, water, cover, places to raise young and the use of sustainable maintenance practices (i.e., soil and water conservation, controlling exotic species, organic practices). The program offers signs to install at certified spaces as education and outreach tools to the public.

The North American Butterfly Association offers a **Butterfly Garden Certification** program to the public to improve garden habitats for butterflies[284]. To be certified as a North American Butterfly Association Butterfly Garden, the garden must contain at least three species of caterpillar food plants, at least three species of nectar plants, and avoidance of the use of pesticides. Multiple types of educational signs are available for installation in certified gardens.

The Xerces Society has developed a **Pollinator Protection Pledge** that provides four steps for improving pollinator habitat in Developed Areas and agricultural areas[285]. The four recommended steps including growing pollinator-friendly flowers, providing nest sites, avoiding the use of pesticides, and spreading the word to others about the need to improve pollinator habitat. Pollinator Habitat signs are available as well as recommended information for sharing on social media.

Developed spaces can be certified as **Monarch Waystations** by Monarch Watch through a program to create, conserve and protect habitat for the RSGCN Monarch[286]. Guidance is available for the public to create waystations or to certify existing spaces that meet the requirements for certification. Waystations must be at least 100 square feet in size, receive at least six hours of sun a day, have soil types and drainage suitable for growing milkweed and nectar plants, provide shelter from predators and the elements, have at least 10 milkweed plants of at least two species, provide a mix of nectar plants across multiple seasons, and a plan to conduct regular maintenance of the space with activities like watering, removing invasive plants, and eliminating the use of insecticides. Monarch Waystation signs are available to increase education and outreach to the public.

The National Audubon Society manages **Plants for Birds** and **Bird-Friendly Building** programs, which together can create **Bird-friendly Communities**[287]. The Plants for Birds program encourages the public to improve Developed spaces for birds by creating native plant gardens[288]. The Bird-Friendly Building program addresses the threats of light pollution and collisions with glass for birds, with a **Lights Out** network of cities and states reducing the hazards to birds from lights[289].

The USFS **Urban and Community Forestry Program** provides technical, financial and educational assistance to developed communities with the goal of improving the tree canopy of Developed Areas in the Northeast and beyond[290]. The program is overseen by the **National Urban and Community Forestry Advisory Council** and guided by a **Ten-Year Urban Forestry Action Plan** with the current plan spanning 2016 to 2026. Educational and scientific resources are provided on the **Vibrant Cities Lab** website[291], which includes an **Urban Forestry Toolkit**, and through a National Webinar Series. The NEAFWA region falls within the Eastern administrative region of the USFS with the exception of Virginia, which is within the Southern region.

The Arbor Day Foundation manages the **Tree City USA** program that provides a framework for communities to grow and maintain urban forests[292]. Communities in all 14 NEAFWA states and the District of Columbia have been designated as Tree City USA communities. Additional programs enhance urban forests on school campuses, at healthcare facilities and along utility corridors. In 2021 more than 941,000 trees were planted and nearly $1.4 billion invested in urban forestry management nationally.

The **Animal and Plant Health Inspection Service (APHIS)** of the USDA addresses wildlife conflicts with people, often in Developed Areas[293]. APHIS operates an **Airport Wildlife Hazards Program** to reduce the risk of wildlife (primarily birds) collisions with aircraft. **Bird Air Strike Hazard (BASH) plans** for airports and airfields minimize the attractiveness of airport and airfield facilities to wildlife with a variety of techniques such as maintenance of specific mowing heights to reduce grassland-like habitat. The **Wildlife Services** program of APHIS also assist communities and property owners in managing waterfowl on golf courses, reduce deer damage to gardens and landscaping, disperse vultures roosting near homes and vehicles, protect publicly managed parks from invasive species, and a number of other wildlife management activities in Developed Areas.

Other resources are available to address wildlife-vehicle collisions and wildlife crossings of transportation corridors in Developed Areas. The USFS published a guide to **Highway Crossing Structures for Wildlife** in 2021, summarizing the state of knowledge and techniques to improve wildlife safety and habitat connectivity along transportation corridors (Ament et al. 2021). In 2021 the federal **Wildlife Crossings Pilot Program** was established as part of the Infrastructure Investment and Jobs Act to provide $350 million in grants over five years for projects to reduce the risk of wildlife collisions with vehicles and improve habitat connectivity. Eligible projects include state, regional, federal, local and tribal agencies.

Some RSGCN and Watchlist bat species use bridges, culverts and buildings in Developed Areas for roosting. Sparks et al. (2019) developed a manual of BMPs for transportation projects to protect bats in Developed Areas. The manual includes survey techniques, measures to enhance habitat for bats and mitigation types for unavoidable impacts.

Best practices and guidance for addressing potential impacts from transportation corridors in Developed Areas on aquatic habitats (i.e., Rivers and Streams, Riparian and Floodplains) are discussed in Sections 2.11 and 2.13.

In addition to the aforementioned national and regional programs to improve habitat condition in Developed Areas for wildlife, several Northeast states and major cities offer programs to improve habitat for urban wildlife:

- Boston's **Urban Wilds Program** manages 29 "urban wild" spaces across the city for habitat protection, passive recreation and environmental education
- The **Keystone 10 Million Trees** for Pennsylvania Partnership program seeks to plant ten million trees across urban forests, riparian buffers, abandoned mine lands and farmland in Pennsylvania by 2025, reaching the halfway point in 2022
- **WildlifeNYC** is a city sponsored campaign in New York City to educate city residents about urban wildlife and invite them to participate in tree plantings, park beautification projects and other events
- TNC and the New Jersey Department of Environmental Protection updated the **Connecting Habitat Across NJ (CHANJ)** project in 2022, with a CHANJ Mapping Tool and accompanying guidance to facilitate strategic land use planning decisions and mitigate the impacts of transportation system on wildlife through projects like wildlife tunnels for turtles and salamanders

2.24.4 HABITAT MANAGEMENT

Developed Areas are managed at the local and county level through several types of land use plans. Many counties and local communities have developed smart growth initiatives to guide future development and redevelopment. The EPA has compiled a list of smart growth planning resources, including for community resiliency to climate change, equitable development, disaster resilience and recovery, green building and more[294].

In the Northeast, the USFWS and the DSL project developed the **Nature's Network** regional planning tool to identify priority areas for regional conservation using a model of projected urban growth[13]. The Massachusetts **BioMap3** tool**20**, a partnership between the state and TNC, to assist state and local governments and their partners to strategically plan wildlife and habitat conservation projects. BioMap3 can also be used to assist local, county, regional and state planning for Developed Areas.

2.24.5 HABITAT MONITORING

The distribution and extent of Developed Areas is monitored through several remote sensing land cover assessment programs. The National Land Cover Dataset (NLCD) maps the extent of Open Space, Low Intensity, Medium Intensity and High Intensity Developed Areas every three years[5]. A spatial dataset of building footprints for the entire country is available from Microsoft Maps, which is updated periodically[295]. Regionally, the Designing Sustainable Landscapes program at the University of Massachusetts monitors the extent of 15 subtypes of Developed Areas in the Northeast by combining multiple spatial datasets, including NLCD, building footprints, road, and rail networks. DSL also projects future patterns of development in the Northeast, releasing forecasts for 2040 and 2080 in October 2022.

The **Urban Wildlife Information Network** aims to make cities better for humans and wildlife through an alliance of urban wildlife scientists in communities across the US and Canada[296]. The Network shares research and monitoring information to improve the understanding of urban wildlife and the relationships people have with them. Resources developed by the Network include standardized monitoring protocols, training tools and educational programming for all ages. In the Northeast, at least ten cities, zoos and academic institutions are a part of the Urban Wildlife Information Network as of 2022.

2.24.6 PARTNERS

See the Habitat Condition section for projects and programs conducted by partners to improve urban wildlife habitat.

2.24.7 CITIZEN SCIENCE (PUBLIC INVOLVEMENT)

There are a number of citizen science initiatives that gather information on the presence and abundance of wildlife in Developed Areas. The National Audubon Society, Cornell Lab of Ornithology and partners manage the **Great Backyard Bird Count** program that enlists the public to identify and count birds during a specified time window annually[297]. The Cornell Lab of Ornithology has created the **MERLIN app** that allows the public to not only identify birds they see but also collects location data on those observations[298]. The Smithsonian's National Zoo and Conservation Biology Institute recruits and trains citizen scientists to collect data on the impacts of urbanization on birds as part of the **Neighborhood Nestwatch** program[299].

Odonata Central, a citizen science program to collect and identify sightings of dragonflies and damselflies, sponsors an annual **Odolympics** to monitor odonate distribution in a specific window of time[300]. The **Butterflies and Moths of North American (BAMONA)** project collects observations of Lepidoptera from the public in a database of species occurrence information[301]. Other wildlife apps like **eBird**[302] and **iNaturalist**[303] also collect information on wildlife sightings in Developed Areas and other habitat types from the public.

SquirrelMapper[304] is a citizen science project developed by the Urban Wildlife Information Network and partners to monitor the distribution of the two color morphs of Eastern Gray Squirrel (*Sciurus carolinensis*). Participants can explore an interactive squirrel map of reported sightings of the two color morphs. The project also involves citizen scientists in the classification of observational data collected with a Squirrel Spotter online game to identify squirrels on roads and in forests.

OpenTreeMap is a citizen science program sponsored by the USDA to map and explore urban forests[305]. **Nature's Notebook** tracks seasonal changes in plants and animals across the US in a citizen science project sponsored by the USGS and the **National Phenology Network**[306]. The USDA Cooperative Extension Service offers **Master Watershed Stewards** and **Master Gardener** programs to train and educate citizen scientists in a number of conservation topics, who work primarily in Developed Areas.

The **City Nature Challenge** is an international four-day bioblitz competition held every April since 2016 to see which city can collect the most observations of nature, find the most species, and involve the most people in the event[307]. The citizen science project utilizes iNaturalist or a city's custom platform to collect photographs of any plant, animal or other signs of life in Developed Areas. In 2022 more than 67,000 people participated in the bioblitz, documenting more than 50,000 species worldwide. In the Northeast, cities in Maine, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, Maryland, Virginia, and Washington DC participated in 2022.

Citizen science project directories are available at citizenscience.gov, scistarter.org and anecdata.org.

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2.27 ENDNOTES

Many online resources are available for learning about topics in this chapter. However, URLs are not permanent resources; pathways may be changed or removed over time. These endnotes were all accessed in January and February of 2023, and were active at that point in time.

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CHAPTER 3: THREATS TO NORTHEAST HABITATS AND SPECIES

SWAP Element 3

Descriptions of problems which may adversely affect species identified in the 1st element or their habitats, and priority research and survey efforts needed to identify factors which may assist in restoration and improved conservation of these species and habitats.

Suggested components:

A. The Plan indicates sources of information (e.g., literature, databases, agencies, or individuals) used to determine the problems or threats.
B. The threats/problems are described in sufficient detail to develop focused conservation actions (for example, "increased highway mortalities" or "point-source pollution" rather than generic descriptions such as "development" or "poor water quality").
C. The Plan considers threats/problems, regardless of their origins (local, state, regional, national and international), where relevant to the state's species and habitats.
D. If available information is insufficient to describe threats/problems, research and survey efforts are identified to obtain needed information.
E. The priority research and survey needs, and resulting products, are described sufficiently to allow for the development of research and survey projects after the Plan is approved.

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HOW TO USE THIS CHAPTER

This Chapter provides:

- An overview and background of key regional efforts and classification systems for context
- Identification of the top threats to species on the 2023 RSGCN list:
  - Pollution
  - Climate Change
  - Invasive & Problematic Species, Genes, & Diseases
  - Natural System Modifications
  - Biological Resource Use
  - Residential & Commercial Development
- A section for each of the top 6 priority regional threats with:
  - Description of the general effects on Northeast RSGCN
  - Breakdown of the different ways the overall threat impacts Northeast RSGCN and their habitats, with some species and taxa-specific examples
  - Identification of interactions and synergies with other threat categories
  - Description of useful tools and resources for learning more about the threat
- References and resources
- *Supplemental Information 3* describes the threat classification hierarchy system referred to throughout the chapter

3.0 REGIONAL OVERVIEW

The third required element of State Wildlife Action Plans (SWAPs) describes the problems impacting species and their habitats, priorities for research, and factors that will improve the efficacy of conservation and restoration activities. The Northeast states, through the Northeast Fish and Wildlife Diversity Technical Committee (NEFWDTC), developed a consistent framework for classifying problems and issues (threats), although the adoption of threat ranking criteria varied from state-to-state in their SWAPs. The Northeast Lexicon developed the first classification framework in 2013 and updated the system for 2022 (Crisfield and NEFWDTC 2013 and 2022). The Northeast Conservation Synthesis (TCI and NEFWDTC 2013) and the Northeast SWAP Database (TCI and NEFWDTC 2020a) used this standardized classification framework in their analyses and structure. The 2017 SWAP Synthesis (TCI and NEFWDTC 2017), the 2020 Limiting Factors to Northeast RSGCN report (TCI and the NEFWDTC 2020b), and the Regional Conservation Needs (RCN) program summarized the framework in several reports and projects. NEAFWA's NEFWDTC and Northeast State Wildlife Action Plan Subcommittee, State Wildlife Action Plans, and synthesized regional products provide the foundation to assess and address shared threats collaboratively and prioritize them for action implementation across the region.

This chapter summarizes information about the threats identified through the 14 Northeast State Wildlife Action Plans, which the 2017 SWAP Synthesis analyzed in (TCI and NEFWDTC 2017). It also presents and compares the threats from the 2015 SWAPs to more recent, finer-scale threat information identified and confirmed by regional taxonomic experts for the 2020 Limiting Factors to Northeast RSGCN report (TCI and the NEFWDTC 2020b), as well as additional information from key published data sources and provided by the taxonomic teams during the 2023 RSGCN list review. This chapter then provides greater detail about the top threats in the Northeast and their impacts on species of conservation concern.

There are many challenges confronting fish and wildlife in the Northeast states. Human activities and natural processes that affect wildlife species and habitats in negative or detrimental ways are threats, as are management challenges such as deficiencies in data or resources for particular species or habitats and characteristics of species that may prevent them from responding positively to conservation or recovery actions, referred to as limiting factors. Threats may affect a species or habitat directly or they may be indirect, affecting a species or habitat through one or more intermediary actors or processes. Fish and wildlife management agencies cannot manage these threats independently of one another. Many threats, especially climate change, act synergistically with one another, facilitating or amplifying their combined impact.

3.1 ANALYZING NORTHEASTERN THREATS

There is no comprehensive assessment of threats to fish and wildlife and their habitats across the Northeast region. The Northeast states identified threats to fish, wildlife, and their habitats in their individual Wildlife Action Plans in 2005 and 2015.

The **2007 SWAP Synthesis** report from the Association of Fish and Wildlife Agencies (AFWA) compiled information on priority threats from all 50 states from the original SWAPs in 2005 (TCI 2007). Wildlife diversity program managers and SWAP coordinators provided priority threats cited in their SWAPs. Results were analyzed and presented at national and regional scales. This report indicates that the greatest threats to Northeast wildlife and habitats were Habitat Loss and Degradation from Development, Water Quality from Pollution, Disruption or Alteration of Natural Systems, Invasive and Other Problematic Species, and Climate Change (Figure 3.1).

After the 2015 SWAP revisions, the Northeast region synthesized these results in the **2017 SWAP Synthesis** (TCI and the NEFWDTC 2017). Pollution, Residential and Commercial Development, Natural System Modifications, Wildlife Disease and Invasive Species, and Climate Change emerged as the top regional threats (Figure 3.1). These threats were shared by most states, affected the greatest number of species and habitats, and were cited most frequently in SWAPs.

In 2020, additional threat and vulnerability information was added to the Northeast SWAP Database (version 3.0) for the RSGCN species and presented in the **RSGCN Limiting Factors Report** (TCI and NEFWDTC 2020a, 2020b). This report provided additional context that helped explain why some of these threats were so impactful in the Northeast. Characteristics of life history, behavior, and habitat-specific vulnerabilities, collectively referred to as Limiting Factors, work in concert with threats, amplifying their effects. The top regional threats in the Northeast are intertwined with these Limiting Factors; any conversation involving threats should also acknowledge these factors and consider the complex interactions between them.

As part of the **2023 RSGCN list update** (see *Chapter 1* for more information), the Taxonomic Teams reviewed threat information for RSGCN from the published literature, the 2017 SWAP Synthesis, and the 2020 Limiting Factors Report. Pollution (Threat 9.0), Climate Change (Threat 11.0), Invasive & Problematic Species, Genes, & Diseases (Threat 8.0), Biological Resource Use (Threat 5.0), and Natural System Modifications (Threat 7.0) are the top threats in the region (Figure 3.1). These threats impact the greatest number of RSGCN species.

2007 SWAP Synthesis	2017 SWAP Synthesis	2023 Conservation Synthesis
1. Development 2. Pollution 3. Natural System Modifications 4. Invasives & Diseases 5. Climate Change	1. Pollution 2. Development 3. Natural System Modifications 4. Invasives & Diseases 5. Climate Change	1. Pollution 2. Climate Change 3. Invasives, Problematic Natives, Genes, & Diseases 4. Biological Resource Use 5. Natural System Modifications

Figure 3.1 Comparison of the top five threats to species of conservation concern based on the 2007 SWAP Synthesis, 2017 SWAP Synthesis, and this 2023 Regional Conservation Synthesis. Threats are presented in rank order for each analysis.

From 2007 to 2023, the top threats have remained largely consistent, though their relative ranks have shifted. In fact, results from the 2007 SWAP Synthesis, 2017 SWAP Synthesis, and this 2023 Regional Conservation Synthesis highlight most of the same threats as global wildlife threat prioritization efforts (Wilson 1989, Yiming and Wilcove 2005, Maxwell et al. 2016, Tilman et al. 2017, Bellard et al. 2022). The continued high ranking of the same threats across all regional analyses highlights their importance to conservation in the Northeast. The notable changes in 2023 are Development and Natural System Modifications ranks are lower, while Climate Change, Invasive & Problematic Native Species, Genes, & Diseases, and Biological Resource Use ranks have risen.

The rank shifts reflect the data used to inform each Synthesis product. For the first two Syntheses, data came directly from the SWAPs. As a result, it included threat information on both habitats and species. This 2023 Regional Conservation Synthesis is closely tied with the RSGCN list updates, and as a result, primarily reflects species threat information. The same threats can impact species and habitats differently. For example, Natural System Modifications are a higher rank in the SWAP Syntheses because these are direct threats to many habitats, while largely indirect threats to species. Invasive species impact habitats directly, and species both indirectly through the habitat and directly through competition and predation with other invaders, elevating the importance of this threat from a species lens. Biological Resource Use primarily impacts forested habitats, but species from many different habitats, especially aquatic ones, are imperiled by this threat as it includes harvest and collection. Further investigation of the differential influence of threats on Northeast habitats and species would better inform future management actions and regional planning. The updated regional SWAP Synthesis post-2025 SWAP revisions will enable this analysis.

Ranking the relative importance of threats can be a useful tool for framing these issues. However, it is critical to remember these ranks are highly contextual. The taxon, species characteristic, timescale, and ecosystem under consideration may result in ranks being ascribed to different importance levels (Bellard et al. 2022). All of the threats RSGCN face are important and intertwined. Species conservation will require whole-system approaches that take into account the complex interactions these threats can have on one another.

3.1.1 THREAT CLASSIFICATION IN THE NORTHEAST

States applied the Region 5 USFWS and AFWA SWG Guidance and Best Practices (2012) to define and identify "Key Issues or Threats" to habitats and SGCN. States developed individual approaches to classify these threats inclusively through their internal and external experts and partners but coordinated and collaborated in developing the Northeast Lexicon and Synthesis RCN projects that provided consistent terms, data, and information sharing across the region. In late 2022 AFWA issued a 2nd edition of **Voluntary Guidance for States to Incorporate Climate Adaptation in State Wildlife Action Plans and Other Management Plans**, updating guidance from 2009 (AFWA 2022). The updated guidance includes instructions for incorporating climate change adaptation into the context of the SWAP elements, including tools and examples of adaptive management strategies utilized by some states.

The previous Regional Conservation Synthesis addressed regional threats by summarizing the threats identified in the 2005 Northeast SWAPs and RCN projects conducted to date (TCI and NEFWDTC 2013). The 2005 SWAP threats data were classified using the system jointly developed by the International Union for the Conservation of Nature (IUCN) and Conservation Measures Partnership (CMP), the **Direct Threats Classification System, version 1.1** (Salafsky et al. 2008). Following the development of the 2015 SWAPs the **Northeast State Wildlife Action Plan Synthesis: Regional Conservation Priorities** report synthesized the threats to both species and habitats identified in the 14 revised 2015 SWAPs (TCI and NEFWDTC 2017). These threats were classified with the CMP **Direct Threats Classification System, version 2.0,** which was released in 2016 with minor revisions to the IUCN-CMP version 1.1 classification (CMP 2016).

In December 2019 the IUCN released an updated **Direct Threats Classification System, version 3.2**, with some Level 3 categories to allow for more detailed threats descriptions (IUCN 2019). In 2021 Lamarre et al. (2021) advanced a regional threats classification system consistent with both the CMP Direct Threats Classification System version 2.0 and IUCN version 3.2, releasing the **Standardized Classification of Threats to Biodiversity: Definitions for Quebec's Conservation Data Centre, version 1.0.** This regional classification system includes a third-level hierarchy, providing more detailed threat categories applicable to the NEAFWA region. The new Level 3 threat categories allow for an actionable level of detail, such as specifying a specific source of pollution or a specific invasive species or disease of concern. The Terwilliger Consulting, Inc. team found it necessary to add additional categories to capture threats not fully identified by the Quebec classification system. The full **Quebec classification system with the TCI modifications** is described in *Supplementary Information 3*. The **2022 Northeast Lexicon** recommends the use of this modified regional threat classification scheme for the 2025 SWAPs in the Northeast (Crisfield and NEFWDTC 2022).

In December 2022, IUCN released a draft **Direct Threats Classification System, version 3.3,** with Level 3 threat categories applicable at the global scale (IUCN 2022). This system was introduced too late to be used in this analysis but should be reviewed in the future to determine if it should be incorporated into a Northeast Lexicon update.

The first level of the threat classification hierarchy, which has been largely consistent throughout the various versions, has twelve categories:

- Residential & Commercial Development
- Agriculture & Aquaculture
- Energy Production & Mining
- Transportation & Service Corridors
- Biological Resource Use
- Human Intrusions & Disturbance
- Natural System Modifications
- Invasive & Other Problematic Species, Genes, & Diseases
- Pollution
- Geologic Events
- Climate Change & Severe Weather
- Unknown Cause of Decline

Throughout this document, threats will refer to the associated codes used in *Supplementary Information 3*, e.g., Pollution (Threat 9.0), Agricultural & Forestry Effluents (Threat 9.3).

3.1.2 NORTHEASTERN THREAT DATA SOURCES

There are two primary sources of information for threat data to Northeast priority species. Development of the **Northeast SWAP Database, version 3.0** (TCI and NEFWDTC 2020a) occurred in conjunction with the 2017 SWAP Synthesis to store information from the 14 Northeast SWAPs within the data organization structure described in the original Lexicon (Crisfield and NEFWDTC 2013). This database was created in 2015 and supplemented with information from the 2018 RSGCN list and the 2020 Limiting Factors Report. The second source in the **Northeast RSGCN Database, version 1.0** (TCI and NEFWDTC 2023). This database compiled information from the SWAP Database, NatureServe, IUCN Redlist, state experts, scientific literature, and other sources to generate a preliminary understanding of Northeastern RSGCN to inform and store information from the 2023 RSGCN list update.

Threat information in both of these databases represents a snapshot of the current knowledge and may change in the future as new information becomes available. Information on threats for some of the species on the 2023 RSGCN list, especially invertebrates, is currently lacking. These threat summaries need to be reviewed for consistency and accuracy as a comprehensive review of all species accounts by taxonomic experts will continue as part of the RCN grant program and RSGCN update process. The Northeast SWAP Database reflects similar data deficiencies, especially for invertebrates. Many of the RSGCN and SGCN invertebrate species lacked associated threats in the 2015 SWAPS and therefore the 2017 SWAP Synthesis, though the 2020 Limiting Factors analysis added some additional information for invertebrate RSGCN.

For this Regional Conservation Synthesis, threats from both the Northeast SWAP Database and Northeast RSGCN Database are analyzed and ranked according to the number of species known to be impacted. This measure evaluates the relative importance of each threat in terms of its pervasiveness – how widespread the impacts of the threat are across all RSGCN.

3.1.3 COMPARISON OF THREATS TO RSGCN

Threats in the Northeast SWAP Database and the Northeast RSGCN Database were originally ranked using different criteria in the earlier SWAP Synthesis. To more directly compare the information in both datasets, threat information for the 2018 RSGCN list from the Northeast SWAP Database was ranked using the same methodology as the 2023 RSGCN list from the Northeast RSGCN Database. These results are displayed in Table 3.1 below.

The 2023 RSGCN list includes a combined total of 418 RSGCN and Proposed RSGCN species (see *Chapter 1* for descriptions of these categories). The 2018 list includes 358 RSGCN. The increased numbers in the 2023 list reflect a larger number of invertebrate taxonomic groups reviewed and the ability to include non-SGCN species as Proposed RSGCN in 2023. There is also a difference in data completeness for the two lists. The Northeast RSGCN Database contains at least some threat information for all 418 species, though invertebrate taxonomic groups are likely still data deficient. The Northeast SWAP Database contains threat information for only 169 RSGCN, and nearly 80% of the 149 data-deficient species are invertebrates. The inclusion of many more invertebrate taxonomic groups in the 2023 list combined with greater data coverage may also explain some of the threat differences between the 2018 and 2023 RSGCN lists.

Table 3.1 Number of Northeast species from the 2023 and 2018 RSGCN lists impacted by each Threat Category, based on Lamarre et al. (2021). The 2023 list includes both RSGCN and Proposed RSGCN (see Chapter 1 for more information on these categories). Total species is the total number of species on each RSGCN list. Species with threat information is the total number of species that have any threat information included in the appropriate database (Northeast RSGCN Database for 2023; Northeast SWAP Database for 2018). The top five threats for each RSGCN list are shaded in gray.

Threat Category	*Count of 2023 RSGCN & Proposed RSGCN*	*Count of 2018 RSGCN*
Pollution	338	132
Climate Change	305	116
Invasive & Problematic Species, Genes, & Diseases	228	96
Biological Resource Use	200	118
Natural System Modifications	198	116
Residential & Commercial Development	169	108
Transportation & Service Corridors	144	98
Energy Production & Mining	137	96
Human Intrusions & Disturbance	129	94
Agriculture & Aquaculture	118	75
Other	96	68
Geological Events	1	0
Total Species	*418*	*358*
Species with Threat Information	*418*	*169*

Comparing the two databases reveals remarkably high consistency (Table 3.1). Four of the top five threats are the same across the two groups, despite variance in the species reviewed. Pollution (Threat 9.0) is the top threat for both the 2023 and 2018 RSGCN lists. Climate Change (Threat 11.0) ranked second in 2023 but tied for third in 2018. Invasive & Problematic Species, Genes& Disease (Threat 8.0) ranked third in 2023 but was not one of the top five threats for 2018. Biological Resource Use (Threat 5.0) was ranked fourth in 2023 and second in 2018. Natural System Modifications (Threat 7.0) was the fifth-ranked threat in 2023 and tied for third in 2018. Residential & Commercial Development (Threat 1.0) ranked sixth in 2023 and fifth in 2018.

Residential & Commercial Development ranks for both the 2018 and 2023 RSGCN list is somewhat surprising, considering that development ranked highly in 2007 as well as in most global threat prioritizations (e.g., Wilson 1989, Yiming and Wilcove 2005, Maxwell et al. 2016, Tilman et al. 2017, Bellard et al. 2022). The high degree of development and alteration already present in the Northeast landscape may mute the impacts of development on many species. These species may respond negatively to development, but these impacts are harder to observe because unaltered habitat is generally unavailable for comparison, making it difficult to isolate the impacts of development from other threats.

3.2 THE GREATEST THREATS TO NORTHEAST RSGCN

Despite variations in ranks between the 2023 and 2018 datasets, almost the same set of threats are identified as being high priorities in the Northeast region. This highlights that these threats are widespread across the region and within different taxonomic groups and their habitats. The rest of this chapter will highlight key information about the threat categories that are impacting the greatest number of 2018 and 2023 RSGCN species. This includes the top five threats for the 2023 RSGCN list, plus Residential & Commercial Development as this threat ranked highly in other regional and global analyses. The top threats to Northeast Regional Species of Greatest Conservation Need are:

- Pollution
- Climate Change
- Invasive & Problematic Species, Genes, & Diseases
- Natural System Modifications
- Biological Resource Use
- Residential & Commercial Development

Each of the following sections will provide a general overview of how each threat impacts Northeast RSGCN. It then will break each threat down following the secondary and tertiary levels of the Quebec Threat Classification system, as amended by TCI for the Northeast states, and describe in more detail the various ways each threat can impact priority species, with examples specific to RSGCN. As threats cannot be addressed in isolation, each section also identifies ways that threats are interconnected, providing the context necessary for planning conservation actions. The sections also include descriptions of useful tools and resources for learning more about each threat.

These descriptions are not a complete review of each of these topics. Every species responds differently to each threat in this list, adding significant complexity to the analysis. Additionally, species responses can vary depending on the sex, life stage, or behavior of an individual. Habitat type, condition, and other external factors may also exacerbate species responses. It is not feasible to cover these intricacies for all of the RSGCN and Proposed RSGCN in the 2023 list within this document. Instead, the focus is on highlighting the relative importance and relevance of each threat to Northeast

RSGCN and their habitats, with an emphasis on recent and emerging information. This information will provide a starting point but should be supplemented with more data specific to the species, habitats, and conditions being managed.

3.2.1 POLLUTION

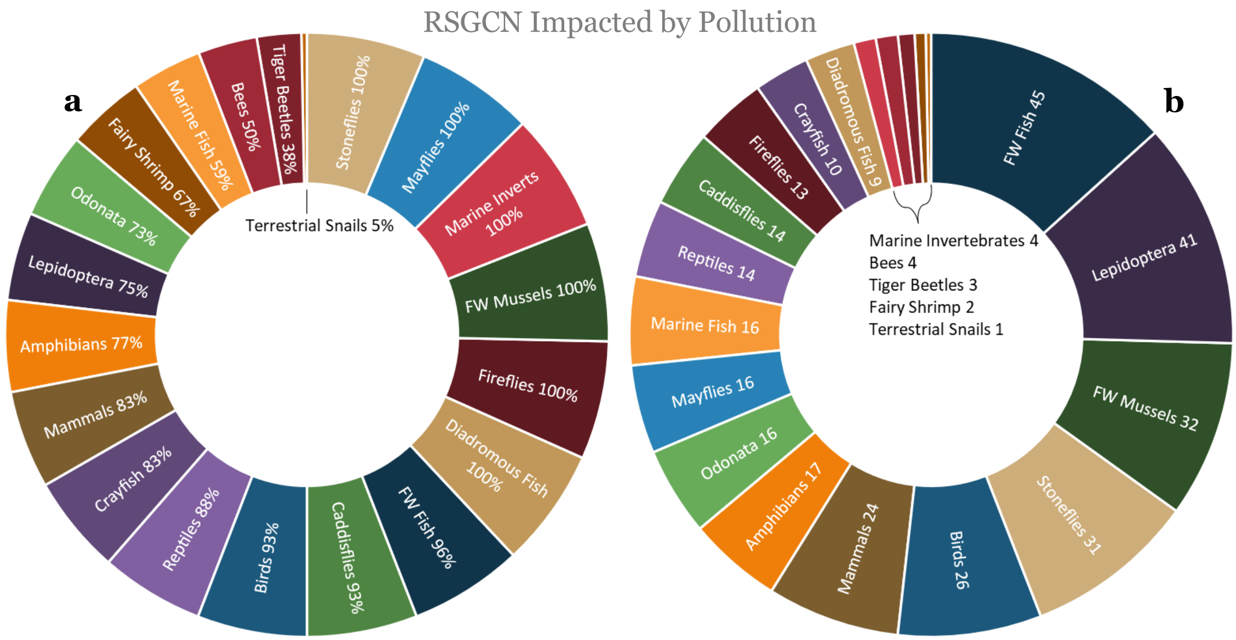

Figure 3.2. Impact of Pollution (Threat 9.0) on RSGCN and Proposed RSGCN. (a) The percentages show the proportion of the species within that taxonomic group known to be impacted by this threat. (b) The total number of species within the taxonomic group known to be impacted by this threat.

Pollution is by far the most common regional threat, impacting 81% (338 species) of the RSGCN and Proposed RSGCN on the 2023 list. Many of the taxonomic groups that are most heavily impacted are aquatic; pollution imperils the entire diversity of the stonefly, mayfly, marine invertebrate, freshwater mussel, firefly, and diadromous fish taxonomic groups (Figure 3.2a). Though pollution does not impact all freshwater fish or lepidopterans, these two groups contribute the largest number of species impacted (Figure 3.2b). For most of the remaining taxonomic groups, the proportion of impacted species is above 50%. The only groups where the proportion is less than 50% are tiger beetles and terrestrial snails. These low numbers are likely the result of data deficiency, rather than indicating that pollution does not impact these groups. Additional research is required to determine if pollution is a concern.

Pollutants come from point and nonpoint-sources. Point-source pollutants can be traced back to a single identifiable discharge point, such as a pipe, ditch, ship, or smokestack. Nonpoint-source pollutants cannot be traced to a single specific source, as point-source pollutants can. Instead, these pollutants come from many sources throughout the landscape. For example, as water moves overland or through the ground, it collects many different pollutants from many different places and brings them all together in more concentrated areas, such as rivers and streams.

Another important aspect of many pollutants is that they can bioaccumulate. Bioaccumulation is the gradual buildup of chemical substances, such as pesticides, in an organism. The body is unable to rid itself of these compounds, so concentrations increase over time, even if the amount of the compound in the environment is very low. As the concentration of the compound in the body increases, individuals may suffer from a wide variety of symptoms, including death, depending on the chemical. Bioaccumulation has important impacts on food webs, as the compounds continue to aggregate in higher tropic levels as predators consume contaminated individuals, a process known as biomagnification.

Many aquatic RSGCN are highly sensitive to pollution: their presence or absence makes them indicators of water quality. Eastern Hellbenders (*Cryptobranchus a. alleganiensis*), mayflies, stoneflies, caddisflies, and mussels thrive in pristine water conditions. Pollution acutely impacts aquatic species because these contaminants are ubiquitous within the habitat. Pollutants are found in the water column, sediments, and potential food sources. By contrast, contaminant distribution is less homogenous in terrestrial systems; combined with the ability of terrestrial species to move away from pollutants, contaminant exposure is a function of concentration and repeated exposure (Smith et al. 2007). In both aquatic and terrestrial systems, exposure from the environment occurs via ingestion, absorption through the skin, accumulation on gills or filters, inhalation, or a combination of multiple pathways (Honda and Suzuki 2020, Smith et al. 2007). Some pollutants, including heavy metals, polychlorinated biphenyls (PCBs), pharmaceutical compounds, and certain pesticides, persist for long periods in the environment, resulting in long-term contamination of the environment and bioaccumulation of these pollutants throughout the ecosystem (McKinney et al. 2015, Ali et al. 2019, Honda and Suzuki 2020).

AGRICULTURAL & FORESTRY EFFLUENTS

Contaminants and effluents from forestry and agricultural activities are known to impact more RSGCN species than any of the other pollutant categories. Though these chemicals can have impacts on species utilizing areas at or near the point of application, the greater impact is their role as nonpoint-source pollutants.

Runoff is the primary culprit in the transport of agricultural and forestry effluents. Rain runs overland and can move faster and gather more pollutants in areas that have lost vegetative cover, as is often the case after agricultural and forestry activities. Additionally, since these pollutants travel downstream, they can still have impacts thousands of miles away from where they entered the water, greatly increasing the area of effect.

The Clean Water Act was implemented as the Federal Water Pollution Control Act in 1948 and expanded in 1972 and regulates pollutant discharges in the waters of the United States. These regulations have increased waterbodies safe for fishing by about 12%, though concentrations in many rivers and streams still exceed water quality standards (Keiser and Shapiro 2019). A major criticism of the Clean Water Act is that it does not have the authority to regulate nonpoint-source pollution, making compliance largely voluntary. This largely reduces the efficacy of this act for managing Agricultural & Forestry Effluents, leading many natural resource agencies to alternative ways of interacting with landowners to achieve pollutant reduction (Ribaudo 2015).

THREAT DESCRIPTIONS AND EXAMPLES

Herbicides and pesticides (Threat 9.3.3) can be highly toxic to non-target species, especially pollinators. Spraying for Spongy Moth (*Lymantria dispar*), a common nonnative forest pest, impacts many of the RSGCN lepidopterans. Neonicotinoid pesticides are known to impact honey bees, but the impacts on wild bee species are largely unknown (Lundin et al. 2015). There are indirect effects on other taxa as well; the loss of insect biomass due to the widespread application of various pesticides imperils insectivorous birds, such as the Eastern Whip-poor-will (*Antrostomus vociferus*). For species dependent on high water quality, including many freshwater mussels and aquatic insects, nonpoint-source pollution may be the most significant threat.

Excessive nutrient inputs (Threat 9.3.1), generally from the application of fertilizers, are primarily a concern for aquatic habitats and species. They can affect stream water chemistry and influence vegetative growth. This growth often benefits invasive species in aquatic habitats and wetlands. High nutrient loads can also lead to algal blooms in larger bodies of water, which can deoxygenate the water, block sunlight, and produce detrimental toxic chemicals, all of which negatively impact many different aquatic species.

Soil erosion and sedimentation (Threat 9.3.2) is a threat that critically impacts aquatic systems. Large sediment loads can settle on the bottom of a water body, smothering some RSGCN directly, such as freshwater mussels, and indirectly impacting other RSGCN by burying important resources. Species will need to seek resources, such as plant and benthic invertebrates, elsewhere if they become buried. Sediments can also alter important structures. Excessive silt and bury spawning shoals and gravel beds for various fish species, smothering eggs and nests. Silt also fills crevices under rocks and other features, leaving species like the Big Stone Crayfish (*Cambarus magerae*) without shelter and protection from predators.

All three forms of agricultural and forestry effluents can influence a species. Atlantic and Shortnose Sturgeon (*Acipenser oxyrinchus* and *A. brevirostrum*, respectively) are vulnerable to nonpoint-source pollution, have the potential to bioaccumulate toxins due to their long lifespan, have some evidence linking reproductive or developmental disorders to chemical pollutants, and require silt-free locations for spawning (Billard and Lecointre 2001).

RELATIONSHIPS WITH OTHER THREATS

Intensive or incompatible agricultural practices without the use of best management practices may have degraded or reduced suitable habitats. Conversion to Annual & Perennial Non-Timber Crops (Threat 2.1), Wood & Pulp Plantations (Threat 2.2), or Livestock Farming & Ranching (Threat 1.3), and Logging & Wood Harvesting (Threat 5.3) leads to the loss of forest cover, grassland habitat, and riparian buffers. These practices also increase runoff from the surrounding areas by removing vegetation, which in turn can increase chemical, nutrient, and sediment inputs. Additionally, Natural System Modifications (Threat 7.0) to the vegetation directly adjacent to water bodies can change water temperature, light levels, and flood patterns.

Climate Change (Threat 11.0) will also exacerbate the impacts of Agricultural & Forestry Effluents on RSGCN. Several taxa were identified as being highly vulnerable and at increased risk from the interactive effects of pollution and climate change, including freshwater mussels and other mollusks, fishes, amphibians, and birds (Pinkney et al. 2015). Climate change is projected to lead to increased frequency and severity of storms. These events intensify the transport of chemicals, nutrients, and sediments into water bodies, enhancing the potential for contamination and eutrophication (Bates et al. 2008; Pinkney et al. 2015). Increasing temperatures due to climate change may alter sensitivity and susceptibility to certain pollutants (Noyes & Lema 2015), increase the risk of hypoxia due to eutrophication and associated algal blooms (Pinkney et al. 2015, Griffith and Gobler 2020), or otherwise alter metabolic processes in ways that alter vulnerability to pollutants (Ficke et al. 2007, Saaristo et al. 2018).

TOOLS AND RESOURCES

The US Geological Service is a repository and resource for many pollution datasets and tools. The **National Water Quality Program** and associated **National Water Quality Assessment Project**[1] track trends and changes in surface water, groundwater, and aquatic habitats. Specific resources relevant to Agricultural & Forestry Effluents include their informational pages on agricultural contaminants[2], nutrients and eutrophication[3], and pesticides and water quality[4]. These pages provide links to additional information, research, and data products related to each topic. Several tools and datasets are particularly relevant. The **Regional Stream Quality Assessment**[5] characterizes water quality factors that are stressors to aquatic life, including contaminants, nutrients, and sediment, to better understand the influence of the stressors in five regions across the United States, including much of the Northeast. These data can be downloaded or explored in their online mapping tool. The **Spatially Referenced Regression On Watershed (SPARROW) attributes**[6] model and its associated products and tools can be used to estimate transport rates of nutrients, sediments, and dissolved solids from inland watersheds to larger water bodies.

The EPA also provides a robust suite of tools and resources related to pollution. The EPA's **National Pollutant Discharge Elimination System**[7] regulates point-source discharge, including forest roads, nutrients, and pesticides. Their resource page includes information about these sources of wastewater and their management.

The EPA **Report on the Environment**[8] tracks more than 80 indicators of human health and ecological condition that show trends in the conditions of the nation's land, water, and air (US EPA 2022). Useful indicators include agricultural fertilizer application rates, nitrate and pesticides in groundwater, nitrogen and phosphorous in streams and rivers, and pesticides in streams. The EPA also has produced other datasets, such as the interactive maps of the **303d Listed and Impaired Waters for the USA**, which identifies waterbodies considered impaired based on pollutant levels exceeding Clean Water Act specifications (US EPA 2015).

Best management practices to protect water quality in adjacent aquatic habitats from agricultural and forestry activities are available from the EPA[9], the US Forest Service[10], and the National Association of State Foresters[11].

DOMESTIC & URBAN WASTEWATER

Similar to Agricultural & Forestry Effluents, Domestic & Urban Waste Water disproportionately impacts aquatic species. These wastewater sources can be point or nonpoint. Due to the wide variety of activities that occur within residential and urban environments, the contaminants are also highly varied. Wastewater is generally collected and treated, but under certain conditions untreated wastewater may be released into water bodies, becoming a point-source pollutant. Once again, nonpoint-source pollution in residential and urban areas carries significant contaminants.

The Clean Water Act was implemented as the Federal Water Pollution Control Act in 1948 and expanded in 1972 and regulates pollutant discharges in the waters of the United States. These regulations have increased waterbodies safe for fishing by about 12%, though concentrations in many rivers and streams still exceed water quality standards (Keiser and Shapiro 2019).

THREAT DESCRIPTIONS AND EXAMPLES

Runoff (Threat 9.1.2) can carry any number of contaminants in it, including those coming from buildings, grassy areas, parking lots, and roadways. Buildings are not a major source of runoff contamination but may have localized inputs such as heavy metals used in paints or construction materials. Grassy areas such as lawns, parks, and golf courses contribute sediments, fertilizers, and pesticides with similar effects to those described above for agricultural effluents. Byproducts from automobiles, such as gasoline residues, break and tire wear, and motor oils, are easily washed from impervious surfaces (Tian et al. 2022). Other chemicals used on roadways, such as salt and sand applied in icy conditions, can be highly detrimental as well (Hintz et al. 2022). In general, runoff negatively impacts water quality in aquatic habitats near developed areas and roadways, impacting any RSGCN with a low tolerance for contamination.

Domestic wastewater (Threat 9.1.1) can add significant nutrient loads to water bodies, especially if untreated sewage is released. The impacts of these releases can be similar to those of excessive nutrient loads described under Agricultural & Forestry Effluents. However, there is also increasing evidence that the presence of various pharmaceuticals in wastewater can be severely disruptive to many species (Holeton et al. 2011, Galib et al. 2018, Petrie 2021).

RELATIONSHIPS WITH OTHER THREATS

Domestic & Urban Wastewater is coincident with Residential & Commercial Development (Threat 1.0) and Transportation & Service Corridors (Threat 4.0), so overlap between these categories is likely. In addition, some of the impacts of Climate Change (Threat 11.0), especially the increased frequency and intensity of storms and precipitation, will further exacerbate the impacts of Domestic & Urban Waste Water. Increased rain frequency means increased overland runoff, resulting in additional transport of pollutants into water bodies (Bates et al. 2008, Pinkney et al. 2018). The combination of increased precipitation frequency, volume, and intensity may overwhelm existing wastewater treatment facilities, potentially resulting in more frequent wastewater releases (Petrie 2021).

TOOLS AND RESOURCES

The USGS is a repository and resource for many pollution datasets and tools. **The National Water Quality Program** and associated **National Water Quality Assessment Project**[12] track trends and changes in surface water, groundwater, and aquatic habitats. Specific resources related to Domestic & Urban Wastewater include resource pages on runoff[13], urban land use and water quality[14], and asphalt sealcoat chemicals[15]. These pages provide links to additional information, research, and data products related to each topic.

The EPA's **National Pollutant Discharge Elimination System**[16] regulates point-source discharge, including municipal and industrial wastewater and stormwater. Their resource page includes information about these sources of wastewater and their management. They also have a **National Menu of BMPs for Stormwater**[17] management to address potential impacts on aquatic habitats from pollution.

The **Waterkeeper Alliance**[18] is a global network of more than 300 local groups dedicated to protecting clean water. The organization monitors water quality, identifies and litigates sources of pollution, advocates for local clean water protections, and conducts education and outreach.

INDUSTRIAL & MILITARY EFFLUENTS

Industrial and Military Effluents impact fewer species than the pollutants discussed above, but their effects are often more acute. These contaminants are generally point-source pollutants. Single pollution events can take an extremely long time to recover from if recovery occurs at all. Because point sources are more easily identifiable and smaller scale, they are theoretically easier to treat and mitigate. Though their impacts may be more limited in scope, these pollutants are highly toxic, persistent, and bioaccumulate and biomagnify. Thus, their influence is severe and long-lasting. Moreover, mitigation is a time-consuming and expensive process. Wind and water currents can disperse chemicals, making them more difficult or impossible to collect efficiently. Additionally, the collected chemicals and contaminated materials must be properly disposed of, or the effects of the pollutant will just be moved to a different location (Kuppusamy et al. 2016).

The Clean Water Act was implemented as the Federal Water Pollution Control Act in 1948 and expanded in 1972 and regulates pollutant discharges in the waters of the United States. These regulations have increased waterbodies safe for fishing by about 12%, though concentrations in many rivers and streams still exceed water quality standards (Keiser and Shapiro 2019).

THREAT DESCRIPTIONS

Oil spills (Threat 9.2.1) are better studied in marine ecosystems and may have wider impacts, but they can also occur in terrestrial or freshwater systems. Because oil spills can happen in any environment, they can impact any species, although they are more commonly thought of as a threat to marine species such as sea turtles, marine mammals, and seabirds. Spills happen during the extraction or transportation of oil, with impacts that vary based on the ecosystem they occur in (Kingston 2002, Baca et al. 2005, Ober 2010). Similar to other pollutants, oil particles have deleterious internal effects on individuals who ingest, inhale, or otherwise absorb them from the ecosystem and can cause mass die-offs of plants, fish, amphibians, birds, mammals, reptiles, and other taxa (Sanders et al. 1980, Piatt et al. 1990, Silliman et al. 2012, Wallace et al. 2017). Oil particles are also harmful externally; they can coat the skin of many species, including turtles, marine and terrestrial mammals, and birds. These oils irritate the skin and interfere with the insulative properties of fur and feathers (Ober 2010). Attempts to preen or otherwise clean the oil off can result in ingestion of the particles. Oil particles collect on filtering structures, such as fish gills, whale baleen, and shellfish ctenidia, clogging these structures and preventing their function, and can coat plant and other food resources, forcing RSGCN to forage for longer times or across longer distances (Ober 2020). Long-term impacts of oil spills are also possible, especially in coastal systems where the residues enter the substrate (Kingston 2002). Oil spills impact RSGCN from many different taxonomic groups, but marine mammals, invertebrates, and turtles were particularly prevalent.

Acid mine drainage (Threat 9.2.2) is a byproduct of many types of mining, though in the Northeast it is primarily associated with coal mining. Mining operations expose various sulfur-containing minerals to surface conditions, where they oxidize and convert into sulfuric acid. These acids, along with associated heavy metals and mining sediments, drain into local ground and surface waters, impacting water quality and pH (Gray 1997, Ray and Dey 2020, Burns 2022). West Virginia may face the greatest threat in the Northeast, with nearly 30,000 miles of streams impacted by coal mining operations. Virginia, the next most impacted state in the region, has 8,000 miles of impacted streams (Burns 2022). Mine drainage is a major concern for several amphibians, mussels, freshwater fish, and crayfish, especially when considering the large number of narrow-range endemics in these two states.

Heavy metals such as **mercury** (Threat 9.2.5) and **lead** (Threat 9.2.6) are highly toxic, persist for long times in the environment, and bioaccumulate throughout the ecosystem (Ali et al. 2019). Bioaccumulation disproportionately impacts higher-level predators due to these characteristics, though they can have severe impacts across many taxa. Mercury can come from several industrial sources, including mine tailings and industrial effluents, and can cause damage to the nervous, excretory, and reproductive systems (Wolfe et al. 1998). Mercury is a particular concern in many piscivores, including predatory fish, birds, and humans, as the longer aquatic food chains allow for more magnification than is present in most terrestrial chains (Chan et al. 2003, Eagles-Smith et al. 2016, Jackson et al. 2016). Two historic but significant sources of industrial lead were the use of lead-based paints and leaded gasoline. The impacts of these sources of lead may be greatest on wildlife living in more urbanized areas where concentrations of lead in the soil are highest (Roux and Marra 2007).

Flame retardants (Threat 9.2.3) are a rapidly growing concern for many wildlife species, though their impacts on Northeast RSGCN and Proposed RSGCN are not yet established. Brominated flame retardants (BFRs) are ubiquitous and include more than 75 different compounds, making it more difficult to identify the impacts on wildlife (Smythe et al. 2022). BFRs are used to reduce the flammability of many products, including textiles, plastics, building materials, and electronics; this widespread use has resulted in their dispersal throughout the environment (Zacs et al. 2018). These chemicals are toxic, persistent, and bioaccumulative, magnifying their impacts throughout ecosystems (Segev et al. 2009, Klosterhaus et al. 2012). They act as endocrine disruptors, carcinogens, and neurotoxins, which has major impacts on human and wildlife health (Segev et al. 2009). In recent decades, several of these compounds have been regulated, which is reducing the output of some of these chemicals, but also contributing to the creation of new ones with unknown impacts (Smythe 2022). Despite significant amounts of research in many different taxonomic groups, significant data gaps exist, including unknown impacts many of the BFRs, a growing body of new compounds, and unclear metabolic pathways (Smythe et al. 2022).

Another group of persistent, bioaccumulative compounds includes polychlorinated biphenys, or **PCBs** (Threat 9.2.4). PCBs share many characteristics with BFRs, acting as endocrine disruptors, immunosuppressants, carcinogens, and neurotoxins, influencing behavior and reproduction (Boyles and Nielsen 2017). Production of PCBs was banned in the United States in 1979 due to concerns about toxicity and chemical stability (Hens and Hens 2018). Several Superfund sites in the Northeast are contaminated by PCBs (Hens and Hens 2018). Even decades after the PCB bans, concentrations remain high in many species, including cetaceans (Jepson et al. 2016), Bobcat (Lynx rufus; Boyles and Nielsen 2017), North American River Otter (*Lontra canadensis*; Carpenter et al. 2014) and freshwater turtles (Adams et al. 2016).

Several **other industrial discharges** (Threat 9.2.7) are also of concern to species on the RSGCN list. Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are a common component in fire suppression foam and other substances used to make products flame, water, oil, or stain resistant. For a review of the impacts of this group of chemicals on wildlife, see Bangma et al. (2022). Similar to BFRs, new PFAS chemicals are being produced, and research is not able to keep pace with these changes. PFASs have been widely produced since the 1950s, but by the early 2000s evidence of the harmful effects of these products on human and wildlife health was becoming more common (Vendl et al. 2021). By 2010, production of many of these chemicals had drastically slowed or stopped as a result of global agreements (Vendl et al. 2021). Consumption of freshwater fish is likely a significant source of the PFAS compound PFOS in much of the United States (Barbo et al. 2023). Pharmaceuticals are another growing concern. Increasing human consumption of these chemicals is resulting in increased pharmaceutical residues in the environment and wildlife (Arnold et al. 2014, Bean et al. 2023). Many of these chemicals enter the environment through wastewater, as sewage is generally not treated for these compounds (Arnold et al. 2014). These compounds may alter activity levels, reproductive success, body condition, stress levels, behavior, and other characteristics in exposed individuals (Arnold et al. 2014). For a review on the effects of different pharmaceuticals on wildlife, see Bean et al. 2023).

RELATIONSHIPS WITH OTHER THREATS

The presence of industrial contaminants is closely tied to the locations where they are produced and used. These forms of pollution often occur in conjunction with Energy Production & Mining (Threat 3.0), Transportation & Service Corridors (Threat 4.0), and Residential & Commercial Development (Threat 1.0). Climate Change (Threat 11.0) may have less of an amplifying effect on this category since these forms of pollution tend to be isolated and episodic, rather than events impacted by changing temperature, precipitation, or weather patterns. Severe weather events may increase the risk of flooding in industrial sites, resulting in an increased risk of spills or other pollution events. In addition, research is just starting to explore how climate change may increase species' sensitivity to various industrial pollutants (McKinney et al. 2015, Pinkney et al. 2015).

TOOLS AND RESOURCES

The USGS is a repository and resource for many pollution datasets and tools. The **National Water Quality Program** and associated **National Water Quality Assessment Project**[1] track trends and changes in surface water, groundwater, and aquatic habitats. Specific resources relevant to Industrial & Military Effluents include their resource pages on sediment-associated contaminants[19], mercury[20], industrial chemicals[21], and emerging contaminants[22].

The EPA administers the **Comprehensive Environmental Response, Compensation, And Liability Act**, informally called Superfund. These are contaminated areas that exist due to improper management of many industrial pollutants. Their Superfund[23] resource page has many resources related to reporting, managing, and remediating superfund sites. They also have datasets and interactive map products for exploring sites in your state, national priority sites, and cleanup operations[24].

NOAA provides scientific expertise, data, tools, training, and assistance related to oil and chemical spill responses in coastal and marine environments. Their **Office of Response and Restoration**[25] focuses on research and tools for ongoing spill events, while the **Damage Assessment, Remediation, and Restoration Program**[26] focuses on cleanup and restoration activities after the initial pollutant containment occurs.

EXCESS ENERGY

Unlike the other pollutants previously discussed in this section, excess energy is not the presence of a chemical or compound that causes direct harm to a species. Instead, byproducts of human presence and activity alter the sensory landscape of an ecosystem, which changes the behavior of species in that environment. Each of these forms of pollution can be an attractant or a deterrent; for some species, it may be both depending on other conditions such as time of year, life stage, or activity type.

THREAT DESCRIPTIONS AND EXAMPLES

Light pollution (Threat 9.6.1) is one of the most common forms of excess energy in the Northeast. Beachfront lighting has long been known to disorient sea turtle hatchlings, but more recent work has also highlighted that excessive light can discourage nesting females and increase hatchling risk of predation (Verutes et al. 2014, Brei et al. 2016, Silva et al. 2017). Excessive nighttime lighting has similar disconcerting effects on migrating birds and can disrupt their circadian rhythms (Cabrera-Cruz et al. 2018). Seasonal "Lights Out" initiatives for both sea turtles and migratory birds are widespread in the United States, but further evaluation of their efficacy may be necessary (Kamrowski et al. 2015, van Doren et al. 2021). Bats, including members of the genus *Myotis*, show mixed responses. They may avoid traveling through areas with artificial lighting and opportunistically forage around light fixtures that are attracting night-flying insects; increased light levels may lead bats to abandon roosting sites and can disrupt circadian rhythms and alter nightly emergence timing (Stone et al. 2015). Some research has indicated that light reduction measures in urban environments can improve conditions for some bat species (Laforge et al. 2019). Nocturnal insects and other invertebrates are also heavily impacted by light pollution (Gaston et al. 2013). Owens and Lewis (2018) and Owens et al. (2020) summarize the many different ways insects respond to artificial lighting. Fireflies are of particular interest as all RSGCN and Proposed RSGCN firefly species are considered threatened by light pollution. Lighting may impact this taxonomic group more than other nocturnal insects because it interferes with their bioluminescent communication signals (Firebaugh and Haynes 2016, Owens and Lewis 2018).

Thermal pollution (Threat 9.6.2) is any deviation from the natural temperature in the ecosystem and is generally a byproduct of certain industrial facilities, such as desalination and power plants. Most commonly, it refers to discharges from cooling systems where the heated water is dumped into a nearby lake, river, or ocean. Other forms of thermal pollution include heat-island effects in urban areas and discharges of cold water from reservoirs into warmer streams. Most aquatic species operate within a limited range of thermal tolerances, which influence many of their biological, chemical, and physiological responses to the environment (Verones et al. 2010). Though these responses are particularly well studied in fish (Beitinger et al. 2000), mussels (Ganser et al. 2015), crayfish (White 1983), and aquatic insects (Herrera et al. 2018, Orr and Buchwalter 2020) are also sensitive the thermal changes. Sudden temperature changes, such as those caused by the discharge of heated water from power plants or cold water from dams, can cause shock in many of these organisms, leading to widespread die-offs (Allman 1998, Clarkson and Childs 2000, Archambault et al. 2014, Buhariwalla et al. 2016). In some unusual cases, species may become dependent on sources of thermal pollution and be negatively impacted if the source of the thermal pollutant is disrupted. Buhariwalla et al. (2016) attributed a temporary maintenance shutdown of a power plant as a contributing factor to Striped Bass (*Morone saxatilis*) mortality in Nova Scotia. The associated pause in warm-water discharge during a cold snap resulted in cold shock, especially among younger year classes. Gradual temperature changes can have more widespread impacts. Warmer water is less oxygenated, which can be a significant physiological stressor. Temperature increases can still be observed hundreds to thousands of miles downstream of the original input, alter mixing and nutrient cycles in lacustrine environments, and reduce ice cover in winter, all of which can result in cascading effects throughout aquatic food webs (Vinna et al. 2017). Since temperatures dissipate more quickly in the air than in water, thermal pollution has less of an impact on terrestrial wildlife. The main exception to this is heat island effects, where high concentrations of buildings and roads re-emit heat from the sun, causing urban and developed areas to be warmer than nearby areas.

Excess noise (Threat 9.6.3) can refer to an increased frequency of high-intensity sound events, such as explosions, or more generalized increases in background noise levels. Species responses to noise pollution vary depending on whether the noise is chronic or intermittent, and can lead to direct or indirect fitness costs (Francis and Barber 2013). Research on the impacts of noise has occurred for just about every taxonomic group, though is disproportionately focused on birds and marine mammals (Shannon et al. 2016). It is also pervasive; Buxton et al. (2017) found that anthropogenic noise doubles background noise levels in more than half of the protected areas in the United States, including more than 10% of designated Wilderness Areas. These effects may be elevated in freshwater and marine environments, as water transmits sound much faster than air. Noise pollution can lead to avoidance of areas with elevated sound levels, alter behaviors in these areas, increase the risk of predation, and interfere with wildlife communication (Shannon et al. 2016, Duquette et al. 2021). Elevated noise levels make vocalizations harder to hear, especially at greater distances, which could heavily impact strongly vocal species such as birds, frogs, and whales. Some terrestrial species, especially birds, respond to increased background level noise by shifting their calls to higher frequencies, but these behavioral adaptations may not be sufficient to overcome the negative impacts of noise (Duquette et al. 2021). For species that echolocate, such as bats and cetaceans, noise pollution interferes with foraging success and can result in increased physiological stress (Holt et al. 2015, Domer et al. 2021). In the Northeast, various Taxa Teams raised concerns about the impacts of certain noise sources on specific RSGCN groups, especially offshore wind installations and marine shipping on marine mammals, sea turtles, seabirds, and diadromous fish. Potential mitigation strategies for various forms of noise pollution have long been a data deficiency, though increasing research is attempting to address the topic (Alquezar and Macedo 2019, Domer et al. 2021, Ditmer et al. 2021, Teff-Secker et al. 2022).

RELATIONSHIPS WITH OTHER THREATS

All three forms of excess energy are intertwined with human activity. Light pollution is closely associated with Residential & Commercial Development (Threat 1.0). Thermal pollution is sometimes a result of development but is more frequently associated with Energy Production & Mining (Threat 3.0) and Natural System Modifications (Threat 7.0). Noise pollution is associated with nearly every form of human activity, including development, energy production, and Transportation & Service Corridors (Threat 4.0). Excess energy, especially light and noise, is intensifying globally, highlighting the need for better management and mitigation of these forms of pollution (Ditmer et al. 2021). The effects of thermal pollution may also be amplified by Climate Change (Threat 11.0), which in turn may exacerbate threats from Invasive Non-native/Alien Plants & Animals (Threat 8.1) by making otherwise inhospitable conditions conducive to invasion (Strubbe and Matthysen 2009, Wolf et al. 2014).

TOOLS AND RESOURCES

Numerous maps of nighttime light pollution levels are accessible online, from a wide variety of data sources. These maps are often developed using remotely sensed data. However, the International Dark-Sky Association is engaging citizen scientists through their **Globe at Night** initiative to track light pollution levels globally (NOIRLab 2023). A recent analysis of this dataset from 2011-2022 has revealed that sky brightness is increasing by 7-10% per year (Kyba et al. 2023). Though the focus of this paper was on implications for astronomy, these light increases will impact nocturnal wildlife as well.

The Bureau of Transportation Statistics recently released a **National Transportation Noise Map** that shows the concentration and relative sound levels of aviation, railway, and highway noise in the continental United States (US DOT BTS 2020). These data could inform background noise level models for local analysis, though responses to episodic sound events (e.g., an airplane taking off) may not be captured. Resources for noise pollution in marine environments are less readily available. Farcas et al. (2020) **validated shipping noise models** in the northeast Atlantic, which may have implications for mapping marine noise in the Northeast region. In addition, a collaboration between researchers at three universities, Meridian, and FishBase has resulted in **FishSounds**, an online database that compiles global information on the effects of sound production on all extant fish species (Looby et al. 2022).

Fewer resources exist for tracking thermal pollution, in part because it is often associated with specific locations and facilities. However, some innovative uses of **remotely sensed thermal imagery** could have applications for tracking thermal pollution in the Northeast (Ling et al. 2017).

AIR-BORNE POLLUTANTS

Atmospheric pollutants can be from point and nonpoint-sources. Often, it is difficult to determine the source of many atmospheric pollutants, making it more difficult to manage them. Airborne pollutants have decreased dramatically in the United States with the introduction of the Clean Air Act in 1970 and its amendments in 1990 (Butler et al. 2001, Murdoch and Shanley 2006, McHale et al. 2021). However, these historic inputs have had long-lasting effects across many habitats and taxonomic groups.

THREAT DESCRIPTIONS AND EXAMPLES

Acid rain (Threat 9.5.1) in particular has altered ecosystems across the Northeast. Acid rain forms when sulfuric and nitric oxides are released into the air by fossil fuel-burning power plants, vehicle emissions, or other industrial plants. These chemicals then react with oxygen and water to form sulfuric and nitric acids before falling back to the ground, where they can drastically alter soil and water chemistry. Amphibians are extremely sensitive to these changes; decreased pH levels impact the success and survival of eggs, larvae, and adults (Pierce 1993). Acidification also impacts the availability of key nutrients such as calcium, which is critically important for shell-forming species such as mollusks and birds. Several authors have investigated the relationship between calcium, terrestrial snails, and birds, highlighting how acid rain can have reverberating effects throughout the food web (Graveland 1996, Hotepp 2002, Mänd et al. 2000). The Central Appalachian Mountains, a hotspot of salamander, mussel, and terrestrial snail diversity received some of the highest rates of acid deposition in the United States (Thomas et al. 2013). The high level of endemism may have exacerbated the impacts of acid rain in this region. The Terrestrial Snail Taxa Team suggested that the historic declines of several species, including the Cherrystone Drop (*Hendersonia occulta*), may have been a direct result of acid rain and should be investigated. Recovery from the impacts of acid rain has been observed in some taxa in the Northeast, including plants (Thomas et al. 2013) and fish (Warren et al. 2017), and other taxa in other regions (Dolmen et al. 2018), but impacts are likely ongoing in both terrestrial and aquatic systems (Jeffries et al. 2003, Lawrence et al. 2020).

Other airborne pollutants, including **smog** (Threat 9.5.2), **ozone** (Threat 9.5.3), and **dust and ashes** (Threat 9.5.4), can impact wildlife species but are not generally considered a major concern for RSGCN in the Northeast. Smog and dust tend to be associated with specific sources, such as a city or forest fire, so their impacts may be more localized.

RELATIONSHIPS WITH OTHER THREATS

Airborne pollution may be intensified by increased Residential & Commercial Development (Threat 1.0), Energy Production & Mining (Threat 3.0), and Transportation & Service Corridors (Threat 4.0). In addition, Climate Change (Threat 11.0) may amplify the effects of these pollutants by increasing the overall stress levels of individuals within impacted environments (Warren et al. 2017). Changing precipitation and weather patterns may also change deposition patterns and rates of airborne pollutants.

TOOLS AND RESOURCES

The **National Atmospheric Deposition Program**[27] has been tracking airborne pollutants in precipitation since 1978. Early programs focused on acid deposition and key nutrients, but additional programs tracking ammonia and mercury have been added over time. More than 50 active monitoring sites are found across the Northeast region, producing extensive data products and maps tracking changes over time.

The **USGS has useful reference pages** on topics including acid rain[28] and volatile organic compounds[29].

The EPA **Report on the Environment**[1] tracks more than 80 indicators of human health and ecological condition that show trends in the conditions of the nation's land, water, and air (US EPA 2022). Useful indicators include acid deposition, air toxins, ozone-depleting substances, sulfur and nitrogen dioxide, and volatile organic compounds.

GARBAGE & SOLID WASTES

According to the EPA, the United States produces 4.9 pounds of municipal solid waste per person per day[30]. These wastes are a variety of substances, including food, yard trimmings, glass, paper, metals, textiles, and plastics. Management of these wastes is a high priority for state and local governments; depending on the type of waste and available management facilities, municipal solid wastes may be recycled, composted, burnt, or deposited in a landfill.

Ideally, the ultimate fate of these wastes is to end up in a waste management facility where they would be treated, processed, or otherwise disposed of. Unfortunately, a portion of these wastes escape during transport and processing, or may be inappropriately disposed of, and never reach a management facility. These escaped wastes enter the environment, becoming a hazard to many wildlife species. Garbage and Solid Wastes may be composed of a variety of substances, but plastics are often a greater concern due to their longevity, durability, and the increasing volume accumulating in ecosystems.

It is important to note that even properly disposed Garbage & Solid Wastes can pose a risk to the environment. For example, processing these wastes can release toxic chemicals into the air when incinerated or recycled, contaminate groundwater leaching out of landfills, and require the conversion of habitat for the construction and expansion of new facilities to keep pace with growing waste production rates. These associated threats are discussed in more detail under Industrial & Military Effluents (Threat 9.2) and Industrial Development (Threat 1.2).

THREAT DESCRIPTIONS AND EXAMPLES

Drifting plastic and entanglement rubbish (Threat 9.4.4) has long been acknowledged as a threat to marine mammals, sea turtles, seabirds, marine fish, and invertebrates (Laist 1997). Sea turtles, whales, and seabirds are known to swallow floating pieces of plastic, resulting in gastrointestinal blockages that they are unable to regurgitate (Wilcox et al. 2015). Individuals that get tangled in discarded debris can drown if it prevents them from surfacing or moving, starve if it reduces their ability to forage, and can become tangled with permanent features. Fishing gear is a particular problem, often referred to as 'ghost fishing.' Not only does ghost fishing gear entangle individuals swimming on or near the surface. When it sinks, it can disturb benthic habitats and species by smothering or abrading surfaces, snagging organisms in the mesh, or translocating individuals as currents cause the gear to drift (Brown and Macfayden 2007, Stelfox et al. 2016, Duncan et al. 2017). In freshwater ecosystems, entanglement with monofilament fishing line is a concern for birds, fish, and turtles, though this phenomenon is vastly understudied (Theijn 2017, Blettler and Wantzen 2019, Azevedo-Santos et al. 2021).

Other types of **garbage** (Threat 9.4.1) are detrimental as species may attempt to ingest or otherwise utilize non-natural materials. Other taxa, such as terrestrial reptiles, freshwater fish, and amphibians likely face similar threats if they opportunistically or accidentally attempt to swallow plastics, though there is far less research in freshwater and terrestrial systems. Some forms of garbage are also entanglement risks, even if they are not in aquatic environments. Plastic netting and erosion control fences and structures have been shown to imperil snakes (Stuart et al. 2001, Kapfer and Paloski 2011, Ebert et al. 2019). Though similar reports for other species are limited, it would be unsurprising if some amphibians, lizards, turtles, and small mammals are similarly at risk. The utilization of plastics and other garbage may also have indirect impacts. This phenomenon has primarily been observed in birds utilizing plastics as nesting materials. The use of plastic may reduce individual fitness by reducing insulative qualities, encouraging parasites or disease, increasing exposure to potential choking and entanglement hazards, or having other unstudied effects (Votier et al. 2011, Blettler and Wantzen 2019, Parthasarathy et al. 2019). Further impacts of plastic utilization among other taxonomic groups still need to be investigated.

The presence of **solid lead** (Threat 9.4.3) impacts a small number of species in the Northeast, primarily apex predators. The primary sources of this form of lead are ammunition and fishing tackle. As was the case for industrial lead products described above, lead products are persistent and have significant health impacts on many forms of wildlife. Solid lead can remain relatively stable in the environment for long periods before breaking down into more soluble compounds that are more easily absorbed by the body, though ingestion of solid lead is also detrimental (Pain et al. 2019). Several different exposure pathways exist, including absorption of soluble lead from the water, soil, or plants, direct ingestion of spent ammunition or fishing tackle, or ingestion of flesh from an animal that was contaminated with lead (Haig et al. 2014) Lead bioaccumulates through the ecosystem, concentrating as it moves up the food chain. Thus, predators and scavengers tend to have the highest concentrations of lead, and the most health impacts. The issue of solid lead has primarily been studied in birds (Haig et al. 2014, Pain et al. 2019) and fish (Truchencki and Radomski 2013), but examples involving mammals are gaining attention (Burco et al. 2012, Chiverton et al. 2022).

Though not a category identified in Quebec's Standardized Classification of Threats, **microplastic pollution** is of increasing concern globally, nationally, and regionally. Microplastics are defined as plastic particles less than five millimeters in size and include fibers, fiber bundles, fragments, films, pellets or beads, and other inorganic shapes. Nanoplastics are particles less than one millimeter in size and another area of increasing research attention. Most plastics weather mechanically into smaller and smaller fragments instead of chemically weathering into other compositions, and as a result, can persist in the environment long-term to permanently and bioaccumulate. Particles may consist of any plastic chemical composition, plus additives (e.g., phthalates, brominated flame retardants, antimicrobials), potentially introducing toxic or harmful chemical contaminants to the environment (Browne et al. 2016, Tian et al. 2020, Mariano et al. 2021, Fauser et al. 2022). Plastic particles may also absorb persistent organic pollutants, trace metals, and pathogens, accumulating harmful chemicals at higher concentrations than the surrounding water column (Browne et al. 2016) and acting as a vector for environmental contamination (Mariano et al. 2021, Fauser et al. 2022). Environmental microplastic pollution sources include the breakdown of litter and fishing gear, spillage of industrial pellets and powders, wastewater treatment effluent, industrial abrasives, drilling fluids for oil and gas exploration, artificial turf, paint on roadways and vessels, urban stormwater runoff, tire wear, air emissions, and many other sources. Duis and Coors (2016) summarize the primary and secondary sources of microplastics at the global scale.

Microplastic pollution has been documented virtually everywhere it has been tested from mountain peaks to ocean floors, including in:

- Air (Prata 2018, Brahney et al. 2020)
- Soil (Chia et al. 2021, Wang et al. 2022)
- Ground water (Chia et al. 2021)
- Drinking water (Kirstein et al. 2021)
- Surface water (Baldwin et al. 2016, Eerkes-Madrano et al. 2015, Eriksen et al. 2013, Li et al. 2018)
- Marine waters (e.g., Duis and Coors 2016, Grace et al. 2022)
- Beach sediments (e.g., Duis and Coors 2016, Horn et al. 2019)
- Shorelines (e.g., Browne et al. 2011)
- Deep ocean sediments (Jones et al. 2022)
- Mountain glaciers (Stefánsson et al. 2021)
- Rain (Brahney et al. 2020)
- Snow (Aves et al. 2022)
- Numerous human food and drink products (e.g., Kwon et al. 2020, Prata et al. 2020a)

Regionally, microplastic pollution has been documented in the Great Lakes and its tributaries (Baldwin et al. 2016), the Delaware River watershed (Baldwin et al. 2021, Bransky and Chen 2022), the Chesapeake Bay estuary (Yonkos et al. 2014, Murphy et al. 2019), and North Atlantic Ocean sediments (Jones et al. 2022) A new research study to identify microplastic pollution in the Connecticut River watershed was initiated in 2020 by The Connecticut River Conservancy. A recent research study supported by the Delaware River Conservation Fund documented microplastic pollution at 100% of survey sites in the Delaware River watershed, finding up to 250 particles of at least 16 types of plastic per cubic foot of water and 90% of the microplastic particles consisting of fibers (Bransky and Chen 2022). Microplastic fibers typically are the byproduct of laundering synthetic fabrics (e.g., polyester, nylon, rayon), contributed via domestic wastewater streams where one garment can produce more than 1900 microfibers per wash cycle (Browne et al. 2011, Prata 2018).

Limited information currently exists on the ecological and human health effects of microplastic pollution and contamination (e.g., Prata et al. 2020b, Sangkham et al. 2022). It is estimated that humans consume a credit card's worth of plastic weekly as a result of the presence of microplastic in food and drink products (Dalberg Advisors and

The University of Newcastle 2019). Microplastic and nanoplastic particles have been documented in human blood (Leslie et al. 2022) and lung tissue (Jenner et al. 2022).

Recent studies document the ingestion of microplastics and nanoplastics by mammals (Yong et al. 2020), seabirds (Duis and Coors 2016, Lavers et al. 2019, Susanti et al. 2020), fish (Lu et al. 2016, Mattsson et al. 2017, Parks et al. 2019), whales (Kahane-Rapport et al. 2022), turtles (Jung et al. 2018, Ugwu et al. 2019), lobster (Woods et al. 2020), mole crabs (Horn et al. 2019), oysters (Sussarellu et al. 2016), freshwater and marine mussels (Browne et al. 2008, Li et al. 2018), zooplankton (Cole et al. 2013), and many other marine invertebrates (Setälä et al. 2014, Sussarellu et al. 2016, Ugwu et al. 2019). Baldwin et al. (2016) and Mariano et al. (2021) summarize the known impacts of microplastic and nanoplastic ingestion by wildlife, such as the brain damage and behavioral disorders in fish documented by Mattsson et al. (2017). Recent evidence documents that impacts may be severe. For example, Tian et al. (2020) found microplastic particle leachate containing a common antioxidant chemical from tire treads induced acute mortality in Coho Salmon (Oncorhynchus kisutch) in the Pacific Northwest.

Several meta-analyses are now available that summarize the state of knowledge about various aspects of microplastic and nanoplastic pollution. Eerkes-Medrano et al. (2015), Baldwin et al. (2016), and Li et al. (2018) summarize the threat of microplastic pollution in freshwater systems, Foley et al. (2018) on fish and aquatic invertebrates, Ugwu et al. (2021) on marine organisms, Chia et al. (2021) in soil and groundwater, and Prata (2018) in air. Sangkham et al. (2022) conducted a review of the state of knowledge of microplastic and nanoplastic pollution and toxicity in the environment, including exposure routes for humans. The threat of microplastic and nanoplastic pollution and contamination continues to be a focus of new research, with journals like the International Journal of Environmental Research and Public Health, Current Opinion in Toxicology, and Marine Pollution Bulletin devoting special issues to the topic (in 2018, 2021 and 2022 respectively).

Sampling for microplastic pollution is challenged by potential cross-contamination from plastic components in sampling equipment, the clothing of personnel, cleansing materials (e.g., rinse water), and the air. Moreover, concentrations may vary significantly, even at small spatial scales (Boshoff et al. 2023). Mariano et al. (2021) reviewed identification and detection techniques for microplastics and the emerging classification of nanoplastics. The National Oceanic and Atmospheric Administration has developed standardized sampling protocols for microplastic pollution in water, beach sediment, and seabed sediments (Masura et al. 2015). As techniques for identifying and measuring microplastic and nanoplastic pollution continue to advance, conservation actions to address this emerging threat will also emerge but are currently lacking.

RELATIONSHIPS WITH OTHER THREATS

Most forms of garbage are human products, linking them closely with human activities under Residential & Commercial Development (Threat 1.0) and Transportation & Service Corridors (Threat 4.0). Fishing gear and lead ammunition are the waste products of Biological Resource Use (Threat 5.0). Some forms of garbage may also amplify Invasive & Problematic Species, Pathogens, and Genes (Threat 8.0) by facilitating the widespread dispersal of invasive species (Blettler et al. 2021), providing surfaces for pathogenic organisms to colonize (Parthasarathy 2019), and subsidizing native predators (Newsome et al. 2015). Increased storm and precipitation intensity and frequency as a result of Climate Change (Threat 11.0) may result in more forms of garbage flushing into aquatic ecosystems.

TOOLS AND RESOURCES

Few resources and tools are available for tracking solid waste at the regional scale. **State waste management agencies** may have tools useful for looking into this topic. The EPA has a **resource page for solid waste**[31], which may have useful resources for learning more about this topic.

3.2.2 CLIMATE CHANGE

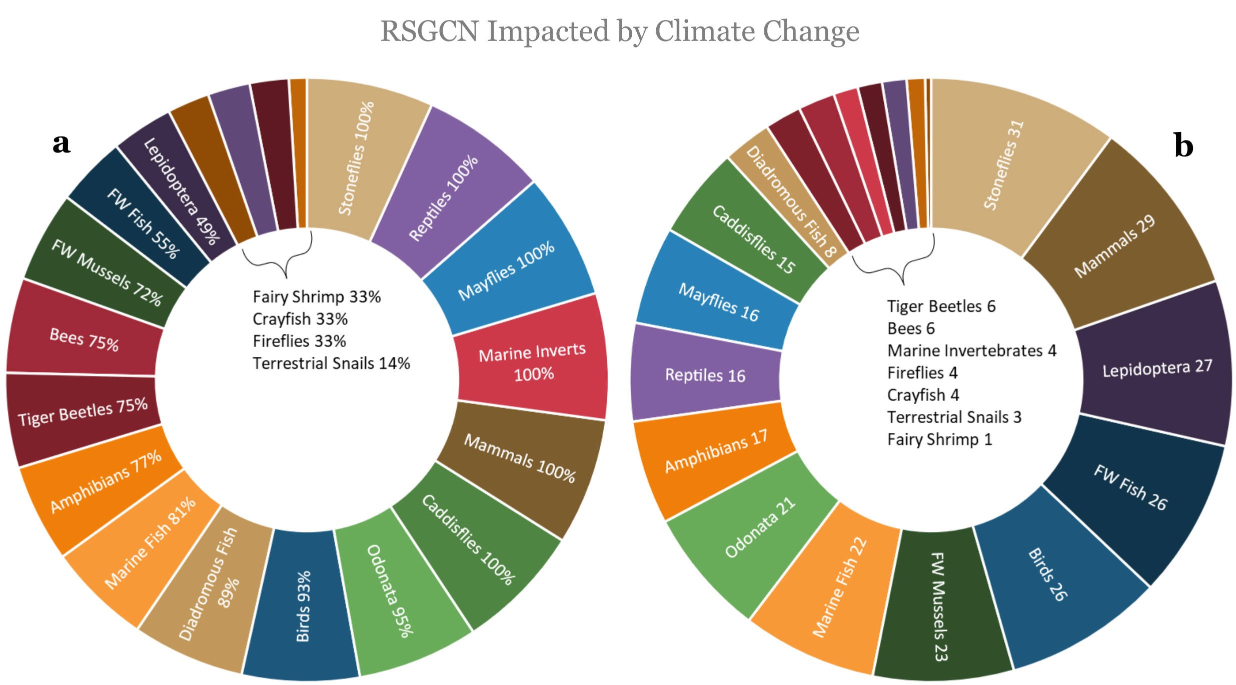

Figure 3.3 Impact of Climate Change (Threat 11.0) on RSGCN and Proposed RSGCN. (*a*) The percentages show the proportion of the species within that taxonomic group known to be impacted

by this threat. (*b*) The total number of species within the taxonomic group known to be impacted by this threat.

Climate Change is a rapidly growing concern in the region, impacting 73% (305 species) of the RSGCN and Proposed RSGCN. All of the species in the stonefly, reptile, mayfly, marine invertebrate, mammal, and caddisfly taxonomic groups are considered vulnerable to climate change impacts, highlighting these groups' sensitivity to future changes (Figure 3.3a). As knowledge of climate change and its impacts on species and habitats is still evolving, it is likely additional species are impacted by this threat in ways we do not yet understand. The low percentages in many of the invertebrate taxonomic groups may increase in the future as new information is uncovered (Figure 3.3b).

At the time of the 2015 Northeast SWAPs, climate change was considered one of the highest priorities of all threats identified. Climate change is considered to be one of the most impactful threats in the Northeast because of uncertainty about the full effects on individual species, variability in species responses, the infeasibility of addressing sources of climate change at local and state scales, and irreversibility of some impacts (TCI and the NEFWDTC 2017).

The Northeast Climate Adaptation Science Center (NECASC)[32], a consortium of USGS and university researchers housed at the University of Massachusetts, Amherst, is a crucial resource for climate-related information, research, and planning in the Northeast. One of the USGS' nine regional Climate Adaptation Science Centers, their goal is to deliver science to help fish, wildlife, water, land, and people adapt to a changing climate. NECASC produced a **regional synthesis** that compiled a summary of the current literature, strategies and actions, tools, and case studies for addressing multiple and simultaneous threats from climate and non-climate stressors to natural and cultural resources into searchable databases[33] (Staudinger et al. 2015). This report analyzed how climate has and is expected to change, the relative vulnerability of fish and wildlife species and their habitats, likely responses of species of concern to these changes, and the approaches, strategies, and actions that could sustain fish, wildlife, and their habitats across the region.

To support the 2025 SWAP revisions, NECASC is developing an **updated Regional Climate Synthesis**[34], which will be available later in 2023 (Staudinger et al. 2023). This updated Climate Synthesis will have six sections, described briefly below:

1. Climate Change Information
    a. Climate projections for multiple climate variables (e.g., temperature, precipitation, sea level rise) across multiple periods (e.g., retrospective, current, and future) and different climate scenarios (e.g., RCP 4.5 and 8.5)
    b. Quantitative visualizations and qualitative descriptions of climate data

    c. Descriptions and guidance on climate model uncertainties and best practices for applying to targets of interest.
2. Species Responses to Climate Change
    a. Review of the climate-change literature for information relevant to the 2023 RSGCN species
    b. Analyze RSGCN range and distribution shifts
    c. Identify data gaps and data deficient species
    d. Generate species profile visualizations that highlight (a) range, depth, elevation, or phenology shifts, (b) describe morphological and population responses, and (c) determine species' climate change vulnerability
3. Climate Vulnerabilities and Risks
    a. Update list and database summarizing regional climate change vulnerability assessments (CCVA) conducted since 2015
    b. Additional vulnerability and comprehensive risk assessment information
    c. Summaries and examples of advances in climate vulnerability assessments and the pros and cons of different approaches to assessing risk
4. Scale-appropriate Adaptation Strategies and Actions
    a. Summaries of adaptive strategies and actions related to NE RSGCN and associated habitat
    b. An updated database of strategies and actions from 2015 that organizes actions for RSGCN around top climate threats
    c. Identify actions with multiple climate and non-climate benefits
5. Case Studies
    a. Describe extreme event result-chains that link system response to multiple threats specific to RSGCN species
        i. Extreme precipitation and pest outbreaks (spongy moth)
        ii. Coastal storms and sea level rise
6. Recent Climate Adaptation Resources

As the updated Regional Climate Synthesis is being released at nearly the same time as the Regional Conservation Synthesis, this document does not go into as much depth on Climate Change as it does for other threats, providing only brief descriptions of the ways climate change can impact species and habitats, synergistic effects of climate change with other threats, and useful partners and resources. The Climate Synthesis will be a far more comprehensive review; managers, biologists, partners, and other users of this document should refer to the Climate Synthesis for the most complete and up-to-date information.

THREAT DESCRIPTIONS AND EXAMPLES

Climate change has the potential to impact nearly every aspect of an ecosystem, including marine (Gruber 2011, Bryndum-Buchholz et al. 2019, Franco et al. 2020), estuarine (He and Silliman 2019, Columbano et al. 2021), terrestrial (Häder and Barnes 2019, Pugnaire et al. 2019), freshwater (Häder and Barnes 2019, Grieger et al. 2020, Woolway et al 2020, Salimi et al. 2021), and atmospheric (Payne et al. 2020) systems Responses are hugely variable across species, making a synthesis of the current trends a complicated endeavor (Staudinger et al. 2013). These impacts are hugely varied, but include:

- Habitat Shifting & Alteration (Threat 11.1), including changing vegetation communities, phenological mismatch, and sea level rise
- Changes in Geochemical Regimes (Threat 11.2) including changes in pH and salinity
- Changes in Temperature Regimes (Threat 11.3) including gradual changes, increased variability, and extremes
- Changes in Precipitation & Hydrological Regimes (Threat 11.4) including gradual changes, increased variability, and extremes
- Severe/Extreme Weather Events (Threat 11.5)
- Other changes in patterns such as altered air or ocean currents

RELATIONSHIPS WITH OTHER THREATS

Climate change is not only a direct threat but often amplifies the negative impacts of many other threats, acting in a synergistic way to increase overall vulnerability (Staudt et al. 2013; Pinkney et al. 2015). Examples of this include:

- Changes in temperature or precipitation make areas more susceptible to the invasion of non-native species or the spread of disease (Burek et al. 2008, Hellman et al. 2008, Rahel and Olden 2008, Dukes et al. 2009, Adlard et al. 2015, Finch et al. 2021, McClure et al. 2022, Tazerji et al. 2022)
- Increased precipitation and storms result in more frequent flooding that increases contaminant loads in runoff (Petrie 2021)
- Sea level rise and coastal development constraining species caught between the two
- Environmental conditions change faster than species can adapt (Sekercioglu et al. 2008, Ralston et al. 2017, Urban 2018)
- Changes in temperature, salinity, or pH increase the stress levels of species, making them more likely to succumb to pollution, competition, or disease (Burek et al. 2008, Ganser et al. 2015, McKinney et al. 2015, Noyes and Lema 2015, Pinkney et al. 2015, Orr and Buchwalter 2020)
- Altered disturbance regimes, especially fire, result in the invasion of non-native species (Bradley et al. 2010, Finch et al. 2021)

- Warmer temperatures and changing nutrient cycles alter the frequency of harmful algal blooms (Chapra et al. 2017, Gobler et al. 2017, Griffith and Gobler 2020, Ralston and Moore 2020)
- Altered temperature or precipitation regimes alter interactions between species (Dallalio et al. 2017)

The complexity and interconnectedness of resources influenced by climate change highlight extensive knowledge gaps and confound conservation planning and implementation of relevant actions. Collaborative initiatives across geopolitical and jurisdictional boundaries help bridge these data deficiencies and allow for a more comprehensive understanding of the impacts of climate change and the responses of species and habitats. With shared concerns related to this global threat, states in the Northeast Region have many opportunities to work together to improve the effectiveness of conservation actions supporting RSGCN on a land- and seascape scale. Addressing sources of climate change (e.g., greenhouse gases) is largely beyond the immediate scope of state resource managers, but implemented actions can be crucial for species adaptation, habitat resiliency, and connectivity. For the near future, site-specific conservation actions that ameliorate non-climate threats are the most immediate options for increasing species viability.

TOOLS AND RESOURCES

Available tools and resources related to climate change are numerous, with additional resources being added frequently. On a national scale, climate change resources include the EPA's **Report on the Environment**[35], which tracks trends in the conditions of the nation's land, water, and air (US EPA 2022). Some of the more than 80 indicators they track, such as greenhouse gas levels, sea and air temperature, and precipitation records, are directly related to climate change.

The importance of non-climate stressors and the interactive effects of climate change has been addressed by the US Global Change Research Program in the **National Climate Assessment**, which is conducted every four years. Development of the Fifth National Climate Assessment is currently underway, with anticipated delivery in 2023. The interaction of climate change with other stressors and the complicated, interacting effects they have on species was a key message in the fourth National Climate Assessment (US Global Change Research Program 2018). This report also has a chapter that summarizes trends within the Northeast region, highlighting the importance of seasonal weather patterns and coastal ecosystems to regional economics and the proactive efforts underway to adapt to future climactic conditions. The US Global Change Research Program is also undertaking a **National Nature Assessment**[36], which is expected to be completed in 2026. This Assessment will take stock of the current status of United States lands, waters, and wildlife and look forwards to how they might change in the future and the implications of those changes on United States economics, human health, and climate.

The **National Fish, Wildlife, and Plants Climate Adaptation Strategy** identified specific strategies and actions for climate-and non-climate threat interactions. Here, the emphasis is to slow, mitigate or reverse the effects of non-climate stressors to increase resilience and allow species to adapt to changing conditions (National Fish, Wildlife and Plants Climate Adaptation Network 2012). In 2021, the National Fish, Wildlife, and Plants Climate Adaptation Network[37] released a new report that describes how climate science had changed over the previous decade, crosswalks the original Strategy with existing conservation plans made at various levels to assess implementation, and provides recommendations for future management actions highlighting the needs and challenges facing natural resource management in the next decade (National Fish, Wildlife and Plants Climate Adaptation Network 2021).

Other regional partners who work together to plan and implement climate-smart planning are the Nature Conservancy's **Center for Resilient Conservation Science**[38] and the **Wildlife Conservation Society**[39]. Mawdsley et al. (2009) identified **sixteen strategies for climate change adaptation**, many of which are in use in Northeastern states. In states where actions to prevent or adapt to climate change are already being implemented, much of the work is done by state fish and wildlife agencies or through partners such as land trusts and through cooperation with other state and federal agencies, including the US Fish and Wildlife Service, National Park Service, and US Forest Service.

3.2.3 INVASIVE & PROBLEMATIC SPECIES, GENES, & DISEASES

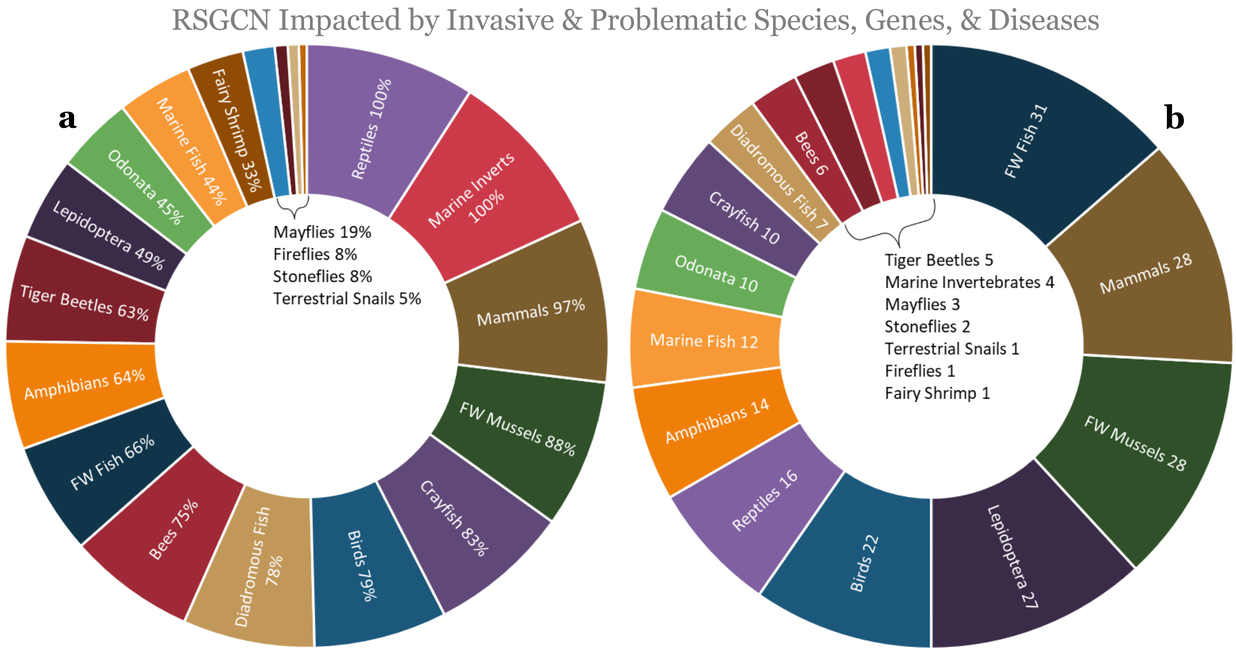

Figure 3.4 Impact of Invasive & Problematic Species, Genes, & Diseases (Threat 8.0) on RSGCN and Proposed RSGCN. (a) The percentages show the proportion of the species within that taxonomic group known to be impacted by this threat. (b) The total number of species within the taxonomic group known to be impacted by this threat.

More than half of the species on the 2023 RSGCN and Proposed RSGCN list – 55%, or 228 species – are imperiled by interactions with invasive or problematic species, face complications due to genetic integrity, are impacted by disease, or have natural biological limitations that reduce recovery potential. This includes all reptiles and marine invertebrates, and all but one mammal (Figure 3.4a). Though not all freshwater fish, mussels, and lepidopterans are associated with this threat, these taxonomic groups contributed as many species, if not more, as mammals (Figure 3.4b). Many invertebrate groups had five or fewer species for which this threat is known to be a cause of decline. This is likely due to data deficiencies and a limited understanding of how these threats impact these groups, rather than an indication that these groups are not sensitive to these threats.

The subjects categorized under this threat are incredibly diverse, touching on invasion ecology, competition and predation, parasitism, population and conservation genetics, epizoology, and other ecological and biological concepts. The breadth of these topics makes it difficult to generalize about the overall trends and patterns within the Northeast region at this topmost level. The impacts of these threats are not concentrated within certain habitat types or taxonomic groups; instead, they are found almost universally. More in-depth descriptions of the different threats and discussions of the trends and patterns in the Northeast are discussed under each threat category below.

INVASIVE NON-NATIVE/ALIEN PLANTS & ANIMALS

The introduction of organisms to novel environments can drastically alter the balance of entire ecosystems. The terminology describing species beyond their native range is complex, including terms such as invasive, introduced, non-native, exotic, alien, and more (Colautti and MacIssac 2004, Falk-Petersen 2006). In this document, the terms invasive and non-native are both used to describe plants or animals that are introduced to a new geographical or ecological system, usually as a result of human activity, and have direct or indirect impacts on the species or habitats native to the system. Invasive species are often considered to have broad, harmful ecological effects that contribute to direct or indirect declines in population health or status of native species (Mooney and Cleland 2001, Clavero and Garcia-Berthou 2005, Doherty et al. 2016, Dueñas et al. 2021), though some authors have suggested that invasions are a symptom, rather than the cause, of these changes (Didham 2005, MacDougall and Turkington 2005, Bauer 2012). Though usually considered a primary driver of ecological degradation in impacted systems, there may be occasions where invasive species may benefit certain native species, though this is usually at the cost of other native species (Rodriguez 2006, Gallardo et al. 2016).

Invasion ecology is a diverse field that is constantly growing. Numerous hypotheses and frameworks exist attempting to describe and explain invasion pathways and the characteristics of a potential invader (Catford et al. 2009, Perkins and Nowak 2013, Gutiérrez et al. 2014). Other researchers have focused on describing the impacts invasive species have on native species, communities, and ecosystems (Thomsen et al. 2011, Gallardo et al. 2016, David et al. 2017, Crystal-Ornelas and Lockwood 2020, Mayfield et al. 2021). The impacts of invasive species are very difficult to monitor, control, or reverse, which is one reason this is a priority threat in the Northeast (Leung et al. 2002, Mehta et al. 2007, Larson et al. 2011, Crowley et al. 2017).

Proactive management at the early stages of invasion involves preventing species from being introduced through policy mechanisms such as state noxious weed lists and importation bans. Proactive management also involves monitoring for new invasions and quickly eradicating them before they spread – a practice known as early detection and rapid response (EDRR; Westbrooks 2004). Preventing or detecting and eradicating invasions early is much more cost-effective than controlling invasions after the species have spread (Leung et al. 2002, Keller et al. 2007). Although proactive prevention and EDRR are the most effective tools for invasive species management, controlling populations at any stage can benefit wildlife. For example, in a meta-analysis of studies from over 200 papers, Bradley et al. (2019a) showed that there is a significant negative, linear relationship between invasive plant abundance (e.g., percent cover, stem count, biomass) and native species diversity. From a management standpoint, this suggests that environmental harm continues to accrue as plant invasions progress. Therefore, reducing invasive plant abundance at any stage of invasion reduces corresponding ecological harm.

In this document, the focus is on three primary roles in which invasive species interact with Northeast RSGCN: consumption, competition, and habitat alteration. Two further potential impacts of invasive species, hybridization with non-native species and infection by non-native diseases, will be discussed below under Introduced Genetic Material (Threat 8.3) and Pathogens and Microbes (Threat 8.4).

Consumption is one of the most direct ways invasive species can impact native species. Generally, consumption refers to examples of predation, but also includes non-native herbivores or insects feeding on native plants and parasitism, including klepto-, nest-, and brood parasites. Invasive predators and herbivores are often more detrimental than native ones because prey species lack co-evolved defenses or evasive mechanisms to protect themselves (Park 2004, Mayfield et al. 2021). Combined with the fact that these invasive species are often generalists whose populations are not impacted by the decline of any one native species, invasive species are released from bottom-up controls preventing their proliferation (Park 2004, Gallardo et al. 2016).

Invasive species can be favored in competitive interactions with native species that occupy the same or similar niches. Competition can be for food, shelter, or other resources; the limited availability of key resources creates these interspecific interactions between native and non-native species. Invaders with biological or behavioral adaptations that amplify their ability to gather or occupy resources will outcompete other species. These invaders are also often released from the pressures of their predators and parasites, allowing populations to grow beyond what native species can achieve and further exacerbating interspecific interactions (Predator Release Hypothesis; Torchin et al. 2001, Catford et al. 2009).

Invasive species often impact native species indirectly by altering habitats. If an invasive species alters or eliminates important niches from the habitat, native species that depend on that niche are also eliminated. For example, Chinese Mitten Crabs (*Eriocheir sinensis*) are extensive burrowers, destabilizing banks that other burrowing crustaceans would otherwise utilize and causing significant erosion and changes in water quality, impacting many aquatic species (Dittel and Epifanio 2009). These species, sometimes termed “invasive engineers” can change the structure, ecosystem function, nutrient cycling, and disturbance patterns of a habitat (Crooks 2002, Cuddington and Hastings 2004, Emery-Butcher et al. 2020).

It is important to note that a single invasive species may fill more than one of the three roles described above depending on the life stage of a native species, or may fit different roles for different native species. Round Goby (*Neogobius melanostomus*) contribute to declines of Mottled Sculpin (*Cottus bairdi*) and Yellow Perch (*Perca flavescens*) twice over by preying upon eggs and competing with young-of-the-year for other food resources and shelter (Zuwerink et al. 2019). Zebra and Quagga Mussels (*Dreissena polymorpha* and *D. bugensis*, respectively), one of the most iconic invasive species in North America, can act as a consumer, competitor, and habitat engineer, depending on which native species are considered. They filter large amounts of plankton out of the water column, which is both direct consumption of the plankton and competition with native mussels and fish for a primary food source, alter water clarity and chemistry, and form dense colonies that exclude other benthic organisms (Strayer 2009).

THREAT DESCRIPTIONS AND EXAMPLES

Invasive aquatic animals (Threat 8.1.3) are known to have wide-ranging effects on many RSGCN (Strayer 2010). The impacts of Zebra and Quagga Mussels are described above but include competition with other species and widespread habitat alteration. Although not as widespread in the Northeast as the two mussels, Asiatic Clams (*Corbicula fluminea*) have similar impacts (Simard et al. 2012). In addition to Roundy Goby, other invasive fish species of concern include Common Carp (*Cyprinus carpio*; Kloskowski 2011), Northern Snakehead (*Channa argus*; Saylor et al. 2012), and Blue and Flathead Catfish (*Ictalurus furcatus* and *Pylodictis olivaris*, respectively; Fabrizio et al. 2018, Schmitt et al. 2019). Most of these fish species are predators; Common Carp and Northern Snakehead are also able to alter their habitats in ways that exclude some native species.

In intertidal systems, concerns about several invasive crustaceans are increasing. European Green and Asian Shore Crabs (*Carcinus maenas* and *Hemigrapsus sanguineus*, respectively), compete with native crustaceans (Griffen and Riley 2015, Zargarpour 2020), prey upon crustaceans and shellfish (Brosseau and Goldberg 2007, Brosseau et al. 2014), and can cause loss of key habitat features such as eelgrass beds (Howard et al. 2019). Chinese Mitten Crabs (*Eriocheir sinensis*) are a more recent transplant in the Northeast region but are known to cause major habitat alterations due to their burrowing habits (Dittel and Epifanio 2009). Spiny and fishhook water fleas (*Bythotrephes longimanus* and *Cercopagis pengoi*, respectively) are a growing concern in the region, where they are already established in the Great Lakes and major watersheds in New York and Pennsylvania. These predatory zooplanktons compete with native species for prey and potentially create conditions beneficial for algal blooms, resulting in cascading effects across all trophic levels (Brown and Balk 2008, Yan et al. 2011, Walsh et al. 2016).

Geographic context is very important for some of the aquatic invaders in the Northeast; some species may be considered invasive only in certain areas. For example, invasive freshwater crayfish are a primary concern for nearly every 2023 RSGCN or Proposed

RSGCN crayfish. Of particular concern in the Northeast region are Virile, Rusty, and Red Swamp Crayfish (*Faxonius virilis, F. rusticus,* and *Procambarus clarkii*, respectively). Though these species are all native to North America, they have been introduced far beyond their home watersheds, largely via bait releases (Lodge et al. 2000, Kilian et al. 2012, Taylor et al. 2019). Their primary impact on native crayfish is as competitors, but some crayfish may have significant impacts on the habitat as well (Lodge et al. 2000, Hale et al. 2016, Kouba et al. 2022). Similarly, some predatory sportfish are native to the Northeast but may be considered invasive in specific water bodies where they have been stocked. Whittier and Kincaid (1999) evaluated the impacts of stocked fish across more than 200 lakes in the Northeast and found that many lakes are now dominated by non-native species. Impacts may be elevated when these predators are introduced to previously fishless waterbodies. For example, the introduction of fish to fishless ponds is known to impact dragonflies (Schilling et al. 2019), fairy shrimp (Leyse et al. 2004), amphibians (Gregoire and Gunzberger 2008), and aquatic macroinvertebrates (Schilling et al. 2009). One of the species on the 2023 RSGCN list is also considered invasive in the region. Rainbow Smelt is the dominant native forage fish in Lake Champlain, where it is imperiled but is considered invasive in the Great Lakes (Bruel et al. 2021). Another species on the 2023 Watchlist, Sea Lamprey (*Petromyzon marinus*), has diadromous populations along much of the Atlantic Coast but is managed as an invasive species in the Great Lakes and Lake Champlain (Hume et al. 2021).

For Northeast RSGCN, **invasive terrestrial animals** (Threat 8.1.1) are a major concern. Non-native mammals have significant impacts on wildlife populations. Feral Cats (*Felis catus*) are of particularly high concern. Predation by free-ranging cats can have major impacts on local vertebrate populations, especially birds and small mammals (Loss et al. 2013, 2022). Cats have been cited as a particular concern for several RSGCN, including Wood Thrush (*Hylochlia mustelina*), Piping Plover (*Charadrius melodus*), Indiana Bat (*Myotis sodalist*), Little Brown Bat (*Myotis lucifugus*), and Block Island Meadow Vole (*Microtus pennsylvanicus provectus*). Off-leash dogs can also disturb local wildlife, especially beach-nesting birds, though these effects are less well-studied (Gibson et al. 2018). Norway and Black Rats (*Rattus norvegicus* and *R. rattus*, respectively) are a concern as potential vectors for disease, predators of small mammals and nests, and competitors with similarly sized omnivores, although these impacts tend to be concentrated around human development (Banks and Hughes 2012). Another invasive mammal in the Northeast is Feral Hogs (*Sus scrofa*). Though more widespread in the Southeast and Midwest regions, several states, including Vermont, New Hampshire, Pennsylvania, West Virginia, Virginia, and Delaware are currently managing Feral Hog populations. Feral Hogs impact forest composition and soil structure with their foraging, rooting, and wallowing activities (Siemann et al. 2009, Meyer et al. 2021). They also can compete with native herbivores and mast-feeding species or prey upon smaller animals; Feral Hogs are particular predators on sea turtle nests in the southeastern United States (Seward et al. 2004, Sieman et al. 2009). The Animal and Plant Health Inspection Service (APHIS) has a National Feral Swine Damage Management Program[40], which has been instrumental in reducing Feral Hog populations and mitigating the damage they cause. This program maintains a website with useful information and resources about Feral Hogs and their management in the United States, including maps of their known distribution.

There are several non-native birds in the region as well. European Starlings (*Sturnus vulgaris*) are widespread across North America and may competitively exclude some cavity-nesting birds, though these effects are not consistent (Koenig 2003, Craig 2020, Meyer et al. 2021). House Sparrows (*Passer domesticus*) are native to Europe and Asia, but have been widely introduced around the world. They are highly adapted to anthropogenic habitats, giving them a competitive advantage in these areas, facilitate the spread of several diseases, and can be aggressive in their competitive interactions with native birds (Hanson et al. 2020). Monk Parakeets (*Myiopsitta monachus*) are native to South America, but escaped and released pets have established breeding populations in several areas in the United States, including southern Virginia and the greater New York City metropolitan area. This species is not known to have any major impacts on native wildlife, but their use of electric facilities as nest sites can cause power outages and maintenance issues (Avery 2020). Another largely urban bird, Feral Pigeons (*Columba livia*) are ubiquitous across much of the Northeast (Carlen 2021). Though they do not tend to compete with many wild bird species directly, these birds are frequently vectors for various diseases that negatively impact wildlife species (Santos et al. 2020). Mute Swans (*Cygnus olor*) are common in much of the region but are native to Europe and Asia. They were introduced largely for ornamental reasons and now are reproducing rapidly (Gayet et al. 2020). This rapid growth is problematic, as the swans deplete food resources, are reservoirs for avian influenza, and aggressively exclude and displace other waterbird species (Gayet et al. 2020). Efforts to control Mute Swan populations are contentious, as attempts to limit the ecological impacts and aggressive interactions with humans are countered by strong public opposition in support of the charismatic species (Hindman and Tjaden 2014, Jager et al. 2016, Gayet et al. 2020). House Finches (*Haemorhous mexicanus*) were confined to the southwestern United States and Mexico until the 1930s when about 100 individuals were released in New York (Britton and Badyaev 2020). Since then, the species has spread throughout the eastern United States where it is now a common feeder bird and an occasional agricultural pest (Britton and Badyaev 2020). Although they do not appear to have major impacts on any native species, the House Finch is susceptible to a form of conjunctivitis, which may be a concern if the disease changes and can infect new host species (Hosseini et al. 2006). Brown-headed Cowbirds (*Molothrus ater*) were originally limited to the prairies of the Midwest, but were able to greatly expand their range in response to the widespread conversion of forests to agricultural areas across much of the United States, and are now considered invasive in the Northeast (Wilson 2020). This species is a nest parasite and can successfully parasitize more than 150 host bird species, including several RSGCN and Proposed RSGCN birds (Wilson 2020).

Terrestrial invertebrates have major impacts on ecosystems as well. The Northeast region has some of the highest concentrations of invasive insects and diseases in the country, a result of elevated opportunities for invasion due to a longer colonized history combined with numerous pathways for human-mediated invasion (Juzwik et al. 2021). Many of these insects, including Spongy Moth (*Lysmantria dispar*), Hemlock Wooly Adelgid (*Adelges tsugae*), Emerald Ash Borer (*Agrilus planipennis*), Winter Moth (*Operophtera brumata*), and Asian Longhorned Beetle (*Anoplophora glabripennis*), either defoliate or kill key tree species in the Northeast, altering key habitats across the region (Juzwik et al. 2021, Meyer et al. 2021). The US National Phenology Network[41] produces short-term phenology forecast maps as a tool to inform management and monitoring actions for all of these invasive forest insects (Crimmins et al. 2020). These Pheno Forecast maps depict the status of the insect's life cycle across the United States and are updated daily. In the southern and western parts of the region, Spotted Lanternfly (*Lycorma delicatula*) is closely associated with another invasive species, Tree of Heaven (*Ailanthus altissima*). While Tree of Heaven is the preferred host, Lanternflies can utilize many different plant species; the current focus is on its impact on agricultural species, but it has major potential to impact forested ecosystems as well (Urban 2020, Barringer and Ciafré 2020).

A growing body of research is highlighting the impacts of invasive earthworm species on forested ecosystems. These earthworms are model invasive engineers, removing leaf litter (Maerz et al. 2009) and altering carbon dynamics (Snyder et al. 2009), nutrient cycling (Bohlen et al. 2004), mycorrhizal relationships (Paudel et al. 2016), and soil structure (Snyder et al. 2013). Native soil invertebrates are impacted either indirectly through the homogenization and alteration of the environment or through direct competition with the worms, which has the potential to cascade up through higher trophic levels (Migge-Kleian et al. 2006, Loss and Blair 2011, Ferlian et al. 2017, Frelich et al. 2019). The taxonomic teams indicated that this is of particular concern for the terrestrial snails, many of which live in the leaf litter. There is some evidence that natural fire regimes may favor native worms, but this research is ongoing, and the full effects are not understood (Meyer et al. 2021).

The primary impact of **terrestrial and aquatic invasive plants** (Threat 8.1.2 and 8.1.4, respectively) on Northeast RSGCN and Proposed RSGCN is as invasive engineers. Invasive plants are a well-known threat to wildlife habitat, altering habitat structure and leading to significant declines in the fitness, abundance, and diversity of native wildlife (Vilà et al. 2011, Pyšek et al. 2012, Buciarelli et al. 2014). Invasive plants have also been linked to increased tick densities, which could alter disease transmission patterns (Williams et al. 2009, Allan et al. 2010, Mathisson et al. 2021). A majority of invasive plants in the United States were introduced intentionally as ornamentals, though other intentional and accidental pathways provide additional routes (Ehan et al. 2013). New introductions through horticulture continue; more than half of the species identified as invasive in the United States are still available for purchase (Beaury et al. 2021). It is worth acknowledging that not all the impacts of invasive plants are negative; some may offer benefits to some wildlife species (Hayes and Horzmueller 2012). There are more invasive plants impacting Northeast RSGCN and Proposed RSGCN than space in this document, but some common and widespread invasive plant species include:

- Phragmites (*Phragmites australis*): a widespread invader of freshwater and brackish wetlands that forms dense colonies which exclude native vegetation, alter hydrology, nutrient, and decomposition cycles, and entangle native species (Meyerson et al. 2000, Hazelton et al. 2014, Cook et al. 2018)
- Japanese Knotweed (*Fallopia japonica*): another widespread, monoculture-forming invader of riparian areas that decreases plant biodiversity, alters streamflow and flooding, and has mixed effects on other taxonomic groups (Vanderklein 2014, Lavoie 2017, Wilson et al. 2017)
- Purple Loosestrife (*Lythrum salicaria*): a wetland plant that alters decomposition rates and nutrient cycling, reduces wetland plant biodiversity, reduces successful pollination in other wetland plants, and changes suitability for wetland specialist birds (Blossey 2001). The introduction of beetles in the genus *Neogalerucella* (*Galerucella*) as biocontrol agents is widely considered effective in many regions, including the Northeast, though the response is variable at different sites (St. Louis et al. 2020, Endriss et al. 2022).
- Didymo (*Didymosphenia geminata*): a diatomaceous alga that can cause large algal blooms that impact fish, benthic invertebrates, and mussels (Clancy et al. 2020)
- Garlic Mustard (*Alliaria petiolata*): an allelopathic forest plant that is of particular concern for butterflies and other pollinators that are dependent on the plants directly impacted via decreased regeneration and growth, disruption of mycorrhizal relationships, or altered nutrient cycles (Stinson et al. 2007, Rodgers 2008)
- Multiflora Rose (*Rosa multiflora*): a plant found in many habitats that was introduced in the United States as an ornamental and for use as “living fences” that forms dense thickets that reduce light and nutrient availability for native plants and may form reservoirs of Lyme disease-carrying ticks (Adalsteinsson et al. 2018, Bowden et al. 2018)

RELATIONSHIPS WITH OTHER THREATS

Invasive species can be introduced to new environments following a large number of different pathways, but many of those pathways are human-mediated (Hulme et al. 2008, Wilson et al. 2009). Residential & Commercial Development (Threat 1.0), Agriculture & Aquaculture (Threat 2.0), Transportation & Service Corridors (Threat 4.0), Biological Resource Use (Threat 5.0), and Human Intrusions & Disturbance (Threat 6.0) have all facilitated the introduction and distribution of invasive species. Furthermore, it is important to highlight the role of disturbance, both natural and anthropogenic, in many invasions. Disturbance creates opportunities by temporarily increasing resource availability, giving invasive species an equal chance to colonize and establish a site without needing to compete with native species (Catford et al. 2009, Meyer et al. 2021). Less intact habitats are more susceptible to invasion, especially by generalist species (Marvier et al. 2004). In the Northeast, the role of anthropogenic activity in invasions is particularly strong for plants (Gavier-Pizarro et al. 2010, Beaury 2021).

In addition, Climate Change (Threat 11.0) will exacerbate the threats of invasives. These changes will impact species at every stage of invasion (Hellman et al. 2008). Many authors have discussed the numerous ways climate change will amplify the impact invasive species have on native species, including:

- Warming temperatures will enhance the winter survival of many invasives, allowing populations to grow and expand their ranges (Rahel and Olden 2008, Hellman et al. 2008, Dukes et al. 2009, Bradley et al. 2010, Mainka and Howard 2010, Staudt et al. 2013, Finch et al. 2021)
- Many invasive species have mechanisms that facilitate rapid dispersal, making them more likely than native species to adapt as climactic conditions shift (Dukes et al. 2009, Finch et al. 2021)
- Increased precipitation and altered streamflow may facilitate the dispersal of invasive plants and animals (Rahel and Olden 2008, Mainka and Howard 2010)
- Climate change alters the frequency, severity, timing, and location of biological disturbances, such as severe storms, fire, and wind events, increasing the likelihood of invasion (Bradley et al. 2010, Staudt et al. 2013, Finch et al. 2021)
- Altered ocean currents may result in increased trans-oceanic transportation of invasives (Mainka and Howard 2010)
- For many forest pests, warming temperatures increase activity levels and the number and duration of breeding cycles, resulting in more frequent outbreaks (Dukes et al. 2009, Finch et al. 2021)
- Stressed ecosystems can't recover as easily (Staudt et al. 2013)
- Changing climactic conditions will likely shift which areas are at risk of invasion, requiring dynamic monitoring protocols (Allen and Bradley 2016)

Proactively addressing the combined impacts of invasive species and climate change will be necessary for effective management, but additional research and communication of results are necessary (Beaury et al. 2020).

TOOLS AND RESOURCES

Since invasion ecology is a matter of movement of species across borders, invasive species management occurs at many different levels. Numerous resources are available for learning more about this complex issue. The **Global Invasive Species Database**, developed by the IUCN and the Invasive Species Specialist Group (ISSG), provides a summary of the known impacts and potential management strategies for more than one thousand species known to negatively impact biodiversity around the world (ISSG 2015). The ISSG is also working on a **Global Register of Introduced and Invasive Species**, which will develop county-level record information for many invasive species (Pagad et al. 2018). Another online database, the Centre for Agriculture and Bioscience International (CABI) **Compendium of Invasive Species**[42], has many informational datasheets on invasive species, though the focus is more on agricultural pests.

Multiple invasive species management and implementation plans have been developed at the national level. The US Department of Agriculture (2004, 2013) lays out four key elements for the management of invasive species in their **National Strategy and Implementation Plan for Invasive Species Management**: prevention, early detection and rapid response, control and management, and rehabilitation and restoration. The **National Invasive Species Council**[43], under the umbrella of the US Department of the Interior, provides guidance on the prevention, eradication, and control of invasive species, as well as the restoration of impacted ecosystems in their **Management Plan and Annual Work Plans**. The annual workplan frames actions under six themes: climate change, wildland fire and invasive species, early detection and rapid response, information management, outreach and engagement, and interagency dialogues (National Invasive Species Council 2016, 2022). The US Department of the Interior (2021) has a comprehensive agency-wide approach intended to build upon existing plans and serve as an overarching invasive species management strategy in their **Invasive Species Strategic Plan**. The five major goals in this document are to increase collaboration both within and outside of the agency, prevent the introduction and spread of invasive species using cost-effective methods, implement early detection and rapid response efforts in collaboration with other partners, control or eradicate established invasive species using cost-effective methods, and improve invasive species data management. The US Forest Service (2013) has its own **National Strategic Framework for Invasive Species Management** which prioritizes and guides the prevention, detection, and control of invasive insects, pathogens, plants, wildlife, and fish species.

There are invasive species programs and resources within many of the federal natural resource agencies. The **National Invasive Species Information Center**[44] is within the US Department of Agriculture, providing invasive species information from local, state, federal, and international sources. The Center maintains an **Invasive Species Profiles List** for aquatic and terrestrial species declared as invasive, noxious, prohibited, or otherwise harmful or potentially harmful in the United States. The Animal and Plant Health Inspection Service additionally maintains a **noxious weeds program**[45] whose purpose is to prevent the introduction of nonindigenous invasive plants. Plants can be designated under the **Federal Noxious Weed Act**[46], which gives the authority to regulate their import and transport, as well as the ability to seize and destroy plant products if necessary to prevent their spread.

The USGS **Biological Threats and Invasive Species Research Program**[47] monitors several biological threats at the national level. They conduct research intended to inform the protection of public safety, property, and ecosystems from invasive species and diseases. The USGS has produced several **data resources and tools** related to invasive species management (Table 3.2).

The US Fish and Wildlife Service has **programs focused on terrestrial invasive species**[48] **and aquatic invasive species**[49]; both programs work on the prevention, eradication, and control of biological invaders. The USFWS also has the authority to designate species as injurious[50] under **title 18 of the Lacey Act**, setting importation and transportation restriction on these species. The USFWS and NOAA also co-chair the **Aquatic Nuisance Species Task Force**[51], a group established by Congress by the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990. Their **Strategic Plan** outlines the goals, objectives, and strategies that guide national and regional prevention, early detection and rapid response, control, research, and outreach activities (Aquatic Nuisance Species Task Force 2019). The Task Force works together with regional panels, partnerships of state and federal agencies, academic institutions, environmental organizations, commercial interests, and regional entities collaborating on aquatic invasive species management The **Northeast**[52] **and Mid-Atlantic**[53] **regional panels** set regional priorities and work together with the Task Force to develop and implement strategic, coordinated, action-oriented approaches to prevent and control aquatic invasive species.

Non-governmental organizations are also focused on invasive species management. The **North American Invasive Species Management Association**[54] is a network of land managers and other professionals implementing management programs to prevent the detrimental impacts of invasive species across the country. They support invasive species management professionals with training opportunities, inventory and data standards, and outreach and networking events that bring together diverse stakeholders and interest groups. The Association developed a PlayCleanGo brand for outreach materials and a Weed Free Product Standards and Certification Program to prove assurance that noxious weeds are not spread through the movement of forage, mulch, or gravel. The **Reduce Risks from Invasive Species Coalition (RRISC)**[55] is a nonprofit organization dedicated to educating the public on the risks of invasive species to the environment, public health, and the economy and promoting cost-effective strategies to reduce those risks. The organization profiles an Invasive Species of the Month as part of its education and outreach activities. The Coalition recognizes best practices for invasive species management by giving awards for private sector and state government achievements in prevention, control, and risk management.

The **Center for Invasive Species and Ecosystem Health**[56] at the University of Georgia is another group focused on the development, consolidation, and dissemination of information and programs focused on invasive species, forest health, and natural and agricultural management. They have also developed several invasive species tools and data resources (Table 3.2).

Significant amounts of invasive species coordination and management happen regionally. The National Park Service's Northeast, Mid-Atlantic, and National Capitol Area **Invasive Plants Management Teams**[57] have highlighted a list of 18 target species for management and provide the expertise needed to prevent introductions of new species, reduce existing infestations, and restore native plant communities and ecosystem functions at national parks across the region. Other regional organizations such as the **Northeast-Midwest State Foresters Alliance**[58] consider invasive species a key issue and are working to identify and prioritize research needs as well as effective prevention, management, and restoration actions.

Table 3.2 Data resources and tools related to invasive species. For more information on each of these data resources and tools, see the associated citation and link.

Database	*Data Manager*	*Citation & URL*
Plant List of Attributes, Names, Taxonomy, and Symbols (PLANTS) – Invasive and Noxious Species Search	USDA – NRCS	(USDA NRCS 2023) https://plants.usda.gov/home/noxiousInvasiveSearch
US Register of Introduced and Invasive Species (US-RIIS)	USGS	(Simpson et al. 2022) https://www.sciencebase.gov/catalog/item/62d59ae5d34e87fffb2dda99
Nonindigenous Aquatic Species (NAS) Database and Flood and Storm Tracker (FaST) maps	USGS	(USGS 2023) http://nas.er.usgs.gov

Invasive Species Habitat Tool (INHABIT)	USGS	(Englestad et al. 2022) https://gis.usgs.gov/inhabit/
Catalog of US Federal Early Detection/Rapid Response Invasive Species	USGS	(Simpson et al. 2020) https://www.sciencebase.gov/catalog/item/5bf87027e4b045bfcae2ece6
*climatch*R	USGS	(Erickson et al. 2022) https://www.usgs.gov/software/climatchr-implementation-climatch-r
National Institute of Invasive Species Science (NIISS) Database	USDA	(National Institute of Invasive Species Science 2017) https://data.nal.usda.gov/dataset/national-institute-invasive-species-science-niiss-database
Early Detection and Distribution Mapping System (EDDMapS)	Center for Invasive Species and Ecosystem Health	(CISEH 2023) https://www.eddmaps.org/
Invasive and Exotic Species of North America	Center for Invasive Species and Ecosystem Health	(CISEH 2018) https://www.invasive.org/index.cfm
Invasive Plant Atlas of the United States	NPS, Center for Invasive Species and Ecosystem Health	(Swearingen and Bargeron 2016) https://www.invasiveplantatlas.org/
Global Avian Invasions Atlas (GAVIA)		(Dyer et al. 2017) https://figshare.com/articles/dataset/Data_from_The_Global_Avian_Invasions_Atlas_-_A_database_of_alien_bird_distributions_worldwide/4234850

The Great Lakes region has additional programs. The **EPA's Great Lakes program**[59]manages aquatic nuisance species. Their resource page has information on the aquatic invaders present and the work EPA is doing to address them. The Great Lakes Environmental Research Laboratory and NOAA maintain the **Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS)**[60], a one-stop shop for information about aquatic nonindigenous species in the region. GLANSIS provides tools to generate custom lists of species for a geographic area of interest, explore species distributions and data through a map tool, and access risk assessment literature, methods, and project results from partners. The system integrates spatial datasets from collaborators, allowing the exploration of habitat relationships and the creation of custom maps. Partners supporting GLANSIS include the Great Lakes Sea Grant Network, GLRI, USGS, and others.

Several regional tools are also available. The **Invasive Plant Atlas of New England**, which later became the Invasive Plant Atlas of the United States, was one of the first tools that documented both presence and absence data for the region using citizen science (Bois et al. 2011). The **Marine Invader Monitoring and Information Collaborative (MIMIC)**[61] is another citizen science tool that has been searching for marine invaders along the New England Coast since 2006. Another major partner in the region, the **Northeast Climate Adaptation Science Center**[62], coordinates the **Regional Effort on Invasive Species and Climate Change (RISCC) Management**[63] program, an initiative that aims to develop management-relevant research to improve invasive species management in the face of climate change. RISCC produces 2-page management challenge documents that synthesize the current state of knowledge about a topic related to invasive species and climate change, such as identifying **100 plant species likely to invade** the region in the future (Bradley et al. 2020). A similar effort is underway to identify the **top 100 aquatic species likely to invade** the Northeast[64].

Many states are exploring new tools for invasive species monitoring. Larson et al. (2020) **reviewed several tools with significant potential, especially for the early detection of invasive species**, including eDNA, remote sensing, and citizen science. Many states are already using new citizen science-based tools such as **iMap Invasives**[65], **EDDMapS**[66], and **iNaturalist**[67] as reporting systems for invasive species. Some states have more coordinated programs dedicated to invasive species, such as **New York's Partnerships for Regional Invasive Species Management**[68]. States are also attempting to reduce the chances of new invasions by addressing potential invasion pathways. Except for the District of Columbia, every state in the Northeast Region **regulates the sale of some invasive plant species**, though enforcement of these regulations is varied (Beaury et al. 2021). **Education programs and regulations** aiming to reduce the transport of firewood containing Emerald Ash Borer, the release of bait species such as crayfish, worms, or minnows, the movement of any Spotted Lanternfly life stage, and the movement of invasive plants and mussels snagged on boats and trailers between water bodies are widespread across the Northeast. **Native Plant Societies** perform education and outreach about the value of native and the hazards of non-native plants in individuals' gardens and on the landscape.

PROBLEMATIC NATIVE PLANTS & ANIMALS

For most species, interactions with other native species that result in mortality, such as predation and competition, occur at a natural rate that is not a cause of population decline. Native plant and animal species generally become problematic because some other factor acts as either a competitive benefit or a stressor to one of the species in the ecosystem, upsetting the ecological balance with the others. This may mean the impacts of these interactions with native species may result in higher levels of mortality than in less impacted systems.

THREAT DESCRIPTIONS AND EXAMPLES

Increased predation by mesopredators (Threat 8.2.5) is one of the most prominent threats in this category. Many native mesopredators are subsidized by human activities. Humans can create large influxes of resources that release predators from bottom-up controls, allowing predator populations to grow beyond what local prey populations can support (Newsome et al. 2015). Anthropogenic fragmentation may also enable predators to travel greater distances more quickly (Beyer et al. 2016, Gómez-Catasús et al. 2021) or make certain habitats more permeable to predators, and thus prey species more vulnerable (Schneider 2001, Chalfoun et al. 2002). For many turtles and songbirds, increased nest predation by Raccoons (*Procyon lotor*) and Striped Skunks (*Mephitis mephitis*) is a major concern. Freshwater mussels have many native predators, including Raccoons, Otters (*Lontra canadensis*), Muskrats (*Ondatra zibethicus*), turtles, and birds, whose predation rates are compounding declines caused by other threats. The stocking of Striped Bass (*Morone* saxatilis) has contributed to population increases for this species, which in turn is contributing to declines of prey species such as the American Eel (*Anguilla* rostrata). Shorebird species are facing increasing predation following the widespread recovery of falcons (Ydenberg et al. 2017, Hope et al. 2020). Other native mesopredators that are having increasing impacts include Coyotes (*Canis latrans*), Bobcats (*Lynx rufus*), and gulls. Increased predation by large predators (Threat 8.2.6) is much less of a concern in this region, as most large predators, such as Wolves (*Canis lupus*) and Cougars (*Puma concolor*), are considered extirpated from the Northeast.

In marine ecosystems, the primary large predators in the region are seals and sharks. The recovery of these species, especially Harbor and Gray Seals (*Phoca vitulina* and *Halichoerus grypus*, respectively) and White Sharks (*Carcharodon carcharias*), has been a contentious issue in coastal New England, encompassing fisheries management, human safety, and conservation (Bogomolni et al. 2021, Bratton 2022). These top predators can alter fish behavior (Shea et al. 2020) and abundance and may also depredate fish from fishing gear (Jog et al. 2022), sparking concern from commercial and recreational fisheries. Though some research has suggested that the impact of these predators on the local fisheries is minor (e.g., Rafferty et al. 2012), the full impacts of their recovery are still largely unknown.

Interspecific competition with favored species (Threat 8.2.8) can have similar additive impacts on priority species facing other threats. However, identifying and isolating the impacts of competition with other native species from other environmental factors is very difficult. As a result, very few species in the 2023 RSGCN and Proposed

RSGCN lists have this threat tagged as a reason for regional concern. A few of the species identified by the taxa teams include Shenandoah Salamander (*Plethodon Shenandoah*) which competes with Red-backed Salamander (*Plethodon cinereus*) for food and shelter, Atlantic Brant (*Branta bernicla hrota*) which compete with Snow Goose (*Anser caerulescens*) for habitat, Delmarva Fox Squirrel (*Sciurus niger cinereus*) which compete with Gray Squirrel (*S. carolinensis*), and Duskytail Darter (Etheostoma percnurum) which are being displaced by Fantail Darter (*E. flabellare*).

Increased grazing by vertebrate and invertebrate herbivores (Threat 8.2.2 and 8.2.3, respectively) can have direct and indirect impacts on other wildlife species. In the Northeast, White-tailed Deer (*Odocoileus virginianus*) have largely been released from predator pressure and benefit from additional anthropogenic resource availability, resulting in significant population increases. Deer browse defoliates forest understories, altering forest regeneration, species composition, biodiversity, nutrient cycling, and invasive species prevalence (Gill and Beardall 2001, Rooney and Waller 2003, Rawinski et al. 2008, Shelton et al. 2014, McWilliams et al. 2018, Kelly 2019, Hanberry and Abrams 2019). Dobson and Blossey (2015) found that deer browse had less impact than invasive earthworms on smaller plants, but the impact may increase as the plants become larger. These impacts then have indirect effects on forest species from many different taxonomic groups, including small mammals (Flowerdew and Ellwood 2001, Shelton et al. 2014), forest birds (Fuller 2001, Crystal-Ornelas et al. 2021), amphibians (Brooks 1999), and invertebrates (Stewart 2001, Shelton et al. 2014). Pollinator RSGCN include some of the species most impacted by deer browse in the Northeast region because pollinators decline as a result of the loss of key host plants (Miller et al. 1992, Wagner et al. 2003, Rooney and Waller 2003, Schweitzer et al. 2011) or plants responding to deer browse by increasing physical or chemical defenses (Lind et al. 2012). Experiments in Japan have shown pollinator diversity increases when deer are excluded from grassland habitats (Nakahama 2020); experiments in the United States have shown increases in plant diversity and abundance as a result of deer exclusion, but the more direct impacts on priority pollinators have not yet been assessed (Webster et al. 2005, Dávalos et al. 2015).

Relatively few widescale **native insect pest epidemics** (Threat 8.2.4) are of concern in the Northeast. However, similar to concerns for invasive insect species, changing climactic conditions may increase the frequency, severity, or distribution of these outbreaks. Moreover, some invasive insects target the same trees as these native insects. Trees that would otherwise be able to recover from outbreaks of a single insect pest are not able to withstand the combined outbreaks of multiple species. The native and invasive insects could amplify the effects of the other pest if they attack different plant tissues, at different points in the growing season, simultaneously, or asynchronously over a multi-year period, amplifying defoliation rates and stress levels and precluding periods of recovery between outbreaks (e.g., Ward and Aukema 2019).

Generally, the impacts of these insects are indirect; defoliation and mortality of trees result in major habitat modification, which can have cascading effects across multiple trophic levels. Eastern Spruce Budworm (*Choristoneura fumiferana*) is responsible for the largest insect-caused defoliation events of coniferous forests in North America. Budworm outbreaks occur every 25-40 years and can last for a decade, but new information on the factors driving these outbreaks is still being discovered (Pureswaran et al. 2016). Several warbler species may be closely linked to these outbreak cycles, and may even play a role in determining their intensity (Venier and Holmes 2010). Budworm outbreaks and the associated forest mortality may have particular impacts on several RSGCN salamanders and snakes (Mitchell 1991) and Canada Lynx (*Lynx canadensis*; Hoving et al. 2004). Sothern Pine Beetle (*Dendroctonus frontalis*) has long been a management concern in the Southeast but has now been found as far north as Rhode Island and Massachusetts. It is associated with the mortality of hard pine species, especially Pitch Pine (*Pinus rigida*), though the full impact on northeastern pine species is not yet known (Dodds et al. 2018). This beetle may be a particular concern for pitch pine barrens, a rare xeric habitat type associated with many unique species. Pine Beetle outbreaks may represent an increase in resource availability for certain insectivorous species, such as woodpeckers, but these benefits may be outweighed by the loss of critical nesting trees and the changes to over- and understory structure (Tchakerian and Coulson 2011). The Forest Tent Caterpillar (*Malacosoma disstria*) is one of the most widely distributed insects in North America and is a pest of oak, maple, and aspen species (Dukes et al. 2009). Outbreaks of this species are generally shorter, lasting only 3-4 years, but repeated defoliation can result in significant mortality (Dukes et al. 2009).

Ectoparasites (Threat 8.2.7) are another threat that is currently of conservation concern in the Northeast, in part because the effects of many parasites at the individual and population levels are not always well understood. In general, these parasites induce limited mortality in their hosts as they consume relatively small amounts of blood before falling off to complete the rest of their life cycle. However, ectoparasites can cause host mortality if parasite loads become excessive. Winter Tick (*Dermacentor albipictus*) populations have been increasing as a result of warmer, milder winters. Larger parasite loads are resulting in unprecedented mortality rates – greater than 50% – in Moose (*Alces alces*) calves across the southern parts of their distribution (Jones et al. 2019, DeBow et al. 2021). The tick is also reducing female productivity, increasing the likelihood of failed pregnancies, especially in smaller individuals (Pekins 2020). Though Moose are currently Watchlist rather than RSGCN in the Northeast, this parasite is a high priority as managers are still trying to determine the full impacts. Another mammalian ectoparasite, sarcoptic mange, is caused by the mite *Sarcoptes scabiei*. This mite can result in hair loss, skin irritation, and fissuring, and can result in mortality as a result of emaciation or secondary infections of the skin (Niedringhaus et al. 2019). Sarcoptic mange is commonly associated with Red Foxes (*Vulpes vulpes*), Gray Wolves (*Canis lupus*), Coyotes (*Canis latrans*), and American Black Bears (*Ursus americanus*), but can also infect humans and domestic animals (Niederinghaus et al. 2019). This wide host range suggests the mite is highly adaptable and could move to other high-priority species. Gray Fox (*Urocynon cinereoargenteus*) is a Watchlist species that overlaps significantly with several of the other commonly infected species. However, mange is extremely rare in Gray Fox, a phenomenon that is poorly understood and deserves further research (Niederinghaus et al. 2019).

Though currently poorly understood, the potential role of ectoparasites on freshwater mussel declines is being highlighted as a serious data gap that needs to be addressed (Gangloff et al. 2008, Brian and Aldridge 2019, Aldridge et al. 2023). A large group of parasitic copepods, collectively known as sea lice, may be a concern for many marine and diadromous fishes. These parasites exist at low levels in the environment, but can reach harmful levels in fish farms and aquaculture facilities and spread to wild populations (Johnson et al. 2004, Costello 2009, Frazer et al. 2012). The impacts of the louse (*Lepeophtheirus salmonis*) on Atlantic Salmon (*Salmo salar*) are particularly well-studied and include elevated stress levels, reduced recruitment, and mortality (e.g., Krkosek et al. 2013, Ugelvik and Dalvin 2022). This concern is largely tied to farmed fish and closely related species, but monitoring for outbreaks of other sea lice species should continue in high-priority fish.

Habitat alteration by beavers (Threat 8.2.1) can have major impacts on both terrestrial and aquatic RSGCN. Beavers are widely acknowledged as ecosystem engineers as their activities profoundly alter hydrological, geomorphological, and ecological characteristics and processes within their environment, increasing landscape heterogeneity (Rosell et al. 2005, Brazier et al. 2020). Beaver meadows are often associated with high biodiversity; studies have shown increased species richness of plants (Wright et al. 2002, Bartel et al. 2010), birds (Rossel et al. 2005, Nummi and Holopainen 2014), mammals (Rossel et al. 2005, Nelner and Hood 2011), fish (Rosell et al. 2005), and amphibians (Cunningham et al. 2007), and increased habitat suitability for rare butterflies (Bartel et al. 2010), and fish (Rosell et al. 2005, Malison et al. 2014, Bylak and Kukula 2018). For some aquatic species, the presence of beaver dams is detrimental. Beaver-modified landscapes favor lentic species over lotic ones, often inundating stream features such as riffles that are important to many aquatic invertebrates (Rosell et al. 2005, Washko et al. 2022). The inundated water above the dam can be significantly warmer, which influences oxygen levels and can result in die-offs under extreme conditions (Rosell et al. 2005, Kemp et al. 2012). The dams slow water flow rates, which impacts downstream sedimentation and forms a physical barrier to stream connectivity, both of which can have severe impacts on fish and mussel species that are already impacted by stream fragmentation (Rosell et al. 2005, Kemp et al. 2012).

Though not a category identified by the Quebec Standardized Classification of Threats, **harmful algal blooms** are a group of problematic species with significant impacts in the Northeast. Various species of phytoplankton, macroalgae, cyanobacteria, and even some protists are present in fresh, brackish, or marine environments. They form the basis of many aquatic food chains and are a critical food resource for many species, especially during the early spring when few other resources are available (Porter 1977, Sigler et al. 2014). However, under certain conditions, high nutrient loads and warmer temperatures promote excessive algal growth, while wind conditions, tides, and currents consolidate the algae in large colonies, often referred to as bloom (Paerl et al. 2001, Sellner et al. 2003, McGillicuddy et al. 2003, Anderson et al. 2008, Gobler et al. 2017, Griffith and Gobler 2020). These blooms can create floating mats or cloud the water, blocking sunlight from reaching benthic plants and invertebrates and depleting nutrients from the water (Paerl et al. 2001, Gatz 2020). Some forms of algal blooms can become barriers to movement, forcing animals away from important resources (Maurer et al. 2021). They also create anoxic conditions and deplete oxygen levels in the water body either directly by extracting it for photosynthesis or indirectly after the algae die and decompose, which leads to die-offs of fish and mussels (Paerl et al. 2001, Gatz 2020). Some forms of harmful algae produce toxic compounds, which can lead to severe health consequences or mortality when ingested (Nelson et al. 2003, Shumway et al. 2003, Sellner et al. 2003, Broadwater et al. 2018, Gatz 2020). Harmful algal blooms are known to cause mortality in fish (Paerl et al. 2001, Fire et al. 2012, Starr et al. 2017), marine mammals (Simeone et al. 2015, Starr et al. 2017, Broadwater et al. 2018), birds (Shumway et al. 2003, Stewart et al. 2008, Starr et al. 2017, Rattner et al. 2022), sea turtles (Amaya et al. 2018, Ley-Quiñónez et al. 2020), shellfish (Shumway 1990, Griffith et al. 2019), marine invertebrates (Turner et al. 2021), and terrestrial species including domestic animals and humans (Pybus et al. 1986, Shumway 1990, Stewart et al. 2008).

RELATIONSHIPS WITH OTHER THREATS

Human activity in Residential & Commercial Development (Threat 1.0) subsidizes several species, such as Raccoons, by providing additional food resources and allowing their populations to grow far beyond what their prey can support. Agriculture & Aquaculture (Threat 2.0) can also provide additional resources for these human-adapted species, such as White-Tailed Deer feeding in agricultural fields. Transportation & Service Corridors (Threat 4.0) have altered how some animals move through the environment, in some cases creating pathways that enable predators to travel more quickly between habitats and in others causing avoidance of fragmented areas. Species already impacted by forms of development and agriculture, Energy Production & Mining (Threat 3.0), Biological Resource Use (Threat 5.0), Human Intrusions & Disturbance (Threat 6.0), or Natural System Modifications (Threat 7.0), may become more susceptible to other impacts caused by interactions with native species.

Climate Change (Threat 11.0) is altering the ecosystems and interspecific interactions of native species. Species that are better able to adjust to changing temperature and precipitation regimes have a competitive edge over species that are not able to respond as quickly. Climate change is expected to result in many species shifting further north or up in elevation to remain within their preferred climatic conditions (Ralston et al. 2017). However, high elevation and headwater species don't have much space to move into, leaving these species trapped between limited habitat availability and competition from other species moving into their existing range (Sekercioglu et al. 2008, but see Urban 2018). Some of these interspecific interactions are even more complicated; Dallalio et al. (2017) demonstrated that climate change may actually decrease competition between Shenandoah Salamander (*Plethodon shenandoah*), a high-elevation RSGCN, and Red-backed Salamander (*Plethodon cinereus*), but increased water temperatures would largely counteract this potential benefit. Some native insects and arthropods may also benefit from climate change. Historically, winter temperatures in the Northeast restricted the northernmost distributional edge of a species or caused sufficiently high winter mortality to prevent major outbreaks. Warmer, milder winters are allowing the Southern Pine Beetle to expand far beyond its historical range and increasing Winter Tick populations to lethal levels.

Climate Change (Threat 11.0) and Pollution (Threat 9.0) amplify harmful algal blooms. Nutrient inputs from wastewater, fertilizers, aquaculture facilities, and other sources are a major component in bloom formation (Sellner et al. 2003, Anderson et al. 2008). The influx of nutrients supports much larger algal populations than the water body otherwise could. Warmer temperatures allow algae to grow faster, and elevated atmospheric CO_2 levels provide additional resources for photosynthesis that match the increased nutrient availability (Gobler et al. 2017, Griffith and Gobler 2020).

TOOLS AND RESOURCES

Resources for monitoring or tracking problematic native species tend to be localized because the impacts of many problematic native species are context dependent and are not always negative.

The US National Phenology Network[69] produces short-term **Pheno Forecast maps** as a tool to inform management and monitoring actions (Crimmins et al. 2020). These maps depict the status of the insect's life cycle across the United States and are updated daily. Native insect pests that the Phenology Network currently forecasts include Apple Maggot (*Rhagoletis pomonella*), Bagworm (*Thyridopteryx ephemeraeformis*), Bronze Birch Borer (*Agrilus anxius*), Eastern Tent Caterpillar (*Malacosoma americanum*), Lilac Borer (*Podosesia syringae*), Magnolia Scale (*Neolecanium cornuparvum*), and Pine Needle Scale (*Chionaspis pinifoliae*).

The **Assessing Vegetation Impacts by Deer (AVID)**[70] project sponsored by Cornell University and the New York Department of Environmental Conservation engages citizen scientists in monitoring plants for one year to document the impact of deer browsing on forest health.

A diverse suite of resources is available for harmful algal blooms. The US Geological Survey[71,72], Environmental Protection Agency[73], National Oceanic and Atmospheric Administration[74], National Institute of Environmental Health Sciences[75], Center for Disease Control[76], and National Office for Harmful Algal Blooms[77] all have **website hubs with numerous resources, publications, and data** about harmful algal blooms. The National Oceanic and Atmospheric Administration's **National Centers for Coastal Ocean Science** has produced useful tools for forecasting and monitoring algal blooms[78,79], allowing managers to plan for and respond to these events more rapidly. Algae blooms are also tracked globally in the **Harmful Algal Event Database** and the **Harmful Algal Information System** (IOC UNESCO 2023a,b). The Intergovernmental Oceanographic Commission of UNESCO maintains these products and provides access to information on harmful algal events, harmful algae monitoring and management systems worldwide, and maps and data products.

New tools for predicting the impacts of algal blooms and methods for detecting them are also being developed. Chapra et al. (2017) developed a modeling framework for **predicting the effect climate change** is likely to have on reservoirs and highlighted that some of the largest increases in the occurrence of cyanobacterial harmful algal blooms will likely be in the Northeast. Ralston and Moore (2020) reviewed recent studies modeling harmful algal blooms and their response to climate change and made **recommendations for improving future modeling efforts**. Multiple researchers have also been exploring the use of **remote sensing technology** as a tool for identifying, tracking, and understanding harmful algal blooms (Isenstein et al. 2014, Wolny et al. 2020).

INTRODUCED GENETIC MATERIAL

The scientific literature has long acknowledged that the introduction of novel genetic material can have severe impacts on wild populations (Cross 2000, Mooney and Cleland 2001, Araki and Schmid 2010, Valiquette et al. 2014, Todesco et al. 2016, Varney et al. 2018). Sources of genetic variation can be human-altered, human-transported, or natural. Though the source of the introduced genetic material may vary, the overall result is the hybridization of local and novel individuals and the introgression of non-native genes into the broader population. Hybridization is a complex issue, with important implications for conservation (Woodruff 1973, Allendorf et al. 2001, Genovart 2009). It is also important to note that hybridization is largely a natural process and not intrinsically a threat (Barton 2001, Abbott et al. 2013, Adavoudi and Pilot 2022). Hybridization can occur naturally as isolated events (e.g., Hull et al. 2007) or occasionally within hybridization zones, areas of overlap between two species' distributions (e.g., Koen et al. 2014). In these cases, the incidence of hybridization is generally low enough to not have major impacts on the species as a whole. Hybridization is more likely to have negative impacts on a population if it is already facing other stressors that have restricted the total number of breeding individuals or if the population is naturally genetically isolated.

There are three primary ways hybridization can threaten a species: (1) hybrids are fitter than their progenitors, (2) hybrids are less fit than their progenitors, or (3) hybridization changes the genetic landscape for the parent species (Todesco et al. 2016). Hybrids that are fitter than their progenitors competitively exclude one or both of the parent species and may eventually replace them in the landscape in a process referred to as genetic swamping (Wolf et al. 2001, Todesco et al. 2016). Candy Darter (*Etheostoma osburni*), a federally endangered RSGCN, is an example of genetic swamping in the Northeast, as hybridization with Variegate Darter (*E. variatum*) is widespread and still spreading (Gibson et al. 2019). Swamping can also occur with genetic units besides species, such as in island populations of American Marten (*Martes americana*) and translocated mainland populations (Colella et al. 2019) and native subspecies of *Phragmites* with the highly invasive subspecies (Meyerson et al. 2010). Hybrids that are less fit than their progenitors or that carry maladaptive traits can lead to the extinction of the parent species by reducing reproductive success and wasting reproductive effort, referred to as demographic swamping (Wolf et al. 2001, Todesco et al. 2016). Demographic swamping is much less common than genetic swamping and is more frequently observed in plant species (Todesco et al. 2016). The final impact of hybridization, changes to the genetic landscape, are the result of the introgression of new genes into the greater population or species, rather than individual-level interactions.

The impacts of these population or species-level genetic changes can be grouped into four categories: loss of genetic variation, breakdown of localized adaptation, changes to the within-population genetic composition, and simplification of the population structure between populations (Laikre et al. 2010). Decreased genetic variation can occur as a result of a large influx of introduced, very similar genetic material, such as would occur when stocking fish or animals for recreational use. These genetically swamped populations are more susceptible to outbreaks of disease or parasites, which can further decrease genetic variation as the population collapses (Laikre et al. 2010). The spread of non-native genes can interfere with localized adaptation, reducing fitness by replacing alleles with non-adaptive ones (Laikre et al. 2010). In populations that were previously isolated, this can reverse evolutionary trajectories and potential speciation by returning the population to a similar composition to populations elsewhere (Laikre et al.

2010). The genetic composition of a population – the particular mix of alleles present – can change if the introduced genetic material contains alleles that were not previously present (Laikre et al. 2010). Finally, genetic structure – the organization of genetically distinct populations across a landscape or species' range – can be impacted by releases that homogenize the genetic composition between populations (Laikre et al. 2010). In some cases, intermixing of the local and introduced genetics via hybridization is not necessary for these deleterious effects to occur; the introduced individuals could outcompete or prey on native populations or increase the transmission of diseases or parasites that disproportionately impact the native individuals (Weber and Fausch 2003, Bradbury et al. 2020).

The impacts of introduced genetic material are particularly well studied in farmed fish species, such as the Atlantic Salmon (*Salmo salar*; Lage and Kornfield 2006), but the implications are similar for farmed shellfish (Varney et al. 2018), marine species (Kitada 2018), and gamebirds (Evans et al. 2009, Champagnon et al. 2009, Champagnon et al. 2012), as well as for recovery activities for freshwater mussels (Hoftyzer et al. 2008, McMurray and Roe 2017), fish (Minckley 1995, George et al. 2009), and mammals (Pacioni et al. 2019).

THREAT DESCRIPTIONS AND EXAMPLES

Human-altered genes generally come from cultivated sources, such as agriculture (Threat 8.3.1), silviculture (Threat 8.3.2), and aquaculture (Threat 8.3.3). This includes both genetically modified organisms (GMOs) and breeding stock where intentional or unintentional human choices and actions result in artificial selection, such as selecting for more domesticated individuals (Hagen et al. 2019). These genes generally enter wild populations either due to individuals escaping cultivation facilities, broadcast distribution of gametes, such as is the case for wind-pollinated plants or spawning fish or shellfish, or the release of large numbers of captively raised recreational species, often referred to as stocking. **Human-transported genes** are the result of stocking efforts that do not utilize local populations as broodstock, the translocation of individuals from another population in an attempt to bolster a failing population or reintroduce a species to an area where it has been extirpated, or hybridization with non-native species. For stocked species, differentiating between human-altered and human-transported genes can be very difficult, and both may be occurring depending on propagation facility practices.

In the Northeast, cultured or stocked species are a major source of human-transported genetic material. Atlantic salmon are farmed offshore in Maine and have been stocked from many different sources across the region, resulting in very few wild populations with sufficient genetic integrity (Lage and Kornfield 2006). The contamination of their genetics prompted the Fish Taxa Team to specify that only the wild populations should be listed as RSGCN in the 2023 list. Other fish species with a history of stocking that may be influencing wild genetics include Striped Bass (*Morone saxatilis*; Woods et al. 1995, LeBlanc et al. 2019), lake trout (*Salvelinus namaycush*; Krueger and Ihssen 1995, Baillie et al. 2015), and brook trout (*Salvelinus fontinalis*; Perkins et al. 1993, Kazyak et al. 2022), all of which are included in the 2023 list as Watchlist [Assessment Priority] species. Cultured shellfish are known to influence the genetics of nearby populations of Eastern Oysters (*Crassotrea virginica*; Varney et al. 2018) and may also impact Bay Scallops (*Argopecten irradians*; Bert et al. 2011). Northern Bobwhites (*Colinus virginianus*) have a long history of being stocked in the region. Extensive research has been conducted to determine the impact of these introduced individuals on wild population survival rates (deVos and Speake 1995, Sisson et al. 2000), productivity (Eggert et al. 2009), behavior (Hutchins 2003, Eggert et al. 2009), and genetic integrity (Valentine 1997, Evans et al. 2006). Bobwhite populations in the Northeast are heavily impacted by these releases; the Bird Taxa Team suggested that Virginia is the only state that likely still has viable wild populations, supporting their decision to defer this species to the Southeast and Midwest which support more populations with wild genetics.

Hybridization between co-occurring native species is also a concern for some of the species on the 2023 Northeast RSGCN list. Perhaps one of the most famous examples is the hybridization between Golden-winged and Blue-winged Warblers (*Vermivora chrysoptera* and *V. cyanoptera*, respectively), which is contributing to declines in the Golden-winged Warbler (Gill 1980, Vallender et al. 2007). Mallards (*Anas platyrhynchos*) and American Black Duck (*Anas rubripes*) form a species complex, with the genetic distance between the two species decreasing (Heusmann 1976, Mank et al. 2004, Lavretsky et al. 2019). In addition to the Candy Darter, hybridization is a concern for Slender Chub (*Erimystax cahni*; Kuhadja et al. 2009) and Stripeback Darter (*Percina notogramma*; Loos and Woolcot 1969). Saltmarsh Sparrow (*Ammospiza caudacuta*), a species already facing significant impacts due to habitat and sea level rise, may be hybridizing with Nelson's Sparrow (*Ammospiza nelson*; Shriver et al. 2005, Walsh et al. 2011).

RELATIONSHIPS WITH OTHER THREATS

As the source of much introduced genetic material comes from cultivated sources, this threat is tightly tied to Agriculture & Aquaculture (Threat 2). Because these sources of genetic contamination are embedded within the landscape, it is difficult, if not impossible, to prevent all introductions. Many aquaculture facilities attempt to sterilize their crops as a method of reproductive and genetic containment, but these are not always successful (Piferrer et al. 2009, Golpour et al. 2016, Xu et al. 2022). Continued work will be necessary to further improve methodologies for preventing the intrusion of foreign genetic material into native populations. Climate Change (Threat 11.0) may also influence this threat by potentially expanding the ranges of some species, either native or invasive, and increasing the area of the hybridization zone.

TOOLS AND RESOURCES

Several authors have **assessed the success rates of animal translocations** and may provide additional insights into the viability of translocations as a recovery tool for imperiled populations (Griffith et al. 1989, Seddon 1999, Fischer and Lindenmayer 2000). The release of individuals to bolster a species, whether for recreational or recovery purposes, should consider the genetics of both the wild and introduced populations to prevent the introduction of detrimental genetic material. Other important considerations include randomly selecting individuals to prevent artificial selection, ensuring there are sufficient breeders to capture the genetic variability of the population, and not stocking in areas where the wild populations are stable due to natural reproduction rates (Ryman 1991, Jennings et al. 2010). Genetic considerations for recovery work are often complicated by the fact that locally adapted populations may be extirpated or too small to support the removal of individuals for breeding. In these cases, the selection of an appropriate genetic source is a primary consideration, as is ensuring the habitat and other conditions will contribute to the successful establishment of the released individuals and establishing monitoring protocols to track the success or failure of individuals. The IUCN's Species Survival Commission produced the **Guidelines for Reintroduction and Other Conservation Translocations**, a handbook that outlines considerations that should be made before, during, and after any recovery effort (IUCN SSC 2013). George et al. (2009) provide additional **guidelines specific to the propagation and translocation of freshwater fish**.

A growing topic related to stocking is climate-adaptive population supplementation. The idea of this concept is to use stocking practices to align climate-associated traits, such as drought or thermal tolerance, of propagated species with the likely future environmental conditions at the places they are released. The Northeast Climate Adaptation Science Center hosted a **Climate-Adaptive Population Supplementation Workshop**[80] in 2022 that brought together individuals from federal and state agencies, academic institutions, nonprofit organizations, and private companies together to develop this concept and discuss how they could contribute to managing priority populations.

PATHOGENS & MICROBES

Most discussions about pathogens and microbes focus on the negative impacts on their hosts, widespread outbreaks, and their potential role in species extirpation or extinction. However, much like native predators, pathogens and microbes are an integral part of all ecosystems that co-evolved with the community. Through their direct influence on their hosts, they shape populations, communities, and ecosystems (Hudson et al. 2006, Preston et al. 2016). Increasingly, research is demonstrating the importance of these microscopic organisms as sources of biodiversity, mediators of inter- and intra-specific interactions, directors of energy flow and biomass in food webs, modifiers of biogeochemical cycles, sources of disturbance dynamics, and even shapers of evolutionary pathways (Hudson et al. 2006, Thompson et al. 2010, Selakovic et al. 2014, Preston et al. 2016, Hamede et al. 2020).

As was the case with Ectoparasites (Threat 8.2.7), many pathogens and microbes are present in the environment but remain at low enough levels that they do not have much impact. However, under certain conditions, a pathogen or microbe that was previously relatively benign can shift into an emerging infectious disease with severe and widespread impacts (Daszak et al. 2000, Adlard et al. 2015). There are two primary theories for explaining why the characteristics of a disease change: the novel and endemic pathogen hypotheses. The dynamics of novel pathogens share many similarities with invasive species. Novel pathogens are those that have expanded or been introduced into a new area or have evolved a new strain. Thus, their hosts are naïve and highly susceptible to infection (Rachowicz et al. 2005). Endemic pathogens were already present in the environment but have either shifted into a new host, have changed the intensity of their effects due to other environmental factors and stressors, or escaped prior human notice (Rachowicz et al. 2005). Understanding whether a pathogen is novel or endemic has important conservation implications, as the methods for managing the pathogen may differ. The focus for novel pathogens is often on controlling distribution, while endemic pathogen studies often focus on understanding the environmental conditions that have increased the intensity of the effects on the host (Rachowicz et al. 2005). Experimental tests and genetic testing may be able to help identify the pathogen's origins (e.g., Rachowicz et al. 2005, Warnecke et al. 2012).

Much of the earlier study of wildlife diseases was focused on zoo animals and zoonotic diseases, infections that spread between humans and animals. Recent decades have seen an increase in research on emerging infectious diseases in wildlife, driven by increased awareness and advances in the fields of parasitology and epizoology (Daszak et al. 2000, Cunningham et al. 2017). The reason that these pathogens are such great threats to wildlife populations is that they are infectious; healthy organisms can become infected via contact with other individuals of the same or different species or from the environment.

For some infectious diseases, multiple hosts are necessary for different life stages. An example of this is a disease that requires a reservoir species where the disease can survive and multiply, a primary host where the disease reaches sexual maturity, and a vector species that transmits the disease between the two. Lyme disease, one of the most frequently reported vector-caused diseases in the Northeast, is caused by the bacterium

Borellia burgdorferi, for which the primary vectors are ticks in the genus *Ixodes* (Kilpatrick et al. 2017). Tick larvae feed on small vertebrates, including White-Footed Mice (*Peromyscus leucopus*), the primary reservoir for *B. burgdorferi* (Ostfeld et al. 2006). Nymphs and adults feed on a variety of larger mammals, transmitting the bacterium as it feeds. White-tailed Deer are the predominant host for these later life stages, but other animals, including livestock, dogs, and humans, can be infected with Lyme disease. With so many hosts, managing this disease is difficult, especially since we know that climatic and forest masting conditions influence the risk of Lyme disease indirectly by favoring the tick hosts (Ostfeld et al. 2006, Bregnard et al. 2021). In the Northeast, ticks and mosquitoes are the primary vectors of several diseases, and snails are vectors for several wildlife parasites.

Another form of transmission between species is the introduction of a disease into a host it did not previously infect. Most infectious diseases are specific to certain hosts; transmission to other species is unlikely because the disease cannot survive and reproduce in alternative hosts. Under certain conditions, a disease may adapt or mutate, allowing it to be transmitted to a new host species. There are three possible outcomes of transmission to a new species: isolated infection events between the original and new hosts that do not spread (dead-end hosts), infections that spread between the old and the new host across a local population before fading (spillover), and epidemic or sustained transmission between members of the new host species (host-switching) (Parrish et al. 2018). Dead-end hosts are not generally a concern for wildlife management except as a potential signal of an emerging spillover or host-switching event. Often, spillover events happen at the intersection of wildlife and domestic animals, such as the transmission of bovine tuberculosis and epizootic hemorrhagic disease from farm animals to White-tailed Deer, or canine distemper and parvoviruses transmitting between domestic dogs and wild carnivores. Host-switching is one of the biggest concerns in disease ecology, as it can result in the widespread transmission of highly virulent diseases.

Though not a direct threat to wildlife populations, the impacts on human health are a critical component of disease and wildlife management. Increasing human populations, combined with the invasion of natural habitats, are resulting in an increased frequency of zoonotic outbreaks (van der Hoek et al. 2018). In the Northeast, many communities exist within a matrix of wildlife populations, resulting in many opportunities for the transmission of diseases that have major impacts on humans. This includes the recent global COVID-19 pandemic, a zoonotic originally transferred from bats that we now know can also spillover into other wildlife species that act as reservoirs for the disease, including White-tailed Deer in the United States (Kuchipudi et al. 2022). For more information on other zoonotic diseases in the United States, see (US DHHS et al. 2017). Recognition that human, animal, and ecosystem health are intrinsically intertwined has led to the One Health concept, which advocates for holistic and transdisciplinary approaches to disease (Destoumieux-Garzón et al. 2018). One Health is increasingly incorporated into research on wildlife health (e.g., Jenkins et al. 2015, Cunningham et al. 2017, Turner et al. 2021, Kuchipudi et al. 2022), helping to build a fuller understanding of the impacts on target species, implications for human health, and potential management approaches.

All Northeast RSGCN are vulnerable to the threat of infectious disease. Emerging diseases are potentially more urgent and dynamic than other top threats, making them a challenge to manage. The complexity of coping with this threat is apparent when considering that diseases can be introduced and spread through many vectors and then exacerbated by pervasive anthropogenic and environmental factors. Again, similar to invasive species, the most effective management tool for diseases is to prevent their establishment. States must collaborate on this shared threat because of potential rapid transmission beyond state borders and the difficulties of controlling or eradicating diseases once established in native populations. Once established, strategic approaches require regional protocols and planning to react quickly and effectively to minimize the impacts of new and emerging diseases while also working continuously to manage diseases and invasions that are already affecting populations.

THREAT DESCRIPTIONS AND EXAMPLES

Various infectious agents cause diseases in wildlife. This includes **bacterial** (Threat 8.4.1), **viral** (Threat 8.4.2), and **fungal pathogens** (Threat 8.4.3), various internal parasites including **worm-induced** (Threat 8.4.4), and **protozoan-induced diseases** (Threat 8.4.5), and prion diseases (Threat 8.4.6). These infectious agents vary in terms of biology and infection mechanisms[81]. For an in-depth overview of methodologies and techniques applicable to studying wildlife diseases, see Franson et al. (2015).

Wildlife diseases in the Northeast are too diverse to summarize based on infectious agents, general effects, or even impacted species. Instead, the sections below provide a brief overview of high-concern diseases broken out by broad taxonomic groups.

MAMMALS

The pathogens and microbes impacting mammals are better studied than those of many other taxonomic groups in part due to the increased risk of zoonotic disease transference between wildlife, livestock and other domestic animals, and humans and the charismatic nature of many of these species.

White-Nose Syndrome (WNS) is one of the most devastating infectious diseases currently in the Northeast. Caused by the fungus *Pseudogymnoascus destructans*, the disease was first identified in bats in New York in 2006, making the Northeast the epicenter. The disease was highly virulent and spread rapidly, highlighting the need for focused research and monitoring (Blehert et al. 2009). For a more detailed description of the progression of WNS and its impacts on bats, see Frick et al. (2016) and Hoyt et al. (2021). By the time of the 2013 Conservation Synthesis, WNS had been found in every state in the Northeast Region and was the focus of three regionally funded projects (TCI and NEFWDTC 2013). For a description of these projects, see *Chapter 4*. At this time, researchers had determined that White-Nose Syndrome caused skin damage and altered the torpor cycle and metabolism of overwintering bats (Cryan et al. 2010), recognized that the disease was causing precipitous declines in several bat species (Gargas et al. 2009, Frick et al. 2010), assessed key data gaps and methods for addressing them (Foley et al. 2011), determined the mechanism by which the fungus caused mortality (Warnecke et al. 2012), recognized that it could potentially lead to the extirpation of the federally endangered Indiana Bat (*Myotis sodalist*; Thogmartin et al. 2013), and developed tools for detecting the presence of the fungus (Lorch et al. 2013).

Research on White-Nose Syndrome has been extensive since 2013. Though not a complete list, researchers in the last decade have:

- Confirmed that the fungus is native to Europe and was introduced to North America (Leopardi et al. 2015)
- Determined that *P. destructans* is highly persistent, and can remain in the soil for years (Hoyt et al. 2015)
- Found that hibernation, and not birth pulses, are the driver in seasonal infection spikes (Langwig et al. 2015)
- Developed non-destructive tools for determining infection status and severity (McGuire et al. 2016)
- Identified changes in bat genetic structure in the region (Lilley et al. 2020, Gignoux-Wolfsohn et al. 2021)
- Found a relationship between fungal loads and mortality levels, identifying management targets (Hoyt et al. 2020)
- Studied the disease recovery process in infected bats (Fuller et al. 2020)
- Identified high-priority data gaps and research needs (Bernard et al. 2020)
- Determined preferred bat habitat also has higher fungal loads, but over time a greater portion of the population is shifting to ‘refugia’ sites where the pathogen is less prevalent (Hopkins et al. 2021)
- Quantified the scope and severity of WNS to hibernating bats (Cheng et al. 2021)
- Compared the assemblage of skin fungal communities between bat species that are and are not impacted by White-Nose Syndrome and found that impacted species have lower overall fungal diversity, and identified one yeast species that may inhibit *P. destructans* (Vanderwolf et al. 2021)
- Synthesized data from across the United States to identify trends in the response of each impacted bat species to White-Nose Syndrome (Hoyt et al. 2021)

- Evaluated the effect of artificially cooling hibernacula as a potential tool for combating White-Nose Syndrome (Turner et al. 2022)
- Field-tested an antifungal treatment that can be applied to entire bat colonies, rather than individuals, with no apparent detrimental impacts on bat behavior or health (Gabriel et al. 2022)

The White-Nose Syndrome outbreak facilitated an unprecedented level of coordination across the United States. The US Fish and Wildlife Service developed a national plan for managing White-Nose Syndrome, with seven key elements including communication, monitoring, and research (USFWS 2011). This national plan organizes the efforts of the **White-Nose Syndrome Response Team**[82] which, along with similar groups from Canada and Mexico, form the **North American Bat Conservation Alliance**[83]. These groups facilitate communication between the many individuals involved in bat conservation and share important resources such as decontamination protocols and management recommendations, while also continuing to track the spread of White-Nose Syndrome. Other national products include the **North American Bat Monitoring Protocol**, which standardizes survey methods for hibernacula and maternity colony counts and acoustic surveys (Loeb et al. 2015). The US Forest Service and US Geological Survey both have significant resources devoted to White-Nose Syndrome and produce numerous reports and research products on the subject, such as this report describing the impacts of timber harvest on forest management on three species impacted by White-Nose Syndrome (Silvis et al. 2016), or an assessment of the potential risk of transmitting the disease to North American bat populations (Runge et al. 2020). You can find more research and information on their websites.

As of 2023, White-Nose Syndrome is now known to occur in 38 US states and 8 Canadian provinces and is suspected to be present in five more states (WNS Response Team 2022). At least twelve bat species in North America are known to be impacted by this disease, including seven Northeastern species: Indiana Bat (*Myotis sodalis*), Northern long-eared Bat (*M. septentrionalis*), Little Brown Bat (*M. lucifugus*), Eastern Small-footed Bat, (*Myotis leibii*), Tri-colored Bat (*Perimyotis subflavus*), Big Brown Bat (*Eptesicus fuscus*), and Gray Bat (*Myotis grisescens*), of which the first five species are RSGCN (Hoyt et al. 2021). Most states have been tracking population declines with annual surveys. The Mammal Taxa Team indicated that declines in some species were greater than 90%, but other species appear to be stabilizing, which was also confirmed in Hoyt et al.'s (2021) results.

Another highly visible infectious disease in the Northeast is **Brainworm**. Brainworm is caused by the parasitic nematode *Parelaphostrongylus tenuis*. This parasite's primary host is White-tailed Deer (*Odocoileus virginianus*). When the nematode is sexually mature, it lays its eggs in nearby tissues. When the eggs hatch, the larvae migrate to the gastrointestinal system and are shed along with fecal material. Various gastropod species consume the mucus layer on deer pellets, consuming the immature nematode as well. Eventually, White-tailed Deer contract the parasite by consuming vegetation with contaminated snails on it. Brainworm infects the meningeal tissue of White-tailed Deer with relatively little impact. When consumed by other cervids, such as Moose (*Alces alces*), the parasite spreads into and causes significant damage to neurological tissues that results in motor impairment, limb weakness, apparent deafness or blindness, listlessness, circling or weaving movements, fearlessness, and mortality (Anderson 1964, Lankester 2010). The parasite has been found across much of northern and eastern North America since the 1960s (Anderson 1964, Wasel et al. 2003), but has become an increasing concern for Moose in the Northeast only in the last few decades (Lankester 2010, Wattles and DeStefano 2011). Brainworm infection rates in Moose are related to the density of White-tailed Deer, as higher deer populations result in increased prevalence of the parasite (Wattles and DeStephano 2011, Lankester 2018, Ditmer et al. 2020). Winter conditions play a role in controlling the population size of both White-tailed Deer as the primary host and the various gastropod species that act as intermediate hosts (Lankester 2018). As winter conditions in the Northeast get warmer and deer populations continue to grow and expand, the threat of brainworm, as well as other parasites including Winter Tick, will increase, especially on the southern distributional edge for Moose (Murray et al. 2006, Timmermann and Rodgers 2017, Lankester 2018, DeBow et al. 2021).

Another potential risk to Moose is **Chronic Wasting Disease**. Chronic Wasting Disease is a prionic disease of White-tailed Deer and is the only one known to affect free-ranging wildlife. It results in brain degeneration, emaciation, abnormal behavior, and death. For a more complete description of the history, distribution, and ecology of this disease, see Escobar et al. (2020) and other resources available from the National Wildlife Health Center. The Northeastern states have been monitoring for the disease since the early 2000s, where it is known to occur in five states (Evans et al. 2014). While the major concern with this disease is for deer and, in the western United States, elk, there have been a few isolated incidents of wild Moose contracting the disease (Baeten et al. 2007, Pirisinu et al. 2018). Until we have a better understanding of the mechanisms that lead to spillover infections in Moose, we cannot determine if this disease will become an important threat in the Northeast. Continued monitoring of Chronic Wasting Disease in both White-tailed Deer and Moose will be necessary to track the continued spread of this disease and its potential transference into other cervid species (Evans et al. 2014).

A highly contagious disease affecting rabbits and hares, **Rabbit Hemorrhagic Disease**, is of increasing concern in North America. Mortality events involving the original strain (RHDV1) of this virus have been affecting domestic and wild European rabbit (*Oryctolagus cuniculus*) populations around the world since the 1980s (Abrantes et al. 2012). However, around 2010, a new strain (RHDV2) emerged in France that was also able to infect members of the genera *Lepus* and *Sylvilagus* (Asin et al. 2022). The first outbreak of this new strain in North America occurred in captive lagomporph populations in Quebec in 2016, followed by outbreaks in British Columbia in 2018 and 2019 (Asin et al. 2022). In 2020, reports of RHDV2 in wild populations in the American southwest, as well as captive animals in New Mexico and New York, rapidly increased concerns about this disease (USDA APHIS 2020). Since that time, it has continued to spread in wild lagomporphs in the western United States (Asin et al. 2021, Williams et al. 2021). As of 2023, there have been no further records of RHDV2 in captive or wild lagomorphs in the Northeast region. However, this disease is a major concern for the Northeastern lagomorph RSGCN and Watchlist species, New England Cottontail (*Sylvilagus transitonalis*), Appalachian Cottontail (*Sylvilagus obscurus*), and Snowshoe Hare (*Lepus americanus*), as the effects on these species are unknown but likely to be severe. The New England Cottontail working group and mammal biologists across the region are preparing by updating protocols to include decontamination, vaccination, and other methods to protect native rabbits and hares (New England Cottontail Initiative 2021, Pennsylvania Game Commission 2021). Additionally, the US Animal and Plant Health Inspection Service maintains a **map showing the current distribution of known RHDV2 occurrences** (USDA APHIS 2022). Currently, treatment options for this virus are limited, but Bosco-Lauth et al. (2022) have tested a potential vaccine for use in domestic rabbits. While widescale application of this vaccine to wild populations is not reasonable, it could be effective in preventing transmission from captive populations or for inoculating key Northeast populations, such as those in the New England Cottontail captive propagation facilities.

A contributing factor to Allegheny Woodrat (*Neotoma magister*) declines may be infection by the **Raccoon Roundworm** (*Baylisacaris procyonis*). This intestinal nematode is generally benign in its primary host, the Raccoon (*Procyon lotor*), but in woodrats and other species that act as intermediate hosts, the parasite enters the nervous system and causes death either directly or indirectly by making the host more susceptible to predation (LoGiudice 2003). Researchers have confirmed that areas with a lower prevalence of *B. procyonis* tend to have more stable woodrat populations, but additional research will be needed to more clearly separate the impacts of the roundworm from the other threats contributing to woodrat decline (Owen et al. 2004, Smyser et al. 2013*a*, Wolfkill et al. 2021). For a more complete description of these other factors, see LoGiudice (2008). An experimental application of bait containing the medication Pyrantel nearly eliminated *B. procyonis* from treated sites and may be a valuable tool for the protection of existing Allegheny Woodrat populations or improve success in future translocation and recovery projects (Smyser et al. 2013b).

Another parasite may be mediating the interactions of Northern and Southern Flying Squirrels (*Glaucomys sabrinus* and *G. volans*, respectively). The **nematode *Strogyloides robustus*** infects both species. However, Northern Flying Squirrels appear more susceptible to the parasite, which is highly prevalent in Southern Flying Squirrel populations (Pauli et al. 2004). Where the two species overlap in distribution, the Southern species likely introduces the parasite to Northern populations, leading to reduced competitive capability (Pauli et al. 2004). This may prove problematic for the Virginia Northern Flying Squirrel (*G. s. fuscus*) subspecies included on the 2023 RSGCN list.

Several viruses have widespread impacts on northeastern carnivores, and can spillover into domestic cats and dogs. While these diseases can cause mortality events, they tend to be isolated both spatially and temporally, making them generally of lower concern in the Northeast. **Rabies** is perhaps the most infamous example. This virus can infect any mammal species, but raccoons, foxes, skunks, and bats are the most common reservoirs in the eastern United States. Dedicated dog vaccination programs greatly reduced the incidence in pet populations, but translocations helped spread the virus among wildlife populations (Wallace et al. 2014). Oral vaccines are being used to reduce the prevalence and transmission rates of the variant that is widespread across the eastern United States and may in the future be effective in eliminating the disease (Slate et al. 2009). Canada, Mexico, and the United States cooperatively work on managing this disease as part of the **North American Rabies Management Plan** (NARMP 2008). APHIS has a **National Rabies Management Program**[84], which has useful resources related to the disease.

One family of viruses that are the source of disease outbreaks in many species is the **morbilliviruses**. There are seven known morbilliviruses, including human measles. Two morbilliviruses called rinderpest, one of which has been largely eradicated, are primarily a concern for livestock but may occasionally spillover into native ungulate populations and are not a major concern in the Northeast. Feline morbillivirus is primarily a concern in Feral Cat populations, but there is some potential for it to spillover into *Lynx* species in the Northeast. The other three morbilliviruses include canine distemper, phocine distemper, and cetacean morbillivirus. Canine distemper is perhaps the most flexible of these diseases, capable of infecting all families of terrestrial carnivores as well as pinnipeds, while the other two strains tend to be more specific (Deem et al. 2000). All three of these diseases are known to cause mass mortality events, though they do not generally happen with high frequencies (Deem et al. 2000, Jo et al. 2018).

Marine mammals may be particularly impacted by viral infections. For a more comprehensive list of the many viruses known to impact marine mammals, see Bossart and Duignan (2018). Simeone et al. (2015) found that viruses were the most commonly reported source of marine mammal mortality in the Northeast from 1972-2012, comprising more than 75% of all records. Records of mass mortalities of marine mammals due to viruses do not appear to be increasing, but a more reliable, centralized collection of data is needed to better track these trends (Gulland and Hall 2007, Jo et al. 2018). The National Oceanic and Atmospheric Administration maintains the **Marine Mammal Health and Stranding Response Program**[85] and coordinates emergency responses to sick, injured, distressed, or dead marine mammals. As part of this program, they investigate **unusual marine mammal mortality events**[86] in the United States.

Another class of viruses with major impacts on carnivores is the **parvoviruses**. These viruses are organized into three general lineages – feline, canine, and mink – all of which can be found in the Northeast. For a more in-depth overview of this class of viruses, see Steinel et al. (2001). Once again, these diseases can infect domestic animals, but vaccination against them is common for household pets (Kimpston et al. 2022). A new parvovirus was recently identified from Red Foxes (*Vulpes vulpes*) in Newfoundland; though it was not found in a suite of other carnivores, Gray Fox (*Urocynon cinereoargentus*) were not tested and may be susceptible (Canuti et al. 2021).

Many different herpesviruses impact Northeast mammals but do not generally have major impacts. A few other diseases that tend to spillover between wild and domestic animals include feline immunodeficiency virus and the bacteria that cause leptospirosis and tuberculosis.

BIRDS

Birds are a major reservoir for several vector-borne zoonotic diseases in the Northeast (e.g., Zika Virus, Eastern Equine Encephalitis) and have the ability to transfer diseases large distances due to their migratory patterns (Reed et al. 2003, Fuller et al. 2012). Despite this, there are relatively few pathogens and microbes that are of major concern for the management of bird RSGCN in the Northeast.

West Nile Virus (WNV) is one of the most cosmopolitan zoonotic diseases, with confirmed infections in birds, amphibians, mammals including humans, and reptiles, though only avian species appear to support viral loads high enough for transmission to other individuals via mosquito vectors (Pérez-Ramírez et al. 2014). This virus first emerged in the US in 1999 and primarily affected corvids (Friend et al. 2001). In the decades since its emergence, WNV has been identified in more than 300 bird species in the US alone (US CDC 2016) and has been identified as the driving reason behind population declines in many species (LaDeau et al 2007, George et al. 2015). Though many states used to have systems in place to test for WNV in dead birds, many of these programs were discontinued once WNV spread to all states in the continental US in

2012. The disease has been identified as a particular concern for Ruffed Grouse (*Bonasa umbellus*; Eastern Grouse Working Group 2020, Nementh et al. 2021, Kunkel et al. 2022).

Periodic outbreaks of various strains of Influenza A are a rapidly growing concern for bird species. A group of these viruses is referred to as **Highly Pathogenic Avian Influenza (HPAI)**. This group has many different strains which have been a major source of avian mortality worldwide since 1996, though before the early 2000s, most outbreaks were associated with domesticated poultry (Hill et al. 2022, Ramey et al. 2022). The distribution, frequency, and intensity of these outbreaks appear to be increasing, and they are increasingly impacting wild bird species as well as domestic ones (Hall et al. 2015, Ramey et al. 2022). Moreover, the disease has recently spilled over into seals in New England, one of the first population-level mortality events in mammals associated with this disease (Puryear et al. 2022). As this disease evolves rapidly and transfers easily between species, containment and eradication are unlikely and will require structured decision-making within a One Health framework to address at a global scale (Ramey et al. 2022, Harvey et al. 2022). APHIS[87], the CDC[88], and USGS[89,90] all have resources and tools devoted to tracking outbreaks of Avian Flu. However, understanding the role this disease plays with wild bird populations will require sustained, cost-effective investment in standardized sampling, testing, and reporting at national and global scales (Machalaba et al. 2015).

Outbreaks of conjunctivitis, a disease that causes inflammation of the eye tissues, were a cause of serious decline for House Finches (*Haemorhous mexicanus*) in the 1980s (Hartup et al. 2001). The bacterium ***Mycoplasmosa gallisepticum*** was identified as the infectious agent. While House Finches are not native to the eastern United States, this disease is still potentially of concern in the Northeast because it can spill over into wild passerine populations (Hosseini et al. 2006, Sawicka-Durkalec et al. 2021).

Recently in 2021, a mortality event centralized in the mid-Atlantic region generated a regionally-coordinated response. Symptoms included crusty eyes and neurological behaviors, followed by death, across several different passerine species. Consistent and coordinated messaging from state fish and wildlife agencies and local Audubon chapters encouraged reporting of bird mortalities, as well as preventative measures such as removing bird feeders and bird baths until after the outbreak died down. The USGS National Wildlife Health Center, Southeastern Cooperative Wildlife Disease Study, Wildlife Futures Program (University of Pennsylvania), and Indiana Animal Disease Diagnostic Laboratory all worked to identify the cause, and were able to eliminate many of the usual disease culprits (USGS National Wildlife Health Center 2021, Greening et al. 2022). Ultimately, reported cases dropped off late in the summer, leading many of the affected jurisdictional agencies to lift the feeder guidance. In early 2022, many agencies again sent out messaging to ensure feeders were removed or kept clean and to report any further mortalities, but the outbreak did not re-occur. As of 2023, some of the occurrences in Maryland and the District of Columbia have been attributed to an unspecified conjunctivitis bacterium, but results for the rest of the region are still pending (USDA APHIS 2023). A manuscript describing the multi-agency response is in prep and will hopefully be submitted soon (Bryan J. Richards, USGS Emerging Disease Coordinator, *pers. comm.*). Regardless of the ultimate diagnosis, this event is significant because it demonstrated that rapid, collaborative, regional responses to emerging issues are possible, significantly increasing common understanding, collective messaging, and collaboration between many different entities.

There are a handful of other diseases that have caused periodic outbreaks in wild bird species, including Duck Plague, Avian Botulism and Cholera, and Newcastle Disease. For more information, see Friend and Franson (1999) and Friend et al. (2001). One disease currently known from Alaska may become more prevalent in the future. This disease, called Avian Keratin Disorder, causes beak overgrowth in several bird species from across different orders (Handel et al. 2010, Zylberberg et al. 2021). The disease agent has tentatively been identified as a poecivirus. Though most testing for this disease has occurred in Alaska, testing of an individual from Maine was positive for this disease (Zylberberg et al. 2021). This may suggest the disease is more widespread across North America than previously believed, but further study will be necessary to determine if it will become a threat in the Northeast. Finch Trichomonosis, a disease that is currently spreading in Europe, may also become a concern in the future if it is introduced to North America (Lawson et al. 2011).

AMPHIBIANS & REPTILES

One of the most widespread disease-causing agents in amphibians is the fungus ***Batrachochytrium dendrobatidis* (*Bd*)**, a causative agent of the disease chytridiomycosis. For a description of the characteristics of this pathogen and its impacts on hosts, see Voyles et al. (2011). This fungus was first identified in 1997, and has since been confirmed on all continents and is considered a leading cause of amphibian declines and extinctions (Fisher et al. 2009). To date, more than 2500 amphibians have been tested for *Bd* globally and the disease has been found in more than half of the species sampled (Monzon et al. 2020, Olson et al. 2021). The global pattern of *Bd* distribution and impacts suggest it is a non-native pathogen whose spread was anthropogenically facilitated by international amphibian trade (Fisher and Garner 2007, Fisher et al. 2009). The fungus likely originated in Asia, as amphibians in these areas still carry high loads of the fungus, but do not suffer from the virulent effects (Fu and Waldman 2019). However, the eastern United States may represent the site of the historical diversification of the fungus that resulted in the modern *Bd* lineages that are now widespread globally (Byrne et al. 2022).

The biology of this fungus greatly affects its ability to spread and persist in the environment, with important implications for sampling for the disease. First, *Bd* populations vary seasonally, with zoospore density and associated disease prevalence and intensity highest during early-season sampling in the spring (Lenker et al. 2014, Chestnut et al. 2014, Petersen et al. 2016). These results suggest warm and dry summer conditions may help clear up infections, but they also suggest summer surveys may underestimate the actual prevalence of the fungus and highlight the complications with comparing results across different sites and seasons (Petersen et al. 2016). Chestnut et al. (2016) also demonstrated that tests may imperfectly detect the presence of the fungus, which can be alleviated by testing multiple samples from the same site. *Bd* is also able to survive for a sustained time outside of its host, keeping water bodies infective (Johnson and Speare 2003). This longevity combines with water connectivity, as more connected wetlands have greater *Bd* occurrence, which may have important implications for the transmission of this disease across larger areas (Hulting et al. 2022). On the other hand, the long-term presence of *Bd* in aquatic habitats makes it possible to test for its presence using eDNA, rather than needing to capture and sample from potential hosts (Kamoroff and Goldberg 2017, Barnes et al. 2020). For an overview of diagnostic tests and sampling protocols for *Bd* in host individuals, see Hyatt et al. (2007).

Despite its relatively recent discovery and rise as a major source of conservation concern, *Bd* has been present in North America for more than a century. Review of museum records has made it possible to better assess when and where *Bd* has been introduced (Monzon et al. 2020). Talley et al. (2015) found records of *Bd* as early as 1888 in Illinois, currently the earliest known record of the disease. In Florida, Karwacki et al. (2021) detected *Bd* as early as 1928. Similar reviews of museum records have not yet occurred in the Northeast, but may provide valuable insights into the presence and spread of the disease in the region.

Surveys for *Bd* in the Northeast region did not occur for many years, in part because no major amphibian mortality events occurred that prompted more in-depth testing. Gahl et al. (2011) exposed seven common northeastern species to *Bd* and found that these species had different responses to the infection, with some species demonstrating complete mortality and others none; this highlights that some species could act as reservoirs for the disease within the region, promoting the transmission to more vulnerable species. Longcore et al. (2007) surveyed anurans primarily in northern New England and found that chytridiomycosis was widespread in members of the family Ranidae, but absent in other species, a finding that was further confirmed by Richards-Hrdlicka et al. (2013) and their testing of anurans and salamanders in Connecticut. Plethodontid salamanders in the southern Appalachians had a surprisingly low incidence of *Bd* over a 50-year period, less than 1%, suggesting that declines in these species may be due to other sources (Muletz et al. 2014). In contrast, the prevalence of

Bd in some of these same plethodontid species in New Brunswick was quite high, up to 12.9%, highlighting the need for further research to determine if these differences are due to seasonal, geographic, or other sources of variation (Jongsma et al. 2019). Eastern Hellbender (*Crypotbranchus allegheniensis*), another salamander that has undergone significant declines in recent decades, is also commonly positive for *Bd*, but the fungus may not impact overall individual health (Bales et al. 2015).

Another chytrid fungus that is quickly rising in global importance is ***B. salamdrivorans* (*Bsal***; Martel et al. 2013). Described in 2013, this fungus also appears to have originated in Asia and is the cause of several recent salamander die-offs in Europe (Martel et al. 2013, Gray et al. 2015). Many of the symptoms of *Bd* and *Bsal* are similar, but *Bd* tends to be more pathogenic to frogs and tends to cause thickening of the skin, whereas *Bsal* is more pathogenic to salamanders and usually causes skin ulcerations (Gray et al. 2015). For a more complete overview of the impacts of *Bsal*, known status and distribution, and monitoring protocols for the disease, see North American Bsal Task Force (2022a).

Though *Bsal* has not yet been discovered in North America, it is a major concern for the Northeast, especially the southern Appalachians, as it is a global hotspot of salamander biodiversity, The full impact on Northeastern species is unknown, but laboratory experiments have suggested that Eastern Newt (*Notophthalmus viridescens*) may experience high levels of mortality, while plethodontid salamanders may be somewhat resistant to the disease (DiRenzo et al. 2021). However, as resistance to *Bsal* has been assessed in only ten species so far, much more work is needed to determine the likely susceptibility and potential impacts on North American salamanders (Pereira and Woodley 2021, DiRenzo et al. 2021). Work should also be done to assess the vulnerability of anurans to this disease, as they may also be susceptible (Grear et al. 2021). Additional research has highlighted that the pathogenicity of *Bsal* may be influenced by temperature, suggesting that Eastern Newt populations in the northeastern United States and southeastern Canada may be more at risk than more southern populations (Carter et al. 2021).

Many efforts have focused on predicting and preparing for the invasion of this disease. Numerous authors have highlighted the importance of the amphibian pet trade as the likely distribution pathway of *Bsal* (Richgels et al. 2016, Yap et al. 2017, Grear et al. 2021, Connelly et al. 2023). Yap et al. (2015, 2017) combined a *Bsal* habitat suitability model with salamander richness, identifying four high-risk zones in North America: the highlands of central Mexico, the south coast of British Columbia, the western United States, and the southeastern United States. Richgels et al. (2016) overlaid similar habitat suitability and salamander species richness data with pet trade and import patterns and found the West Coast, Mid-Atlantic, and southern Appalachians were at the greatest risk. Moubarak et al. (2022) conducted a similar spatial analysis based on the ecological niche of *Bsal* in its native range and found that most of the Northeast region falls within the suitable range for *Bsal*, in contrast to other risk assessments that suggested greater impacts further south, but complimenting the results from Carter et al. (2021) suggesting that temperatures in the Northeast may be more conducive for the fungus.

These impact assessments and other calls to action (e.g., Gray et al. 2015) led to the creation of the **North American *Bsal* Task Force**[91]. The Task Force has released two documents to guide *Bsal* monitoring and management in the United States (North American *Bsal* Task Force 2022a,b). The **Strategic Plan** summarizes interdisciplinary scientific and managerial guidance for a successful response to the detection of *Bsal* in North America, following similar concepts to those used in many invasive species Early Detection and Rapid Response (EDRR) programs. The Strategic Plan highlights the importance of having policies in place to restrict the importation of *Bsal*-susceptible species, establish protocols for ensuring imported individuals are disease free and for handling and quarantining infected individuals, identify field mitigation responses for outbreaks, and reduce accidental transmission following future establishment. The Implementation Plan outlines the objectives, goals, and priorities of the eight working groups organized under the Task Force. It is intended to adapt over time as new information, goals, and priorities are identified, and will be updated periodically on the Task Force website.

Ranaviruses are another group of multi-host pathogens with even broader tolerances than the chytrid fungi, as they infect many ectothermic species. Though first identified – and most comprehensively studied – in amphibians, reptiles, and fish are also hosts of this family of viruses (Lesbarrères et al. 2012). Ranaviruses were first identified in the 1960s but have since been identified as the cause of several mortality events in frogs, turtles, and fish on all continents except Antarctica (Lesbarrères et al. 2012). A review of United States amphibian mortality events in the late 1990s and early 2000s revealed that ranavirus infections caused significantly more mortality events than chytrid fungus, though they were often associated with widespread and abundant species rather than species known to be in decline (Green et al. 2002). Other viruses are a concern for some Northeastern freshwater turtle species but do not generally have major impacts in the region. For an overview of these other viruses, see Okoh et al. (2021).

Ranaviruses can transmit between species from different taxonomic classes and have differential impacts on these hosts (Brenes et al. 2014). As a result, some species may act as reservoirs for the disease, maintaining their presence in the ecosystem and repeatedly re-infecting populations that are more sensitive to the disease (Brenes et al. 2014). Additionally, ranaviruses can persist in the environment outside of their hosts in both soil and water, especially at low temperatures, again increasing the chance of transmission (Nazir et al. 2012). As is the case for many other diseases, the severity and prevalence of ranavirus infections can increase in the presence of other stressors in the environment, such as salinity (Hall et al. 2020) and chemical contaminants (Smalling et al. 2022).

Gray et al. (2009) reviewed the ecology and pathology of ranaviruses in amphibians, summarizing the known research, possible reservoirs and transmission pathways, drivers of outbreaks and other stressors that alter infection rates, pathology and diagnostics, rise to global prevalence as an emerging disease, management and conservation strategies, and future research needs. They highlighted the need to better understand the genetics of the various ranavirus species, determine species-specific vulnerabilities to the different ranaviruses, the role of additional stressors in ranavirus virulence, and co-occurrence with other diseases such as *Bd*. Wirth et al. (2018) conducted a similar review of ranaviruses and reptiles, highlighting methods for diagnosing and surveying for the disease, known host ranges and impacts, disease pathology and transmission, likely vectors and reservoirs, immune responses, treatment options, and future research needs. The key data deficiencies for ranavirus in reptiles are their pathogenesis and transmission, as it often involves terrestrial, rather than aquatic species, and host immunity and immune evasion strategies (Wirth et al. 2018). For in-depth discussions on the known ranavirus species and their taxonomy, distribution, replication and transmission, pathology and diagnosis, host impacts, ecology, and antiviral adaptations, see Gray and Chinchar (2015).

In the Northeast region, ranaviruses are known to cause mortality in anurans, turtles, and salamanders, though ranavirus-induced mortality has not yet been observed in hellbenders and plethodontid salamanders (Duffus et al. 2015). A recent report confirmed the presence of ranavirus in the Common Snapping Turtle (*Chelydra serpentina*), the first known occurrence in this species (McKenzie et al. 2019). No ranavirus infections have yet been recorded in North American snakes or lizards. The limited available information about this disease prompted a Regional Conservation Needs project to understand the extent to which ranavirus was impacting amphibians and reptiles in the Northeast (Smith et al. 2016). This project developed a standardized protocol for screening for the disease in Wood Frog (*Lithobates sylvaticus*) larvae across Delaware, Maryland, New Jersey, Pennsylvania, and Virginia, setting the stage for future research and conservation efforts.

Several different diagnostic assays have been used to test for ranavirus (see Wirth et al. 2018). Several methods involve the use of swabs or non-lethal tissue samples, though these methods may underestimate infection prevalence (Gray et al. 2012, Goodman et al. 2013). Improvements in environmental DNA (eDNA) methodologies may make this method highly effective for aquatic species (Hall et al. 2016, Wirth et al. 2018). Moreover, eDNA can be used to test for ranaviruses and *Bd* simultaneously (e.g., Barnes et al. 2020).

Monitoring and management for *Bd*, *Bsal*, and ranavirus are critical in the Northeast due to the wide host range and high virulence of these diseases. The Northeast Partners in Amphibian and Reptile Conservation (NEPARC) have developed **best management practices for disinfecting field equipment** (NEPARC 2014) and **construction machinery** (Julian et al. 2020) to minimize the risk of spreading herptile pathogens. Gray et al. (2017) also discuss considerations for study design, sample collection, biosecurity, and intervention strategies to minimize disease transmission. In addition, attempts to consolidate information, increase multidisciplinary research, and improve understanding of *Bd* and *Bsal* resulted in the creation of the **Amphibian Disease Portal** (Koo et al. 2021). This repository of global chytridiomycosis data enables and accelerates amphibian research and conservation and provides a framework for future research on many different diseases. Similar needs around ranavirus resulted in the **Global Ranavirus Reporting System** (Duffus and Olson 2011). This open-source database contains global detection and non-detection data, providing insights into pathogen emergence patterns and host range and susceptibility, as well as being an archive of ranavirus studies (Brunner et al. 2021).

Starting in 2006, severe and often fatal skin infections were increasingly observed in several snake species across the eastern United States (Lorch et al. 2016). **Snake Fungal Disease (SFD)**, also called ophidiomycosis, is caused by the fungus *Ophidiomyces ophiodiicola* (Lorch et al. 2015). For an overview of the natural history, ecology, and epidemiology of SFD, see Allender et al. (2015b). It was originally observed in Timber Rattlesnake (*Crotalus horridus*) populations, prompting a Regional Conservation Needs grant project to assess the prevalence of the disease in New England (McBride et al. 2015). This project found that overall regional prevalence at that time was around 33%, but even with the relatively high incidence, most individuals were in good health.

Though originally identified in Timber Rattlesnakes, the condition has since been found in a large number of snake species, especially members of the family Colubridae and Viperidae, though the impacts vary depending on the species (Lorch et al. 2016). Most evidence had previously supported the idea that SFD is native to North America, and has recently changed in virulence, potentially as a result of environmental changes (Lorch et al. 2016, Davy et al. 2021). However, recent genetic analysis has revealed that the disease is likely not native but has been introduced multiple times to North America within the last few hundred years, explaining its wide distribution (Ladner et al. 2022).

Snake Fungal Disease can create infections, lesions, sores, and nodules in the skin and, in severe cases, cloudiness of the eyes and facial disfigurement. Often, snakes respond by increasing molt frequency in an attempt to slough off the infected tissues; multiple molts in quick succession may be necessary to fully rid the snake of infection (Lorch et al. 2016). Environmental factors, such as temperature and humidity, may influence infection, which may have important implications for climate change (Allender et al. 2015b, Lorch et al. 2016). Infected snakes demonstrate altered behavior, moving shorter distances and spending more time basking than uninfected individuals (Tetzalff et al. 2017, McKenzie et al. 2021). Though infection status does not appear to have an impact on short-term survival rates, longer-term studies are needed to fully understand the effects on long-term survival and movement (McKenzie et al. 2021).

Effective diagnostic tests for SFD are available (Allender et al. 2015a, Baker et al. 2019). Unfortunately, no effective treatment for SFD in wild populations has been found (Allender et al. 2015b). Prevention is the best countermeasure at this time, though the disease does appear to already be widespread throughout the region (Lorch et al. 2016). Disinfectants for field gear have been tested, setting a baseline of effective methods to prevent transmission of the fungus between individual snakes (Rzadkowska et al. 2016, Gray et al. 2017). Other biosecurity considerations are discussed by Gray et al. (2017).

The rising number of terrestrial herptile diseases has focused the efforts of the **Partners in Amphibian and Reptile Conservation National Disease Task Team**[92]. This team recognizes the importance of collaboration among government and non-government agencies, universities, and the public in responding to disease emergence. This team works to facilitate and guide communication and collaboration amongst the PARC regions, federal and state agencies, and other partners.

Sea turtles face a unique suite of diseases. **Fibropapillomatosis (FP)**, widely thought to be initiated by a herpesvirus, is one of the most important. Originally discovered in Green Sea Turtles (*Chelonia mydas*) in 1938, it has now been found in all seven sea turtle species, though it is most widespread and well-studied in Green Sea Turtles (Jones et al. 2016). FP results in the formation of tumorous growths and lesions on areas of soft skin, especially around the head, flippers, and tail, though they can also form on the carapace and plastron (Jones et al. 2016). Generally, these tumors are considered benign with a high rate of recovery and not a major source of mortality, but depending on location, they can interfere with movement, vision, feeding, and breathing (Patrício et al. 2016, Dujon et al. 2016). Records of the disease from the 1930s indicate that prevalence was low, around 1.5%; starting in the 1980s, outbreaks became increasingly common, with prevalence between 20-60% (Jones et al. 2016). Many researchers have suspected that an external stressor might be associated with the increased emergence of the disease; possibilities have included ultraviolet light exposure, temperature, parasites, pollutants, and harmful algal blooms (Dujon et al. 2021). In their review, Dujon et al. (2021) found that FP was more prevalent in areas with greater exposure to harmful algal blooms with carcinogenic biotoxins present in the algae. Currently, there are no effective treatments for the disease, but managing nutrient loads that promote harmful algal blooms may prevent or reduce disease outbreaks (Dujon et al. 2021).

Sea turtle eggs face additional pathogenic agents. One rapidly emerging disease is **Sea Turtle Egg Fusariosis (STEF)**, discovered only in the last few decades. This disease has been linked to two fungi species within the *Fusarium* (*Neocosmospora*) *solani* complex, *F. keratoplasticum* and *F. falciforme* (Smyth et al. 2019, Gleason et al. 2020). These fungi are distributed globally, with very little known about their ecology and epidemiology (Smyth et al. 2019). The eggs are likely infected by coming into contact with contaminated substrates in and around the nesting site or from contact with gravid females (Gleason et al. 2020). Nests in drier sands appear to be less susceptible, as the fungi prefer warm, moist environments (Gleason et al. 2020). The specific method of transmission between the environment and turtle eggs is not fully understood, as uninfected eggs still occur in the presence of the fungi, suggesting other factors influence infection rates and disease suppression (Gleason et al. 2020). Additionally, the fungi have also been isolated from skin swabs of adult turtles, suggesting they may also play a role in their transmission (Gleason et al. 2020). Recent research has also revealed that these fungi may have impacts beyond the nests; these fungi have been isolated from skin lesions on post-hatchling turtles and may have been the causative agent (Greeff-Laubscher and Jacobs 2022). Additionally, though this disease has long been associated with sea turtles, Carranco et al. (2022) identified it as the cause of hatching failure in an Amazonian freshwater turtle, which may have implications for other freshwater species. Additional research on these fungal agents is necessary to fully understand their impacts on different life stages and implications for Northeastern freshwater turtles.

As all sea turtles in the Atlantic are federally endangered or threatened, the National Oceanic and Atmospheric Administration oversees a **Sea Turtle Stranding and Salvage Network**[93]. State, federal, and private partners work together to gather information on the causes of sea turtle mortality, injury, and illness by collecting data from stranded sea turtles. Data and samples from these turtles inform research on diseases impacting sea turtles, including FP and STEF.

FISH

Research on fish diseases tends to be skewed towards those pathogens and microbes that impact harvested, stocked, and farmed species. Widespread stocking in Northeast rivers and streams, especially of both native and non-native salmonids, has facilitated the distribution of many diseases. In addition, warming temperatures and increasing numbers of aquaculture facilities may be increasing fish vulnerability to disease (Vollset et al. 2021). As research on the impacts of many of these diseases on wild populations is limited, it is not easy to determine if any one of these diseases, or a combination of several of them, is significantly contributing to the declines of any RSGCN or Proposed RSGCN species. Thus, this section provides a very brief overview of several fish diseases that could influence species of conservation concern, but further research is necessary to determine the full impacts.

- **Whirling Disease** is a debilitating disease caused by the parasite *Myxobolus cerebralis*, which has a complicated two-host lifecycle involving an oligochaete *Tubifex tubifex* and a salmonid fish. This disease causes irregular swimming patterns and skeletal and pigment abnormalities in many salmonids including Brook Trout (*Salvelinus fontinalis*), Lake Trout (*Salvelinus namaycush*), and Atlantic Salmon (*Salmo salar*; Sarker et al. 2015). The disease is though to be native to Europe, but has been introduced in North America, where it caused a near-complete collapse of salmonid fisheries in Colorado and Montana (Sarker et al. 2015). Whirling Disease has been detected in several hatcheries and wild populations in the Northeast, though it has not yet caused widespread declines in the region (Sarker et al. 2015). The species' range is continuing to expand, which could impact fisheries in several states (Ksepka et al. 2020).
- **Infectious salmon anemia (ISA)** can be a devastating viral disease in farmed Atlantic Salmon that also spills into wild populations, though they appear to be more resistant to the disease (Nylund et al. 1995).
- **Swim bladder sarcomas** are caused by viruses and are known to impact Atlantic Salmon, though it is not known how widely this disease is distributed in wild North American populations (Paul et al. 2006, Bowser et al. 2006).
- American Eel (*Anguilla rostrata*) are impacted by **the invasive nematode *Anguillicola crassus***, which causes damage to the swim bladder. This damage can influence buoyancy, which could increase mortality at turbines (Pflugrath et al. 2019). Prevalence, abundance, and intensity vary across developmental stages and environmental factors, though more research is needed to determine if this parasite is a significant contributor to eel declines (Warshafsky et al. 2019).
- **Furunculosis** is caused by the bacterium *Aeromonas salmonicida* and is a common, recurring disease in hatcheries and aquaculture facilities worldwide (Dallaire-Dufresne et al. 2014, Baset 2022).
- **Viral hemorrhagic septicemia** is a devastating viral disease of fish globally, found in more than 140 freshwater and marine species, and is expected to continue to expand its range (Escobar et al. 2018).
- Striped Bass (*Morone saxatilis*) are increasingly impacted by the bacterial disease **mycobacteriosis**. Warmer temperatures and decreased oxygen levels increase susceptibility to the disease (Lapointe et al. 2014). In the Chesapeake Bay, incidence and mortality rates are very high; Striped Bass are likely at their thermal maximum in this area, and management will need to incorporate the influence of both disease and temperatures on the species (Groner et al. 2018).
- For a review of other **tumor-causing diseases** in fish, see Coffee et al. (2013).
- For a review of **infectious diseases of salmon species**, see Miller et al. (2014).

INVERTEBRATES

As is the case for many other aspects of invertebrate ecology, knowledge of pathogens and microbes that impact these species is limited. Disease impacts on many invertebrate taxa are unknown and baseline information is lacking in most RSGCN and Proposed RSGCN species. Most of the diseases known to impact Northeast invertebrate RSGCN are those that infect species with economic value and are often studied through the lens of the propagation and culture facilities that raise captive populations of these species.

Declining bumble bee populations have been linked to several pathogens and microbes. ***Nosema bombi*** is a fungal pathogen contributing to the decline of *Bombus* species across North America. Authors suggest that the fungus is native, but its distribution and transmission have been largely facilitated by the use of commercially reared bumble bees in greenhouse operations (Cameron et al. 2016). Researchers isolated this pathogen from 22 of the 36 North American bumble bee species; American Bumble Bee (*Bombus pensylvanicus*), a Northeast Watchlist [Assessment Priority] species, has one of the highest prevalence rates (Cordes et al. 2012). A destructive intestinal parasite, ***Crithidia bombi***, is commonly found in commercial *Bombus* species and is thought to be one of the causes of Colony Collapse Disorder in honeybees and can spillover from commercial bumble bees to native species (Otterstatter and Thompson 2008). Recent research has revealed that transmission of this parasite occurs on flowers where bees deposit fecal matter (Figueoroa et al. 2019). Moreover, the pollen of certain flowers may depress *C. bombi* populations; more research is needed to understand the role of diet in individual health (LoCascio et al. 2019). Some flower flies may be suitable vectors for the parasite, though they are not suitable hosts (Davis et al. 2021). One northeastern species, *Bombus impatiens*, has greatly increased in relative abundance, potentially because this species is resistant to the two pathogens above (Averill et al. 2021).

Eastern Oysters (*Crassotrea virginana*) are sensitive to several diseases. **Dermo**, caused by the protozoan *Perkinsus marinus*, caused significant declines in oyster populations starting in the 1940s. Outbreaks of Dermo are linked to high salinity levels and elevated temperatures (Ford and Smolowitz 2007). Climate change may increase the risk of outbreaks of this disease in the future. Another disease, **MSX**, is caused by the parasite *Haplosporidium nelsoni*. This parasite is not native, originating in the Pacific. Researchers have been trying to understand the dynamics of MSX since the first outbreaks in the 1960s, but research has been hampered because Eastern Oysters are not the primary host; another as of yet unidentified species is present and acting as either the primary host or vector (Ford et al. 2018). Outbreaks of Dermo and MSX in the Northeast in the 1990s prompted the development of disease-resistant lines for use in commercial aquaculture operations (Frank-Lawale et al. 2014). This could have implications for the genetics of wild populations, as disease-resistant strains are now cultured on much of the east coast. Moreover, the population declines may have decreased genetic diversity, making the populations more vulnerable to further impacts (Schulte 2017). Interestingly, populations in Delaware Bay naturally developed resistance to MSX, though they remained susceptible to Dermo (Bushek and Ford 2016). Disease remains a significant impediment to the recovery of Eastern Oysters (Smolowitz 2013, Schulte 2017).

American Lobsters (*Homarus americanus*) suffer from **Epizootic Shell Disease (ESD)**, which first emerged in Long Island Sound in the 1990s. This bacterially-induced disease causes infections in the shell of the Lobster, which result in subsequent infections, interfere with molting, and can cause mortality when infections are severe (Carlon et al. 2018). Warmer temperatures and increased CO_2 levels facilitate the disease, increasing individual susceptibility (Barris et al. 2018, McLean et al. 2018). Lobster populations in the southern portions of their range have been decreasing in recent decades as a result of the disease, and the range of the disease has been spreading further north and increasing in prevalence (Groner et al. 2018, Reardon et al. 2018). Climate change is likely to continue increasing the distribution and prevalence of this disease in the coming decades (Rheuban et al. 2017, Groner et al. 2018). This highlights the need for more research and monitoring to determine the likely effects on the Northeast region, especially in the Gulf of Maine, a water body that is heating more rapidly than 99% of the world's oceans (Pershing et al. 2015). Outbreaks of shell diseases are also occurring in other marine crustaceans. A recent outbreak in Jonah Crab (*Cancer borealis*) highlighted the need for more research to be conducted on the topic to determine if the incidence of these outbreaks and associated mortality events are increasing (Carlon et al. 2018).

Sea stars on the Pacific coast have been suffering from widespread outbreaks of a disease called **Sea Star Wasting Disease (SSWD)**, which is causing mass mortality events in several events. The cause is likely a densovirus, but the understanding of this disease remains incomplete (Hewson et al. 2014, Work et al. 2021). In recent years, similar disease outbreaks of disease have been observed in Common Seastar (*Asterias forbesi*) on the Atlantic coast. Current research suggests that the events in the Atlantic are not the result of the same virus associated with the disease in the Pacific (Bucci et al. 2017). A closely related virus is widespread across both infected and uninfected seas stars in the Atlantic, suggesting that the virus is a natural part of these species' microbiome and not the cause of the disease, but again, further research will be necessary to confirm the pathogenicity of these viruses (Jackson et al. 2020).

Interest in **diseases of freshwater mussels** has been increasing in recent years. Carella et al. (2016) and McElwain (2019) provide reviews on the state of knowledge for pathogens of unionid mussels globally. These reviews describe the pathogens and parasites known to impact freshwater mussels, but none of these agents have yet been linked to mussel declines and die-offs in the United States. The limited information available is prompting calls for more coordinated efforts to understand mussel health, especially given the extreme imperilment of this group (Waller and Cope 2019). In addition, some authors have highlighted the importance of considering the potential of transmitting pathogens, microbes, or parasites before utilizing captive propagation or translocation as tools to bolster populations and ensuring the use of best practices to prevent the accidental spread of these threats (Brian et al. 2021).

No diseases were identified as having significant impacts on any RSGCN or Proposed RSGCN in the following taxonomic groups:

- Crayfish
- Fairy, tadpole, and clam shrimp
- Fireflies
- Tiger beetles
- Dragonflies and damselflies
- Mayflies
- Stoneflies
- Caddisflies
- Butterflies and moths
- Terrestrial snails

It is important to remember that this is not an indication that these groups do not have any pathogens or microbes that are impacting populations, just that the current information available for these species has not studied this topic in detail. Further research is needed to understand how this threat may impact Northeast RSGCN and Proposed RSGCN from these taxonomic groups.

PLANTS

Plant diseases can have similar indirect impacts on Northeastern wildlife as invasive and problematic native insects. These diseases defoliate and kill key plant species, altering the structure and composition of many ecosystems, causing cascading effects across all tropic levels. Changing climactic conditions may also increase the frequency, severity, or distribution of these disease outbreaks in the future. Some plant diseases that are current or historic concerns for RSGCN and Proposed RSGCN in the region include:

- **Chestnut Blight**: A fungal disease caused by *Cryphonectria parasitica* that infests American Chestnut (*Castanea dentata*) and is responsible for the near extirpation of this species and significant alteration of eastern forest structure and composition (Hepting 1974). This eliminated a key food resource from eastern forests, which some authors link to Allegheny Woodrat declines (LoGiudice 2008). Efforts to breed blight-resistant American Chestnuts are ongoing. The American Chestnut Foundation[94] and the State University of New York College of Environmental Science and Forestry have regional efforts (Powell et al. 2019). The planting of disease-resistant strains has started. Further monitoring and research will determine if these efforts will successfully re-establish American Chestnuts (Gurney et al. 2011, Clark et al. 2014).
- **Beech Bark Disease**: A fungal disease caused by members of the genus *Neonectria*, especially *N. coccinea*, that infests American Beech (*Fagus grandifolia*), causing tree mortality, bark scarring, and significant root sprouting

(Cale et al. 2017). The Lepidoptera Taxa Team suggested this disease may be a particular concern for the RSGCN butterfly Early Hairstreak (*Erora laeta*), which feeds on beechnuts.

- **Beech Leaf Disease**: This disease is caused by the nematode *Litylenchus crenatae* and has only recently been discovered, so its impacts and distribution are not yet fully understood (Ewing et al. 2019). It is expanding into the region, adding another threat to the already impacted American Beech. Once again, the Lepidoptera Taxa Team is concerned that this disease will negatively impact Early Hairstreak.
- **Eelgrass Wasting Disease**: This disease is caused by the protist *Labyrinthula zosterae* and infests Eelgrass (*Zostera marina*). Increasing ocean surface temperatures appear to be linked to increasing outbreak frequency (Plaisted et al. 2022). The disease was widespread in the region in the 1930s, leading to the extinction of the Eelgrass Limpet (*Lottia alveus*). Several Northeast RSGCN and Proposed RSGCN, such as Bay Scallop (*Argopecten irradians*) depend on Eelgrass beds as nurseries and would be negatively impacted by new outbreaks.

RELATIONSHIPS WITH OTHER THREATS

Pathogens & Microbes are frequently influenced by anthropogenic activity. Residential & Commercial Development (Threat 1.0) and Agriculture & Aquaculture (Threat 2.0) and the resulting environmental degradation can increase species' susceptibility to disease. Habitat fragmentation increases the likelihood of interactions between wildlife in unaltered habitats and wild and domestic animals, such as livestock and pets, in disturbed areas, increasing cross-species transmission (Dobson and Foufopoulos 2001). Agriculture and aquaculture facilities can be major sources of disease outbreaks due to the large numbers of individuals present, which can then spillover into wild populations; this is a particular concern with open-ocean aquaculture facilities (Dobson and Foufopoulos 2001). Developed areas can contain concentrated resources, such as bird feeders or landfills, which concentrate larger numbers of animals together, again increasing inter-individual and inter-species transmission (Oro et al. 2013, Wasi et al. 2013). Higher levels of Pollution (Threat 9.0) can act as a stressor and increase a species' susceptibility and vulnerability to disease (Staudt et al. 2013, Hamede et al. 2020). Some forms of pollution, especially wastewater and agricultural runoff, may contain potent reservoirs for certain diseases as well.

Climate Change (Threat 11.0) is likely to have significant impacts on disease threats. Geographic range shifts may occur for some pathogens, parasites, and disease vectors, increasing their ability to spread (Staudt et al. 2013, Tazerji et al. 2022). Warmer and wetter climates are likely to benefit several fungal pathogens (Dukes et al. 2009, Fisher et al. 2012, Finch et al. 2021) and invertebrate disease vectors (Tompkins et al. 2015, Tsao et al. 2021), increasing their impact. Moreover, climate and pollution may interact synergistically, with severe impacts on wildlife health (Noyes and Lema 2014).

TOOLS AND RESOURCES

Many resources for wildlife health and the intersection with human and domestic animal health are available. Tools and resources specific to a disease or taxonomic group are included in the sections above. Those included in this section are more general tools and resources that are relevant across all taxonomic groups.

The USGS' **National Wildlife Health Center**[95] is dedicated to wildlife disease detection, control, and prevention. They provide information, technical assistance, coordination, and research on wildlife health issues, monitor and assess the impacts, determine underlying causes of outbreaks and transmission, and develop methodologies and technology for disease prevention and control. One of their tools, the **Wildlife Health Information Sharing Partnership-event reporting system (WHISPers)** promotes collaboration and sharing of wildlife health information, providing situational awareness and timely information about wildlife disease threats (Richards et al. 2022, USDA APHIS 2023).

APHIS's **National Wildlife Disease Program**[96] is focused more on the agricultural impacts of wildlife, livestock, and human diseases, but also participates in the monitoring of high-profile wildlife diseases, including Chronic Wasting Disease, Avian Influenza, and Rabbit Hemorrhagic Disease Virus.

The **Wildlife Disease Association**[97] is an international society of scientists from many different backgrounds united in their mission to promote healthy wildlife and ecosystems, biodiversity conservation, and environmentally sustainable solutions to One Health challenges.

The **Southeastern Cooperative Wildlife Disease Study (SCWDS)**[98] was founded as an agreement between the Southeast Association of Fish and Wildlife Agencies and the College of Veterinary Medicine at the University of Georgia as a diagnostic and research service for the specific purpose of investigating wildlife diseases. They provide expertise to state and federal agencies and are a collaborative environment where wildlife managers, state and federal authorities, and researchers come together to ensure the welfare of wildlife, domestic animals, and human health. They also produce the Field Manual of Wildlife Diseases in the Southeastern United States, a pocket-sized reference of field investigation methodologies and descriptions of the primary pathogens and diseases associated with 25 mammal and bird species.

Similar to SCWDS, the **Northeast Wildlife Disease Cooperative (NEWDC)** operated out of Tufts University from 2013 to 2020. This consortium of veterinary diagnostic laboratories provided educational opportunities, wildlife diagnostics, cutting-edge research, and collaboration with fish and wildlife agencies in the region, and disseminated current information regarding fish and wildlife diseases to various organizations in the Northeast United States. The cooperative entered a dormant phase when the Director of NEWDC transitioned to a new position. Moving forward, disease threats will be managed through a coordinator hired by the Northeast Association of Fish and Wildlife Agencies with funding from the US Fish and Wildlife Service. The **Northeast Regional Fish and Wildlife Health Coordinator** will encourage and support the work carried out by fish and wildlife health practitioners to address zoonotic and other wildlife diseases. This position will work with Coordinators from other regions, encouraging collaboration nationally, and helping develop regional strategies for the prevention, detection, control, and eradication of wildlife diseases. This position is anticipated to be filled in March 2023. Until then, inquiries may be directed to the Wildlife Management Institute.

The **Cornell Wildlife Health Lab**[99] works to promote the health and long-term sustainability of wildlife populations through the integration of the fields of wildlife ecology and veterinary medicine. The Lab conducts disease surveillance and collaborative research; develops diagnostic tools; and communicates findings through training, teaching, and public outreach. The lab is based at the Cornell University College of Veterinary Medicine Animal Health Diagnostic Center.

The **Wildlife Futures Program**[100] is a partnership between the Pennsylvania Game Commission and the University of Pennsylvania's School of Veterinary Medicine (Penn Vet). This program is a science-based, wildlife health program that serves to increase disease surveillance, management, and research to better protect wildlife across the Commonwealth of Pennsylvania and beyond. Their Animal Diagnostic Laboratory provides in-depth, rapid diagnostic information to support disease control, health management, and performance of livestock, poultry, wildlife, fish, and companion animals. They provide active surveillance of animal diseases, identification of emerging diseases through the development and application of new diagnostic methods, and training and education for new diagnosticians, veterinarians, and graduate students as proactive measures to ensure the viability of Pennsylvania's animal industries.

INTRINSIC BIOLOGICAL LIMITATIONS

The threats described under this category are not part of Quebec's Standardized Classification of Threats but have been included in this document because they have major impacts on the ability of a RSGCN to recover from historic declines. Even if other threats, such as habitat loss or pollution, are eliminated, recovery cannot occur unless these underlying threats are dealt with. These threats are critical considerations for any restoration actions and methods for addressing them must be incorporated from the initial planning stages.

THREAT DESCRIPTIONS AND EXAMPLES

The first major intrinsic biological limitation is the **loss of genetic integrity**. In many ways, this is the inverse of the threats described under Introduced Genetic Material (Threat 8.5) above. Loss of genetic diversity becomes an independent threat for isolated populations or species already facing precipitous declines (Frankham 2003). Smaller population sizes leave the whole population more susceptible to stochastic events, potentially eliminating important sources of genetic diversity (Kendall 1998, Melbourne and Hastings 2008). As the populations persist, they face two major concerns as the result of reduced diversity: reduced reproductive output due to inbreeding, and reduced adaptive capacity (Frankham 2003, Willi et al. 2006). Inbreeding is caused by the accumulation of deleterious alleles in the population and is known to depress survival, fecundity, and viability across a wide variety of taxonomic groups (Neaves et al. 2015). Over time, fewer and fewer individuals are recruited into the breeding population, further decreasing population size and intensifying the impacts over multiple generations, potentially resulting in extinction (Frankham 2003, Neaves et al. 2015). Adaptive capacity is reduced in small populations due to the limited variation in the gene pool, reducing the likelihood of successfully responding to challenges like environmental change or disease (Nicotra et al. 2015, Ujvari et al. 2018). Some of the impacts of reduced genetic variability are long-lasting, and can still be detected many generations later (Matocq and Villablanca 2001).

In general, RSGCN with greater dispersal capacity, like birds and other migratory species, may be less likely to become limited by genetic diversity, while sedentary species, such as mussels, and species that exist in naturally isolated populations, such as high elevation salamanders, may be more at risk. Fragmentation can also result in decreased diversity, as it reduces connectivity, and the associated gene flow, between populations.

In the Northeast, many of the species threatened by lost genetic diversity are mussels and fish. Historic damming of rivers and streams fragmented and isolated many populations, reducing needed gene flow across the landscape. Mussels may be the most heavily impacted group amongst the 2023 RSGCN: the Mussel Taxa Team identified genetic diversity and small population sizes as a concern for more than 16 species, including Brook Floater (*Alasmidonta varicosa*), Dwarf Wedgemussel (*Alasmidonta* heterodon), Longsolid (*Fusconaia subrotunda*), Golden Riffleshell (*Epioblasma Florentina aureola*), Atlantic Pigtoe (*Fusconaia masoni*), Cumberland and Appalachian Monkeyface (*Theliderma intermedia* and *T. sparsa*, respectively), and Tennessee Bean (*Venustaconcha trabalis*). Diamond Darter (*E. cincotta*), Duskytail Darter (*E. percnurum*), and Bridle Shiner (*Notropis bifrenatus*) are all facing challenges due to their small, isolated populations. One species, the Maryland Darter (*Etheostoma sellare*) may already be extinct as a result of inbreeding depression. The decimation of many bat species by White-Nose Syndrome has raised concerns about the genetic diversity in remaining populations, but further research is needed to determine the overall effect (Foley et al. 2010, Gignoux-Wolfsohn et al. 2020, Lilley et al. 2020). The Bird, Mammal, Crayfish, Bee, and Lepidopteran Taxa Teams also all identified several species where low genetic diversity is a concern.

Another intrinsic biological limitation that threatens some RSGCN is the **decline or loss of a species that the RSGCN is dependent upon**. If sufficient food resources or host species are not present, their dependents cannot persist in the landscape. The types of relationships between these interdependent species and RSGCN vary, as do the underlying cause of the declines. In the case of many pollinators, they are highly dependent on specific plant species or groups as the primary food source for larval life stages and nectar resources. The general impacts of deer browse (Threat 8.2.3) on these lepidopteran hostplants has been described by several authors (e.g., Miller et al. 1992, Rooney and Waller 2003, Schweitzer et al. 2011). Other researchers have directly linked deer browse with pollinator population declines in Frosted Elfin (*Callophrys irus*; Frye 2012), West Virginia White (*Pieris virginiensis*; Davis and Cipollini 2013), Diana Fritillary (*Speyeria idalia*; Wells and Tonkyn 2014), and bumblebees (Sakata and Yamasaki 2015).

Decreased biomass is also problematic for RSGCN that are not dependent on a single key food resource. The Allegheny Woodrat (*Neotoma magister*) consumes a wide variety of forest fruits, seeds, and nuts. Despite their varied diet, one of the factors thought to be contributing to their imperilment is the loss of the American Chestnut as a food resource (Logiudice 2008). Many RSGCN are insectivorous, so the global decline in insect biomass is of grave concern (Wagner 2020). Aerial insectivores such as Eastern Whip-poor-will (*Antrostomus vociferus*) are impacted by decreases in overall insect biomass (Spiller and Dettmers 2019), and decreased availability of plankton or forage fish such as Atlantic Menhaden (*Brevoortia tyrannus*) will have impacts on seabirds, predatory fish, and marine mammals (Friedland et al. 2013, Anstead et al. 2021).

Declines of interdependent species are critical in symbiotic relationships as well. Freshwater mussels are highly dependent on fish for dispersal, as larval glochidia attach to the host's gills before dropping off in new areas. Damming of river systems prevents the movement of fish hosts, which can lead to declines in these critical species (Vaughn 1993, Vaughn 1997). Parasitic relationships, such as the case of cuckoo bees, also put RSGCN at risk. Cuckoo bees infiltrate the hives of other bee species and lay their eggs, leaving them for the host to raise. Ashton Cuckoo Bumble Bees (*Bombus ashtonii*) parasitize other *Bombus* species, including several that are already imperiled and included on the 2023 RSGCN list. Any threats that impact bumblebees, such as loss of floral resources, impact these nest parasites twice over; directly as they also need nectar sources, and indirectly as their host populations decline (Colla et al. 2012, Richardson et al. 2019). Another bee on the RSGCN list, the Macropis Cuckoo Bee (*Epeoloides pilosulus*) is another cuckoo bee that parasitizes *Macropis* bees, including two RSGCN and one Watchlist [Assessment Priority] species, though no research has yet connected analyzing the declines in these species.

The final threat under this category is **recruitment failure**. Recruitment refers to the process of adding or moving individuals to a population or age class and can occur via reproduction and growth or immigration, though this document focuses on reproduction. Critically, recruitment adds individuals to the breeding population to replace individuals that are no longer reproducing or have died. When recruitment failure happens as a temporally or geographically isolated event, it is not likely to have severe impacts on the species as a whole. It is only when recruitment failure happens repeatedly or across a large area that it becomes a threat. While recruitment failure may be the result of other threats, it must be treated independently. Recruitment failure may continue even after the root cause is addressed, as the historic alteration to the structure or composition of the remaining individuals still prevents any reproduction from happening. This is a major concern for some turtles, which are generally long-lived species with very low juvenile survival rates (Iverson 1990, Paterson et al. 2012). Even if adults in the population continue to breed and lay eggs, this reproductive effort is wasted if insufficient numbers of eggs recruit to juveniles and insufficient numbers of juveniles recruit to adults. Many turtle conservation efforts utilize headstarting as a tool for improving juvenile survival. In the Northeast, headstarting has benefited the Massachusetts population of the Northern Red-bellied Cooter (*Pseudemys rubriventrris*; Haskell et al. 1996), Blanding's Turtle (*Emydoidea blandingii*; Buhlmann et al. 2015, Carstairs et al. 2019), Wood Turtle (*Glyptemys insculpta*; Mullin 2019), and Diamond-back Terrapin (*Malaclemys terrapin*; Herlands et al. 2004). Mussels are similarly long-lived with very low juvenile survival, in part due to the specific needs of both their larval and juvenile stages. Relict populations of adult mussels with very few or no juveniles may be the result of a combination of factors that increased stress levels to lethal levels for younger age classes (Strayer and Malcom 2012). Similar to the turtle headstart programs, many imperiled mussels are propagated and grown to larger sizes before being released (Jones et al. 2006, Gum et al. 2011, Haag and Williams 2013), though there have been few attempts to evaluate the success of these efforts. One other species that is potentially impacted by recruitment failure is the American Eel (*Anguilla rostrata*). Decreased eel ladder counts for this species have been linked to recruitment rates, but more research is needed to more completely understand all the factors that may be contributing to the decline (Castonguay et al. 1994, Sullivan et al. 2009).

RELATIONSHIPS WITH OTHER THREATS

The threats described under this category are unusual in that they are very closely linked to or are the compounded result of many other threats. Decreased genetic diversity is frequently a result of fragmentation, which can be caused by Residential & Commercial Development (Threat 1.0), Agriculture & Aquaculture (Threat 2.0), Energy Production & Mining (Threat 3.0), Transportation & Service Corridors (Threat 4.0), Biological Resource Use (Threat 5.0), or Natural System Modifications (Threat 7.0). Pollution (Threat 9.0) can also play a role if it results in large mortality events, decreasing the size of the population. Species interdependence is closely linked to any threat that decreases the availability of an important host or food source, but Invasive & Problematic Species, Genes, & Diseases (Threat 8.0) and Climate Change (Threat 11.0) may be key drivers in shifting relationships. Recruitment failure is often the result of changes wrought by historic threats, and recovery may continue to be hampered by these or other considerations.

TOOLS AND RESOURCES

There are not relevant tools and resources for this threat because these Intrinsic Biological Limitations are species and location specific and highly contextual. In general, any actions that improve connectivity may help reduce the potency of these threats, but more information on alleviating the impacts of these threats is needed.

3.2.4 BIOLOGICAL RESOURCE USE

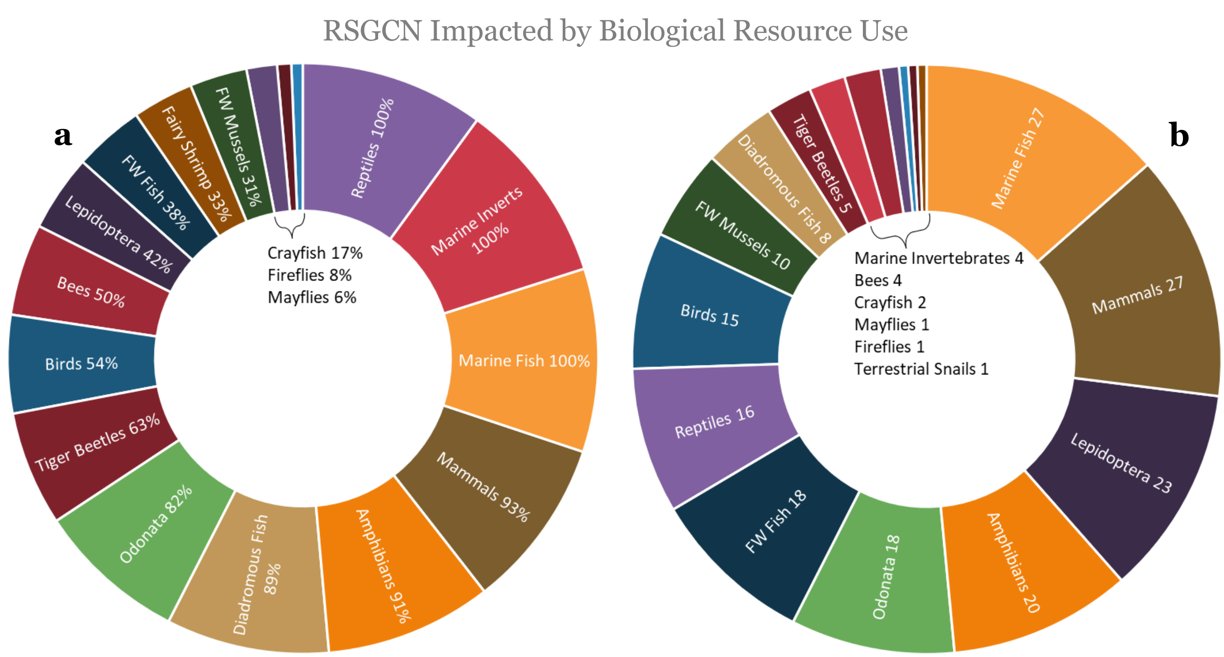

Figure 3.5 Impact of Biological Resource Use (Threat 5.0) on RSGCN and Proposed RSGCN. (a) The percentages show the proportion of the species within that taxonomic group known to be impacted by this threat. (b) The total number of species within the taxonomic group known to be impacted by this threat.

Biological Resource Use impacts 48% (200) of the species included as RSGCN and Proposed RSGCN in the 2023 list. This includes all members of the marine invertebrate, reptile, and marine fish taxonomic groups (Figure 3.5a). Mammals, amphibians, and diadromous fish are also largely included in the species impacted by this threat. Most of the species known to be impacted by biological resource use are vertebrates or are harvested for human consumption. This threat likely has less impact on most terrestrial invertebrate species, but the smaller numbers may also reflect data deficiencies in these groups (Figure 3.5b).

Biological Resource Use refers to the removal of biotic components of the environment for human consumption or benefit. This includes hunting and fishing, bycatch in regulated animal harvest, persecution and management of species considered dangerous or problematic, unregulated collection of wildlife for any purpose, and the harvest of timber and other plant products. The impacts of Biological Resource Use on RSGCN and Proposed RSGCN are often direct, physically removing individuals from the ecosystem. The exception to this is logging, which indirectly impacts many species by removing, fragmenting, and otherwise altering habitat. Regardless, these removals have major impacts on the individual, population, community, and ecosystem levels.

The individuals removed are intended for human use or benefit, as opposed to the mortality of flora and fauna as a result of some other threat factor. These removals can be either intentional, where the species is the target, or unintentional, where the species is collected incidentally along with a target species. Many of these forms of Biological Resource Use are regulated, but some species, especially invertebrates and amphibians, may lack formalized protections at state, national, or international levels. Other species are targeted despite legal prohibitions on their collection. Due to the human dimensions of this threat coordinated actions, consistent messaging, and shared regulatory decisions are needed across the Northeast for successful management.

Historically, many species in the Northeast were negatively impacted by forms of biological resource use. Hunting for sustenance led to significant declines in many iconic mammals and birds in the region (Foster et al. 2002). Persecution of large predators and other “nuisance” species, including bounty systems, led to declines and regional extirpations (Foster et al. 2002). Historic overfishing contributed to population crashes and declines of many marine fish species and coastal ecosystems (Jackson et al. 2001). Logging and the collection of plant species altered habitat on large scales across the region, contributing to widespread species declines and shifting wildlife communities better suited to agricultural landscapes (Foster et al. 2002). Human use of biological resources has had a strong influence on the ecosystems in the Northeast.

HUNTING & COLLECTING TERRESTRIAL ANIMALS AND FISHING & HARVESTING AQUATIC RESOURCES

The collection of terrestrial and aquatic wildlife and wildlife products has been occurring for millennia and continues to be a driver in wildlife declines globally. Removal of individuals from the ecosystem, frequently referred to as take, can occur for several reasons, be intentional or unintentional, and be managed or unmanaged. Regulation of species collection is a state, national, and international management concern, and requires coordination with the many organizations with jurisdiction over fish and wildlife species. Regardless of the type of take, collection can have significant cascading impacts on populations, communities, and ecosystems.

One important consideration for the management of terrestrial animals and aquatic resources is that responsibility may be shared with other agencies. For example, state marine programs usually have jurisdiction over marine plants and animals, though diadromous fish are often shared responsibilities as they transverse both marine and freshwater environments. Some state fish and wildlife agencies may not have authority over all invertebrates. They work closely with those regulatory authorities (e.g., the state Department of Agriculture) and often have cooperative agreements with these agencies.

THREAT DESCRIPTIONS AND EXAMPLES

Consumptive uses of wildlife include both use as food and collection for specific animal parts, such as furs or shells. While species from nearly every taxonomic group are consumed globally, the focus in the Northeast is generally on vertebrate species. In terrestrial ecosystems, most **hunting** (Threat 5.1.1) and **trapping** (Threat 5.1.2) targets mammal and bird species, though a very small number of amphibians and reptiles are also targeted. In aquatic ecosystems, fish and shellfish are targeted by **recreational or subsistence** (Threat 5.4.1) and **commercial fisheries** (Threat 5.4.2). These forms of take are generally regulated and managed by the state or other jurisdictional agencies, such as the regional fisheries management councils, via harvest seasons, quotas, and other regulations.

Overexploitation occurs when species are harvested at rates greater than reproduction and regrowth occur. When a species is overexploited, there are not enough individuals to interact which leads to a downward spiral of decreasing birth rates and shrinking population sizes. Overexploitation has additional impacts beyond the populations of the target species. The effects cascade to higher trophic levels and across the wider community, which can lead to widespread collapses in the ecosystem (Jackson et al.

2001, Humphries and Winemiller 2009). Even if the impacts of overexploitation are reduced, these systems may not have the capacity necessary to recover (Walsh et al. 2006, Humphries and Winemiller 2009). In the United States, overexploitation of bison, elk, and other big game sparked some of the earliest conservation efforts in the country and the development of a conservation ethic that still shapes the management of game species and their habitats (Organ et al. 2010, Heffelfinger et al. 2013).

Harvest of wildlife populations can lead to demographic shifts as individuals with certain characteristics may be disproportionately targeted. Larger individuals and males with more impressive horns, antlers, or plumage are often preferred. As these individuals are often the older members of a population, this can cause shifts in the age structure and sex ratio. As a result, overharvested populations often have lower fecundity and survivorship, increased mortality rates, destabilized social structures and hierarchies, truncated age and size classes, and altered age or size at maturity (Walsh et al. 2006, Milner et al. 2007, Fenberg and Roy 2008, Heffelfinger et al. 2013, Uusi-Heikkilä et al. 2015). These phenotypic changes may also be accompanied by behavioral changes, selecting individuals that are characteristically different than in unharvested populations (Uusi-Heikkilä et al. 2015, Leclerc et al. 2017). Significant research has gone into determining if these demographic and behavioral changes also have a genetic component, indicating human-driven evolution in these populations, though phenotypic plasticity may also account for some of these variations (Harris et al. 2002, Walsh et al. 2006, Fenberg and Roy 2008, Heffelfinger et al. 2013, Pinsky and Palumbi 2014, Uusi-Heikkilä et al. 2015, Festa-Bianchet and Mysterud 2018).

Relatively few RSGCN and Proposed RSGCN species continue to be impacted by regulated, intentional harvest. Many of these historical pressures have been reduced through the reduction of bounty systems, the establishment of conservation measures such as the Marine Mammal Protection Act, and management strategies such as the establishment of seasons, take limits, and size restrictions. These conservation measures have contributed to the recovery of seal populations in the Gulf of Maine (Bogomolni et al. 2021). Careful management can balance the recreational and subsistence uses of these species with the biological requirements necessary to maintain stable populations. For some species, harvest pressure remains high due in large part to practices outside of the Northeast region and the United States. Migratory birds and many marine species migrate in and out of the jurisdictional areas of the region, limiting the ability of Northeastern states to manage overexploitation in seasonal habitats. Fishing in international waters and the harvest of migratory species on their wintering grounds may be contributing to species declines within the region. Management of these threats will require international coordination and cooperation. Finding the balance of sustainability requires close coordination between regulatory agencies and commercial industries, as well as sound, unbiased scientific monitoring.

An additional source of take associated with collection and harvest is the unintentional capture of a species while pursuing a different target species, or **bycatch**. Bycatch occurs when fishing, hunting, or trapping gear are not selective and capture any species that come in contact with the equipment, leading to the capture, wounding, and mortality of non-target species. This phenomenon is particularly well studied in marine ecosystems, where various commercial fisheries incidentally capture numerous species. Marine bycatch contributes to declines in many fish species, sharks, marine mammals, sea turtles, and seabirds (Glass 2000, Molina and Cooke 2012, Senko et al. 2014). Estuarine and freshwater turtles are frequently caught in fish and crab traps (Rook et al. 2010, Bury 2011). Furbearer trapping can capture non-target species, generally other mammalian carnivores (Jachowski et al. 2021, Fogarty et al. 2022).

Bycatch can be reduced by establishing area or seasonal closures that protect vulnerable species or sensitive life stages or changing or modifying gear so that it excludes or deters non-target species or allows for their escape. Glass (2000) describes some of the common net design considerations and modifications used to mechanically sort target and non-target species. Bull (2007) discusses approaches for reducing seabird bycatch. More recent research is exploring the use of sensory deterrents for marine species, especially cetaceans and sharks (Hamer et al. 2012, Jordan et al. 2013, Hannah et al. 2015, Martin and Crawford 2015). Exclusion devices prevent seals and turtles from getting caught in nets and traps (Rook et al. 2010, Bury 2011, Jenkins 2012, Königson et al. 2014). In terrestrial systems, the Agreement on International Humane Trapping Standards has historically been used as a benchmark, but these standards may need to be updated to incorporate modern technology that will improve furbearer welfare, trap efficiency, and selectivity (Proulx et al. 2020).

Both closures and multiple gear modifications should be considered, depending on the target species, vulnerable non-target species, ecosystem, and tradeoffs between non-target species captured and target species released (Senko et al. 2014). Establishing seasonal closures can be very effective for species with very different life histories. However, climate change is shifting the timing of historically predictable recurring life events for many species (Staudinger et al. 2019). This may cause mismatches with these closures, reducing their efficacy under changing conditions. Gear modifications takes advantage of the behavioral or physiological characteristics of target and non-target species to reduce the impact on the non-target species. While these methods may be effective when the bycatch species is extremely different from the target species, such as is the case with sea turtle exclusion devices in shrimp trawls, this method is less successful when the species are more similar. For example, river herring such as American Shad (*Alosa sapidissima*) and Alewife (*Alosa pseudoharegus*) form large multi-species schools with commercially harvested species such as Atlantic Herring (*Clupea harengus*), which can result in many of the river herring species being caught as bycatch. Similarly, American Marten (*Martes americana*) and Fisher (*Pekannia* *pennanti*) have significant overlap in body sizes and similar behaviors, making the Marten susceptible to capture in Fisher traps.

Poaching and persecution of terrestrial animals (Threat 5.1.3) **and aquatic species** (Threat 5.4.4) are increasing concerns in the Northeast. The effects of these forms of take are similar to those for overexploitation described above for fishing and hunting. When it occurs at unsustainable levels, it results in population declines and extirpations, with associated demographic, phenotypic, and genetic shifts (Morton et al. 2021).

Persecution of snakes, especially venomous species like the Timber Rattlesnake (*Crotalus horridus*) has been occurring for hundreds of years, contributing to declines in these species (Montague 2022). Many predatory mammals and birds faced similar persecution, as they were believed to prey on livestock and desirable game species (Foster et al. 2002). Bats have also historically been persecuted due to misconceptions about the species; the spread of COVID-19 heightened concerns that persecution of these species would again increase (MacFarlane and Rocha 2020). Protection of persecuted species and outreach and education about these species has greatly reduced the levels of persecution in the region, though further efforts are needed for some species.

Poaching and illegal wildlife trade are contributing to major declines for several RSGCN and Proposed RSGCN. Export for traditional medicines, food, and pet trade has long been cited as a concern for several amphibians and reptiles (Schlaepfer et al. 2005). Illegal and unsustainable wildlife trade is a complex issue, as it involves global supply and demand, enforcement of state, federal, and international laws and agreements, online marketplaces that are largely not monitorable, and a complex, culturally-driven understanding of the underlying issue (Fukushima et al. 2021). The awareness of and intensity of this threat has increased dramatically in the Northeast for freshwater turtles since 2000, in response primarily to the increasing demand for pet turtles in Asia (Easter et al. 2023). The United States has some of the highest freshwater turtle diversity in the world, with the Northeast and Southeast regions most heavily impacted by the illegal export of turtles (Easter et al. 2023). Widespread recognition of this problem led to the creation of the Collaborative to Combat the Illegal Trade in Turtles[101], which builds relationships between state, federal, and tribal agency biologists, law enforcement, and researchers from academic and non-governmental organizations, allowing them to collaboratively address the needs associated with illegal turtle trade. This group, along with the Partners for Amphibian and Reptile Conservation's Turtle Network Team, works to develop regulations to address current risks, provide resources for law enforcement activities and confiscated turtle care, enhance communication and public outreach, and develop scientifically-informed guidance for the treatment of confiscated turtles. In 2022, the Convention on International Trade in Endangered

Species (CITES) voted to include 21 United States turtle species in Appendix II, providing international trade protections for these species (Center for Biological Diversity 2021).

There are a few other forms of take, though they are not generally considered a major concern in the Northeast. **Non-lethal harvesting of terrestrial animals** (Threat 5.1.3) involves the collection of animal products in ways that do not result in the mortality of individuals, such as the collection of molted feathers, shed antlers, or bat guano. Generally, these activities do not have direct impacts on any species, but in some instances, the collection activities themselves may be disruptive if individuals are still present. **Management and control of terrestrial animals** (Threat 5.1.5) and **aquatic species** (Threat 5.4.4) generally involves the targeted culling of species whose populations are thought to be too large, but the removed individuals are not consumed. Some common examples of this in the Northeast are the application of lampricides in streams to decrease non-native populations of Sea Lamprey (*Petromyzon marinus*) and netting of Common Starling (Sturnus vulgaris) flocks to reduce impacts on crops. Unfortunately, several RSGCN and Proposed RSGCN fish are also sensitive to the lampricides, including American and Northern Brook Lamprey (*Lethenteron appendix* and *Ichthyomyzon fossor*, respectively), Lake Sturgeon (*Acipenser fulvescens*), and Hellbender (*Cryptobranchus alleghaniensis*). Starlings can form flocks with other species, including Rusty Blackbird (*Euphagus carolinus*), which is also trapped by the nets. The impacts of these management strategies need to be carefully considered to develop best practices that reduce impacts on non-target species.

RELATIONSHIPS WITH OTHER THREATS

The exploitation of wildlife species tends to follow patterns, with take occurring in concentrated areas. The location of these areas is often influenced by their proximity to Residential & Commercial Development (Threat 1.0) and Transportation & Service Corridors (Threat 4.0). Because of the direct interactions between humans and wildlife, these threats can facilitate the spread of Invasive Non-native/Alien Plants & Animals (Threat 8.1) and Pathogens & Microbes (Threat 8.4). These activities are also the source of many forms of Garbage & Solid Waste (Threat 9.4), such as lead ammunition, abandoned fishing gear and other entanglements, and garbage. Climate Change (Threat 11.0) is likely to amplify the effects of overexploitation on wildlife species, adding additional stressors to already high-risk environments (e.g., Staudt et al. 2013).

TOOLS AND RESOURCES

State fish and wildlife agencies have tools for tracking hunting and fishing activities in their state through their licensing systems. Many agencies conduct hunter, trapper, and fisherman surveys to determine hunter effort, satisfaction, and opinions. However, these surveys are unique to each state and may collect very different information. It is difficult to analyze these activities consistently across the region due to the individuality of the data collected by each state.

Every five years, the US Fish and Wildlife Service coordinates the **National Survey of Fishing, Hunting, and Wildlife-Associated Recreation**[102] which determines American participation in, expenditure on, and values around these activities. The survey has been conducted since 1955, providing a long-term dataset showing changes in demographics, behavior, and opinion over time. The most recent report on the 2015 survey is currently available; the report for the 2022 surveys should be available in the summer of 2023. The Fish and Wildlife Service also works with state fish and wildlife agencies to administer the **National Migratory Bird Harvest Survey**[103]. This survey has collected information for estimating hunter effort and harvest levels of doves and pigeons, waterfowl, American Woodcock (*Scolopax minor*), and rallid birds since 1955.

Kroodsma et al. (2018) used Automatic Identification System (AIS) data to develop **maps of global commercial marine fishing activity**. AIS are navigational tools used to reduce collisions in open waters. In the last decade, the International Maritime Organization mandated that all vessels greater than 36 meters transmit signals, which can be picked up by ground stations and satellites and analyzed at global scales. The organization Global Fishing Watch[104] hosts an interactive version of these maps, providing tools to look at patterns over time. NOAA Fisheries is also implementing **electronic monitoring of American fishing fleets**[105], adding additional detail to marine fisheries data.

Many organizations participate in the management of Northeast fisheries, including the Great Lakes Fishery Commission[106], Northeast Regional Ocean Council[107], Mid-Atlantic Regional Council on the Ocean[108], New England Fishery Management Council[109], Mid-Atlantic Fishery Management Council[110], and the Atlantic States Marine Fisheries Commission[111]. These partner organizations both manage fish populations and have species and habitat conservation programs to support imperiled species. These groups all have suites of geospatial data and information about fisheries management. For more information about these partners and their products, see *Chapters 2* and *7*.

LOGGING & WOOD HARVESTING

Much of the Northeast was deforested and converted to agricultural land use in the 1800s and early 1900s, though significant areas have been reforested in the century since (Foster et al. 2002). More than half of the land area in the Northeast region is now forested (Anderson et al. 2023). As a result, logging, wood harvesting, and other silvicultural practices have the potential to impact large portions of the landscape.

In recent decades, researchers have recognized that timber harvest is a disturbance factor just like wind and fire. Planning harvest activities so they emulate natural disturbance regimes in terms of scale and frequency may help maintain forest health while simultaneously meeting human needs (Seymour et al. 2002, Long 2009, Kuulkuvainen et al. 2021). Additional research has investigated the carbon storage capacity in forests managed utilizing disturbance-based silviculture (Thom and Keeton 2020). These practices may maintain a diverse forest matrix that can support a wide variety of species' needs (Thom and Keeton 2020, Kuulkuvainen et al. 2021). Research in the Northeast has highlighted the dominance of timber harvest as a disturbance factor in the region and predicted how forest biomass levels are likely to change based on changing climate and future timber harvest projections (Brown et al. 2018). Increasing demand for timber products is likely to elevate harvest intensity and frequency. These increases may slow the accumulation of biomass over the next 150 years, though they will likely not stop it completely (Brown et al. 2018). However, intensified harvest regimes may alter the age structure of the forests, keeping much of the landscape in younger forest age classes (Brown et al. 2018).

In the Northeast, the majority of forests are privately owned, adding additional complexity to the management of these landscapes (Thompson et al. 2017, Butler et al. 2021a). These landowners are driven by a variety of socioeconomic drivers that shape if, when, and how they decide to harvest timber on their properties (Butler et al. 2021a, Sass et al. 2021). Landscape-level management of forested landscapes in the Northeast thus requires understanding the opinions of these landowners and involving them in the development of policies, programs, and management plans to benefit forested habitats (Butler et al. 2021a, Sass et al. 2021).

While forest harvest may result in direct mortality of RSCN and Proposed RSGCN, the primary impact for many species is the loss alteration of habitat. Timber harvest changes the structure, composition, and function of forested ecosystems. The use of heavy equipment has major impacts on the soil, causing compaction and rutting, which in turn alters the properties of the soil, changes nutrient and carbon cycling, and slows plant growth and regeneration (Cambi et al. 2015). The logging roads themselves have additional impacts, fragmenting habitat, facilitating the spread of problematic species, causing avoidance of high traffic areas, impacting water quality, and increasing infiltration of forested areas by hunters or for other recreational uses (Boston 2016). Some native predators also utilize these forest roads, increasing their abundance and predation rates (e.g., Gómez-Catasús et al. 2021). The removal of tree biomass affects nutrient and carbon cycles, which can affect future regeneration (Berger et al. 2013, Ranius et al. 2018). Timber harvest can differ greatly from natural disturbances in the structure it creates; harvested forests tend to have significantly less coarse woody debris and fewer standing dead trees (Berger et al. 2013). Openings are sunnier, supporting different species than would grow in the understory of the surrounding forest.

Nearby aquatic habitats are also significantly impacted. Forest harvest can alter stream flow rates by decreasing evapotranspiration rates and increasing overland runoff (Berger et al. 2013). This runoff simultaneously increases sedimentation rates, and can also carry various nutrients and chemicals (Berger et al. 2013, Boston 2016, Ranius et al. 2018). If harvest occurs in riparian areas, it increases light penetration to the water and can increase temperatures, which negatively impacts many aquatic species (Berger et al. 2013). Harvest practices can also change the influx of woody debris into aquatic systems (Berger et al. 2013).

THREAT DESCRIPTIONS AND EXAMPLES

Forestry harvest practices are diverse to meet a variety of economical, esthetic, and ecological purposes. As a result, they can have variable impacts depending on the harvest intensity, scale, and equipment used. **Complete removal of forest cover** (Threat 5.3.1), such as clear cuts, removes the greatest amount of biomass from the ecosystem. These harvesting practices often result in large, even-aged stands. These cuts can be highly disruptive to some wildlife species, though they may provide habitat for others (Ram et al. 2020). **Partial removal of forest cover** (Threat 5.3.2) allows for the retention of some canopy cover and includes practices such as shelterwood cutting and selection harvesting. The retention of forest patches can provide refuge from the impacts of harvest on local wildlife, as well as being a seed source for the regeneration of the harvested area (Fedrowitz et al. 2014). **Improvement cutting in natural forests** (Threat 5.3.3) is more selective, removing certain trees to improve the growth of those that are left. Common examples of this include pre-harvest thinning, tending felling, and sugarbush management. Importantly, while these practices may retain canopy cover, they can change the composition of the stand by selectively removing species that are undesirable for the management goals of the stand.

Other activities associated with timber harvest can impact wildlife species. **Artificial regeneration of forest stands** (Threat 5.3.4) involves the seeding or planting of harvested areas to reduce erosion and speed up regeneration rates. However, this practice can have unintended ecological impacts. As the seeds or seedlings are generally sourced from nursery stock, they are not locally adapted to the site they are planted, which can interfere with evolution and create monocultured stands that are more vulnerable to disease or insect outbreaks (Ratnam et al. 2014, Liu et al. 2018). Tree planting may also increase fire risk, especially under changing climatic conditions (Hermoso et al. 2021). Researchers have also shown that artificially and naturally regenerated forests have different species diversity, abundance, and assemblages (Kosewska et al. 2018). **Management of cutting areas** (Threat 5.3.5) includes several practices for handling debris from the timber harvest and soil treatments to improve natural regeneration. Traditional harvest typically removes just the bole of the tree, leaving the branches and other debris behind. This debris provides important habitat for numerous species, especially small mammals and amphibians. Piling the debris into piles or windrows greatly increases small mammal diversity and abundance, and also provides important hunting opportunities for predatory RSGCN such as American Marten (*Martes americana*; Sullivan et al. 2017, 2021). Downed logs and debris also create protected microhabitats with higher moisture content, an important component for forest amphibians, especially salamanders (Otto et al. 2013, Clipp and Anderson 2014). Forest harvest practices that ensure the availability of debris benefit many species. In contrast, practices such as whole-tree harvest and harvest for energy production leave far less debris behind, with significant impacts on many ecological components and species (Berger et al. 2013, Ranius et al. 2018). Scarification and other soil treatments can improve germination rates of certain tree species but can also disturb soil biota (Yamazaki and Yoshida 2020, Smenderovac 2023).

Significant research has gone into understanding the reactions of various species to different timber harvest practices. Though not a complete catalog, the following papers include recent reviews of key taxonomic groups and provide a starting point for further research:

- Small mammals: Zwolak 2009, Sullivan et al. 2017, Demarais et al. 2017, Kellner et al. 2019, Larsen-Gray and Loehle 2022
- Birds: Demarais et al. 2017, Castaño-Villa et al. 2019, Kellner et al. 2019, Basile et al. 2019, Ram et al. 2019, Lott et al. 2021, Larsen-Gray and Loehle 2022, Akresh et al. 2023
- Herptiles: Otto et al. 2013, Demarais et al. 2017, Thompson and Donnelly 2018, Kellner et al. 2019, Cordier et al. 2021, Martin et al. 2021, Larsen-Gray and Loehle 2022
- Terrestrial invertebrates: Korpela et al. 2015, Kosewska et al. 2018, Ram et al. 2019
- Aquatic species: Cristan et al. 2016, Warrington et al. 2017, Coble et al. 2019, Schilling et al. 2021, Rajakallio et al. 2021

Sustainable, compatible forest management should incorporate the needs of many different species, anthropogenic uses and purposes, and ecological services. As a result, the managed forest landscape must be dynamic and heterogenous to meet all of these sometimes conflicting needs.

RELATIONSHIPS WITH OTHER THREATS

As is the case with many extractive practices, logging and wood harvesting is influenced by accessibility (Thompson et al. 2017). As a result, these activities are often related to the location of roads (Threat 4.1.1). Logging activities are also associated with the conversion of forested land to other uses, such as Residential & Commercial Development (Threat 1.0), Agriculture & Aquaculture (Threat 2.0), and Energy

Production & Mining (Threat 3.0). Logging roads increase the distribution and mobility of Invasive Non-native/Alien Plants & Animals (Threat 8.1), Problematic Native Plants & Animals (Threat 8.2), hunters (Threat 5.1.1), and recreational vehicles (Threat 6.1.1). Some forest practices may magnify the impacts of Pathogens & Microbes (Threat 8.4), as is the case for bats impacted by White-Nose Syndrome (Silvis et al. 2016). Deforestation can intensify the impacts of Dams & Water Management/Use (Threat 7.2) and increase sedimentation (Threat 9.3.2) and other forms of Pollution (Threat 9.0) in nearby streams. Climate Change (Threat 11.0) is likely to intensify some of these effects, especially hydrology, and may also interact to increase the risk of fire (Threat 7.1.1).

TOOLS AND RESOURCES

The US Forest Service has significant resources for informing forest management nationally. The **Forest Inventory and Analysis (FIA)**[112] program reports on forest status and trends, including species composition, tree size and age, forest health and growth, harvest and wood production, and land ownership. The program has been operating since 1930, producing long-term monitoring and inventory datasets that inform analysis of American forests. One of their products is the **National Woodland Owner Survey**[113], which is implemented by the Family Forest Research Center out of the University of Massachusetts, Amherst. This survey aims to better understand who owns forests in the United States, their motivation for owning forested lands, and their historic and future management objectives. This survey is conducted on a five-year cycle, with the most recent survey completed in 2018 (Butler et al. 2021b). Other data products include tools for analyzing inventory and monitoring programs, state-level summaries of FIA data, urban tree data, and tools for exploring the National Woodland Owner Surveys.

Many best practices for timber harvest and logging operations have been developed. The **Young Forest Project**[114] is a partnership of private, public, tribal, and commercial forest landowners working to enhance and maintain the availability of early successional, young forests and shrublands for wildlife. Their website has best management practices, instructional guides and manuals, and a list of demonstration site projects in the Northeast, Mid-Atlantic, and Midwest. Oehler et al. (2006) produced a book that included sections with **recommendations on improving young forests and forest openings for wildlife**, which could be used to inform timber harvest operations. The US Army Corps of Engineers produced a set of **best management practices for stream crossings**, including temporary crossings utilized in logging operations (USACE 2015). Individual states may also have their own best management practices describing harvest methodology, stream and riparian area protection, and logging road management. **Best management practices to protect water quality** in adjacent aquatic habitats from forestry activities are available from the US Forest Service[115] and the National Association of State Foresters[116].

Other authors focus on species-based recommendations. A RCN project titled **Best Management Practices (BMPs) for RSGCN Species in Northeast Forests** produced field guides and management guides for five forest RSGCN: Bicknell's Thrush (*Catharus bicknelli*), Wood Thrush (*Hylocichla mustelina*), Canada Warbler (*Cardellina canadensis*), Rusty Blackbird (*Euphagus carolinus*), and American Marten (*Martes americana*). For more information on this project, see *Chapter 4*. The White-Nose Syndrome Response Team produced a document outlining **forestry best management practices for bat species** (Taylor et al. 2020).

Other important partners for forest management, including the **National Alliance of Forest Owners**[117], the **National Association of State Foresters**[118], **and the Northeast-Midwest State Foresters Alliance**[119] are described in *Chapter 2*.

GATHERING OF TERRESTRIAL PLANTS OR FUNGI

Most of the threats under this category are not as relevant to Northeast RSGCN, as plants have yet to be included as RSGCN. However, since at least half the Northeast states list plants as SGCN, these threats are still relevant to high-priority species in many states. This is a complicated management issue, as many state fish and wildlife agencies do not have primary jurisdiction over wild plant species; regulatory authority and responsibilities vary by state. Management will require coordination with the state agencies that do have responsibility for plants.

Most of the plants that are collected for uses besides timber are forest species and are often referred to as Non-Timber Forest Products (NTFPs). Collectors of NTFPs include commercial collectors where these products are a primary or supplementary source of income and a rapidly growing number of recreational harvesters and foragers collecting for personal use (Vaughn et al. 2013). Many land managers see NTFP management as a daunting task due to a lack of information about sustainable harvesting practices, unclear regulations and enforcement capabilities, and uncertainty about gatherer culture and mindsets (Vaughn et al. 2013). For a more complete assessment of NTFPs in the United States, see Chamberlain et al. (2018).

A few examples of Northeast commercially and recreationally exploited plant species include:

- American Ginseng (*Panax quinquefolius*) – a medicinal plant that has largely disappeared in the wild
- Ostrich Fern (*Matteuccia struthiopteris*) Cinnamon Fern (*Osmunda cinnamomea*), and Royal Fern (iO. spectabilis) – the source of fiddleheads, a popular wild-harvested food that can be negatively impacted by high-intensity harvest

- Wild Leek/Ramps (*Allium tricoccum*) – another wild-harvested food plant that is frequently overharvested
- Sugar Maple (*Acer saccharum*) – primary species tapped to collect sap for syrup production. Red (*A. rubrum*) and Silver Maple (*A. saccharinum*) also can be tapped, but generally produce less abundant, lower quality sap
- Salt hay (*Spartina patens*) – saltmarsh species collected and sold for a variety of uses, especially as a weed-resistant mulch
- Pine straw (*Pinus sp.*) – fallen needles from various pine species, often in plantation settings, collected and sold as a ground cover and mulch
- Wild berries, fruits, and nuts – collected for consumption and value-added specialty products, such as jams, syrups, and flours
- Evergreen boughs and other greenery – collected for wreaths, winter decorations, and floral arrangements
- Medicinal plants – collected for use in traditional medicine
- Birch bark – collected for traditional crafts and other value-added products
- Wild mushrooms – collected for personal consumption and specialty markets

There are a few instances where the regulated harvest or management of a plant species could have indirect impacts on wildlife. This generally falls into one of two categories: the widespread removal of a plant leads to habitat alteration, or the collected plant is an important host or food resource for a RSGCN or Proposed RSGCN species. The Taxa Teams did not identify any RSGCN or Proposed RSGCN impacted by the threats in this category. The effects may be localized and not widespread enough to be a regional concern or our understanding of how the harvest of these plants impacts RSGCN and Proposed RSGCN species is currently limited. For example, the Ostrich Fern Borer (*Papaipema sp. 2 nr. pterisii*) populations may decrease in areas where their host plant is impacted by collection. Saltmarsh Sparrow (*Ammospiza caudacuta*) and other saltmarsh birds may avoid areas managed for salt hay or may lose nests as a result of management practices such as mowing. More research will be necessary to determine the influence of human exploitation of these plant resources on the RSGCN and Proposed RSGCN that are associated with them.

3.2.5 NATURAL SYSTEM MODIFICATIONS

RSGCN Impacted by Natural System Modifications

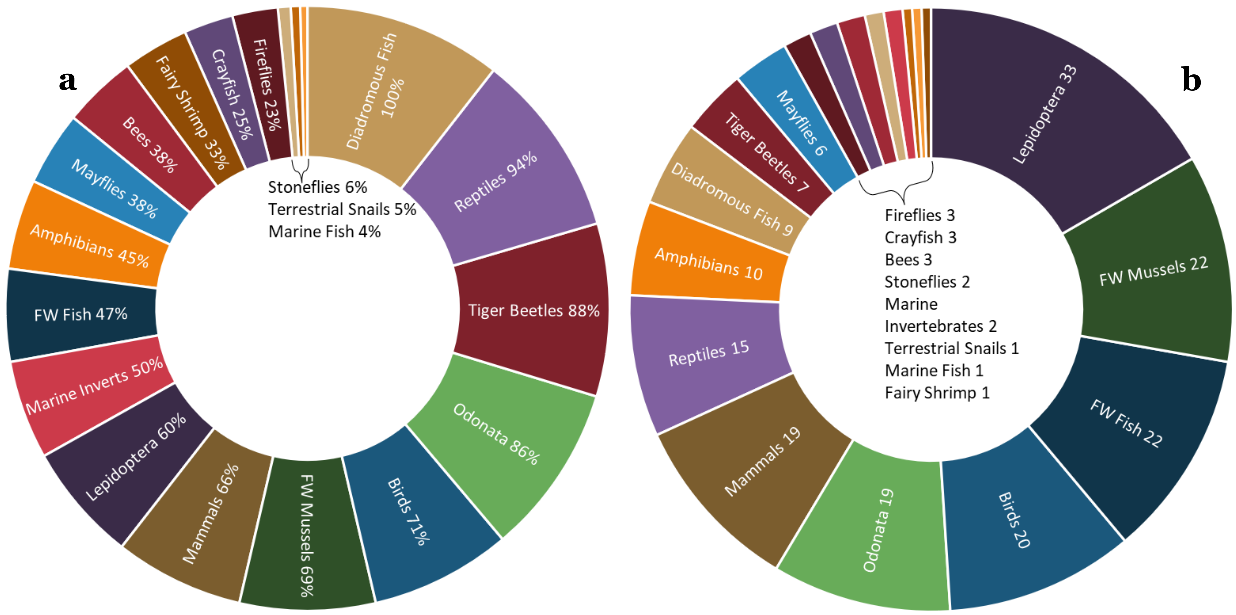

Figure 3.6 Impact of Natural System Modifications (Threat 7.0) on RSGCN and Proposed RSGCN. (a) The percentages show the proportion of the species within that taxonomic group known to be impacted by this threat. (b) The total number of species within the taxonomic group known to be impacted by this threat.

A total of 198 species – 47% –on the 2023 RSGCN and Proposed RSGCN list are impacted by Natural System Modifications. Diadromous fish, reptiles, tiger beetles, and odonates are the most heavily impacted, with more than 80% of the species in each of these groups known to be imperiled by these threats (Figure 3.6a). The largest number of species impacted are lepidopterans, freshwater mussels, and freshwater fish (Figure 3.6b). For the other invertebrate groups and marine fish, very few species are tagged to this threat, both in terms of total numbers and proportion of the taxonomic group. This is likely due to data deficiencies and a limited understanding of how natural system modifications can impact these groups, rather than an indication that these groups are not sensitive to these threats.

Natural System Modifications are a threat to many RSGCN and Proposed RSGCN species because, while they may not eliminate a habitat, they alter the structure and function of these ecosystems. Habitat degradation or other impacts on quality and condition can make some habitats unsuitable for more sensitive species. Some of these modifications can alter important processes, such as disturbance and succession, changing the functionality of a habitat over long time scales. Other modifications may fragment habitats, preventing species movements and isolating populations.

Many species in the Northeast RSGCN and Proposed RSGCN list are considered indicator species, where their presence or absence is indicative of habitat condition at that site. These indicator species can be related to the presence of pollutants or other contaminants (e.g., Evers et al. 2003), management history (e.g., Blossey et al. 2019), or overall ecosystem health (e.g. Edsall et al. 2005, Jones et al. 2009). In particular, aquatic insects such as mayflies, caddisflies, and stoneflies are frequently considered indicators of water quality and are sensitive to changes in streamflow. Many insects, such as the Northern Barrens Tiger Beetle (*Cicindela patruela patruela*) and Buchholz's Gray Moth (*Hypomecis buchholzaria*) are closely associated with pine barrens habitats and often decline in the absence of fire.

FIRE & FIRE SUPPRESSION

In the Northeast region, fire is one of the disturbance factors that shape the landscape along with wind and storms, anthropogenic activity, beavers, and insect outbreaks (Van Lear and Harlow 2002). These disturbances can function independently or interactively with one another, creating complex, dynamic landscapes across the region (Turner 2010, Cannon et al. 2017). An ecosystem's fire regime – the patterns in fire frequency, intensity, timing, size, and duration – determines the vegetation structure and composition, which in turn influences the wildlife communities that form (Archibald et al. 2013). Fire regimes vary across the region. In much of New England and New York, fire tends to occur infrequently, on a timescale of 200 years or more, but when fires do occur, they are often more severe, replacing large swaths of forest (Brown and Smith 2000). Further south, fires tend to happen more frequently, but are generally of lesser intensity, burning the understory rather than replacing the canopy (Brown and Smith 2000). Indigenous burning of forested habitats played a role in shaping the fire regimes in the eastern United States, but our understanding of the intensity and frequency of these burns and their impact on the environment is evolving, suggesting that these burns were not as widespread as previously though, especially in the New England area (Ryan et al. 2013, Oswald et al. 2020). In many cases, our knowledge of historic regimes, current conditions, and likely future changes is limited, as is our understanding of the impacts of prescribed fire on both above-ground and below-ground communities, highlighting the need for additional research in fire ecology (McLauchlan et al. 2020).

Fire can result in the mortality or injury of wildlife, though these impacts are generally considered minor at the population level (Jolly et al. 2022). Exceptions to this are species with limited mobility that are unable to flee or small, isolated populations that cannot depend on immigration from other populations to recolonize the site (Smith 2000). Timing is a critical component in determining the impacts of fire on wildlife. Burns that happen during nesting seasons or while wildlife are immobile, such as overwintering insect pupae or hibernating bats, have much greater impacts on populations (Smith 2000). Many wildlife species, especially those that occur in fire-prone habitats, have developed adaptive behavioral and morphological traits that improve their chances of survival (Pausas and Parr 2018).

THREAT DESCRIPTIONS AND EXAMPLES

Changes in fire regimes have significant impacts on species in ecosystems because they alter key processes that shape plant communities. Some unique habitat types, such as pine barrens, xeric grasslands, and sandplains are dependent on regular fires to maintain the community and prevent the incursion of other species that are not fire-adapted. **Suppression in the fire regime** (Threat 7.1.2) results in the intrusion of plant species that are poorly adapted to fire but are shade-tolerant and able to overtop and shade out fire-tolerant species that require more sunlight (Nowacki and Abrams 2008). Fire-adapted grasslands and open savannah-like habitats gradually transition into closed-canopy forests, which alters ground litter composition, fire fuel accumulation, and moisture levels (Nowacki and Abrams 2008). In the eastern United States, historic fire suppression has resulted in compositional shifts from fire-adapted oak and pine forests to mixed mesic hardwoods (Nowacki and Abrams 2008). It has also caused the age classes to shift and resulted in fewer open areas (Lorimer and White 2003). Species that are dependent on open, xeric, fire-prone habitats are excluded over time as their habitats become rarer. The physical activities of actively suppressing fires, such as creating firebreaks or usage of fire retardants, can also have impacts on wildlife and are summarized by Backer et al. (2004).

Increases in the fire regime (Threat 7.1.1) are also problematic for many species. These impacts are more difficult to summarize and are largely contextual, dependent on which aspects of the fire regime - frequency, intensity, timing, size, or duration – are changing, and which species is under consideration. Changing climactic conditions, such as decreased precipitation and increased temperatures, may make the ensuing fire more intense (Flannigan et al. 2000, Reilley et al. 2022). The history of fire suppression in the region has also resulted in altered fuel loads and forest structure, which can increase the intensity of fires when they occur.

The use of prescribed fires as a habitat management tool in the Northeast is growing (e.g., Harper et al. 2016). Most prescribed burns occur in seasons that are most conducive to safety, rather than aligning with periods when natural fires would have most commonly occurred (Knapp et al. 2009). These associated changes in burn timing and intensity can have severe effects on some species. For example, the Frosted Elfin (*Callophrys irus*) is dependent on plants in the genera *Lupinus* and *Baptisia*, which are fire-adapted species. Burning in these habitats releases nutrients that the plants utilize, providing higher-quality forage to the butterflies. However, if burns occur in the spring, they may damage or destroy pupae located in the leaf litter or near the soil surface, leading to long-term population declines (Jue et al. 2022, Meyer et al. 2023). Planning and timing prescribed fires should consider these aspects of fire and species ecology to minimize impacts on RSGCN and Proposed RSGCN.

RELATIONSHIPS WITH OTHER THREATS

Climate Change (Threat 11.0) is driving many of the changes in fire regimes, as increased temperatures, decreased precipitation, and shifts in the timing of these cycles influence the aspects of fire regimes. Some of the other threats can be ignition sources for fires. Transportation & Service Corridors (Threat 4.0) have started several wildfires, including the deadly 2018 Camp Fire in California, which transmission lines (Threat 4.2.1) sparked. Vehicles on Roads & Railroads (Threat 4.1) can produce sparks, as can equipment used for Logging & Wood Harvesting (Threat 5.3). Residential & Commercial Development (Threat 1.0) may also be a source, especially in low-density areas and campgrounds where human activities, such as campfires, occur close to flammable habitats. Invasive Non-native/Alien Plants & Animals (Threat 8.1) can either invade after a fire or can greatly influence fire conditions, as many species promote increased fire occurrence and intensity (Grace et al. 2001, Brooks et al. 2004, Fusco et al. 2019). Fire may also interact with Pathogens & Microbes (Threat 8.4), shaping the dynamics of diseases and disease vectors (Albery et al. 2021, Gallagher et al. 2022).

TOOLS AND RESOURCES

There are a large number of tools and resources available related to fire monitoring and management. Though far from a complete list, the following resources provide a starting point for learning more about these topics:

- The **National Interagency Fire Center**[120] houses fire management programs from the Bureau of Land Management, National Park Service, US Fish and Wildlife Service, Bureau of Indian Affairs, and the US Forest Service. In conjunction with their partners, this group provides leadership, policy oversight, and coordination to manage the nation's wildland fire programs.
- The National Oceanic and Atmospheric Administration produces several **maps, tools, and other products for wildfire management**, including predictive map products for fire risk, satellites and models for tracking active fires, and forecasting tools for monitoring flood risk after the fire as part of its wildlife program[121].
- The Environmental Systems Research Institute's (ESRI) **Disaster Response Program**[122] has a page devoted to wildfires with maps and other spatial products tracking active fires, air quality, and containment operations.
- The US Forest Service has an **informational page devoted to fire science**[123], including research, fire management, forecasting, and rehabilitation.
- The fire programs of the US Forest Service and the US Department of the Interior jointly manage the **Landscape Fire (LANDFIRE) and Resource Management Planning Tools**[124]. This program provides landscape-scale geospatial products that describe vegetation, wildland fuel, and fire regimes across the United States to support cross-boundary planning, management, and operations.

DAMS & WATER MANAGEMENT/USE

Water management activities have significant impacts on aquatic habitats, altering many of the ecological processes that shape these environments. All of the threats in this category modify the flow of water through aquatic ecosystems by changing a combination of the water volume, speed, timing, temperature, and availability. Human water control structures, such as dams and culverts, directly interfere with the flow, manipulating these characteristics. Activities that withdraw water from the system entirely for human purposes have impacts beyond the water body. The reduction of water from the system can alter local hydrology and lower the water table, which has particular impacts on many upland habitats, especially sensitive areas like ephemeral wetlands and cave systems.

THREAT DESCRIPTIONS AND EXAMPLES

The most commonly cited threat to RSGCN and Proposed RSGCN within this category is **water level management using dams** (Threat 7.2.1). Many natural barriers, such as beaver dams, waterfalls, and canyons, also exist in riverine systems, but the impacts of natural and anthropogenic barriers can differ (Fuller et al. 2015). These impacts vary dependent on the size, purpose, and location of the dam and the species being considered (Fuller et al. 2015, Turgeon et al. 2019). Globally, most river systems are impacted by dams; the United States has some of the highest levels of riverine habitat fragmentation globally, with very few free-flowing river reaches remaining (Nilsson et al. 2005, Grill et al. 2019, Barbarossa et al. 2020).

One of the greatest impacts of dams is as a physical barrier to species movement. Fragmentation can isolate populations and reduce gene flow, leading to long-term population declines and extinction (Reidy Liermann et al. 2012, Fuller et al. 2015, Carvajal-Quintero et al. 2017). Connectivity is one of the most important factors in determining the distribution of fish species globally, highlighting the vulnerability of this group to dams and other barriers (Carvajal-Quintero et al. 2019). Diadromous fish are particularly vulnerable as they often must bypass dams to reach spawning grounds (Waldmann and Quinn 2022). Translocation and passage structures such as fish ladders or elevators may help these species bypass these structures, but are not always effective or sufficient (Roscoe and Hinch 2010, Waldmann and Quinn 2020, Pires et al. 2021). Dams also fragment the habitat for freshwater invertebrates, such as mussels, crayfish, and insects (Vinson 2001, Strayer 2006, Santucci et al. 2005). Freshwater mussels in particular may be doubly impacted, as the dams fragment both the mussel populations and the fish species they depend on (Vaughn 1997).

The physical barrier of a dam causes inundation upstream, transforming lotic habitat to lentic (Friedl and Wüest 2002). This changes water flow velocity, movement, temperature, turbidity, and stratification (Friedl and Wüest 2002, Herbert and Gelwick 2003). Impoundments may also provide habitat for greater numbers of larger piscivores and invertivores, which impacts species from lower trophic levels (Herbert and Gelwick 2003, Gido et al. 2009). Some invasive species may do well in these altered habitats (Nilsson et al. 2005). Nutrient and oxygen levels can be altered in the impoundment (Nilsson et al. 2005). Downstream, the primary impacts are on water quality and habitat condition. Water releases from the dam result in temperature fluctuations, increased sedimentation and turbidity, and bank scour (Lessard and Hayes 2003).

Water management using culverts (Threat 7.2.3) has similar impacts on aquatic connectivity as dams, though they tend to occur in smaller riverine systems (Strayer 2006, Fuller et al. 2015). Generally, the height differential at culverts is less than that at dams, but small sizes, steep terrain, and significantly higher numbers of culverts still make them a significant barrier to movement in higher stream reaches (Fuller et al. 2015, Frankiewicz et al. 2021, Waldmann and Quinn 2022). Habitat improvement for riverine species will require the mitigation of both dams and culverts (Januchowski-Hartley et al. 2013).

In recent decades, interest in dam removals as a method of restoring habitat has increased. The Northeast region has some of the highest concentrations of removed dams in the country, with many of these removals concentrated in Pennsylvania and coastal and northern New England (Foley et al. 2017, Bellmore et al. 2017). Dams in the Northeast are often older than those elsewhere in the country, heightening concerns about potential dam failure (Hansen et al. 2020). Despite relatively high numbers of removals, few studies have evaluated the effects of these actions, especially before-and-after analyses and over longer time scales (Bellmore et al. 2017). Dam and culvert removal and other fish passage projects have been shown to have significant benefits for various diadromous fish (Waldmann and Quinn 2022).

Withdrawal of surface (Threat 7.2.6) and **groundwater** (Threat 7.2.7) can have significant impacts on nearby aquatic ecosystems, including rivers, streams, wetlands, lakes, and ponds. These impacts can spread into upland habitats as well by lowering the water table, which has implications for the vegetation in these areas. Water is extracted for residential or commercial use, irrigation, hydraulic fracking, or other uses. Effects of extraction include decreased volume in aquatic environments, alteration of flow regimes, lowered water tables, drought, and salinization (Bierkins and Wada 2019, Saha and Quinn 2020). The taxonomic teams highlighted these concerns for species that are dependent on ephemeral water bodies or cave systems, as these systems are reliant on water tables remaining stable for at least part of the year, and even small withdrawals can impact water levels.

Beaver dam management (Threat 7.2.2) does not impact very many Northeast RSGCN and Proposed RSGCN. However, the dismantling, removal, or other management of beaver dams and associated water levels can impact or remove beaver meadow habitat from the landscape. Species that are habitat specialists or otherwise dependent on these areas are adversely impacted by these activities. However, management of beaver dams tends to be highly localized, usually an attempt to reduce human-wildlife conflict. As a result, the impacts are also highly localized rather than pervasive across the landscape.

Similarly, **drainage in agricultural** (Threat 7.2.4) and **forest environments** (Threat 7.2.5) reduces the availability of wetlands and moist microhabitats within these environments, which may have impacts on some species in these areas, but does not likely lead to widespread declines across the region. Agricultural drainage is much more common in the Midwest and Southeast than in the Northeast; in these regions, this threat is likely to have a much greater impact (Blann et al. 2009). For a detailed description of the impacts of drainage on aquatic ecosystems, see Blann et al. (2009).

Though not included in the Quebec Standardized Classification of Threats, the taxonomic teams highlighted the importance of **tidal water restriction** as a threat to some species. Tidal restriction occurs when the construction of roads, causeways, bridges, and tidal gates restricts connection points between coastal wetland areas and the open ocean. The limited openings that remain greatly reduce or prevent water from moving back and forth between the two areas. The restriction of tidal water reduces turnover, allowing contaminants to build up, altering salinity and oxygen levels, and preventing nutrient and sediment movement (Portnoy and Allen 2006). Tidal restrictions also change the vegetative community in the wetland, allowing the incursion of species less tolerant of flooding and brackish water (Roman et al. 1984, Hinkle and Mitsch 2005). Restoration of tidal flow can have many benefits, including increased carbon cycling (Wozniak et al. 2006), exclusion of invasive and upland plant species (Smith et al. 2009, Smith and Medeiros 2013), and restoration of microbial (Lynum et al. 2020), plant (Roman et al. 2002, Buchsbaum 2021), fish (Roman et al. 2002), and avian (Buchsbaum 2021) communities.

RELATIONSHIPS WITH OTHER THREATS

Water is managed and extracted for many different human uses and thus interacts with many other threats, including Residential & Commercial Development (Threat 1.0), Agriculture & Aquaculture (Threat 2.0), and Energy Production & Mining (Threat 3.0). Climate Change (Threat 11.0) is also likely to amplify the impacts of threats under Dams & Water Management/Use, as changing precipitation rates and hydrological regimes may result in decreased water availability, especially when coupled with continued and often increasing anthropogenic demand.

TOOLS AND RESOURCES

Several tools and resources are available for learning more about dams and other barriers. Global Dam Watch produced the **Global Georeferenced Database of Dams (GOODD)**, a digitized collection of more than 38,000 dams greater than 15 meters in height, enabling analysis of the impacts of dams on the environment and nearby communities (Mulligan et al. 2020). The US Army Corps of Engineers (USACE) maintains a **National Inventory of Dams**, with information on more than 90,000 dams nationwide (USACE 2022).

Regionally, the **Northeast Aquatic Connectivity Project**, completed in 2012, created a regional inventory of dams, impassable waterfalls, and anadromous fish habitats across the Northeast to inform landscape-level conservation efforts (Martin and Apse 2011). The resulting spatial dataset allows aquatic connectivity to be addressed at the landscape scale and prioritizes barriers for mitigation (Martin and Levine 2017). The **Connecting the Connecticut**[125] project developed an interactive GIS-based application to estimate continuous unimpacted daily streamflow at ungagged locations in the Connecticut River basin.

Other resources for aquatic connectivity include **frameworks developed for selecting, planning, and launching dam removal projects** (Tonitto and Riha 2016, Hansen et al. 2020). The New England District of the USACE also developed **best management practices for stream crossing on both tidal and non-tidal streams** in the Northeast describing new and replacement crossings and culvert extensions to minimize impacts (USACE 2015). Many states have their own best management practices and regulations regarding stream crossings and should be referred to when embarking on any project.

There are numerous resources devoted to dam removal information. The US Geological Survey manages a **Dam Removal Information Portal (DRIP)**[126], which is a tool for exploring dam removal science and research (Wieferich et al. 2021). American Rivers, a non-profit organization devoted to increasing awareness of the importance of rivers, maintains a **map of United States dams removed since 1912**[127]. The Northeast Climate Adaptation Science Center has a project devoted to evaluating the **effectiveness of removing obsolete dams and other structures as a climate resilience strategy**[128].

Many different partners are working on issues related to watershed connectivity, including the **North Atlantic Aquatic Connectivity Collaborative**[129], **Chesapeake Bay Program**[130], **Coalition for the Delaware River Watershed**[131], and the US Fish and Wildlife Service's **Fish and Aquatic Conservation Program**[132]. These partners are valuable resources, with information, data, management guidelines, and established partnerships. For more information on these and other partners, see *Chapter 7*.

OTHER ECOSYSTEM MODIFICATIONS

The threats in this category can be broken into two groups. Natural processes, such as succession and erosion, gradually change landscapes over time, which can lead to the exclusion or addition of certain species as conditions shift. The remaining threats under Natural System Modifications are generally activities that alter or reduce available habitat for human purposes, especially recreation, safety, or aesthetics. These forms of manipulation do not eliminate habitat but can have significant impacts on the quality of the habitat that is available. For species that have specialized requirements or are sensitive to human activities, these modified sites may no longer be suitable.

THREAT DESCRIPTIONS AND EXAMPLES

Vegetation succession (Threat 7.3.2) is a naturally occurring event in any ecosystem. As was discussed above under fire suppression (Threat 7.1.2), the true threat is the lack of disturbance events. Without disturbance, habitat naturally shifts to later successional stages, which is detrimental to species that depend on early successional, grassland, or shrubland habitats (DeGraaf and Yamasaki 2003, Litvaitis 2003). It has also altered the density and openness of many forested areas (Lorimer and White 2003). The northeastern landscape has changed significantly over the last few centuries, with these disturbance habitats largely disappearing and forest composition shifting and homogenizing (Litvaitis 2003, Thompson et al. 2003). Recognition of the importance of these early successional, disturbance-driven habitats to species like the American Woodcock (*Scolopax minor*), Golden-winged Warbler (*Vermivora chrysoptera*), and New England Cottontail (*Sylvilagus transitionalis*) led to the formation of the Young Forest Project[133]. This organization brings together many different partners to create suitable habitats using a variety of management strategies and has resources for managing habitats for key young forest species.

Natural erosion and sedimentation (Threat 7.3.3) is another threat that gradually changes habitats and makes them less suitable for species. Erosion is the physical removal of soils, rock, and other materials from one location, and is the opposite of deposition, which is the addition of those materials at another location. Generally, natural erosion is not a major threat to most RSGCN and Proposed RSGCN because species can move from sites that are being eroded to nearby suitable areas where sediments are being deposited. While the taxonomic teams identified many species where erosion and sedimentation are a concern, all of these examples were cases where the sedimentation was caused by anthropogenic activities or structures, such as deforestation, dams and water management structures, and shoreline protection structures.

Beach habitats on both coastlines and lakes are often heavily modified for human recreation and safety. **Shoreline alteration** (Threat 7.3.1) includes many structures engineered to stabilize shorelines, prevent the loss of sands and other substrates to natural erosion, and protect coastal communities from wave action, storms, and flooding. In the Northeast, Massachusetts, Connecticut and New Jersey have the highest number of coastal engineering structures along marine sandy beach habitats (Rice 2017). The installation of these structures is referred to as shoreline hardening or armoring, as soft sediments are replaced with rock, concrete, and metal. Hardening and armoring have significant ecological impacts. Ironically, although the intent of many of these structures is to prevent erosion, they interrupt littoral drift patterns, the geological process that transports sediments along the shoreline. In natural systems, erosion and accumulation of sediments occur simultaneously, replenishing the beach. When sediments are trapped by these structures, they cannot erode and be transported to a new location. As a result, shorelines in the downdrift area continue to erode but have no sediments available to replace those that are lost. This may have particular impacts on sea turtles, as they return to natal beaches that decrease in size and suitability over time. This also can impact nesting shorebirds and waterbirds, as suitable habitats become less available.

Other ecological impacts of shoreline armoring include altered hydrodynamics, increased scouring and turbidity, and degraded and eliminated nearby habitats (Defeo et al. 2009, Prosser et al. 2018). In addition, some animals, such as Diamondback Terrapins (*Malaclemys terrapin*) can get trapped by armoring structures as they attempt to move between terrestrial and aquatic habitats (Egger and the Diamondback Terrapin Working Group 2016). As a result, armored shorelines tend to have a less complex structure, reduced biodiversity, and lower species abundance (Dugan et al. 2018, Lawrence et al. 2021). Some of these impacts can be lessened by changing the slope and shape of existing structures, adding features such as crevices or pits that increase structure complexity, or attaching additional structures that mimic unique microhabitats such as rock pools (Chapman and Underwood 2011).

Another form of shoreline alteration is the creation of dunes both actively through manipulation with heavy equipment and passively using sand-trapping features such as sand fences. Generally, the manual creation of dunes is less desirable, as these dunes do not function in the same way as natural dunes (Rice 2009). Creating a dune using sand fencing is a much slower process, but effective in creating more natural habitats. Sand fences can become a hazard or barrier to wildlife when they are unburied due to erosion and storms or when they are placed in long, continuous sections without gaps that allow animals to pass through them (Rice 2009). This has been particularly noted as a threat for sea turtles, as it results in females nesting in subpar locations (e.g., Witherington et al. 2011a,b). Research has investigated how the fence material, orientation, and design affect dune accretion (Miller et al. 2001, Grafals-Soto and Nordstrom 2009, Itzkin et al.

2020). Dunes that develop as a result of sand fences do not share all the same qualities as natural dunes, tending to be taller but not as wide and with fewer ridges that support unique microhabitats (Nordstrom et al. 2012). This has shaped best management practices for projects using fencing to re-establish dunes (Rice 2009, Guilfoyle et al. 2019).

Beach development (Threat 7.3.4), as defined by Lamarre et al. (2021) in the Quebec classification system, refers to the creation of beaches, especially the addition of substrate (beach nourishment) and other maintenance activities such as raking. Nourishment is often a response to beach erosion, replacing the sediments removed by waves, tides, and currents with sediments from other locations. Impacts of nourishment are variable, dependent on the timing, location, qualities, and volume of the imported sediments (Defeo et al. 2009). It can directly impact species by burying them or compacting and crushing individuals (Defeo et al. 2009). This is primarily a concern for invertebrates and sea turtle nests. In turn, this leads to indirect impacts on other taxonomic groups, especially birds, as the newly nourished area is depauperate of much of the prey base and can be significantly altered, destroying dune vegetation and nearshore habitat (Peterson and Bishop 2005, Defeo et al. 2009). Best management practices for beach nourishment include limiting the use of heavy equipment, nourishing alternating sections that create small refugia from the impacts, selecting sediments with similar characteristics to those already on the beach, and not sourcing sediments from sensitive areas like nearshore sandbars that reduce the need for replenishment in the first place (Guilfoyle et al. 2019). Other maintenance activities like raking, grooming, and cleaning are generally employed on beaches with heavy recreational use. These practices may remove trash and other litter from the beach, but they also remove young dune plants and wrack, disturb local fauna, and make the sand more vulnerable to erosion (Defeo et al. 2009). Raking can also prevent the formation of complex natural dunes systems with a greater variety of habitats (Nordstrom et al. 2012).

An alternative approach for protecting shorelines and managing beaches that is gaining interest is the construction of living shorelines. These installations incorporate natural and nature-based features, rather than armoring features, for the protection of shorelines and other coastal habitats. When installed, living shorelines provide similar erosion prevention and wave action reduction functions as traditional armoring structures, but additionally create habitat heterogeneity and continuity between upland and aquatic areas (Bilkovic et al. 2016). Living shorelines may also increase the resilience of shorelines to future conditions, including changing climate, when installed in ways that make use of the dynamic nature of these areas (Mitchell and Bilkovic 2019). Authors have reviewed the use of various living shoreline techniques, especially those applicable to New England, highlighting benefits and approaches that may be valuable across the Northeast region (Donnell 2017). Other recent research has highlighted that living shorelines can function similarly to natural marshes, including carbon and nutrient cycling, plant productivity, and habitat availability for numerous taxonomic groups (Isdell et al. 2021).

At this point, living shoreline approaches are still a new concept and most installations have been recent. In recent years, awareness has been growing that living shorelines are not appropriate in all locations or for all conditions (O'Donnell 2017). Areas with high wave action may prevent the successful establishment of plantings without the construction of suitable protection structures (Mitchell and Bilkovic 2019). Some sites, such as areas in front of important infrastructure and developed areas will still require more intensive shoreline protection, though aspects of living shorelines could be incorporated to create protective structures that provide more ecosystem services than traditional structures (O'Donnell 2017). Moreover, shorelines are highly dynamic systems; living shoreline design must consider not just the current desired status, but that the installation must be situated in a way that allows for landward migration in response to sea level rise (Bilkovic et al. 2016, Mitchell and Bilovic 2019). More long-term research and monitoring will be necessary to evaluate living shoreline effectiveness over time and under different, changing conditions and to determine best practices for siting, planning, and design that will ensure their successful installation (O'Donnell 2017, Smith et al. 2020).

Though much of the discussion of shoreline alteration and beach development has been focused on coastal habitats, many of these concepts are relevant to lake environments as well. Research in these locations is more limited, but armoring has demonstrated impacts on fish and macroinvertebrate assemblages in lakes of various sizes (Jennings et al. 1999, Brauns et al. 2007, Chhor et al. 2020). Research in the Great Lakes linked shoreline hardening to bluff recession, altered sedimentation patterns, and deposition rates, with significant, irreversible impacts on nearshore communities and ecology (Meadows et al. 2005).

Sea bottom trawling (Threat 7.3.6) is an alteration that impacts marine environments. Fisheries methods that utilize bottom-dragging equipment impact more global seabed habitats than any other, though trawling appears to be declining globally (Halpern et al. 2008, Halpern et al. 2019). Determining the full extent of trawling is difficult, but new technologies for measuring relative impact are available (Amoroso et al. 2018).

Trawling gear drags along the bottom of the seabed, resuspending sediments in the water column, smoothing the seafloor, removing significant biomass, and causing significant damage to seafloor structures and biota (Hiddink et al. 2017). In turn, this can greatly reduce biomass and biodiversity, as the trawled areas are often relatively barren and take significant amounts of time to recover. Different types of trawling equipment have variable impacts. Otter trawls have the least impact, removing the least total biomass and causing the least disturbance of the seabed, while hydraulic dredges have the greatest impact and impacted communities require longer recovery periods (Hiddink et al. 2017). McConnaughey et al. (2020) reviewed different equipment and management practices, comparing their relative impacts and offering guidance on identifying best practices that meet varying management priorities.

Species with shorter lifespans can recover more rapidly, which may have important implications for the sensitivity and responses of certain communities to trawling pressure (van Denderen et al. 2015, Hiddink et al. 2019). In an attempt to protect these sensitive ecosystems, the United Nations General Assembly released a series of resolutions highlighting the importance of these deep-sea ecosystems and calling for reduced impacts in vulnerable areas (Ashford et al. 2019). In response, the Northwest Atlantic Fisheries Organization has identified Vulnerable Marine Ecosystems, areas that are closed to bottom fishing; as of 2023, 27 Vulnerable Marine Ecosystems have been identified in international waters in the northwest quadrant of the Atlantic (UN Food and Agriculture Organization 2023). While these protected areas have reduced bottom fishing impacts, some research has shown that their current placement may be excluding important unique, high-diversity areas, highlighting the need for these designations to be periodically evaluated (Ashford et al. 2019, Murillo et al. 2020).

Riverine habitats are also often heavily modified for human purposes. Though not identified as a threat under the Quebec Threats Classification System, **stream channelization** greatly alters the structure and function of riverine habitats. Channelization refers to the practice of deepening, widening, and straightening river and stream channels to improve navigability, reduce flood frequency and intensity, or drain moisture from wetlands. Riverine habitats are naturally variable, with variations in flow speed and direction, water depth, substrate, and temperature. Changes to water depth, width, and flow impact aquatic vegetation, substrate, and water quality (Brooker 1985). Channel straightening increases flow speeds compared to more meandering channels, increasing sediment transfer, eliminating pools and riffles, and reducing in-stream vegetation (Brooker 1985, Lennox et al. 2016). Associated removal of riparian vegetation increases erosion, removes cover, and raises water temperatures (Brooker 1985). In general, channelized reaches are less meandering. As a result, these channels are also more homogenous, lacking the microhabitat patches, such as riffles and pools, that are characteristic of other stream habitats (Hohensinner et al. 2018). As a result, channelization changes the diversity and assemblage of plants and animals present in the altered stream reaches (Brooker 1985, Rambaud et al. 2009, Lennox et al. 2016).

An activity often associated with channelization is the **removal of snags in water courses** (Threat 7.3.5). Generally, this refers to the removal of large woody debris or boulders to improve water flow, for esthetic value, or to facilitate navigation. Similar to stream channelization, these activities can increase flow speeds and bank erosion, with similar impacts on the biota of the river or stream (Gippel 1995, Gurnell et al. 1995). Biologists have long recognized that these structures, especially woody debris, serve important roles as a food resource and habitat for many species (e.g., Benke et al. 1985). However, it is only in the last few decades that the importance of in-stream woody debris has been recognized, both as wildlife habitat and for stream stabilization, and incorporated into management activities and planning (Wohl 2014, Wohl et al. 2016).

RELATIONSHIPS WITH OTHER THREATS

As many of the threats in this category are the result of human actions altering natural habitats, these impacts are frequently associated with other anthropogenic threats, especially Residential & Commercial Development (Threat 1.0), Transportation & Service Corridors (Threat 4.0), Biological Resource Use (Threat 5.0), and Human Intrusions & Disturbance (Threat 6.0). Invasive Non-native/Alien Plants & Animals (Threat 8.1) can increase erosion and sedimentation. Some invasive plants destabilize streambanks (e.g., Lavoie 2017), as do species that burrow in streamside areas (e.g., Harvey et al. 2019).

Climate Change (Threat 11.0) will also intensify the effects of some of these ecosystem modifications. Increased precipitation and storm frequency and intensity will increase erosion and sedimentation of both riverine and coastal habitats. Channelized stream reaches will be even more vulnerable, as currents already run faster in these areas. Sea level rise further alters shorelines and beach management activities, and potentially leads to coastal squeeze as shorelines are simultaneously pressured by development and other disturbances inland (Defeo et al. 2009). Changing temperatures and precipitation levels may also alter succession patterns, as changing conditions may favor different species than those that were there historically.

TOOLS AND RESOURCES

As vegetation succession and erosion are natural processes that are happening across all landscapes at all times, it is difficult if not impossible to develop tools to track these forces. Tools and resources related to stream channelization and snag removal are also not available. Instead, most tools and resources focus on tracking human-caused Natural System Modifications.

Marine and coastal ecosystems have the greatest number of tools and resources available. Rice (2009) outlined **BMPs for avoiding, minimizing, and mitigating the adverse impacts of shoreline stabilization** projects on dune, beach, nearshore, offshore, inlet, and estuarine habitats. These BMPs advocate for a “do nothing” approach first, where human structures are pulled back proactively from shorelines in anticipation of sea level rise and climate change-driven weather patterns and utilizing shoreline stabilization only where this is not a viable approach (Rice 2009).

These BMPs were incorporated into conservation strategies for the federally-listed Piping Plover (USFWS 2012) and a technical report developed by the US Army Corps of Engineers that provides **suggested coastal management approaches that minimize impacts on shorebirds and sea turtles** (Guilfoyle et al. 2019).

The National Oceanic and Atmospheric Administration conducted a literature review on the effects of overwater structures, shoreline hardening, and other anthropogenic changes to marine habitats; this document includes summaries of 73 documents published between 2010 and 2021 (Shinn 2021). They also maintain a Digital Coast resource[134] that provides data, tools, and training resources for addressing coastal issues, including data and maps for land cover, sea level rise, elevation, hurricanes, coastal flooding, imagery, socioeconomics, weather and climate, marine habitat and species, ocean uses and planning areas, water quality, infrastructure, and more.

NOAA's Office for Coastal Management developed the **US Great Lakes Hardened Shorelines Classification**[135] data layer, which identifies natural and artificial segments, structure types, and condition (NOAA Office for Coastal Management 2019). The **Center for Coastal Resources Management**[136] produces inventories of shoreline structures in the mid-Atlantic. NOAA's Habitat Blueprint[137] program includes an interactive **map showing the locations of existing NOAA-funded living shoreline project**s[138].

The Program for the Study of Developed Shorelines[139] at Western Carolina University maintains a database that represents the most comprehensive compilation of beach nourishment history in the United States. Their **Beach Nourishment Viewer**[140] contains information on the linear distance, total volume, and cost of each identified coastal beach nourishment project in their system, dating back to 1923. The American Shore and Beach Preservation Association, in conjunction with its partners, developed its own **National Beach Nourishment Database**[141]. This tool contains information on nourishment projects on both coastal and lake shorelines, improving understanding of how anthropogenic activities influence long-term change (Elko et al. 2021).

Partners such as the **Great Lakes Restoration Initiative**[142] and **National Marine Fisheries Service**[143] has extensive libraries of information and data products that can inform decision-making processes for Natural System Modification projects. See *Chapter 7* for descriptions of these and other partners and their resources.

3.2.6 RESIDENTIAL & COMMERCIAL DEVELOPMENT

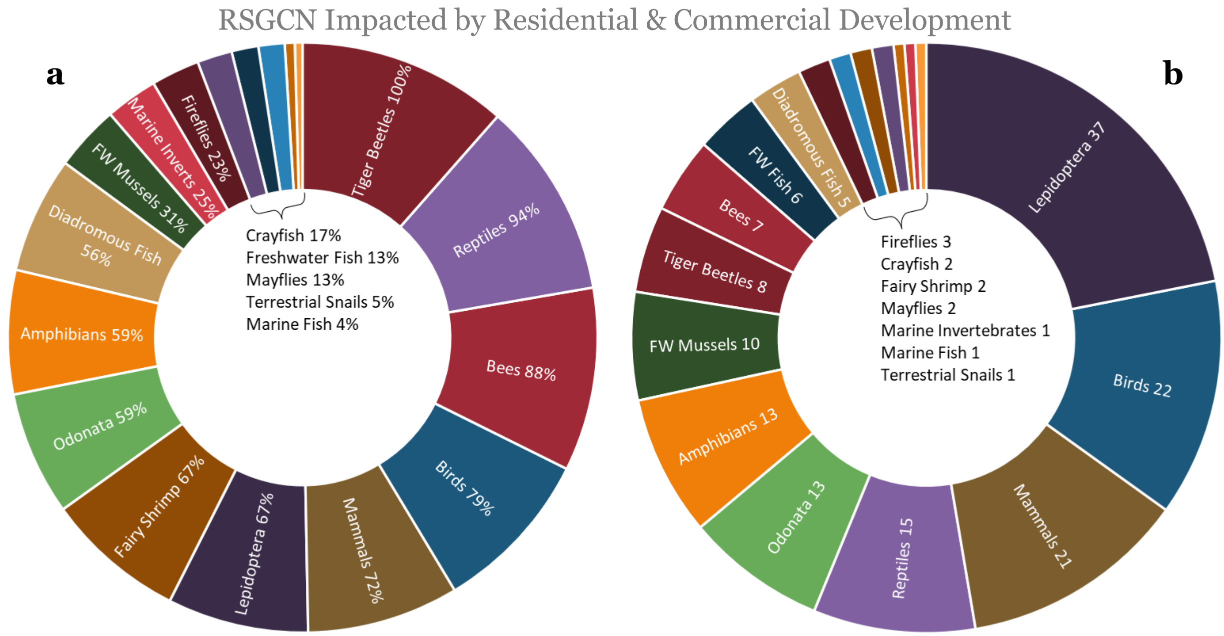

Figure 3.7 Impact of Residential & Commercial Development (Threat 1.0) on RSGCN and Proposed RSGCN. (a) The percentages show the proportion of the species within that taxonomic group known to be impacted by this threat. (b) The total number of species within the taxonomic group known to be impacted by this threat.

Residential & Commercial Development does not rank as highly as the other threats in 2023 discussed in this document. However, it impacts at least 40% (169) of the species on the RSGCN and Proposed RSGCN lists and remains a major concern in the Northeast. All eight tiger beetles are impacted by this threat, as are most reptiles and bees (Figure 3.7a). Lepidopterans, birds, and mammals provide the largest number of species impacted by development, though smaller proportions of these groups are impacted (Figure 3.7b). Aquatic species appear to be less impacted by this threat, potentially since development more directly impacts terrestrial habitats. However, data deficiencies for many invertebrate taxonomic groups likely make it appear that development is not a concern for these species when in reality we are uncertain what the impacts truly are.

The most direct impact of development is habitat loss and alteration. Habitat loss can eliminate key areas or result in decreased habitat area, which in turn restricts the number of individuals and species able to be supported by the remaining habitat. Development also fragments habitats into smaller patches. Fragmentation alters the arrangement of habitat such that it results in reduced habitat area, increased patch isolation, and the creation of more edge habitats. Smaller habitat patches support less diverse wildlife communities and fewer individuals as a result of limited resource availability (Laurance et al. 2002, Haddad et al. 2015). Isolation between patches restricts the movement of individuals between patches, which has consequences for metapopulation dynamics and genetic integrity (Lande 1988, Laurance et al. 2002). Increased edge habitat can change the community structure by altering patterns of energy flows and resource availability while also creating space for unique interactions between species that do not usually interact (Laurance et al. 2002, Ries et al. 2017). All of these changes to habitat structure impact ecosystem processes, such as nutrient cycles, pollination, and succession, and change the resilience of the ecosystem (Haddad et al. 2015).

Studying wildlife interactions with development is complicated because not all species respond in the same way (Birnie-Gauvin et al. 2016). Responses are often contextual and dependent on the reason for habitat loss, the surrounding landscape matrix – the patterns and organization of habitat types – and the intensity of human activity and use. Many species change their behavior in response to development, either avoiding areas of anthropogenic disturbance or changing their behaviors in ways that allow them to utilize these areas (Lowry et al. 2013, Ritzel and Gallo 2020). Others adapt and evolve to be better able to utilize anthropogenically-altered environments (Cheptou et al. 2017, Johnson and Munshi-South 2017). Even in species that can utilize developed areas, factors such as increased stress levels, lesser nutritional content of available food resources, anthropogenic noise interfering with communication, and increased exposure to hazards such as pollution and disease can have negative impacts on individuals (Birnie-Gauvin et al. 2016).

In the Northeast region, the impacts of development are almost ubiquitous. The region contains some of the most densely populated areas in the United States, which have been heavily modified by human land use change since European colonization. Very little of the region remains unimpacted by the effects of development and agriculture, and these impacts are likely to increase over the next few decades (Theobald 2010, Venter et al. 2016). Urban centers are not the only concern. Areas where low-density housing is developed near or intermixed with natural habitats, commonly referred to as the wildland-urban interface, are also widespread in the Northeast (Radeloff et al. 2005). These interfaces alter the risk of fire, vehicle collisions and mortality, invasion of non-native and human-subsidized species, and disease transmission (Bar-Massada et al. 2014, Kreling et al. 2019). In the conterminous United States, a total of ten states have at least 33% of their area within the wildland-urban interface; eight of these states are within the Northeast region (Radeloff et al. 2005). Connecticut, Rhode Island, and Massachusetts are particularly impacted, with more than 65% of their area within the wildland-urban interface (Radeloff et al. 2005). This high level of intermixing has implications for conservation for the region. An analysis of Conservation Opportunity Areas identified in the 2015 SWAP revisions showed that a majority of these sites are vulnerable to future projected development or are constrained by current development

(Carter et al. 2019). Management of this threat will require careful planning to balance the needs of the growing human population in the region and conservation priorities.

HOUSING & URBAN AREAS

The development of Housing & Urban Areas significantly modifies the environment, converting suitable habitats into vast amounts of impermeable surfaces, including buildings, roads, and parking lots. The replacement of local vegetation with concrete, asphalt, and metal raises temperatures by reflecting solar radiation to the areas nearby (Shepherd et al. 2013, Bounoua et al. 2015). Impermeable surfaces also repel significant amounts of water, making management of runoff a critical concern in these areas.

Housing & Urban Areas also alter the sensory environment for wildlife species. Heightened noise pollution levels in these environments can prevent communication in auditory species, increase stress levels, and reduce the detection of predators or other hazards (Slabbekoorn and Ripmeester 2008, Lowry et al. 2013). In turn, this may cause some species to alter how they behave or communicate (Lowry et al. 2013, Ditmer et al. 2021, Duquette et al. 2021). Light pollution is also a significant hazard, interrupting circadian rhythms, disorienting migratory species, and causing avoidance of high-light areas and altered movement patterns (Cabrera-Cruz et al. 2018, Laforge et al. 2019, Ditmer et al. 2021). For more information on how sound and light pollution impacts wildlife, see the section on Excess Energy (Threat 9.6).

Some of these features can be hazardous for wildlife. Bird collisions with man-made structures, especially windows, are a major source of mortality. Estimates suggest as many as 1 billion birds die from collisions annually in the United States alone (Loss et al. 2014). Light pollution compounds the risk of collision, as nocturnally-migrating birds are disoriented by the lights and do not perceive the barrier (Parkins et al. 2015, Lao et al. 2020, van Doren et al. 2021). Researchers trying to understand the characteristics and patterns of collisions identified that the risk is greatest at large buildings surrounded by relatively low levels of development and smaller structures (Hager et al. 2017). Collisions with cars, trains, boats, and aircraft are also a major concern in developed areas. Vehicle-wildlife collisions are a source of both animal and human mortality and injury (Huijser et al. 2008). Because vehicles often are moving at extremely high speeds, wild animals are often not able to detect the vehicle, identify it as a threat, and employ an appropriate escape response in time to avoid collision (Lima et al. 2015). Billions of vertebrates are killed annually in collisions in the United States, and those numbers are likely to increase as development continues to spread.

Residential yards and gardens often incorporate non-native plants, reducing their value as native wildlife habitats and making them a key vector for species invasions (Paker et al. 2014, Pardee and Philpot 2014, Beaury et al. 2021, Larson et al. 2022). Companion animals, especially cats, cause greater mortality than building collisions in developed areas in the United States (Loss et al. 2013). Proximity to domestic animals can increase the transmission of diseases, creating reservoirs in both wild and domestic populations that continue to reinfect one another (Hassell et al. 2017). Humans can also influence disease transmission by providing food resources that aggregate higher numbers of wildlife, such as bird feeders and bird baths (Adelman et al. 2015, Lawson et al. 2018). For more information on how invasive and non-native species and diseases impact wildlife, see the section on Invasive Non-native/Alien Plants and Animals (Threat 8.1) and Pathogens & Microbes (Threat 8.4).

THREAT DESCRIPTIONS AND EXAMPLES

Dense housing and urban areas (Threat 1.1.1) have some of the greatest impacts on wildlife habitats because they generally represent permanent, irreversible changes to the ecosystem. Urbanization transitions the landscape from native habitat types to intensive anthropogenic use, completely altering the structure and function of available habitat.

Urban areas can increase the frequency and intensity of thunderstorms and rain events by altering atmospheric conditions and carbon and water cycles, further exacerbating the issue of runoff (Niyogi et al. 2017, Singh et al. 2020). Urban runoff often contains contaminants, including pollutants from vehicles, litter and household wastes, fertilizers and pesticides, pet waste, and water and chemicals used to clean buildings and other structures (Müller et al. 2020). These pollutants are increasing the salination levels in freshwater resources across the Northeast (Kaushal et al. 2005, Utz et al. 2022).

Suburban areas have less impermeable surfaces, but still greatly alter ecosystem function. The prevalence of intensively managed lawns and other greenspaces in urban and suburban areas can reduce plant and insect diversity. Management practices favor annual plant species and reduce floral resources for pollinators, resulting in cascading effects within ecological communities (Watson et al. 2020). These areas also require significant chemical input in the form of fertilizers, pesticides, and herbicides, which again contribute to pollution rates (Watson et al. 2020). Interestingly, developed areas across the country are more similar to one another than they are to neighboring natural ecosystems, highlighting how anthropogenic management significantly alters these landscapes (Groffman et al. 2014).

Low-density housing areas (Threat 1.1.2) may be less altered than urban and suburban areas, existing within a matrix of less altered habitats. Despite this, many of the impacts on species are largely the same (Hansen et al. 2005, Glennon and Kretser 2013). The effects of low-density development are poorly studied compared to urban areas, and require further research to better understand the impacts on nearby ecosystems and wildlife.

A final threat is the **alteration of features within urban and suburban environments**. While development is a major threat for many species, others have been able to adapt and make use of features within developed areas as replacements for natural habitat features. However, changing practices within developed landscapes may limit the availability of these replacements. For example, many bats can make use of attics and abandoned buildings as roosts and hibernacula. However, concerns related to public health often cause homeowners to evict bats from these spaces and install devices that prevent their return (Arias et al. 2020). Chimney Swifts (*Chaetura pelagica*) have long nested in household and industrial chimneys. The installation of chimney caps has been suggested as a contributor to their declines, though some authors suggest other threats are more critical (Fitzgerald et al. 2014). Vacant lots can support diverse pollinator communities, but these sites often have negative associations and are seen as 'wasted' space that needs to be cleaned up, improved, or otherwise altered (Hall et al. 2016, Kim 2016). More research will be necessary to understand the importance of these developed features to RSGCN and Proposed RSGCN species and best practices for their management.

RELATIONSHIPS WITH OTHER THREATS

Development is associated with higher densities of Transportation & Service Corridors (Threat 4.0). Demands for energy and water in these areas can contrite to additional Energy Production & Mining (Threat 3.0) and Dams & Water Management/Use (Threat 7.2). Other forms of Natural System Modifications (Threat 7.0), especially fire suppression (Threat 7.1.1) and shoreline alteration (Threat 7.3.1), are frequently associated with developed areas. Housing and Urban areas are frequently the source of Invasive Non-native/Alien Plants & Animals (Threat 8.1), subsidize Problematic Native Plants & Animals (Threat 8.2), or are reservoirs for Pathogens & Microbes (Threat 8.4). Pollution (Threat 9.0) is closely associated with development. Climate Change (Threat 11.0) is likely to exacerbate some of the effects of urbanization, especially heat island effects and increased storm intensity, especially in areas where precipitation and temperature regimes are already changing (Staudt et al. 2013).

TOOLS AND RESOURCES

Numerous techniques and programs are available to improve Housing & Urban Areas for wildlife. Multiple partner organizations offer **guidance and certification of developed spaces as improved habitats** for birds and pollinators. Others offer programs for urban forestry and canopy trees. Some address specific hazards such as light pollution, collisions with glass, aircraft, or vehicles, and the use of transportation infrastructure by bats. See *Chapter 2* for descriptions of these programs.

Some RSGCN and Watchlist bat species use bridges, culverts, and buildings in developed areas for roosting. Sparks et al. (2019) developed a **manual of BMPs for**

transportation projects to protect bats in developed areas. The manual includes survey techniques, measures to enhance the habitat for bats, and mitigation options for unavoidable impacts.

Maintaining connectivity is a critical issue in a landscape that is increasingly fragmented. Plans for maintaining connectivity for wildlife will need to be grounded in ecological data, establish partnerships with nearby communities, and incorporate sociopolitical and socioeconomic information (Lacher and Wilkerson 2013). As developed and urbanized areas increase in the Northeast, state fish and wildlife agencies will need to work closely with local and state planning and zoning organizations to ensure natural resource areas are sufficiently protected from impacts. Wildlife managers should also consider long-term trends for planning land acquisition and management activities. Local, comprehensive plans are needed to manage the needs of wildlife and human across the landscape. Researchers at Harvard Forest considered **four development scenarios and their potential influence on the Massachusetts landscape**, providing a framework that could help shape discussions on the future of development in the Northeast (Thompson et al. 2014).

COMMERCIAL & INDUSTRIAL AREAS

Commercial & Industrial Areas share several similarities with Housing & Urban Areas: increased impermeable surfaces contributing to changed hydrologic and temperature regimes, elevated pollution levels, altered sensory environments, more physical hazards, and heightened exposure to non-native species and disease. However, commercial and industrial areas may produce greater amounts of different pollutants than housing and urban areas, especially Industrial & Military Effluents (Threat 9.2) and Air-Borne Pollutants (Threat 9.5).

THREAT DESCRIPTIONS AND EXAMPLES

Common examples of **commercial and industrial areas** (Threat 1.2.1) include industrial parks, manufacturing plants, offices, shopping centers, military bases, power plants, seaports, shipyards, and airports. Many of these areas are intergraded with Urbanized & Housing Areas, making it difficult to identify risks that are unique to commercial and industrial areas. One unique threat is the use of wildlife deterrents to reduce populations for human health and safety, such as the various methods used on airfields to reduce bird strikes (Bradbeer et al. 2017, Folkertsma et al. 2017).

Landfills (Threat 1.2.3) consolidate human trash and garbage in small areas, including significant food resources. Many species, especially those that are considered opportunistic scavengers, take advantage of these resources, though diverse communities may be present (Oro et al. 2013, Arnold et al. 2021). Predators in turn are attracted to these sites by the presence of smaller prey species (Oro et al. 2013). Non-native species, such as rats, feral pets, and Feral Hogs (*Sus scrofa*) are often present in these areas (Mayer et al. 2021). While these areas are potential resources for some species, some species experience tradeoffs between survival and reproductive demographics (e.g., López-García et al. 2021). Landfills also facilitate the ingestion of plastics, which can have severe consequences for wildlife (Seif et al. 2018). Landfills pollute nearby water, air, and soil through the release of leachate and toxic gases, which has major implications for nearby habitats and wildlife (Vaverková 2019, Bandala et al. 2021). The decomposition and other chemical reactions occurring within a landfill can also produce heat, causing thermal pollution (Basit et al. 2022).

Two additional commercial industrial areas, **open dump sites** (Threat 1.2.2) such as junkyards and **nuclear waste disposal facilities** (Threat 1.2.4) are not considered major threats to Northeast RSGCN and Proposed RSGCN by the taxonomic teams, but have localized impacts on some species. These sites may have particularly high heavy metal contamination (Wasi et al. 2013). More information is needed to determine if these threats are significant for the region.

Restored and reclaimed landfills and similar industrial sites can provide suitable habitats for many species, especially pollinators and grassland species (Tarrant et al. 2013, Camerini et al. 2014, Gobeil and Gobeil 2014, Webster 2021). Airfields may also be beneficial, though these areas must balance improved habitat benefits for some species against the increasing risk of airplane strikes (Blackwell et al. 2013). Managing these open industrial areas could be beneficial for many species.

RELATIONSHIPS WITH OTHER THREATS

Similar to Housing & Urban Areas, Industrial & Commercial Areas are associated with higher road densities (Threat 4.1.1) and may lead to the development of additional Energy Production & Mining (Threat 3.0). Depending on the type of industrial area, significant Dams & Water Management/Use (Threat 7.2) may also occur. These sites subsidize Invasive Non-native/Alien Plants & Animals (Threat 8.1), Problematic Native Plants & Animals (Threat 8.2), and Pathogens & Microbes (Threat 8.4). Pollution (Threat 9.0) is closely associated with industrial and commercial areas.

TOOLS AND RESOURCES

Many of the tools and resources available related to Commercial & Industrial Areas are similar to those available for Housing & Urban Areas. Partner organizations offer **guidance and certification of developed spaces as improved habitats** for birds and pollinators. See *Chapter 2* for descriptions of some of the programs.

One resource could be particularly useful for landfills, airfields, and other open Commercial & Industrial Areas. Oehler et al. (2006) produced a book that includes sections with **recommendations on improving grassland and shrubland areas for wildlife**, which could be used to inform the management of these industrialized areas.

TOURISM & RECREATIONAL AREAS

Tourism and recreational areas differ from the other forms of development in that they do not usually involve the installation of extensive impermeable surfaces. Nonetheless, the installation of recreational infrastructure can fragment habitats and lead to alteration in how and which species make use of those areas. Human activity and presence may cause some species to avoid these sites, while others may benefit. In general, recreational areas are associated with increased human activity, which results in elevated noise levels, artificial lighting, and litter.

Interest in the impacts of recreational uses on wildlife is rapidly increasing, contributing to the rise of recreational ecology as a field of research. Research attempting to understand the influence visitor numbers and behaviors have on the natural environment tends to focus on four mechanisms: disturbance of individuals, harvest or take, habitat alteration, and the modification of biotic relationships (Sumanapala and Wolf 2019). Balancing the increasing desire for natural recreation and nature-based tourism with the needs of the ecosystems will require careful management (Wolf et al. 2019).

The global COVID-19 pandemic drastically changed the nature of outdoor recreation in the Northeast and across the United States. Many states in the region saw unprecedented increases in state land visitation during the pandemic, while simultaneously dealing with decreased staffing levels and shifted operations priorities, leaving many states unprepared to handle the influx. The Northeast Fish and Wildlife Diversity Technical Committee has expressed an interest in learning more about recreational impacts on wildlife and habitats in the region and determining how these impacts are likely to change in the future.

Many researchers have studied the influence COVID-19 has had on different aspects of outdoor recreation. Many new outdoor recreationists started during the pandemic, but the use of urban spaces and outdoor recreation by those who live in urbanized settings decreased, potentially a reflection of stricter COVID-19 transmission reduction recommendations in these areas (Rice et al. 2020, Taff et al. 2021). COVID-19 forced federal and state land management agencies to shift priorities and change how they communicate and interact with the public (Miller-Rushing et al. 2021, Perry et al. 2021). In the Northeast region, National Forests saw visitation rates increase by as much as 61%, which contributed to negative impacts including overcrowding, vegetation damage, and littering (Ferguson et al. 2022a,b). Understanding the long-term effects of COVID-19 on outdoor recreational sites will require further research.

THREAT DESCRIPTIONS AND EXAMPLES

Docks and marinas (Threat 1.3.5) link shorelines to deeper waters, increasing human access to these areas without the need for a boat. The National Oceanic and Atmospheric Administration conducted a literature review of the effects of overwater structures, shoreline hardening, and other anthropogenic changes to marine habitats; this document includes summaries of 73 documents published between 2010 and 2021 (Shinn 2021). Most research on these threats focuses on estuarine and marine ecosystems, but the implications are similar for freshwater ecosystems as well.

Docks, piers, and other overwater structures change sedimentation rates and organic matter accumulation, which can have impacts on nearby ecosystems (Vasilas et al. 2011). They also limit the growth of seagrasses, algae, and other plants by restricting the amount of sunlight that can reach them, which in turn impacts the communities dependent on these ecosystems (Gladstone and Courtenay 2014, Rehr et al. 2014, Cordell et al. 2017). As a result, the communities surrounding docks and marinas are often significantly different than those in nearby unaltered habitats (Munsch et al. 2014, Pereira et al. 2017). The shadows cast by overwater structures also deter many species, leading to avoidance of these areas (Able et al. 2013, Grothues et al. 2016). Some research has demonstrated that artificial lighting can be used to minimize the avoidance of these areas in some species (Ono and Simenstad 2014). Overwater structures can also alter the relative vulnerability of certain species or age and size classes to capture by recreational fishers (Lamont et al. 2022).

Marinas have some unique impacts. Marinas contain significant infrastructure that supports boating activities, such as fueling and pumping stations, moorings, and repair and cleaning facilities. The presence of these amenities greatly increases boating traffic, pollution, and associated impacts in these areas. Marinas tend to have higher turbidity, temperatures, and pH, which impact the recruitment of various taxa (Rivero et al. 2013). Many marinas contain populations of many invasive species, potentially the result of higher water temperatures and lower oxygen levels (Lagos et al. 2017). These areas are also heavily impacted by many pollutants, which contaminate the water and sediments (Valdor et al. 2019).

Parks and sport fields (Threat 1.3.1) nested within a more developed landscape matrix can provide habitat refuges for urban wildlife, especially pollinators, birds, and mammals. These areas can serve as important habitats and linkages between habitats for many species (Beninde et al. 2015). However, the management practices used in these areas may be detrimental to the species that are attempting to use them. The intensive management of these sites, especially the use of pesticides, is also detrimental to many species, especially pollinators and other invertebrates (Park et al. 2015, Baldock 2020). Pesticide use will also impact invertivores by reducing available food resources for these species. These areas are also often structurally simple, dominated by maintained lawn areas with few floral resources, trees, and shrubs, limiting available microhabitats (Ikin et al. 2013, Eyles et al. 2015). Frequent mowing keeps vegetation short and promotes the growth of annual grasses which are of limited value to pollinators and grassland species (Watson et al. 2020). The particular arrangement and type of structural complexity within these areas influence the communities that exist there (Gallo et al. 2017, Normandin et al. 2017). Encouraging land managers to plan for more complex structure will benefit many urban species (Eyles et al. 2015, Baldock 2020). The taxonomic teams highlighted the management of urban and suburban greenspaces as a particular concern for several RSGCN species, including Yellow-Banded Bumble Bee (*Bombus terricola*) and Eastern Meadowlark (*Sturnella magna*).

Campgrounds (Threat 1.3.2) and **recreational trails** (Threat 1.3.4) can be a particular threat to wildlife because these locations are largely intended to encourage human enjoyment and the use of protected natural areas. Outdoor recreation has long been considered relatively benign to conservation, but evidence showing negative impacts on wildlife species is growing (Larson et al. 2016). Researchers have demonstrated that some wildlife species avoid recreational trails and campgrounds, though these impacts are species- and context-dependent (Larson et al. 2016, Marion et al. 2016, Kays et al. 2017, Naidoo and Burton 2020, Farmer et al. 2022). Use of these recreational areas generally results in trampling, which can have impacts on vegetation, soil, and water that increase with higher intensities of human usage (Monz et al. 2013, Marion et al. 2016). Wildlife can be flushed or startled by human activities, which may cause them to abandon important resources such as food or young (Monz et al. 2013). In some cases, wildlife can alter their usage of these areas in response to seasonal or weekly patterns in human activity levels, but further research is needed to determine if these patterns of avoidance have long-term effects (Nix et al. 2018, Farmer et al. 2022).

The feeding of wildlife at recreational sites, whether intentional or unintentional, can increase the likelihood of conflict between humans and wildlife (Marion 2019). The consistent availability of food resources can habituate animals to human presence in these areas, reducing an animal's fear responses (Hudenko 2014). Unfortunately, reduced fear can lead to increased aggression while pursuing food resources in recreational areas, altered population sizes, and dependency on human-provisioned foods (Marion 2019). These interactions can become particularly dangerous when they involve larger animals such as bears and can result in the termination of problematic individuals (Hudenko 2014, Greene 2016).

For recreational trails, impacts vary by the types of activities they are used for. The impacts of hiking are the most widely studied, but trails utilized for horseback riding, mountain bikes, off-highway vehicles, and snowmobiles have their own impacts (Larson et al. 2016, Sumanapala and Wolf 2019, Naidoo and Burton 2020). These forms of recreation can have more significant impacts on soil conditions and vegetation, especially if the trail is poorly maintained or badly designed (Larson et al. 2016). Regardless of the purpose of the trail, human use can facilitate the spread of weeds and other undesirable plants (Pickering et al. 2016, Pickering 2022). Motorized vehicle use is generally louder than hiking and may thus have a greater impact area, though the increased speed of motorized activities may mean wildlife are not able to respond to the disturbance as rapidly (Marion 2019). Trails for motorized vehicles are also generally wider, which may make them a more significant barrier to movement for some species (Soulard 2017).

Ski resorts (Threat 1.3.3) have significant impacts on the vegetation and soils of alpine and subalpine habitats. The initial construction of ski runs requires the removal of trees and other vegetation and the smoothing of slopes using heavy equipment to machine-grade the area and remove topsoil, boulders, and vegetation (Freppaz et al. 2013, Rixen 2013). These activities often cause compaction, expose mineral soils, and perturb and thin the soil layer, which in turn can lead to significant erosion, alteration of soil chemistry, texture and structure, nutrient cycling, and reduced plant re-growth (Roux-Fouillet et al. 2011, Freppaz et al. 2013). In the winter, snow is compacted by skiers and grooming equipment, which decreases its insulative properties, resulting in decreased soil temperatures that may prevent or delay vegetative and microbial growth (Freppaz et al. 2013, Rixen 2013). The compaction also delays the melting of snow in the spring, which can have impacts throughout the summer (Rixen 2013). The delayed melting can result in shorter growing seasons for high elevation plant species (Meijer zu Schlochtern et al. 2014).

The artificial production of snow can further impact vegetative growth and the overall hydrology of the surrounding ecosystem. Artificial snow has different characteristics compared to natural snow, including a more homogenous structure, additional salts, additives, and other chemicals, and higher pH levels (Meijer zu Schlochtern 2014). While the addition of artificial snow may better insulate the ground, it also will take even longer to melt and may add significantly more water to the system in spring than is otherwise present (Roux-Fouillet et al. 2011, Rixen 2013, Meijer zu Schlochtern 2014). The increased volume of water can result in greater stream flow and erosion (David et al. 2009). Water bodies surrounding ski areas may also impact nearby water quality (Wemple et al. 2007, Kangas et al. 2012).

Ski slopes are also known to have significant impacts on the faunal communities. Ski run construction and management alters the assemblage of small mammals (Hadley and Wilson 2004, Rolando et al. 2013a), arthropods (Kašák et al. 2013, Rolando et al. 2013b), reptiles (Sato et al. 2014), and birds (Rolando et al. 2013a). Some species avoid ski resort areas in winter, likely a response to increased activity at these sites (Slauson et al. 2017). Much of the research on the impacts of ski resorts on wildlife is focused on European species. More work will be necessary to understand the impacts in the Northeast.

RELATIONSHIPS WITH OTHER THREATS

These forms of development are intended to increase human access to natural areas. As a result, they are often coupled with increased Biological Resource Use (Threat 5.0) and Human Intrusions & Disturbance (Threat 6.0). Humans may transport Invasive Non-Native/Alien Plants & Animals (Threat 8.1) when utilizing recreational areas. Human presence also often increases Pollution (Threat 9.0) in recreational areas. Climate Change (Threat 11.0) is likely to have particular impacts on docks and marinas and ski resorts due to changing temperatures and precipitation regimes, but all recreational areas are likely to compound climate-related stress in nearby ecosystems.

TOOLS AND RESOURCES

The EPA has a **resource page**[144] on vessels, marinas, and ports with information on preventing and reducing pollution in these areas. This includes an interactive map of the designated no-discharge zones, areas where boat sewage cannot be released. Many states also have **Clean Marina Programs**. These are voluntary, incentive-based programs that encourage marina operators and recreational boaters to engage in environmentally sound practices. Examples of these practices can be found in the Massachusetts and Rhode Island Clean Marina guides (Massachusetts Office of Coastal Zone Management 2001, Rhode Island Coastal Resources Management Council 2006).

Parks, sports fields, and other developed greenspaces are increasingly recognized as an important part of developed areas as they improve human physical and mental health, protect against flooding, and provide important habitat patches and linkages for wildlife. The Georgia Department of Environmental Protection produced a greenspace best practices document to guide the planning and implementation of these spaces (Georgia Environmental Protection Division 2014). Oehler et al. (2006) produced a book that includes sections with **recommendations on improving grassland and shrubland areas for wildlife**, which could also be used to inform the management and design of parks, sports fields, and campgrounds.

3.3 THREAT AMPLIFIERS AND LIMITING FACTORS

Some species may have characteristics that make them more vulnerable to certain threats. These characteristics can be intrinsic biological traits that affect how that species responds to threats or they can work synergistically with the threat, increasing a species' exposure to a threat and its impacts.

Threat amplifiers and limiting factors are crucial considerations for wildlife management and recovery planning. These amplifiers and factors may limit a species' ability to respond positively to conservation or recovery actions, even if the underlying threat or threats are alleviated. The sections below describe some common threat amplifiers and limiting factors in the Northeast region, using examples from RSGCN and Proposed RSGCN species that illustrate these patterns. These descriptions are not comprehensive lists of threat amplifiers, limiting factors, and affected species. These are only a few examples intended to prompt further consideration and discussion when planning management activities.

SPECIFIC HABITAT REQUIREMENTS

Habitat specificity is a threat amplifier because species that have unique habitat requirements have far less available habitat overall, making even small amounts of habitat loss or degradation a significant impact. Some species are so specialized they require specific habitat features; loss of these features is a threat even if the greater habitat remains intact. Some of the habitat specialists on the 2023 RSGCN and Proposed RSGCN list include:

- Bethany Beach Firefly (*Photuris bethaniensis*): dependent on isolated, freshwater interdunal swales
- West Virginia Salamander (*Gyrinophilus subterraneus*): known only from a single incompletely protected cave system in West Virginia
- Maryland Glyph (*Glyphyalinia raderi*): requires calcium-rich environments, especially near outcrops on steep, forested slopes
- Saltmarsh Sparrow (*Ammospiza caudacuta*): nests along the Atlantic Coast in salt marsh habitats dominated by cordgrass, salt meadow grass, and blackgrass
- Appalachian Tiger Beetle (*Cicindela ancocisconensis*): usually found along rocky mountain streams and small rivers
- Red-cockaded Woodpecker (*Dryobates borealis*): requires older and larger live pine trees in open forests and savannah-like habitats, preferably with some form of heart rot to make excavating nest cavities easier
- Coalfields Crayfish (*Cambarus theepiensis*): preferentially uses sites under large rock slabs as shelter in riverine environments; these areas are some of the first areas filled by sedimentation

Habitat specialists are more sensitive to habitat modification and other forms of degradation (González-Suárez et al. 2013, Rocha-Ortega et al. 2020), are less able to respond to changing climatic conditions (Estrada et al. 2015, Hossain et al. 2018), and have lower adaptive capacity (Ofori et al. 2017), all of which make them vulnerable.

SPECIES INTERDEPENDENCE

Dependence on another species, whether it is as a food resource or a symbiotic host, has similar impacts on habitat specificity. If sufficient food resources or host species are not present, their dependents cannot persist in the landscape. Common examples of species interdependence in the Northeast include mussel glochidia and their associated fish hosts, lepidopteran plant hosts, kleptoparasitic bee hosts, and pollinator nectar resource plants. Examples of this threat amplifier were discussed under Intrinsic Biological Limitations (Threat 8.5); more detailed examples are in the text in this section above.

SEASONAL VULNERABILITIES

Seasonal movement amplifies threats because migrations, whether long-distance or local, bring species into contact with threats that may not be present during more sedentary periods of their life cycle. Of the 418 species included on the 2023 RSGCN list, more than 60 of them are long-distance migrants, present in the region for only a portion of the year. This includes many birds, bats, diadromous and marine fish, marine mammals, sea turtles, and the Monarch Butterfly (*Danaus plexippus*). At least 30 more species are local migrants, traveling shorter distances within the region or between certain habitat features, such as winter hibernacula, breeding pools, and nesting sites. This includes most amphibians and reptiles, cave-dwelling bats, and freshwater fish. For birds and bats, given the increasing number of wind energy installations, it is important to determine migration timing and triggers, routes, and any differences in pattern between sexes so that the impacts of wind turbines can be determined and best management practices can be developed (Northrup and Wittemeyer 2013). Anthropogenic lighting may also be a major problem for nocturnally-migrating species (Cabrera-Cruz et al. 2018). For diadromous fish, the presence of dams and other structures has long been recognized as a barrier to seasonal migrations, which has long-reaching effects on populations (Waldman and Quinn 2022). Even for species that are not long-distance migrants, traveling between different sites for seasonal purposes, such as breeding or hibernating, can be risky. For example, road mortality can result in significant declines in amphibian populations during synchronized overland movements to breeding areas (Gibbs and Shriver 2005).

Migrations also require huge energy expenditures, necessitating resource inputs before and during migration (Myers 1983, Reed et al. 2003, McGuire and Guglielmo 2009). These energy requirements require many species to pause at stopover sites to reprovision, such as the well-studied example of Red Knot (*Calidris canutus rufa*) feeding on Horseshoe Carb (*Limulus polyphemus*) eggs in Delaware Bay. In some ways, the threat of habitat loss is tripled for migratory species; loss of important wintering, stopover, or breeding sites outside of the Northeast can reverberate through the populations of the species impacted within the region (Martin et al. 2007, Thogmartin et al. 2017).

Seasonal activity may also increase the vulnerability of some species to certain threats, especially Climate Change (Threat 11.0). Nearly 150 species on the Watchlist and RSGCN list are known to hibernate, enter sustained periods of torpor, or otherwise overwinter in an inactive manner. Key taxa include most amphibians and reptiles, some freshwater fish and crayfish, insects, and bats. Species that hibernate require specialized habitats or habitat features, and may even need to travel to these sites, exposing them to some of the same threats as migratory species. Once species enter torpor or hibernation, they are highly vulnerable to predation as they are generally operating below optimal metabolic rates (Geiser 2013). Warmer winters may also change the dynamics of certain diseases that impact hibernating species, such as bats and amphibians. Warmer winter temperatures increase the impacts of White-Nose Syndrome on hibernating bats, as the fungal causative agent reproduces more slowly in cooler temperatures (Turner et al. 2022). For insect species that overwinter in egg, larval, or pupal life stages, warming spring temperatures may make these species emerge earlier, leading to phenological mismatches with their environment and important food resources (Scranton and Amarasekarea 2017). Some authors have suggested that the earlier flush of vegetation growth prompted by climate change may shade and reduce temperatures in the soil, preventing the emergence of some butterflies (WallisDeVries and van Swaay 2006).

LIFE HISTORY CHARACTERISTICS

Certain life history characteristics can be limiting factors. These characteristics generally result in reduced genetic variation, leading to many of the problems described under Intrinsic Biological Limitations (Threat 8.5) above. Some key life history characteristics that act as limiting factors include:

- Small populations: Small populations are likely to already be suffering from restricted genetic diversity. Recovery in these populations may not be possible due to inbreeding effects and the accumulation of deleterious alleles. This may be the fate of the Maryland Darter (*Etheostoma sellare*), which is possibly extinct.
- Late maturity: Species that take a long time to reach sexual maturity are vulnerable to being removed from the population before they can reproduce, reducing the overall reproductive output. If individuals are consistently removed from the population before reproducing, recruitment rates can decrease and the overall age structure will shift over time to older, potentially no longer reproductive individuals. This is the case in some freshwater turtle populations that have been exploited for export as pets for long periods.

- Low fecundity: Species that do not produce very many young take much longer to recover from any population declines, putting them at a greater risk of extinction. For example, Shortnose and Atlantic Sturgeon (*Acipenser brevirostrum* and *A. oxyrinchus*, respectively) may go multiple years between spawning.
- Limited dispersal: Species that cannot travel long distances are more sensitive to threats like fragmentation. Isolation of populations can result in decreased genetic diversity, as it reduces connectivity, and the associated gene flow, between populations. Populations with limited dispersal capacity are also more vulnerable to extinction and less likely to be rescued by colonization events.

DATA DEFICIENCY

Data deficiency isn't a species characteristic, but it can threaten imperiled species and restrict fish and wildlife agencies' ability to effectively protect and manage species of concern. These species are often treated as a lower-priority concern because there is no information to support urgency in their conservation (Parsons 2016). This is problematic because trends indicating population declines or other changes may not be noticed until after the species crosses critical imperilment criteria.

In addition, it is not possible to effectively address a threat without knowing what the threat is. While some threats can be mitigated using similar methods, most will require specialized management approaches. A lack of basic ecological and biological information about a species may result in conservation actions having negative consequences for the species they are intended to benefit. Monitoring species before and after changes are made is crucial for developing informed and adaptive management practices.

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3.5 ENDNOTES

Many online resources are available for learning about the topics in this chapter. However, URLs are not permanent resources; over time, pathways are changed or removed. These endnotes were all accessed in January and February of 2023 and were active at that point.

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CHAPTER 4: REGIONAL CONSERVATION ACTIONS

SWAP Element 4

Descriptions of conservation actions determined to be necessary to conserve the identified species and habitats and priorities for implementing such actions. Suggested components:

A. The Plan identifies how conservation actions address identified threats to species of greatest conservation need and their habitats.

B. The Plan describes conservation actions sufficiently to guide implementation of those actions through the development and execution of specific projects and programs.

C. The Plan links conservation actions to objectives and indicators that will facilitate monitoring and performance measurement of those conservation actions (outlined in Element #5).

D. The Plan describes conservation actions (where relevant to the State's species and habitats) that could be addressed by Federal agency or regional, national or international partners and shared with other States.
D1-The Plan describes regional conservation needs and actions.

E. If available information is insufficient to describe needed conservation actions, the Plan identifies research or survey needs for obtaining information to develop specific conservation actions.

F. The Plan identifies the relative priority of conservation actions.

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HOW TO USE THIS CHAPTER

This Chapter provides:

1. An overview and background of key regional efforts to prioritize conservation actions
2. The top seven (7) priority regional actions with:
   - Need and action statements
   - Regional approach
   - 70+ new key regional projects addressing the top regional threats
   - Examples and opportunities for regional implementation
3. References and resources
4. Appendices for Chapter 4 provide:
   A. Regional Project Summary Table
   B. A matrix of priority actions from 2015 SWAPs
5. Supplementary Information 4: IUCN CMP Actions

New information and differences from the 2013 synthesis

The 2013 regional conservation synthesis summarized regional conservation actions implemented through the Regional Conservation Needs (RCN), Competitive State Wildlife Grants (CSWG) and Landscape Conservation Cooperative (LCC) programs (TCI and NEFWDTC 2013). Since that time, the regional State Wildlife Action Plan (SWAP) Synthesis provided a collective summary of the conservation actions identified in the 14 2015 Northeast SWAPs, highlighting regional themes and priorities (TCI and NEFWDTC 2017).

This 2023 Regional Conservation Synthesis updates the inventory of RCN projects supported by the Northeast Association of Fish and Wildlife Agencies' (NEAFWA's) Northeast Fish and Wildlife Diversity Technical Committee (NEFWDTC) and Competitive State Wildlife Grant (CSWG) projects undertaken in the Northeast region over the past decade. The synthesis of existing regional conservation actions is now updated to include regional efforts of the Science Applications At-Risk Species (SA ARS) program of the United States Fish and Wildlife Service (USFWS), which address Regional Species of Greatest Conservation Need (RSGCN) and/or Watchlist species also identified as At-Risk Species by the USFWS in 2021 (USFWS Regional At-Risk Species Coordination Team 2021).

Over the last decade, key tools and projects were developed to support NEAFWA's NEFWDTC and SWAPS:

- Northeast Habitat Status and Condition Assessments (Anderson et al. 2011, 2013a, 2016a, 2016b, 2023a)

- Northeast Lexicon (Crisfield and NEFWCTC 2013, 2022)
- Northeast Conservation Synthesis for SWAP Revisions (TCI and NEFWDTC 2013)
- 2013 Northeast RSGCN list update
- Northeast SWAP Database version 1.0 and 3.0 (TCI and NEFWDTC 2015, 2020b)
- 2018 Northeast RSGCN list update
- Northeast Climate Change Synthesis for SWAP Revisions (Staudinger et al. 2015, 2023)
- Northeast SWAP Synthesis, (TCI and NEFWDTC 2017)
- Limiting Factors Report (TCI and NEFWDTC 2020a)
- RSGCN Database version 1.0 (TCI and NEFWDTC 2023)
- 70+ new RCN, CSWG, SA projects completed on RSGCN and their habitats
- This Northeast Conservation Synthesis, including the 2023 RSGCN list (see *Chapter 1*)

The 2023 NEFWDTC website update (www.northeastwildlifediversity.org) allows for web-enabling this Regional Conservation Synthesis and all the relevant projects, databases, and associated communication tools and products. These tools and resources are searchable with filters to provide detailed information for conservation actions and projects, such as the inventory of RCN and CSWG projects. Resources described in Chapter 4 of this Regional Conservation Synthesis plus supplemental materials developed as part of the RCN 3.0 Technical Services project will be centralized on one user-friendly web platform.

4.1 OVERVIEW OF REGIONAL ACTIONS

Conservation actions are any activities that manage, protect, enhance, conserve, or restore fish and wildlife or their habitats. These may include habitat or species management, species or site protection, methods of controlling invasive species, species reintroduction and captive breeding, policy changes, and education programs.

The fourteen 2015 Northeast State Wildlife Action Plans (SWAPs) identified and prioritized conservation actions for each state in the region. Those actions served as a framework for the development of priority actions for addressing top regional threats to priority species and their key habitats at the landscape, watershed, and seascape level across the Northeast. These actions ranged from broad, overarching regional steps to be taken across state boundaries over large landscapes, watersheds, or seascapes and affecting multiple taxa (as recommended by the Landscape Conservation Report (AFWA 2021), to finer-scale actions that address individual species, habitats, or locations.

Information was compiled from the 2015 SWAPs, the Regional Conservation Needs (RCN) program, other key regional partners, and data sources that have become available since the 2015 SWAPs. The Northeast Fish and Wildlife Diversity Technical Committee (NEFWDTC) Technical Services project used the NE SWAP Database version 1.0 (TCI and NEFWDTC 2015) to analyze and synthesize this information in its 2017 SWAP Synthesis (TCI and NEFWDTC 2017). With additional input from its Taxonomic Teams, SWAP Coordinators, and Threat Working Groups, the NEFWDTC developed seven overarching regional conservation action themes. These broad regional actions call for developing and providing information on Northeast conservation priorities (Elements 1 and 2), addressing the top regional threats to these priority species and habitats (Elements 3 and 4), then evaluation of those actions to deliver the most effective regional conservation across the region (Elements 5, 6) with coordination and communication interwoven in all elements, but specifically addressed in Elements 7 and 8.

These priority regional actions are:

1. *Develop science-based information and tools to conserve RSGCN and key habitats in the Northeast.*
2. *Conserve Northeast RSGCN and their habitats from habitat loss and degradation by addressing development, natural systems modification, and biological resource use.*
3. *Protect native species and habitats from the introduction and spread of disease and invasive species in the Northeast.*
4. *Conserve aquatic habitats by addressing pollution and aquatic connectivity in Northeast waters.*
5. *Address climate change impacts to Northeast RSGCN and their habitats.*
6. *Coordinate inclusively across state boundaries to maximize efficiency and effectiveness of fish and wildlife diversity conservation in the Northeast.*
7. *Develop and implement effective regional scale monitoring to inform adaptive management of regional priorities and conservation in the Northeast.*

This Regional Conservation Synthesis focuses on the regional actions that were most frequently cited and shared by the states and links these specific actions to the top regional threats summarized in *Chapter 3*. This chapter includes examples of collaborative regional actions that have been implemented by the Northeast State Fish and Wildlife Agencies, NEFWDTC, and partners to address the most important regional threats to address RSGCN and their habitats.

More specific, finer-scale actions for Species of Greatest Conservation Need (SGCN) and their key habitats are described in the 14 Northeast SWAPs (see links to all 14 SWAPS in 4.2.4 of this chapter) and in the Northeast SWAP Database, which will be updated following the 2025 SWAP revisions. They are analyzed in more detail in the 2017 SWAP Synthesis and Limiting Factors reports (TCI and NEFWDTC 2017, 2020a) and in the RCN Grant Program reports[1]. The RSGCN Database will also be revised to include additional information and priority regional actions for the recently updated 2023 RSGCN list.

The 2017 SWAP Synthesis analyzed actions from 14 Northeast SWAPs using the TRACS action classification system (cross-walked to the International Union for the Conservation of Nature's (IUCN's) Conservation Actions Classification Scheme (www.IUCNredlist.org, *Supplemental Information 4*) as recommended by the 2013 lexicon (Crisfield and NEFWDTC 2013). In 2016, Conservation Measures Partnership (CMP)[2] released the Conservation Actions Classification, version 2.0, replacing the CMP and IUCN joint version 1.0 that was released in 2007 and its version 1.1 update of 2008. The classification system allows conservation actions to be classified and categorized in a three-level hierarchical system, organized into these categories: Target Restoration; Stress Reduction Actions, Behavioral Change; and Threat Reduction Actions, and Enabling Condition Actions (CMP 2020). The updated Northeast RSGCN Database is structured to incorporate species-based conservation actions for RSGCN and Watchlist species as information becomes available, consistent with the CMP Conservation Actions Classification system and as recommended by the 2022 Northeast Lexicon for the 2025 SWAPs (Crisfield and NEFWDTC 2022).

4.1.1 PRIORITIZATION OF REGIONAL ACTIONS

Since 2008, the RCN program framework has guided NEFWDTC to strategically develop high priority conservation actions and projects for fish and wildlife diversity across the Northeast (see *Appendix 4A*). While the RCN program provides guidance on conservation priorities, at the time of the last SWAP revisions no comprehensive regional assessment and priority-setting exercise had been conducted.

In 2017, the network of 14 Northeast State Fish and Wildlife Agencies (NEAFWA) addressed this through its NEFWDTC, SWAP Coordinators, Taxonomic Teams, and Threat Working Groups; and with its USFWS partners, worked together to prioritize the top actions identified in the 14 SWAPs. They relied on the SWAP Database and SWAP Synthesis (TCI and NEFWDTC 2015 and 2017) which had identified "top regional actions" as those most frequently cited by the 2015 SWAPs and addressing the largest number of RSGCN and their key habitats. Through a 2017 priority setting exercise, they refined these "Regional Priority Actions" that NEAFWA and their partners could take together to conserve and restore northeast RSGCN and their habitats at the regional scale.

The original Northeast Conservation Synthesis (TCI and NEFWDTC 2013) provided an inventory of regional projects through 2012. Since 2013, almost 100 RCN, CSWG, and SA regional projects have been funded, targeting priority species and habitats, identifying threats and indicators, and developing conservation actions to address them in the form of a diverse toolbox of Best Management Practices (BMPs), protocols, and conservation planning data and tools. Projects developed collaboratively demonstrate NEAFWA's strategic approach in which each project builds on its predecessors to advance a unified, state-driven regional framework for developing and implementing priority regional fish and wildlife conservation. These can be customized to address local efforts to prevent or minimize threat impacts to RSGCN and their key habitats, both terrestrial and aquatic. The most current SWAP and RSGCN, RCN, and key partner information and tools facilitate prioritization of on-the-ground conservation work.

Ongoing prioritization occurs annually. The NEFWDTC, SWAP coordinators, and partners review current RSGCN and key habitat and threat information as updated by taxonomic experts across the region. From this information, new and emerging regional priorities are identified and updated. The NEFWDTC then implements these priorities through RCN, Competitive State Wildlife Grants, and other partners and funding sources on a regional scale. Over the past decade, multiple regional projects have been developed in response to these annual prioritization efforts and to strategic analyses of RSGCN and NEFWDTC efforts. Updating the RSGCN list and working with taxonomic experts across the region to provide up-to-date information on the key needs of these regional priority species helps identify priorities for conservation and funding. These priority needs are then implemented through the RCN program and other key regional funding sources including CSWG.

Regional Priority Actions can be taken at multiple levels or scales. The broad, regional scale, overarching actions are the focus of this chapter. These actions are coordinated across state boundaries at landscape and watershed levels. Tools and projects developed regionally provide the consistent framework to ensure effective implementation at the customized state or local level. Examples and opportunities for implementation at multiple scales are provided for each overarching action in the following sections.

These top seven overarching actions prioritized for the Northeast region address key goals and targets of many partner plans at multiple scales, including the most recent Global Diversity Framework from the Kunming-Montreal Convention on Biological Diversity[3], the National Fish, Wildlife and Plants Climate Change Adaptation Strategy recommendations (National Fish, Wildlife, and Plants Climate Adaptation Network 2021). and reflect a diversity of other partner plans from the global to local scale.

4.1.2 KEY FISH AND WILDLFIE AGENCY PROGRAMS SUPPORTING RSGCN REGIONAL ACTIONS

There are many regional organizations and partners working in conservation across the region (see *Chapter 7* for a more complete list of partners). The key regulatory agency programs have supported significant work over the past decade (primarily RCN, CSWG, and SA that will be referenced throughout this chapter).

Tribal Nations. Twenty-five federally recognized Tribal Nations reside in the Northeast Region, along with the many others that have not received federal recognition. While each Tribal Nation is unique, they all contend with similar challenges, which include the need to protect their sovereignty and self-determination and keep their people safe. As important as Tribal conservation may be, Tribal Leaders must address a wide variety of concerns. Some Tribes have well-developed conservation programs, others may have only one Natural Resource contact, and some do not have any contact person in that position.

Like other federal agencies, the US Fish & Wildlife Service has a trust responsibility to the federally recognized Tribal Nations. The trust responsibility stems from the fact that all places in the United States were Indigenous homelands at one time. Tribal Nations received the government's promise that the Tribes' sovereignty and self-determination would be respected, the Tribes' interests would be protected, and the Tribes would be provided with a land base for their occupation and benefit. Honoring these promises is a perpetual obligation for the federal government. This is the basis of the trust responsibility. The Northeast Region of the U.S. Fish & Wildlife Service works to uphold the trust responsibility in a wide variety of ways. There are many things that the Service is called upon to do with Tribes, or for Tribes, as required by policy or regulation. For anything that the Service funds, permits, or does, the Service considers whether that proposed action has the potential to affect the interests of any federally recognized Tribal Nation. If it does, the Service informs the Tribe listens, to any concerns, and does what is feasible within the Service's authority to address those concerns. The Service's actions may warrant Tribal consultation under the Endangered Species Act, NEPA, National Historic Preservation Act (Sec. 106), and Bald and Golden Eagle Protection Act, among other laws.

In addition to the Service's obligatory relations with Tribal Nations, there are ways that the various programs within the Service can seek partnerships and the alignment of conservation priorities with Tribes. This may involve technical assistance or funding.

Service programs that work with Tribes in the Northeast include Ecological Services, Fisheries and Aquatic Conservation, and the National Wildlife Refuge System. For more than two decades, the Service's Tribal Wildlife Grants Program (TWG) has provided funding for Tribes' conservation projects and capacity-building. TWG is administered by the Service's Wildlife and Sport Fish Restoration program (Tim Binzen and Richard Zane, USFWS Tribal Liaison, pers. comm. 2023).

Federal Fish and Wildlife Agencies. At the federal level, the USFWS and National Maine Fisheries Service (NMFS) have important roles and responsibilities in conserving fish and wildlife, while the Department of Agriculture shares a regulatory role for plants and some invertebrates (mainly insects). The Endangered Species Act provides the framework for addressing the most critically imperiled species. In the Northeast, more than 100 fish, wildlife, and plant species are listed as Threatened or Endangered under the Act, with approximately 75 more scheduled for review. Hundreds of other species are at risk of becoming candidates as well, and for many of these species, prelisting conservation actions may be able to address threats and reverse declines. The many programs of the USFWS address its mission to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people[4].

The USFWS' Wildlife and Sportfish Restoration program administers grant programs that distribute millions of dollars annually to state agencies and Tribes to manage fish, wildlife, and habitats and evaluate and enhance SGCN throughout the region. Since 2008, a portion of the State Wildlife Grant Program funding has been used for competitive grants to encourage interstate collaboration, innovation, and species conservation at larger scales. The Competitive State Wildlife Grants (CSWG) funds can be used for research, fish and wildlife surveys, species restoration, habitat management, and monitoring (see *Appendix 4A*).

The Science Applications program, in coordination with other USFWS programs and state partners, generated a list of 76 Priority At-Risk Species (ARS) representing a diverse array of taxa and habitats from across the Northeast Region where coordinated conservation effort may preclude the need to list these species under the Endangered Species Act (USFW Regional At-Risk Species Coordination Team 2021). Eleven At-Risk teams recently formed to address species or multi-species groups. Each At-Risk Team works together with partners to carry out a variety of conservation actions, including habitat management, species and habitats surveys, development of conservation strategies, propagation, and research.

State Fish and Wildlife Agencies. At the state level, the 14 Northeast State Fish and Wildlife Agencies (NEAFWA) regulate and are charged with the conservation of fish and wildlife. NEAFWA's Northeast Fish and Wildlife Diversity Technical Committee (NEFWDTC) is specifically charged with guiding regional efforts in fish and wildlife diversity. An important regional funding source to implement conservation is the Regional Conservation Needs Program. Since 2008, the thirteen NEAFWA states and the District of Columbia have contributed 4% of their annual federal State Wildlife Grants (SWG) Program funding to support projects of regional conservation interest. This funding is offered through an annual request for proposals administered by the NEAFWA[5] in collaboration with the WMI and USFWS. The funds are used to address conservation priorities that are shared across multiple jurisdictions.

Funding priorities for the Northeast RCN Grant Program continue to evolve, as many of the initial priorities have already been funded and are reported in this document. The RCN program practices adaptive management, refining priorities and selecting topics for funding that responds to urgent emerging wildlife needs, while at the same time continuing to address longstanding regional conservation concerns and keeping common species common. Details about the specific funding priorities addressed during each RCN grant cycle are available at the RCN website[1].

4.1.3 REGIONAL NEAFWA RCN AND USFWS CSWG AND SA PROJECTS FUNDED IN THE PAST DECADE

Projects completed over the past decade are listed in Table 4.1.1, with information on their funding source, the SWAP Elements/Chapters they address, and an active link to summaries in this chapter. The summary of each project is presented within one of the seven actions that it most directly addresses (as indicated in the Table 4.1.1). Many of these agency projects overlap to supplement each other and address more than one of the seven overarching actions and SWAP Elements. Therefore, they have been grouped or combined if supplemental or sequential. *Appendix 4A* provides a list of all RCN, CSWG, SA key regional projects and the SWAP elements that they address from 2007-2023. This Chapter provides summaries for projects implemented since the 2013 Synthesis. In section 4.2 they are organized by the kind of information or tool and SWAP element they address (see Table 4.1.1).

Table 4.1.1 Collaborative RCN, CSWG, and SA projects that address the regional conservation of RSGCN and key habitats. See *Appendix 4B* or www.northeastwildlifediversity.org for additional information on these projects. Click on the project name to go directly to the summary.

Project Name	Funding Program	Species	Habitats	Threats	Info, Tools 1	Development 2	Disease & Invasive 3	H20 quality Connectivity 4	Climate 5	Coordinate 6	Monitor 7	Research	BMPs protocols
Regional Project Title by Taxa and Topic	**X1**-indicates the primary action (1-7) addressed and the section located in this chapter). Note live links take you to the appropriate section by clicking on the project title. X indicates additional actions and SWAP elements addressed by each project.												
Northeast Regional Conservation Synthesis	RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Northeast Lexicon for SWAP Revisions	RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Northeast SWAP Comprehensive SGCN List	RCN	X			X1								
Northeast Regional Species of Greatest Conservation Need List	RCN	X			X1								
Northeast SWAP Database	RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Modernizing the Northeast Wildlife Action Plan Database	CSWG	X	X	X	X	X	X	X	X1	X	X	X	X
RSGCN Database	RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Northeast SWAP Synthesis	RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Northeast RSGCN Key Limiting Factors Report	RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Five-Factor Analysis	RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Mammals													

Project Name	Funding Program	Species	Habitats	Threats	Info, Tools 1	Development 2	Disease & Invasive 3	H20 quality Connectivity 4	Climate 5	Coordinate 6	Monitor 7	Research	BMPs protocols
Allegheny Woodrat Recovery	RCN	X	X	X	X1		X		X	X	X	X	X
Bats and White-Nose Syndrome	CSWG, RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Gating Caves for Bat Conservation and Protection	RCN	X	X	X	X1	X	X	X	X	X	X		X
New England Cottontail Initiative and Conservation Strategy	CSWG, SA, RCN	X	X	X	X	X	X1	X	X	X	X	X	X
Bat Research in Maryland	CSWG	X	X	X	X1	X	X	X	X	X	X	X	X
Motus 1-3: Identifying Landscape-scale Habitat Use of Multiple SGCN in the Mid-Atlantic Region Using Nanotag Technology	CSWG	X	X	X	X1	X	X	X	X	X	X	X	X
Birds													
Eastern Black Rail projects	RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Restore Eastern Black Rail habitat	CSWG, RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Bird Assessment and Monitoring Standard Operating Procedures	RCN	X	X		X	X	X	X	X	X	X1	X	X
The Conservation of Tidal Marsh Birds: Guiding action at the intersection of our changing land and seascapes	RCN, CSWG, ARS	X	X	X	X	X1	X	X	X	X	X	X	X

Project Name	**Funding Program**	**Species**	**Habitats**	**Threats**	**Info, Tools 1**	**Development 2**	**Disease & Invasive 3**	**H2O quality Connectivity 4**	**Climate 5**	**Coordinate 6**	**Monitor 7**	**Research**	**BMPs protocols**
Testing Salt Marsh Restoration Practices for Saltmarsh Sparrow Conservation	CSWG, ARS	X	X	X	X	X	X	X1	X	X	X	X	X
Distribution and demography of saltmarsh sparrows in the understudied, southern extent of the species' breeding range	CSWG	X	X	X	X	X	X	X	X1	X	X	X	X
Atlantic Coast Beach and Shorebirds (American Oystercatcher, Ruddy Turnstone, and Whimbrel)	CSWG, SA	X	X	X	X1	X	X	X	X	X	X	X	X
Forest Songbirds (Golden-winged Warbler, Cerulean Warbler, Wood Thrush)	SA	X	X	X	X1	X	X	X	X	X	X	X	X
CSWG Eastern Shore Initiative	CSWG		X	X		X1							
Best Management Practices for RSGCN In Northeast Forests	RCN	X	X	X	X	X1	X	X	X	X	X		X
Implementing Bird Action Plans for Shrubland Dependents in the Northeast	RCN	X	X	X	X	X1							

Project Name	**Funding Program**	**Species**	**Habitats**	**Threats**	**Info, Tools 1**	**Development 2**	**Disease & Invasive 3**	**H2O quality Connectivity 4**	**Climate 5**	**Coordinate 6**	**Monitor 7**	**Research**	**BMPs protocols**
Establishing a Regional Initiative for Biomass Energy Development for Early-Succession SGCN in the Northeast	RCN	X	X	X	X	X1							X
Reptiles and Amphibians													
Distribution and Conservation Status of Newly Described Leopard Frog Species	RCN	X	X		X1	X	X	X	X	X	X	X	
Northeast Regional Frog Monitoring	RCN	X	X		X	X	X	X	X	X	X1	X	
Conservation Plan for Blanding's Turtle and Associated Wetland-Dependent SGCNs projects	RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Status Assessment and Conservation Plan for the Eastern Box Turtle	RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Implementation of The Bog Turtle Conservation Plan for The Northern Population, With Benefits to Associated Headwater Wetland SGCN	RCN, CSWG, ARS	X	X	X	X1	X	X	X	X	X	X	X	X

Project Name	Funding Program	Species	Habitats	Threats	Info, Tools 1	Development 2	Disease & Invasive 3	H2o quality Connectivity 4	Climate 5	Coordinate 6	Monitor 7	Research	BMPs protocols
Creating a comprehensive conservation and management plan for the southern lineage of the Bog Turtle and its associated habitats	CSWG, RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Spotted Turtle Conservation	CSWG, RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Conserving Vermont's spotted turtles	CSWG	X	X	X	X1	X	X	X	X	X	X	X	X
Wood Turtle Conservation Plan	CSWG, RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Conservation Planning and Implementation for the Wood Turtle an Associated Riparian SGCN	RCN, CSWG	X	X	X	X1	X	X	X	X	X	X	X	X
Population Declines Due to Loss of Adult and Juvenile Turtles to Illegal Wildlife Trade	CSWG, ARS	X	X	X	X1	X	X	X	X	X	X	X	X
ARS Program efforts for the Northeast Turtles (Blanding's, Spotted, and Wood Turtle) Conservation	ARS	X	X	X	X1	X	X	X	X	X	X	X	X

Project Name	Funding Program	Species	Habitats	Threats	Info, Tools 1	Development 2	Disease & Invasive 3	H20 quality Connectivity 4	Climate 5	Coordinate 6	Monitor 7	Research	BMPs protocols
Hellbender Population Assessment and Protocols	RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Conservation Strategy for the Northern Diamondback Terrapin	RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Ranavirus in Amphibian Populations	RCN	X	X	X	X	X	X1	X	X	X	X	X	X
Timber Rattlesnake Population Assessment	RCN	X	X	X	X1	X	X	X	X	X	X	X	
Snake Fungal Dermatitis in New England Timber Rattlesnakes	RCN	X	X	X	X	X	X1	X	X	X	X	X	X
Conserving Snake Species of Greatest Conservation Need Threatened by an Emerging Fungal Skin Disease	CSWG	X	X	X	X1	X	X	X	X	X	X	X	X
Invertebrates													
Bee Pollinators in NJ	CSWG	X	X	X	X1	X	X	X	X	X	X	X	X
Pollinator Habitat in Xeric Grasslands, Barrens, and Woodlands	RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Bee, Moth, and Vegetation Monitoring	RCN	X	X	X	X	X	X	X	X	X	X1	X	
Pine Barrens Species Conservation	SA	X	X	X	X1	X	X	X	X	X	X	X	X

Project Name	Funding Program	Species	Habitats	Threats	Info, Tools 1	Development 2	Disease & Invasive 3	H2o quality Connectivity 4	Climate 5	Coordinate 6	Monitor 7	Research	BMPs protocols
Farmland Pollinators (Monarch, American and Yellow-banded Bumblebee, Ashton's, Lemon, and Variable Cuckoo Bumble Bee)	SA	X	X	X	X	X	X	X1	X	X	X	X	X
Mountain Butterflies (White Mountain Arctic, White Mountain Fritillary)	SA	X	X	X	X	X	X	X1	X	X	X	X	X
Best Management Practices for Wetland Butterflies	RCN	X	X	X	X1	X	X	X	X	X	X	X	X
Status Assessment of Northeast Land Snails and Invertebrate Database	RCN	X	X		X1	X	X	X	X	X	X	X	
Conservation Assessment of Odonata in the Northeast	RCN	X	X	X	X1	X	X	X	X	X	X		
Other Terrestrial projects													
Regional Focal Areas for Species of Greatest Conservation Need Based on Site Adaptive Capacity, Network Resilience and Connectivity	RCN		X	X	X	X		X	X1	X	X		

Project Name	**Funding Program**	**Species**	**Habitats**	**Threats**	**Info, Tools 1**	**Development 2**	**Disease & Invasive 3**	**H2O quality Connectivity 4**	**Climate 5**	**Coordinate 6**	**Monitor 7**	**Research**	**BMPs protocols**
Staying Connected in the Northern Appalachians	CSWG	X	X	X	X1	X	X	X	X	X	X	X	X
Impact of Climate Change on SGCN	RCN	X	X	X	X			X	X1	X	X		
Integrating Vulnerability Science into a Strategic Conservation Plan for Maine's Species of Greatest Conservation Need	CSWG	X	X	X	X1	X	X	X	X	X	X	X	X
Updating Vermont's 2025 Action Plan with Vermont Conservation Design	CSWG	X	X	X	X	X	X	X	X1	X	X	X	X
Pennsylvania's SWAP Prioritization and Mapping Enhancements	CSWG	X	X	X	X	X	X1	X	X	X	X	X	X
Aquatic Projects													
Determining the Effects of Landlocked Alewives on Anadromous Alewife Restoration	RCN	X	X	X	X		X	X1	X	X	X	X	X
Chesapeake Logperch projects	CSWG, ARS	X	X	X	X	X	X	X	X	X	X1	X	X
Freshwater Mussels	RCN, CSWG	X	X	X	X1	X	X	X	X	X	X	X	X

Project Name	Funding Program	Species	Habitats	Threats	Info, Tools 1	Development 2	Disease & Invasive 3	H_2O quality Connectivity 4	Climate 5	Coordinate 6	Monitor 7	Research	BMPs protocols
Freshwater Mussels (Brook Floater, Cumberland Moccasinshell, Pheasantshell, Tennessee Clubshell, Tidewater Mucket, Yellow Lampmussel)	RCN, CSWG, SA	X	X	X	X1	X	X	X	X	X	X	X	X
Diadromous Fishes Conservation (Alewife, Blueback Herring)	SA	X	X	X	X1	X	X	X	X	X	X	X	X
An Interactive, GIS-Based Application to Estimate Continuous, Unimpacted Daily Streamflow at Ungauged Locations in the Connecticut River Basin	RCN		X	X	X			X1	X		X		X
ELOHA Framework in the Great Lakes Drainage	RCN		X	X	X			X1	X		X		X
The Gulf of Maine Coastal Marine Ecosystem Survey	CSWG	X	X	X	X	X1	X	X	X	X	X	X	X
Terrestrial and Aquatic Habitat Classification Systems, Assessments and Guides	RCN	X	X	X	X	X	X	X1	X	X	X	X	X

4.2 DEVELOP SCIENCE-BASED INFORMATION AND TOOLS TO CONSERVE RSGCN AND THEIR HABITATS

4.2.1 REGIONAL NEED AND PRIORITY ACTIONS

Regional Need: The 2005 and 2015 Northeast SWAPs identified data deficiency as a limiting factor in the effective conservation of SGCN and their habitats in their states. They identified species and habitats of greatest conservation need, but differences in available data, capacity, and approaches to prioritization posed a further challenge to collaborative, regional conservation. Many of the SWAP SGCN and RSGCN/Watchlist species lack the current, consistent status, habitat, threat, and other information needed to inform effective conservation in the Northeast.

Priority Actions: Identify and develop regionally consistent information and priorities for species, key habitat, threats including climate vulnerability. Develop and apply targeted and inclusive communication of NEFWDTC priorities and products (from SWAPs, RCN, and key partners) to inform and guide regional conservation planning and incorporate into partner plans at all levels. Strategically focus "on-the-ground" conservation actions for regional habitat and species priorities by providing incentives, science-based best practices, techniques, tools, and information on land and water conservation to conserve RSGCN and their habitats.

See Priority Species in Chapter 1, Priority Habitats in Chapter 2, Priority Threats in Chapter 3, each with partner and program opportunities and examples. See Table 4.1.1 and Appendix 4A for priority projects completed and Appendix 4B, the SWAP Synthesis, and individual SWAPs for additional priority Conservation Actions.

Each Northeast State revises its plan every ten years and can be accessed through the respective **Northeast SWAP Website links:**

- Connecticut
- D.C.
- Delaware
- Maine
- Maryland
- Massachusetts
- New Hampshire
- New Jersey
- New York
- Pennsylvania - Fish
- Pennsylvania - Game
- Rhode Island
- Vermont
- Virginia
- West Virginia

4.2.2 APPROACH

The Northeast RSGCN list, first developed in 1999 and updated in 2013, 2018, and 2023 is maintained by the Northeast Association of Fish and Wildlife Agencies' Northeast Fish & Wildlife Diversity Technical Committee. As a non-regulatory regional list, its purpose is to provide focus, resources, and collaboration to secure species (and their habitats) of mutual conservation concern for current and future generations in the Northeast. Northeast RSGCN are species for which the region has stewardship responsibility due to their high conservation concern status and populations centered in the region. The 2023 list includes 20 taxonomic groups of vertebrate and invertebrate Species of Greatest Conservation Need derived from Wildlife Action Plans in the NEAFWA planning region. The list is updated every five years to support focused action on high priority Northeast species by the NEFWDTC, development of future SWAPS, and conservation planning and implementation by state fish and wildlife agencies and their partners.

The RSGCN list provides a framework and focus for consistent regional conservation of high priority fish and wildlife species and their habitats, and for identifying and addressing their key threats and vulnerabilities. It includes species that are globally or regionally imperiled and for which the Northeast Region has conservation responsibility. The process for selecting RSGCN is transparent and repeatable, relying on a broad set of well-accepted conservation assessments that cross taxonomic groups (TCI and NEFWDTC 2022). The RSGCN list is used by states and partners to facilitate coordinated conservation action across the region; see *Chapter 1* and the NEFWDTC website[1] for more information on the most current list and RSGCN Database version 1.0 (TCI and NEFWDTC 2023).

The SWAP Database version 3.0 (TCI and NEFWDTC 2020a) compiles specific status, habitat, threats and actions for SGCN and RSGCN from the 14 2015 Northeast SWAPs. It is a repository and a source of SGCN information that is searchable at the regional, subregional, or state level. As the RSGCN Database provides information on priority regional species, the SWAP Database provides broader information on SGCN for each state. The Northeast Fish and Wildlife Diversity website[1] highlights this and other information and tools developed for fish and wildlife diversity conservation over the past decade by the NEFWDTC and its partners.

These resources then inform regionally consistent information and approaches for implementation to effectively address the top regional threats in the Northeast. This Regional Conservation Synthesis applies the 14 SWAP conservation priorities at the regional scale. Additional partner information on regional priorities was referenced and considered in the identification of RSGCN, including USFWS Threatened, Endangered and At-Risk species[6], ECOS website[7] or the ESA page[8], the US Forest Service Sensitive Species[9], NRCS lists of focal species[10], and NatureServe[11].

This state-based SWAP information on regional conservation priorities should be provided and incorporated into planning and regulatory efforts at the local, state, and regional scales. SWAPS/SGCN and RCN/RSGCN serve as valuable resources that can be incorporated into many planning efforts that are required or urged to consider information on fish and wildlife diversity. This includes the State Forest Action Plans, State Comprehensive Outdoor Recreation Plans, USFWS Comprehensive Conservation Plans for National Wildlife Refuges, US Forest Service National Forest Plans, Integrated Natural Resource Management Plans for Department of Defense lands, NRCS Farm Bill projects, and Tribal Wildlife Action Plans, among many others. Planning that occurs at the local level (e.g., county comprehensive plans), the planning district level, or for state-level infrastructure, energy, transportation, and other relevant planning efforts should also ensure that wildlife conservation has been considered in any activities that impact regional and state priority species or their habitats. Additional regulatory and planning efforts, including all federal regulatory departments and agencies, should utilize these data and tools in their standard operating procedures for planning and regulation.

Local, state, and regional partnerships and plans offer a holistic approach to conserving SGCN and RSGCN species and their habitats. In conjunction with restoration tools developed by regional partners, these efforts also support on-the-ground conservation of RSGCN and associated habitats in the region. Effective partnerships and actions include working with existing partners' programs and developing new programs, incentives, and tools relevant to SWAP/RSGCN priorities.

The NEFWDTC incorporates updated information on species, habitats, threats, and actions into its established communication process for internal prioritization. It also shares this information externally with partners to expand conservation efforts and develop the most effective means to address needs and threats. This reinforces the value of the NEFWDTC's RCN process, which seeks to identify and regularly update Northeastern fish and wildlife diversity conservation priorities and issues raised by states and their partners. The information can then be used to inform each iteration of the RCN project funding, identifying the best match of partner roles and capacity to maximize effectiveness, and cast a wider conservation footprint across the region.

4.2.3 PROJECTS PROVIDING INFORMATION AND TOOLS ON REGIONAL PRIORITIES

Appendix 4A provides a list of projects that have advanced the conservation of regional species and habitats through the RCN program and other key regional funding initiatives together with the SWAP elements that they address from 2007- 2023. This Chapter provides a list and summaries for those projects implemented since the 2013 Synthesis. In this section, projects are organized by the kind of tool or information and the SWAP element(s) they address (see Table 4.1.1 for list with links and *Appendix 4A* for all projects).

Partner use of these data and tools expands conservation effectiveness throughout the region, providing for more consistent implementation, monitoring, and evaluation of priority regional conservation targets identified by State Wildlife Action Plans[1].

REGIONAL INFORMATION ON PRIORITY SPECIES AND HABITATS

As part of the strategic development of sequential information and tools for states to work together at the regional landscape and watershed level, the following RCN projects specifically support SWAP revisions and NEFWDTC charges. The NEFWDTC Technical Services contractor (TCI) compiled, analyzed, and synthesized a vast amount of information on almost 20,000 species in the Northeast and conducted reviews of species, habitats, threats, and actions identified in the 14 State Wildlife Action Plans. This assisted state agencies in determining regional species and habitats of greatest conservation need; threats within the region; and actions that could be taken to limit the impact of these threats regionwide. Once these priorities were identified, the RCN program then funded a series of technical analyses, reports, and products, including the RSGCN list, Habitat Condition Assessment, Northeast Lexicon, Regional Synthesis, SWAP Synthesis, Northeast SWAP Database, RSGCN Database and website, and at least 70 additional projects providing information on these regional priorities. All are available on the NEFWDTC website and are summarized below.

Northeast Regional Conservation Synthesis (2013 and 2023) (RCN). To support the 2015 and 2025 SWAP revisions, syntheses of the most current and best available information on the Eight Essential SWAP Elements were produced. These documents provided current regional data and project summaries on species, habitat, threats, actions, monitoring, and partner/stakeholder information most relevant to fish and wildlife diversity, especially RSGCN across the Northeast (TCI and NEFWDTC 2013 and 2023). The documents were organized by SWAP Element to provide the regional context for individual state plans for each of those elements. The new 2013 RSGCN lists were presented along with summaries of the ongoing conservation work by states and their partners. These projects were funded through the RCN and CSWG programs to fill critical data gaps and address conservation needs for the species given high priority by the NEFWDTC representing all 14 SWAPs.

Northeast Lexicon for SWAP Revisions (2013 and 2022) (RCN). Differences in the language used in the 2005 SWAPs spurred the NEFWDTC and SWAP Coordinators to work together to develop the Northeast Lexicon – a set of terminology conventions and a common data framework for SWAPs (Crisfield and NEFWDTC 2013 and 2022). The lexicon addressed the SWAP Elements- species, habitats, threats, actions, and monitoring and provided common classification systems and a common data framework based on the NE SWAP and RSGCN databases. The Northeast Lexicon improves inter-state communication, facilitating regional planning processes by helping states compare species, habitats, threats, actions, and monitoring for collaborative opportunities.

Northeast SWAP Comprehensive SGCN List 2015 (RCN). In 2015, NEAFWA's Northeast Fish and Wildlife Diversity Technical Committee consolidated all 14 SWAP SGCN lists, setting the stage for compilation of species, habitats, threats, and actions data into the Northeast Regional SWAP Database. This facilitated the RSGCN process as well as the NE SWAP and RSGCN Databases.

Northeast Regional SWAP Database version 3.0 (2020b) (RCN). To support State Fish and Wildlife Agencies' efforts to identify regional priorities through access to data contained in the 14 Northeast SWAPs, NEFWDTC's compiled key information from the 14 Northeast SWAPs in a streamlined, searchable database which in turn provided state agencies and their partners with easy access to this information through simple queries and reports (TCI and NEFWDTC 2020b). This also helped in compiling the next RSGCN list while also identifying region-wide patterns and priorities that encouraged states to work together on the shared priorities identified in their SWAPS.

The current CSWG project includes updating and web enabling the database for improved accessibility and use. A CSWG project supported **Modernizing the Northeast Wildlife Action Plan Database beginning in 2023.** Building on prior achievements of the first version of the Northeast SWAP database, the NEAFWA states propose to upgrade this important regional tool to a web-based database to increase accessibility and analytical functionality to proactively address growing resource concerns and facilitate landscape-scale conservation. The database development will be completed in 2026. This work will be guided by a Steering Committee of the NEFWDTC SWAP Coordinators working with contractors and staff who will help ensure a fully functional, user friendly and accessible web platform and interactive product.

Northeast SWAP Synthesis (2017) (RCN). Once the SWAP Database was completed in 2016, NEFWDTC/TCI began an unprecedented compilation of all 14 State

Wildlife Action Plans (SWAPs) in the Northeast Region. TCI compiled and analyzed these data to find common threats to RSGCN and their habitats, determine common conservation actions, and identify actions that could be implemented through regional collaboration and coordination. Recently completed RCN projects set the stage for the compilation and analyses of species, landscapes, threats, and actions data into the Northeast Regional SWAP Database. The SWAP Synthesis report summarizes the database analysis of threats to SGCN and their habitats along with regional conservation priorities and recommendations for collaborative action (TCI and NEFWDTC 2017).

Northeast Regional Species of Greatest Conservation Need List (1999, updated 2013, 2018, and 2023) (RCN). NEFWDTC updates its RSGCN list every five years to identify current regional priority conservation targets. The RSGCN list was first developed in 1999 (Therres et al. 1999) and is maintained by NEFWDTC. It is a non-regulatory regional framework whose purpose is to provide focus, resources, and collaboration in securing species and their habitats for current and future generations in the Northeast. The 2023 list includes 20 taxonomic groups of vertebrate and invertebrate SGCN from SWAPs in the NEAFWA planning region. Northeast RSGCN are species for which the region has stewardship responsibility due to high conservation concern and/or populations that are centered in the Northeast Region. The list is updated every five years to support focused action on high priority Northeast species by the NEFWDTC, development of SWAPS, and conservation planning and implementation by state fish and wildlife agencies and their partners. (See *Chapter 1* and the NEFWDTC website for more information on the most current list).

Northeast RSGCN Key Limiting Factors Report (2020a) (RCN). The 2015 SWAPs identified threats to the state SGCN in the Northeast. The SWAP Database compiled these threats using the classification system outlined in the Lexicon in order to synthesize information at a regional level. However, linkages explaining why threats were responsible for the decline of species or degradation of habitats were not always clear. The Northeast Lexicon builds on the Conservation Measures Partnership threat classification system, which identifies direct threats to species and habitats, but does not capture indirect or amplifying threats (e.g., climate change, shifts in food availability, or predator-prey relationships). Additional data fields were added to the SWAP database to capture these indirect and amplifying threats, called limiting factors. The 2019 RSGCN limiting factors RCN project used these data to better explain how threats impact populations and habitat. The limiting factors were organized in four groups: 1) habitat use and condition factors; 2) migration and wintering strategies; 3) food needs; and 4) vulnerabilities due to reproduction or survivorship. For details see Northeast RSGCN Key Limiting Factor Themes Report (TCI and NEFWDTC 2020a) and *Chapter 3*.

RSGCN Database (2023 version 1.0) (RCN). The RSGCN database, previously part of the NE SWP Database, was created as a stand-alone database to more efficiently address the amount of information and focus of its contents. The information it includes is linked to the NE SWAP database by species ID, and includes state and partner data, RSGCN and conservation status, previous RSGCN lists, partner prioritization, habitat, threats, actions, limiting factors, etc. It is managed as a separate tool from the SWAP database because it encompasses all Northeast species (including non-SGCN), 5yr vs 10yr update, regional vs state lens). The database continues to be updated, as part of the RCN 3 project, and will be available on the NEFWDTC website.

RESEARCH, SURVEY, ASSESSMENT, OR MONITORING INFORMATION AND TOOLS

Five-Factor Analysis (RCN). An important RCN project was developed in 2015 to inform and expedite the federal workplan and listing process. Since 2010, the USFWS has received numerous listing petitions for potentially imperiled species. More than 25% of the species on the current Federal Listing Workplan occur in at least one state in the NEAFWA service region. Many of these species have been included as SGCN in one or more State Wildlife Action Plans developed by NEAFWA state members. A preliminary evaluation by state fish and wildlife agencies in the Northeast identified several species for which federal protection under the Endangered Species Act was potentially not warranted. Frequently, species of lower conservation concern can be precluded from listing if relevant data are compiled, and necessary conservation actions applied. The objective of this project was to facilitate state input and engagement in the USFWS listing process by synthesizing existing state and regional information. It uses the "five-factor analysis" approach of the USFWS applied to selected species for which substantial information is already available. The goals are to support ongoing conservation action and reduce the likelihood of federal listing (Klopfer 2016).

Five-factor status reviews were created for Little Brown Bat (*Myotis lucifugus*), Northern Red-bellied Cooter (*Pseudemys rubriventris*), Popeye Shiner (*Notropis ariommus*), and Chesapeake Logperch (*Percina bimaculata*). By providing this information in a form that can be readily used by the federal Endangered Species review team, the NEAFWA states can facilitate and/or potentially accelerate listing decisions for these four species of relatively low conservation concern and decrease the time needed for agency staff to respond to Service requests for information. Multiple benefits include the reduction of state and federal agency staff time needed for Section 7 compliance reviews for all WSFR funded grants.

Allegheny Woodrat Recovery (2013) (RCN). The objectives of this RCN project were to determine interactions between Allegheny Woodrat (*Neotoma magister*) populations and forest dynamics, to determine incidence of raccoon roundworm (*Baylisascaris procyonis*) parasite load in raccoon feces; to conduct population analysis based on previous mark/recapture data; and to compare the relative efficacy of live trapping vs. remote cameras for detecting presence of Allegheny Woodrats. The study estimated populations at the six long-term monitoring sites. Results suggest that woodrat populations exist at low densities, are continuing to decline in western Maryland, and that certain sites represent critical habitat. These long-term monitoring sites are also considered to be some of the best strongholds for Allegheny Woodrat populations in western Maryland. Low population densities, continued declines in population, and the possible genetic consequences of interbreeding due to low populations put into question the species' long-term viability in the state (Duda et al. 2016, Pearce et al. 2016).

Motus 1-3: Identifying Landscape-scale Habitat Use of Multiple SGCN in the Mid-Atlantic Region Using Nanotag Technology (2018, 2019, 2022) (CSWG). This project provides: 1) geographic and temporal data on migration; 2) full life cycle data to inform habitat management and conservation action decisions for SGCN; 3) corroboration of recent modeling based on NEXRAD radar data identifying high-use migratory stopover sites; and 4) expansion of telemetry monitoring network by adding 46 automated telemetry receiving stations. In 2019, CSWG supported Motus II: Using Nanotag Technology to Identify Landscape-scale Habitat Use of Multiple SGCN in New England. The project will provide these data outputs with an additional focus on American Kestrel (*Falco sparverius*) and Monarch butterfly (*Danaus plexippus*), with full life cycle data to inform habitat management and conservation action decisions for SGCN, provide new data on detection distances to optimize tower construction and placement for species tracking, and expand the telemetry monitoring network by adding 50 automated telemetry receiving stations. The Motus project contributes significantly to landscape- scale monitoring of migratory species in the region. Motus III: PA and VT Portion of Identifying SGCN Habitat Use Across Multiple Scales Throughout the Eastern U.S. Using the Motus Wildlife Tracking System expanded and employed Motus receiving stations to detect animal movements and determine where stopover habitats are, where populations are breeding, and where they are migrating and wintering. Additionally, the Project expanded the telemetry monitoring network by adding 35 automated telemetry receiving stations across West Virginia, Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Connecticut, Delaware, Maine, Maryland, Massachusetts, Pennsylvania, New Hampshire, New Jersey, New York, Rhode Island.

Bat research in Maryland (2017) (CSWG). This project sought to further understand bat status and distribution in the region. Significant Results include recovering tens of thousands of single-nucleotide polymorphisms (SNPs) reliably across each species and finding that the Genotype-by-sequencing (GBS) approach produces highly repeatable results without batch effects. Population structure results were generally consistent for all methods employed. Analyses more capable of detecting gradients showed east-west differentiation for Silver-haired Bats (*Lasionycteris noctivagans*), but such gradients were not apparent for Eastern Red Bats (*Lasiurus borealis*) and Hoary Bats (*L. cinereus*). Coalescent modeling of effective population size indicated historic population expansion. The current effective population is larger for Eastern Red Bats and Hoary Bats than for Silver-haired Bats. While other studies have performed genetic and genomic analyses on long-distance migratory bat species, this research was the first to do so across the species' ranges. Including dozens of sites across North America confirmed the panmictic nature of eastern red bats and hoary bats and detected an east/west split in silver-haired bat population structure. This study greatly increased the coverage across each species' range, though samples from some regions were sparse. Population estimates do not exclude the possibility—suggested by existing population models—that some of these species are at risk for extinction, causing concern about the long-term viability of tree-roosting bats. Genetics is a valuable tool to detect population structure and inform managers of potential subpopulations. Other methods, such as the standardized acoustic surveys conducted by the NABat program, may be better able to detect current population changes in these species.

Eastern Black Rail Assessment and Conservation Plan (2016) (RCN). The Eastern Black Rail (*Laterallus jamaicensis jamaicensis*) is considered one of the most endangered birds in the Northeast region of the U.S. and along the Atlantic Coast. Populations in the Northeast have declined by 85% since 1992, and this species now breeds in no more than a dozen locations per state within its breeding range (Watts 2016). RCN program funds partially supported the creation of a Status Assessment and Conservation Action Plan for the Black Rail across the Northeast planning region. Specifically, the funds supported collection of information from an established consortium of agencies, biologists, academic institutions, and land managers represented on the Eastern Black Rail Conservation and Management Working Group[12]; a value-added synthesis of this information; and development of action items needed for a successful conservation campaign. The final products include a Status Assessment report updated in 2016 which is available the NEFWDTC website.

A project to create and **Restore Eastern Black Rail Habitat (2020) (CSWG)** at six non-tidal freshwater wetlands on Maryland's Eastern Shore was funded through CSWG. Following recommendations from the conservation plan, this project aimed to shift the population to non-tidal habitats that are safe from the threat of sea level rise in order to help stabilize and grow the population. These efforts continue to create ideal conditions to attract and retain Eastern Black Rails in two different settings, creating a complex of wetlands in an area that has historically supported Black Rails.

Testing Salt Marsh Restoration Practices for Saltmarsh Sparrow Conservation. (2020) (CSWG and SA). The Saltmarsh Sparrow (*Ammospica caudacuta*) has experienced dramatic population loss caused by nest and deteriorating conditions in tidal marshes throughout the North Atlantic coast. The purpose of this project is to test a variety of management techniques designed to protect and restore salt marsh habitat. This project will identify the best strategies to be employed in salt marsh habitat restoration, and advance efforts to conserve the imperiled saltmarsh sparrow and other salt marsh dependent birds.

Distribution and demography of Saltmarsh Sparrows in the understudied, southern extent of the species' breeding range (2022) (CSWG). Another C-SWG project will determine the breeding status and distribution of Saltmarsh Sparrows in Virginia for the purpose of developing and evaluating state-level management actions for this Tier IIIa Species of Greatest Conservation Need (SGCN). The species is under review for federal listing and the information gained from this project will help inform the development of recovery criteria and actions, especially for the southernmost extent of the species' breeding range. Distribution and demography of saltmarsh sparrows in this portion of the species' breeding range will be clarified.

Conservation of Tidal Marsh Birds: Guiding action at the intersection of our changing land and seascapes (2010) (CSWG). The goal of this initiative was to provide the information necessary for all states along the New England and Mid-Atlantic Coast (Bird Conservation Region (BCR) 30) to protect regionally important habitats for tidal marsh birds (including direct actions for 26 SGCN). The project's long-term goal is to provide a regionally consistent platform for tidal marsh monitoring in the face of anticipated sea-level rise and upland/watershed development. This Competitive State Wildlife Grant supports work done in Maryland and Virginia that contributes to the Regional Conservation Needs grant awarded in 2010.

Identification of Tidal Marsh Bird Focal Areas in BCR 30 (2013) (RCN). This project conducted bird surveys using both passive and broadcast point count methods along tidal marshes in Maryland and Virginia, recording all bird species detected by sight and sound. In 2011, 398 points were surveyed spanning the Delmarva coastline of Maryland and Virginia and a few sites on Virginia's western Chesapeake Bay coastline. A total of 143 bird species in Maryland and 151 species in Virginia were observed from 273 points surveyed in April to June 2011-2012. Spatial patterns of abundance among 14 marsh bird species were similar in both years. Vegetation data were collected at 261 sample points according to the standardized protocol for the associated RCN project in

2011 and at 256 sample points in 2012. Vegetation data collected at each point included cover classes for local plant communities, the presence of invasive species, percent cover of 1-4 dominant species, and percent cover of pannes/pools/creeks, open water, upland, and wrack. Dead snags were counted in each plot and the tide cycle during data collection was noted. All bird survey and vegetation plot data were submitted to the RCN grant partners for incorporation into the final regional analyses. Final regional maps, estimates of changes in distribution and abundance, and critical areas for long-term protection were determined (Shriver et al. 2012).

The Eastern Shore Initiative (2021) (CSWG). This project protected a total 4,561 acres including 3,885 acres of nationally declining wetland types, 2,435 acres of palustrine forested wetlands, 1,082 acres of palustrine shrub/scrub, 363 acres of palustrine emergent, and 5 acres of estuarine emergent and estuarine forested wetlands located in Accomack County, Virginia. Portions of this acreage will be added to the 5,574 acres currently in the Saxis Wildlife Management Area (WMA), contributing significant habitat to this important migratory bird staging area and preventing the encroachment of potentially damaging residential development. This important land acquisition project enhances the value of other nearby Wildlife Management Areas. Saxis WMA and other state-owned management areas on the Eastern Shore (Virginia and Maryland) are also premiere mid-Atlantic migration and wintering areas for wildlife, as well as destinations for outdoor recreation and viewing opportunities.

Bird Assessment and Monitoring Standard Operating Procedures (2009) (RCN). The RCN program funded the Development of Avian Indicators and Measures for Monitoring Threats and Effectiveness of Conservation Actions in the Northeast. Northeast regional monitoring procedures are now available for birds of grasslands, tidal marshes, and mountain forest habitats that span the northeastern landscape, contain a high percentage of vulnerable species, and encompass the region's major management issues. These coordinated bird monitoring programs can measure region-level threats and management impacts on target birds and habitats identified by SWAPs as being of greatest conservation need. Products of this work include peer-reviewed survey design, protocols, and standard operating procedures for each indicator group (grassland, tidal marsh, and mountain forest birds), along with a regional database for each of these groups. This project also resulted in the development and implementation of a regional coordinated bird monitoring framework (Northeast Coordinated Bird Monitoring Partnership 2007) and the Northeast Bird Monitoring Handbook (Lambert et al. 2009). The mountain bird survey data was gathered as part of the Vermont Center for Ecostudies' high-elevation bird monitoring program, Mountain Birdwatch.

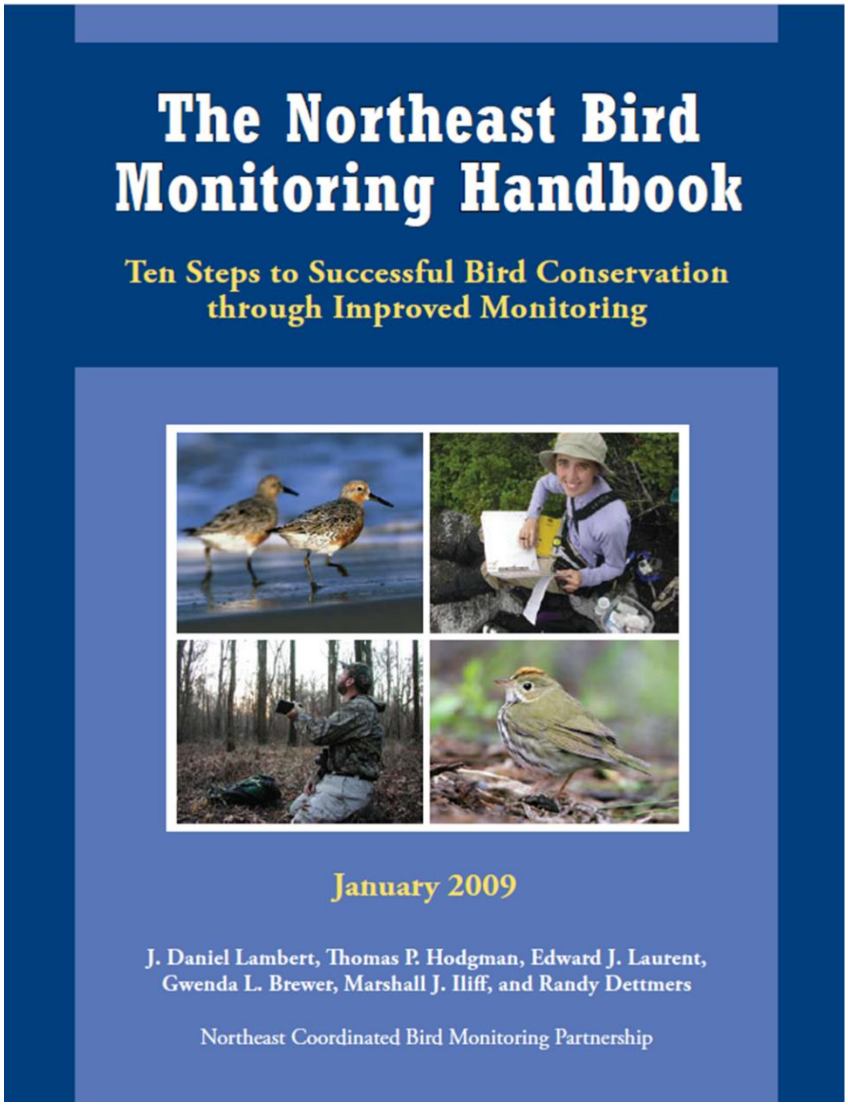

Figure 4.2.1 Northeast Bird Surveys, Protocols, and Monitoring RCN products for regional implementation.

Distribution and Conservation Status of Newly Described Leopard Frog Species (2016) (RCN). Objectives of this study were to: 1) determine which leopard frog species occur presently and occurred historically in ten eastern U.S. states; 2) refine the range of *Rana kauffeldi* relative to the two other leopard frog species; 3) map new, potentially reduced ranges for the two congeners; 4) assess the species' conservation status, particularly in areas where it is already known to be of concern; 5) contrast multi-level habitat associations among the three species; and 6) improve upon the separation of species using acoustic and morphological field characters to facilitate future inventory, monitoring, and status assessments. Significant changes in distribution of these three species were documented and *R. kauffeldi* was confirmed in eight eastern US states: Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, and North Carolina. Eighty-nine percent of these locations were within 20 km of coastal waters. Differing habitat associations were also documented throughout its range. This multi-year, 10-state project demonstrated conclusively that *R. kauffeldi* is a habitat specialist with a small range centered in the most densely populated region of the United States. Making it more susceptible to stochastic events may exacerbate the impact of fungal pathogens and render it vulnerable to habitat fragmentation that in turn results in dispersal to less hospitable sites. Another concern for this species is the coastal proximity of many populations, making it vulnerable to rising sea levels and the increasing frequency and intensity of coastal storms associated with climate change. The study documented that *R. kauffeldi* has disappeared from a large part of its historical range in southern New York and Connecticut, including much of the Hudson Valley and all of Long Island. The study also reported disappearance of *R. pipiens* from much of the southern portion of its range, from Pennsylvania East through northwestern New Jersey, southeastern New York, southern Connecticut, southern Rhode Island, and coastal Massachusetts. A new northern range limit was identified for *R. sphenocephala* in central New Jersey (Schlesinger et al. 2017).

Hellbender Population Assessment and Protocols (2013) (RCN). The Hellbender (*Cryptobranchus allegheniensis*) is a RSGCN; the Common Mudpuppy (*Necturus maculosus*) shares a significant portion of its habitat with the Hellbender; and both have been identified as a Species of High Conservation Concern by the Northeast Partners in Amphibian and Reptile Conservation (NEPARC). Given the habitat overlap of these two species, efforts to detect Hellbenders concurrently generated data useful in monitoring Mudpuppy populations from 2014-2016. The objectives were: 1) to better document Hellbender distribution in the Northeast region; and 2) to develop standardized methodologies for monitoring Hellbender populations while collecting opportunistic information about Mudpuppy distribution. This was accomplished through stream surveys (including environmental DNA detection), improved communication among individuals working with Hellbenders or Mudpuppies, and the establishment of a regional stakeholder working group. Standardized protocols were developed to ensure the consistency and efficiency of Hellbender and Mudpuppy surveys while minimizing disturbance of stream boulder habitat. During the study, environmental DNA samples were collected from sites in New York, Pennsylvania, Maryland, West Virginia, and Virginia. Results of the project include: 1) a more comprehensive map of Hellbender distribution in the Northeast; 2) an eDNA archive (for detection of other stream-dwelling species); and 3) a protocol and communication framework to enable coordinated and efficient conservation of Hellbenders and Mudpuppies (Terrell et al. 2016).

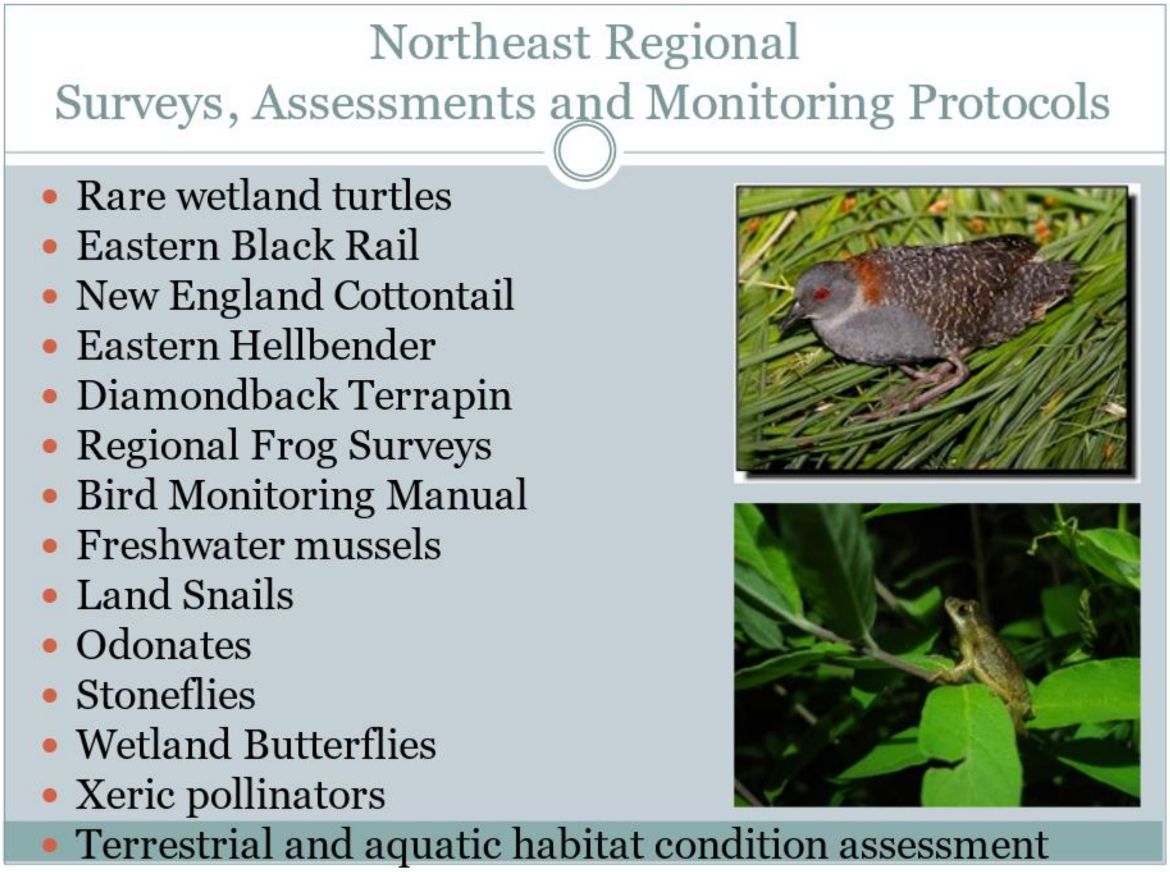

Figure 4.2.3. Example RCN projects providing information and tools on regional priority species and habitats.

Timber Rattlesnake Population Assessment (2016) (RCN). The Timber Rattlesnake (*Crotalus horridus*) was once widespread throughout eastern North America but in the four New England states that were the focus of this study, it now persists only in small, isolated populations. The goals of the study were to: 1) assess the viability of New England Timber Rattlesnake populations; 2), describe the population genetics structure of Timber Rattlesnakes in New England; 3) provide recommendations for genetic management and monitoring; and 4) develop a standardized protocol for monitoring Timber Rattlesnake populations informed by model-based estimates of occupancy and abundance. Model-based estimates of population growth and Population Viability Assessment results both suggest that populations in Vermont, New Hampshire, Eastern Massachusetts, and Connecticut may be declining while the Berkshire Mountains metapopulation does not appear to be declining under current conditions. Reducing anthropogenically-induced mortality is critically important. Available data strongly suggest that some Timber Rattlesnake populations in New England could benefit from genetic rescue. It was recommended that managers consider the ecology and conservation status of each population, available resources, and potential impacts, and then assess the information provided by each method of monitoring in the development of any new project design (Bauder et al. 2018).

Status Assessment of Northeast Land Snails (2016) (RCN). A 2009 RCN project supported the Carnegie Museum's online invertebrate database which provides a wealth of information on invertebrate taxa status and distribution in the Northeast (Fetzner 2011). An additional RCN project sponsored a 2016 Land Snail Assessment of the status and distribution of land snails in the Northeast as a first step to their conservation (Hotepp et al. 2013). As a result, almost 30 species of land snails have been identified as RSGCN or Watchlist species. Land snails are an integral part of native habitats throughout the Northeast, playing important roles in cycling organic material and creating soil, moving energy and nutrients in food chains, and hosting major wildlife parasites. This project informed the important conservation needs and opportunities associated with 245 land snail species of the Northeastern United States, many of which are listed as SGCN or Data Deficient in the 14 State Fish and Wildlife Agencies. This project assisted states in proactive participation in the USFWS Federal Prelisting Process and may lead to preventing or minimizing additional listings under the Federal Endangered Species Act. The project also expanded and upgraded the existing land snail and slug website of the Carnegie Museum of Natural History, using data compiled from other museum collections to produce a more comprehensive resource. There are at least 317 species profiles for the region, 311 with specimen records, and another six that may be reported in the future. Fifty of the species are non-native. Regional maps are integrated into all species profiles (Hotepp et al. 2013).

Conservation Assessment of Odonata in the Northeast (2011) (RCN). A similar assessment of the dragonflies and damselflies of the Northeast serves as the foundation for RSGCN data for these species. Odonata are well represented on imperiled species lists for the Northeast due to narrow distributions, low population abundance, documented threats, and declines of many species. At present, nearly 200 different species are listed as SGCN by at least one Northeastern SWAP. The first Region-wide conservation assessment for the order Odonata (dragonflies and damselflies) was completed for more than 230 species that occupy a wide range of forested lentic and lotic habitats in the Northeast region. This assessment followed a procedure similar to those already conducted for certain vertebrate taxa in the Northeast (e.g., birds, reptiles, and amphibians). It included measures of regional responsibility, conservation concern, and vulnerability in a matrix format that can be used to prioritize species and conservation actions. Odonata were well suited to an assessment of this kind because their distributions and habitat affinities are relatively well known and the number of species is manageable, especially as compared to other insect groups. The project compiled available status and distribution information for all Odonate species in the thirteen states in USFWS Region 5. Regional responsibility was evaluated for all states within the Northeast and updated at the regional scale, supporting conservation decisions that benefit Odonates and their habitats. The resulting prioritization scheme directs limited state and regional resources toward effective conservation actions that benefit Odonata and their habitats and thereby guide implementation of SWAPs (White et al. 2014).

Bee, Moth, and Vegetation Monitoring (2018-22) (RCN). A protocol was developed to track native bee communities at survey sites. Bee identification by regional experts was critical to the effort, and the collection is now with the Native Bee Inventory and Monitoring lab[13]. The **bee monitoring protocol** outlines 5 sampling windows, monthly, from May to September (Crisfield 2021a). Transects are laid out in the target habitat with 24 small bowls of soapy water placed five meters apart and left through the daylight hours or overnight if possible. Observers also net bees for 30 minutes while visiting the site. Samples are submitted with a standardized label to the USGS Native Bee Inventory and Monitoring Laboratory. The **moth monitoring protocol** outlines five sampling windows, monthly, from April to October, adjusted as necessary for latitude (Crisfield 2021b). The primary goals were to develop more complete species lists and document relative abundances for nocturnal moths in Xeric Habitats in the Northeastern US and to link these results with habitat condition data and management strategies which are also being tracked and analyzed. Three 15W UV bucket traps are set at each site. In 2021, 715 macro moths and 354 micro moths were identified across 16 sites, including nine RSGCN.

The Gulf of Maine Coastal Marine Ecosystem Survey: Mapping Biological Hotspots. (2013) (CSWG). The goal of this project was to fill critical knowledge gaps on the basic ecology, distribution, and abundance of 27 SGCN that inhabit the region's coastal marine ecosystem. Using distribution and abundance data, the partners calculated biological hotspot index values and developed digital maps based on habitat use model predictions. This critical information helps partners create effective conservation programs for these species within the Gulf of Maine and provide technical assistance for siting of offshore energy development projects to minimize effects on marine habitats.

Integrating Vulnerability Science into a Strategic Conservation Plan for Maine's Species of Greatest Conservation Need (2013) (CSWG). The Department of Inland Fisheries and Wildlife built upon the ongoing work of the North Atlantic Landscape Conservation Cooperative and other regional conservation partnerships to conduct a comprehensive review and update of the Maine Wildlife Action Plan. The outcome was a new Plan that utilized the best-available climate science to comprehensively address threats to the state's species and habitats. The revised Plan provided better guidance at the scale of specific management regions, outlined a process for achieving measurable goals, and provided usable data to non-governmental conservation partners.

Pennsylvania's SWAP Prioritization and Mapping Enhancements (2013) (CSWG). The Pennsylvania Game Commission and the Fish and Boat Commission voluntarily implemented best practices for State Wildlife Action Plan revision, as recommended by the Association of Fish and Wildlife Agencies. The project included development of a tiered classification system for the state's SGCN, one that incorporates climate change vulnerability indices. Another key outcome was the development of a habitat prioritization matrix which helped the Commission delineate priorities for conservation action such as land acquisition, habitat management, and restoration. Pennsylvania continues to integrate a geospatial component into their revised State Wildlife Action Plan.

Updating Vermont's 2025 Action Plan with Vermont Conservation Design (2021) (CSWG). This project enabled VT to update Vermont Conservation Design data to 1) take advantage of new 0.5m LIDAR-derived land cover data, provide technical assistance by making action plan mapping and data available to all Vermonters; and 2) deliver outreach training to VFWD staff and communicate action plan vision and tools.

CONSERVATION PLANS AND BEST MANAGEMENT PRACTICES

Best Management Practices for RSGCN In Northeast Forests (2014) (RCN). Northeastern forests are considered key habitat for a large suite of wildlife, including several habitat specialists listed as SGCN in multiple states. Their vulnerability to various stressors has prompted the formation of several species--level conservation and research initiatives. This RCN project collaborated with several focused partnerships and with key forest stewards to integrate current ecological and biogeographic information into on-the-ground habitat enhancement. This collaboration produced spatially explicit management and conservation support for five regional SGCN: Bicknell's Thrush (*Catharus bicknelli*), Wood Thrush (*Hylocichla mustelina*), Canada Warbler (*Cardellina canadensis*), Rusty Blackbird (*Euphagus carolinus*), and American Marten (*Martes americana*). For each of these species, the report contains a species profile, conservation status, habitat landscape characteristics, desired habitat conditions, recommended practices and benefits with associated species, and ecosystem services and comprehensive planning. The project engaged both experts and end users to produce scientifically sound and practical guidelines for conserving these species and other SGCN in their guilds. Available occurrence data, distribution models, and stakeholder input delineated and prioritized areas with high management and conservation potential. Working directly with habitat stewards ensured that the recommended practices are implemented in management and conservation opportunity areas. Results include field guides and guidelines to managing habitat for RSGCN in the Northeast and Mid-Atlantic Forests, a final report, and spatial prioritization for implementing these guidelines for RSGCN (Lambert and Reitsma 2017, Lambert et al. 2017).

Young Forest and New England Cottontail Conservation Initiative (2007, 2008, 2009, 2011, 2013, 2014) (CSWG, SA, RCN). As part of its young forest project, NEAFWA's Habitat Technical Committee developed a manual providing information and recommendations on managing and renewing young-forest habitats in the Northeast: Managing Grasslands, Shrublands and Young Forests for Wildlife (Oehler et al. 2006). Multiple resources, including articles, brochures, guidebooks and manuals (e.g., Fergus 2017), presentations, etc. are available online[14].

A Conservation Strategy for the New England Cottontail, a comprehensive plan for conserving the New England Cottontail (Fuller and Tur 2012), and a recent outreach plan (New England Cottontail Outreach Strategy 2018) are also available to help partners implement the conservation strategy for this species. In the short term, the goal of the initiative is to restore 1200 acres of New England Cottontail Rabbit (*Sylvilagus transitionalis)*, (NEC) habitat creating 50 new habitat patches across the species range, with an expected long-term population increase of 720 animals. The goal in the long-term is to avert federal listing by increasing the rate of colonization of habitat patches, thereby stabilizing metapopulation viability. Objectives were to: 1) convene a range-wide recovery steering committee comprised of partnering state wildlife agencies, NRCS, and USFWS; 2) evaluate target properties for habitat restoration and draft a spatially explicit habitat restoration plan; 3) disseminate restoration plans to local stakeholders and partnering agencies; 4) prescribe and implement habitat restoration activities in an adaptive management framework; 5) monitor performance to determine the relative efficacy of implemented actions; and 6) provide technical and administrative support to the states and partnering entities.

The range wide "Conservation Strategy for the New England Cottontail" was completed in 2012 by a multi-agency working group. State conservation summaries were completed for all six states and included in the regional conservation strategy that was peer reviewed in June 2012. A comprehensive landscape analysis was completed to design landscapes to support NEC populations, using models to analyze all parcels in the species range to identify target properties. Across 6 states, 12,439 parcels were ranked as the most likely to be suitable. The best ranked parcels have been adopted as targets for range wide NEC conservation. The formation of a private lands working group has increased the number of private parcels that are visited for evaluation and generated contracts with NRCS, WMI and USFWS Partners for Fish and Wildlife. More than 950 acres have been treated on state lands across all six states since 2009, and the target of 1200 acres was met in May 2014. The **ARS Team supports the New England Cottontail Rabbit conservation (SA)** throughout the region. In 2012, state wildlife agencies from Connecticut, Maine, Massachusetts, New Hampshire, New York, and Rhode Island worked with USFWS and NRCS to finalize a conservation strategy to conserve the New England cottontail throughout its current range.

Atlantic Coast Beach and Shorebirds, Focusing on American Oystercatcher (*Haematopus palliatus***), Ruddy Turnstone (***Arenaria interpres***), Whimbrel (***Numenius phaeopus***) (2022) (SA).** Shorebirds are among the most imperiled birds in North America, with population declines of 33% since 1980. Coastal areas of the Northeast Region host substantial populations of breeding, wintering, and migrating shorebirds, and some of the densest human populations in North America. Anthropogenic threats include habitat loss and degradation, human disturbance, predation, hunting, and sea level rise across their vast hemispheric ranges. The SA Beach and Shorebirds Team focuses on three species that represent a cross-section of shorebird life histories, seasonal habitat use, and management needs in the region. Each is listed as a USFWS Bird of Conservation Concern, and Species of Greatest Conservation Need in most coastal states in the region. To date, the team has focused on identifying its role in supporting existing conservation planning, such as the *American Oystercatcher Hemispheric Conservation Plan*, the *Whimbrel Conservation Plan*, and the *Atlantic Flyway Shorebird Initiative*. Increased engagement between USFWS staff from five programs and collaborative conservation entities such as the *American Oystercatcher Working Group* and groups of external partners with specific expertise in the three species (e.g., NGOs, state wildlife agencies, and universities) is a program priority. Efforts are underway to improve internal coordination across programs in the region. Priorities include:

- Initiating actions to address human disturbance at priority regional refuges
- Planning and pursuing opportunities for habitat acquisition, restoration, & enhancement
- Increasing efficacy and stability of predation management at locations experiencing poor outcomes
- Initiating research to identify priority stopovers (Ruddy Turnstone & Whimbrel) and understand importance of marsh habitat for breeding American Oystercatchers
- Helping initiate the first conservation plan for Ruddy Turnstone
- Engaging with partners to support priority conservation activities in other areas

Forest Songbirds (Golden-winged Warbler (*Vermivora chrysoptera***), Cerulean Warbler (***Setophaga cerulea***), Wood Thrush) (2022) (SA).** More than 1 billion breeding birds have been lost from forest habitats across North America over the past 50 years. Declines of birds associated with early successional, mature, and structurally diverse Eastern deciduous forest have contributed to these overall losses of forest birds, with golden-winged warbler, cerulean warblers, and wood thrush exhibiting some of the steepest declines. These three SGCN species represent those different forest ages and structures that are missing from many Northeastern deciduous forests today. The Forest Songbirds Team is partnering closely with the Appalachian Mountains Joint Venture (AMJV), whose geography overlaps with the core breeding areas of these three forest birds, to engage and support private and public forest landowners in implementing forest management practices that enhance the age and structural diversity of Eastern deciduous forests. A good example of this is a collaborative project, initiated in collaboration with the Service's Partners for Fish and Wildlife program, NRCS, and West Virginia DNR that is aiding private landowners in implementing the forest management activities identified as required practices under landowner incentive programs. The Team looks to collaborate on these kinds of activities within focal landscapes identified within the AMJV geography as well as additional focal areas outside of the AMJV that are important for these three at-risk forest songbirds. It plans to identify key audiences in each focal area for outreach regarding beneficial forest management practices for birds and available resources to assist in implementing them. The Team also seeks to collaborate with other agencies, especially state agencies and USDA, and NGOs with interests in forest bird conservation and creating healthy forest landscapes across the Northeast.

Conservation Plan for Blanding's Turtle and Associated Wetland-Dependent SGCNs (2011, 2017) (RCN, CSWG). Over the past decade, significant advancements have been made, informing and addressing the conservation needs of RSGCN turtles. Multiple partners and grants (RCN and CSWG) have resulted in robust conservation plans, protocols, and best management practices to be implemented regionally for these important RSGCN. They are summarized below with additional information available on the Conservation Planning for Northeast Turtles website[15]. Blanding's Turtle (*Emydoidea blandingii*) is a wide-ranging, semiaquatic species found in discontinuous areas from Nebraska to Nova Scotia. In the eastern United States, Blanding's Turtles occur in discrete areas of Maine, New Hampshire, Massachusetts, New York, and Pennsylvania, with the largest areas of occurrence in New England and northern New York and the largest known population in Massachusetts. Eastern populations are of conservation concern because of habitat alterations, adult roadkill, elevated nest and hatchling depredation, and other factors. In 2004, the Northeast Blanding's Turtle Working Group was formed as a partnership including representatives from four state wildlife agencies (ME, NH, MA, NY), universities, land managers, and researchers. Between 2004 and 2010, the group expanded to involve other key partners and the state of Pennsylvania and published a status assessment summarizing the causes of regional population decline and calling for strategic, proactive conservation measures (Compton 2007).

In June 2014, the Northeast Blanding's Turtle Working Group[16] completed the Conservation Plan for Blanding's Turtle and Associated Wetland-Dependent Species of Greatest Conservation Need in the Northeastern United States. This plan was updated in July 2021 after a second round of sampling and habitat management actions. Both efforts were multi-year collaborative projects funded by the U.S. Fish and Wildlife Service through its Competitive State Wildlife Grant program. Partners included the state wildlife agencies of Maine, New Hampshire, Massachusetts, New York, and Pennsylvania; public partners including the State University of New York at Potsdam, the University of Massachusetts at Amherst, the University of Maine at Orono; and private groups including Grassroots Wildlife Conservation, Inc., and Swamp walkers, Inc., funded by the U.S. Fish and Wildlife Service Competitive State Wildlife Grant (SWG) Program. The resulting website contains conservation and management plans for each of the four RSGCN species: Spotted (*Clemmys guttata*), Wood (*Glyptemys insculpta*), Blanding's, and Box (*Terrapene carolina*) Turtles. It provides survey forms/protocols including the pit tag protocol (NEPARC 2020).

Implementation of The Bog Turtle Conservation Plan for The Northern Population, With Benefits to Associated Headwater Wetland SGCN (2015, 2019) (RCN, CSWG). This project supplemented efforts to perform habitat management, engage in landowner outreach; continue application of a multi-state database; continue implementation of standardized population and habitat monitoring protocols; survey potential and historic wetlands; perform health assessments; draft best management practices; expand upon and refine the recently developed conservation plan; and perform a genetic assessment to determine conservation units for the northern population of Bog Turtle (*Glyptemys muhlenbergii*). Most recently, CSWG supported Creating a comprehensive conservation and management plan for the southern lineage of the Bog Turtle and its associated habitats. The objective of this project is to fill critical information gaps by beginning to address the two most pressing threats for the southern lineage of the bog turtle. This will be achieved by by 1) improving the understanding of the current distribution of the southern lineage of Bog Turtles; 2) determining the status and viability of populations within the southern lineage of Bog Turtles; 3) beginning a genetic study to identify metapopulations, management units, corridors, and current population genetic parameters, habitat management and nesting habitat creation for a subset of populations; 4) reaching out to landowners and law enforcement officials.

Spotted Turtle Conservation (2017, 2022) (CSWG, RCN). The Spotted Turtle Working Group, a team of state and federal biologists and university as well as NGO partners, collaborated to quantify the Spotted Turtle (*Clemmys gutatta*) status and distribution from Maine to Virginia as well as the effects of climate change and habitat fragmentation on the species. As part of this project, the sponsors conducted standardized population assessments at multiple spatial scales, with centralized data analysis, to: (1) establish population baselines; (2) inform a comprehensive adaptive management strategy; and (3) identify priority habitat and population management actions at the regional, state, and local levels. Their website[17] provides a **Status Assessment and 2022 Conservation Plan**, the 2019 Monitoring Protocol, and field and data entry forms with instructions. **A CSWG Project Supported Conserving Vermont's Spotted Turtles: Using Novel Techniques to Detect a Cryptic Species and Identify Unknown Populations.** This project will identify suitable Spotted Turtle habitats and will determine if those habitats are occupied. It will support the development of eDNA sampling protocols in lentic systems, which will be transferrable to other states with Spotted Turtle information gaps and to other SGCN freshwater turtle species. It will use standardized methods and protocols developed for the ongoing CSWG/RCN Spotted Turtle project to evaluate the species' presence at 25 sites and improve priority nesting habitat.

Wood Turtle Conservation Plan (2011, 2014, 2016, 2021) (CSWG, RCN). Conservation Plan for the Wood Turtle in the Northeastern United States is the product of a multi-year, proactive effort among Northeastern State Wildlife Agencies and their partners to articulate a strategic action plan for the protection of regionally significant populations of Wood Turtles in the northeastern United States. The fundamental objective of this Plan is to protect the evolutionary potential of the Wood Turtle by ensuring the persistence of functional, ecologically viable, and regionally significant populations throughout the Northeast Region. To accomplish this objective, and to effectively triage conservation efforts, the sponsors developed a spatially explicit, stratified Wood Turtle Conservation Area Network based on the best available population, landscape, and genetic data. To achieve meaningful conservation of this species it will be necessary to stabilize and ultimately reverse population declines, both within this Conservation Area Network and elsewhere throughout the species' range. The plan includes a standardized survey protocol, field survey, turtle field forms, and a data entry template. Management guidelines, habitat management and poaching brochures, regulatory status, environmental review recommendations, and other helpful resources for Wood Turtles are available through the Northeast Wood Turtle working group website[18].

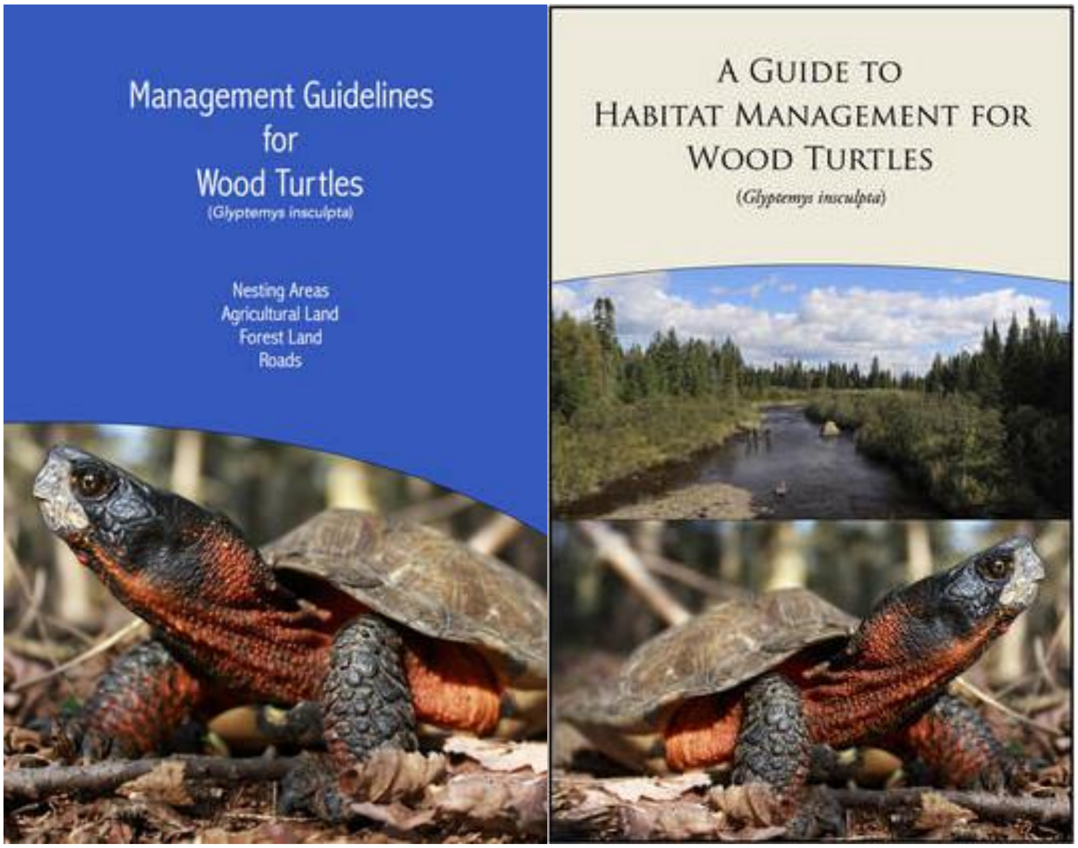

Figure 4.2.2 Management Guidelines for Wood Turtles in the Northeast.

Status Assessment and Conservation Plan for the Eastern Box Turtle (2018) (RCN). Although widespread and still relatively common throughout much of its range, the Eastern Box Turtle (*Terrapene carolina carolina*) has experienced dramatic declines in recent decades. This recent RCN project developed a status assessment and conservation plan for the Eastern Box Turtle in the Northeastern United States (West Virginia to Maine). Products include: 1) a standardized monitoring protocol; 2) a status assessment for the northeastern US; 3) a conservation area network representing conservation priorities for the species; and 4) a set of BMPs. Survey forms and multiple protocols, guides, partners, and other useful information for box turtle conservation are available at the Box Turtle working group website[19]. NEPARC has developed habitat management guidelines, land use planning resources, and references for conservation of this species in the Northeast. Both the regional group (NEPARC) and its national affiliate (PARC) are dedicated to the conservation of herpetofauna and their habitats and provide resource information on this and other reptile and amphibian species[20].

Population Declines Due to Loss of Adult and Juvenile Turtles to Illegal Wildlife Trade (2021) (CSWG, SA). The goals of this project were to 1) assess recently developed health and disease testing protocols and 2) determine the best method and use of genetic information to determine place of origin of confiscated animals. These two actions are designed to slow the rates of decline in eastern, native SGCN turtle populations due to wildlife trafficking by providing states with the information needed to make informed decisions with regard to repatriation.

ARS program efforts for the Northeast Turtles (Blanding's, Spotted, and Wood Turtle) Conservation (2021) (SA). The At-Risk Turtle team is focused on working with the states to implement conservation plans that are informed by standardized monitoring and genetic analysis. All three species have conservation area networks that identify focal area sites also targeted for land protection; management opportunity sites targeted for restoration; and finally, sites in need of surveys. Due to data sensitivity, the Service does not have spatial information for the conservation area networks. The team is working with individual states on the following objectives: 1) securing viable populations through land conservation (using grant programs like LWCA, DE Bay, Chesapeake Wild, and America the Beautiful, and NRCS's Wetland Reserve Easement program); 2) enhancing populations through restoration of habitat (USFWS National Wildlife Refuge lands, DoD lands, and working with NRCS on private lands); 3) decreasing road mortality in areas with high mortality rates (work on refuges and with individual states using DOT funds); and 4) addressing illegal trade in turtles. Related objectives are to provide leadership on the Collaborative to Combat Illegal Trade in Turtles; support LE by: 1) identifying housing for confiscated turtles; 2) assisting states in returning turtles to the wild; 3) conducting genetic and disease screening; 4) developing outreach tools and a long-term strategy to address illegal trade in turtles; 5) assessing population status by continuing surveys on refuges, DoD lands, and through projects with NAFO; 6) continuing to support states in developing CSWGs; assess population status for Spotted, Wood, and Blanding's Turtles; and 7) raising public awareness by continuing to feature work promoting conservation and addressing threats..

Conservation Strategy for the Northern Diamondback Terrapin (2013) (RCN). The Northern Diamondback Terrapin (*Malaclemys terrapin*) is found in eight states of the Northeast Region and is considered Threatened in Massachusetts, Endangered in Rhode Island, and of Special Concern in Connecticut. The species has been identified by the Northeast Partners in Amphibian and Reptile Conservation as a species of regional conservation concern in the Northeast. It is identified in more than three-quarters of the region's SWAPs; and more than 50% of the species' distribution is within the Northeast Region (NEPARC 2010). Therres et al. (1999) also suggested that the Terrapin merited a federal listing assessment. This RCN project represented the first regional, comprehensive view of the status of the Terrapin in the Northeast. The resulting regional Conservation Strategy can guide and coordinate multiple-state laws and policies to protect the terrapin and its habitat and may reduce the need for a federal listing assessment. The strategy includes a status and distribution assessment throughout the northeast; gathering life history information; and identifying threats and conservation actions along with additional resources and needs. This project also conducted a Threat Assessment outlined by the Northeast Lexicon. Populations have declined since the early 1990s due to multiple factors. Bycatch in commercial fishing, loss of habitat, drowning in commercial and recreational crab pots, increased nest failure due to predation from raccoons and other subsidized predators, and road mortality have been the primary causes of population decline. The project compiled state efforts and protocols to advance a Regional Coordinated Survey (terrestrial and aquatic) through the Maryland Coastal Bays Terrapin Project[21]. Using citizen scientists, the Maryland Coastal Bays Program created a database on local terrapin habitats to aid in conservation of the terrapin. The Program has also produced terrapin brochures, fact sheets, field guides, and other outreach information (Egger 2016).

Best Management Practices for Wetland Butterflies (2015) (RCN). This project addressed the uncertain status and distribution of many wetland butterfly species in several Mid-Atlantic States, including SGCN and RSGCN species in the Northeast. Some species declines may be due in part to threats impacting groundwater wetlands, including outright destruction, habitat degradation, and the succession of open wetland habitats to forest or dense shrubland. Climate change and habitat fragmentation may further impact these species and leave them vulnerable to local extirpations. The primary objective of this effort was to enhance and expand populations of wetland butterfly SGCN through developing a greater understanding of the distribution and habitat requirements for these species, and by implementing habitat enhancement projects where needed. Project goals were to: 1) update distribution data for 14 butterfly SGCN in the region; 2) model species distribution and climate conditions for each species; 3) identify and prioritize wetlands that support one or more of these 14 species; 4) implement wetland enhancement and improvement projects; and 5) develop BMPs for species distribution, climate modeling, and wetland enhancement projects. Results should guide targeted survey work for these species as well as prioritize wetlands for enhancement projects. In the long-term, results may serve to improve habitats for these species, offering the potential to increase populations of butterfly SGCN and promote connectivity between populations through increased habitat availability. Fourteen species of wetland-inhabiting butterflies with SGCN status were surveyed in 2016 and 2017 at multiple sites across four states – Maryland, New Jersey, Pennsylvania, and West Virginia. Survey data was used to evaluate the status of each species in all states where they occurred as well as refine the distribution data for each species across the region. All data points were mapped in ArcGIS and used to model species distribution in terms of both habitat and climate. BMPs were developed, and habitat enhancement projects were initiated in Maryland and Pennsylvania. The report includes Life History Guides to the 14 species, the Pennsylvania Habitat

Management Guide for Pollinators, Wetland Butterfly Habitat Enhancement BMPs, and additional resources including a model Wetland Restoration Report (Frye et al. 2018).

Pollinator Habitat in Xeric Grasslands, Barrens, and Woodlands (2018-22) (RCN)[22]. NEFWDTC prioritized another key regional habitat supporting multiple RSGCN taxa and focused on conservation of the fire-adapted xeric habitats that support a diverse fauna including pollinators. This RCN project developed a regional network of experimental adaptive management sites where coordinated management and monitoring leads to improvements in management over time. This includes ensuring adequate representation of forbs, bare soil, and other key pollinator habitat features; improving habitat for other RSGCN; and lowering management costs and treatment frequency to the greatest extent practical. It resulted in improved coordination and sharing of early successional habitat management expertise among states. Standardized regional vegetation and pollinator monitoring protocols were developed, enabling more effective pooling of data and providing a framework for informed, science-based management decisions. The project improved understanding of the abundance and distribution of select, vulnerable pollinator taxa (e.g., bees and butterflies), and of how these species respond to habitat management over time. Results both informed and improved on-the-ground management of at least 500 acres of habitat at regionally significant sites. The project served as a framework for longer-term monitoring and experimental adaptive management practices to improve overall management for these complex, fire-influenced systems (Milam 2018).

This Xerics Habitat for Pollinators Project focused on fire-adapted habitats (xeric grasslands, barrens, and woodlands) in the Northeast to improve the ability of Northeast states to implement cost-effective habitat management for the benefit of native pollinators and other RSGCN that depend upon these priority habitat types. Templates for data collection and reporting were developed along with the vegetation monitoring project protocol, which seeks to provide data consistent with the longstanding monitoring programs at some of the more established sites. A key variable, the percent of vegetative cover, is expected to respond to treatments and to indicate habitat suitability for ground-nesting bees.

Bee Pollinators in NJ (2015) (CSWG). This project enabled New Jersey to comprehensively evaluate the status of bee pollinators for its State Wildlife Action Plan. This project enabled New Jersey to comprehensively assess all species of rare bee pollinators so that Species of Greatest Conservation Need can be determined for its SWAP. Specifically, a state-of-the-art database held by project PI Winfree, along with targeted additional field data collection, helped to determine which bee species are rare in New Jersey and what their habitat and floral conservation needs are. A roadmap was developed for how the State can be effective and efficient in managing for many rare and poorly known pollinator species.

Gating Caves for Bat Conservation and Protection (2016) (RCN). Bats in the Northeast have suffered steep population declines since 2006-07 due to White-Nose Syndrome (WNS). In 2016, the RCN Grants Program awarded funding to Connecticut, New Jersey, New Hampshire, Pennsylvania, and Rhode Island to increase the suitability of known bat hibernation sites by reducing human disturbance. Project funds supported construction or improvements of gates to the openings in caves and mines, structural enhancements to the sites to create better habitats, installation of a sign template for consistent messaging, and the placement of remote surveillance cameras as needed. These on-the-ground efforts involved many stakeholders and matching in-kind services. Even before the threats posed by WNS were known, human disturbance to hibernating bats was a well-documented threat in the Northeast. Many of the pre-WNS conservation efforts focused on better protection of critical winter habitat for bats, which can include caves, abandoned mines, sinkholes, aqueducts, and other locations, natural or man-made, where bats overwinter. Management actions can improve the structures for bats while preventing human disturbance. Protection of winter habitats for bats, even those infected with WNS, is an important component of long-term conservation actions for these species. Monitoring survival among WNS-infected bats in the Northeast has suggested increased resistance to fungal exposure. Therefore, reducing additional threats might allow rebounding populations to respond even more quickly, and ensure that sites receiving future fungal treatment or WNS management efforts will be secure and safe for hibernating bats. Another major step toward keeping these winter habitats safe involves raising awareness of conservation actions through consistent messaging. The combination of site protections, habitat enhancements, and improved messaging/signage should help enhance survivorship of bats at these over-wintering sites. A list of the projects and links to the individual reports are available through the NEFWDTC website.

Pine Barrens Species Conservation (2022) (SA). Pine barrens are a unique habitat type often characterized by sandy soils and fire-dependent plant communities dominated by pine species, though oaks are often also a major component of the ecosystem. Many rare species utilize pine barren habitats, but this project focused on two inhabitants, Frosted Elfin (*Callophrys irus*) and Eastern Whip-poor-will (*Antrostomus vociferus*). The Pine Barrens Team is analyzing data from Science Application's Rapid Response Team, eBird, and other sources to identify priority sites for co-management of the two species. Once sites are identified, the Team will work with Refuges, state conservation agencies, and other partners to enact on-the-ground management to improve conditions for both species. The team also intends to develop Best Management Practices for the two target species within pine barrens and to develop a network of conservation practitioners for sharing research, management practices and needs, and information across the Northeast.

Diadromous Fishes Conservation (Alewife, Blueback Herring) (2022) (SA). Alewife (*Alosa pseudoharengus*) and Blueback herring (*Alosa aestivalis*), collectively known as River Herring, are categorized as SGCN in all New England states, New York, Pennsylvania, New Jersey, Delaware, and Virginia. Blueback herring are additionally categorized as SGCN in South Carolina and Florida. Within the past decade, River Herring Conservation Plans have been released by NOAA Fisheries and the Atlantic States Marine Fisheries Commission (ASMFC). Threats to River Herring populations include reduced access to historic freshwater spawning and nursery habitats, barriers with inadequate fish passage measures, freshwater and estuarine habitat/water quality degradation, climate change impacts, and indirect (bycatch) fishing pressure. In both the marine and freshwater environments, shifts in water temperature, related temporal/spatial shifts in environmental conditions, prey availability, and predation may be negatively influencing River Herring populations. Conservation goals for River Herring are aligned with those established in the ASMFC Amendment 2 to the Interstate Fishery Management Plan for American Shad and River Herring (River Herring Management) (ASMFC Shad and River Herring Plan Development Team 2009): *"Protect, enhance, and restore East Coast migratory spawning stocks of . . . alewife (Alosa pseudoharengus), and blueback herring (Alosa aestivalis) in order to achieve stock restoration and maintain sustainable levels of spawning stock biomass."* Priority objectives include 1) preventing further declines in population abundance, 2) promoting improvements in degraded or historic habitat throughout the species range, 3) improving access to historic freshwater spawning and nursery habitat, and 4) increasing understanding of the influences of River Herring bycatch in commercial fisheries as well as updating the status of stock dynamics and health.

Farmland Pollinators (Monarch, American and Yellow-banded Bumblebee, Ashton's, Lemon, and Variable Cuckoo Bumble Bee) (2022) (SA). In the Northeast, native bumble bee species are experiencing habitat loss, climate related threats, and competition form non-native species. The USFWS has identified five bumble bee species (American bumble bee (*Bombus pensylvanicus*), yellow banded bumble bee (*Bombus terricola*), Ashton's cuckoo bumble bee (*Bombus ashtoni*), lemon cuckoo bumble bee (*Bombus citrinus*), and variable cuckoo bumble bee (*Bombus variabilis*) as well as Monarch butterfly as priority at-risk species in need of proactive conservation. These species, collectively referred to as "farmland pollinators," need region-wide habitat restoration and management. Additionally, little is known about the population status and distribution for many of these rare species. The USFWS provided funding to the Native Bee Inventory and Monitoring Lab for a multi-part project that includes surveys, floral resource research, public outreach, and developing a regional conservation strategy for bumble bees. Additional projects supported by the farmland pollinator team include bumble bee surveys on National Wildlife Refuges across the Region, native thistle seed collection and propagation, and continued support for the New England Pollinator Partnership.

Mountain Butterflies (White Mountain Arctic, White Mountain Fritillary) (2022) (SA). The White Mountain arctic (*Oeneis melissa semidea*) and the White Mountain fritillary (*Boloria chariclea monitus*) are endemic butterflies that were left isolated at the summit of Mt. Washington after the last glaciation period approximately 13,000 years ago. Their distribution is limited to a 2,800-acre alpine zone of the Presidential Range at the White Mountain National Forest. Potential stressors include trampling of habitat by individuals or from off-trail recreational use; lack of redundancy due to the species' limited range; and potential negative effects to both species and their habitat from climate change. The project team is partnering with New Hampshire Fish and Game (NHFG), the White Mountain National Forest, the Mount Washington Observatory (WMO), and the Appalachian Mountain Club to develop and produce a public awareness and education campaign to inform the public of the presence and predicament of these species and develop signage to mark sensitive areas. There are ongoing research projects with NHFG, WMO, the University of New Hampshire, and the Northeast Adaptation Science Center to collect life history and abundance information on these two butterfly species. To date, these studies have successfully identified host species critical to complete the White Mountain Fritillary's reproductive cycle. Captive rearing protocols have been developed and implemented at the WMO and at the NHFG captive rearing facility. Studies that will continue into 2023 include DNA analysis to assess population structure, collection of demographic data, evaluation of impacts of climate change, species distribution modeling, and overwintering experiments.

Freshwater Mussels (Brook Floater (*Alasmidonta varicosa*), Cumberland Moccasinshell (*Medionidus conradicus*), Pheasantshell (*Phasianella ventricosa*), Tennessee Clubshell (*Pleurobema oviforme*), Tidewater Mucket (*Leptodea ochracea*), Yellow Lampmussel (*Lampsilis cariosa*)) (2022) (SA). Across the continent, freshwater mussels have experienced drastic declines. Over 74 % of the 298 freshwater mussel species found in North America are in some state of imperilment, with 93 species federally listed as endangered or threatened (Williams et al. 2017). Habitat degradation, which includes water pollution and impoundments, is by far the leading cause of these declines. Non-native species also have outcompeted some native species. Freshwater mussels provide ecological and economic benefits to people and aquatic ecosystems. Like oysters, they filter millions of gallons of water and act as ecosystem engineers. They're crucial to a multi-billion-dollar pearl jewelry industry, and harvest of mussels is a reserved treaty right for some Native

American tribes. Without intervention, freshwater mussels will continue to disappear within their range, with the risk of losing valuable ecosystem services.

Using adaptive management and working at landscape scales in partnership with states and Tribes, this project aims to restore and conserve these at-risk species of mussels and proactively address threats to avoid the need to list these species under the Endangered Species Act. With input from partners, the ARS program has been building a conservation plan called the *Northeast Region Conservation Strategy for Freshwater Mussels*. It provides a framework and strategies for conserving and restoring at-risk species of freshwater mussels and their habitats from Maine to Virginia and West Virginia. This will inform decisions on feasible, cost-effective actions that Service programs can take with partner support over the next five years to increase representation, redundancy, and resiliency (3 Rs) of each species, and ensure their long-term viability.

In 2022, biologists from 12 States, the Partnership for Delaware Estuary, USGS, and representatives from the Penobscot Nation were interviewed. A suite of questions aimed at identifying priority areas and management and science needs for conservation of mussels. This information is being synthesized into priority area maps and tables which will highlight areas for conducting surveys, habitat restoration, land protection, propagation and stocking, and science needs. Discussions held in 2021 with the Rappahannock, the Chickahominy, and the Upper Mattaponi Indian Tribes in Virginia are also informing priority areas for conservation of at-risk mussels and their host fish in the *Northeast Region Conservation Strategy for Freshwater Mussels*. Interviews with Tribal partners continue to further identify priority areas for conducting conservation for mussels. The strategy will be distributed to State and Tribal partners and other Service offices for review, to finalize the At-Risk Conservation Strategy. Continuing program efforts will work to build local action plans within target watershed and to implement projects. Priority science needs for mussels were also identified and included in the request for proposals through the USGS as well as priority projects for BIL funding that would benefit at-risk mussels.

4.2.4 REGIONAL EXAMPLES AND OPPORTUNITIES

The exceptional collaboration and coordination among state fish and wildlife agencies in the Northeast has driven and advanced collaborative identification, prioritization of needs, action steps to address them, and limiting factors for RSGCN and their habitats. Projects listed below represent key partner and collaborative regional projects and programs that inform SWAPs. Please see *Chapter 7* for a more complete list of Northeast partners.

FOREST MANAGEMENT PLANS

Forest and Woodlands are managed at the state level with a **State Forest Action Plan** (SFAP). These plans outline conservation strategies and priorities like those found in SWAPs, making the states eligible to receive federal funding as authorized by the Cooperative Forestry Assistance Act[23]. State Forest Action Plans are required to incorporate SWAP information, specifically in their habitat assessments, strategies, and shared priorities or goals. The State Forest Action Plans of the Northeast were updated in 2020. The US Forest Service and Northeast-Midwest State Foresters Alliance synthesized the 2020 State Forest Action Plans of the Northeast and Midwest and released a regional summary report in 2022 (USFS and Northeast-Midwest State Foresters Alliance 2022a). With State Forest Action Plans updated on a 10-year cycle that falls halfway between the 10-year cycle of SWAPs, the regional summary report identified "tremendous opportunities for further collaboration on wildlife habitat strategies with state and regional wildlife and forestry agencies, organizations, and other partners" (USFS and Northeast-Midwest State Foresters Alliance 2022a).

The regional summary report identifies 14 common themes across the 21 State Forest Action Plans, including wildlife habitat, adaptation to climate change, carbon management, forest health, clean water, wildfire and prescribed fire, sustainable forest management on public and private lands, and forest-based recreation, among others. Three regional themes address wildlife habitat (USFS and Northeast-Midwest State Foresters Alliance 2022a):

- Wildlife habitat protection: Use land conservation tools to provide forests for wildlife habitat and corridors for wildlife diversity and species of greatest conservation need as identified in the SWAP.
- Wildlife habitat enhancement and restoration: Proactively manage for wildlife diversity with techniques that increase age, class, and structural diversity. Support nurseries to provide native trees and shrubs important for wildlife. Use prescribed burns and other practices to restore natural disturbance regimes and provide diversity in forest age structure. Improve tools to identify where rare ecological features are located and help forest landowners manage for them.
- Collaborative engagement: Work with the state fish and wildlife agency and other partners to support strategies in the SWAP and SFAP for landscape-level habitat conservation and enhancement.

The US Forest Service and Northeast-Midwest State Foresters Alliance produced an accompanying Landscape-Scale Conservation Interactive Web Map that displays multi-state priorities identified in the 2020 State Forest Action Plans. There are 15 landscape-scale priority areas in the Northeast and 18 in the Mid-Atlantic, with five of them shared across the subregions (USFS and Northeast-Midwest State Foresters Alliance 2022b). Individual State Forest Action Plans are available through the National Association of State Foresters[24].

The US Forest Service publication titled Forecasts of Climate-Associated Shifts in Tree Species (ForeCASTS) includes maps identifying future suitable Forest habitat ranges for 213 tree species across the US and globally[25]. Future Forest habitat suitability maps are available for 2050 and 2100 under multiple climate and emissions scenarios. The atlas of maps also quantifies the minimum acceptable distance between current habitat locations which may become unsuitable and the nearest habitat that will remain suitable in the future for a particular species (or group of species). ForeCASTS intends to assist conservation partners and managers in targeting priority tree species for monitoring, conservation, and adaptive management.

OUTDOOR RECREATION PLANS

State Comprehensive Outdoor Recreation Plans (SCORPs) are plans that describe a state's goals and priorities for outdoor recreation, updated every five years as required by the federal Land and Water Conservation Fund. Outdoor Recreation is an important activity that impacts Northeast fish, wildlife, and habitats, including RSGCN, and coordination to incorporate SWAP and regional priorities is encouraged. Individual SCORPs are not on the same revision cycle across the Northeast, with the current plans covering 2017-2022 for some states and others 2020-2025. There is extensive public engagement in the development of SCORPs, which often include polls, surveys and focus groups to determine the public's outdoor recreation needs and wants. Detailed information includes demographic and public participation data on outdoor recreation in the state. The priorities outlined in a SCORP may be implemented at the local level through state and federal grant programs for parks, trails, and a variety of outdoor recreation projects. The Society of Outdoor Recreational Professionals maintains a directory of SCORPs[26]. The 2020 update of the Pennsylvania SCORP, for example, includes the results of a project undertaken by The Trust for Public Land to map public access to the state's outdoor recreation areas, waterways, and trails with demographic data, spatially identifying areas of the greatest need for improved public access. Collaboration and coordination between SWAPs and SCORPs present an opportunity to address both the needs and potential threats of public access to wild spaces.

The Society of Outdoor Recreation Professionals is a national organization with the goal of protecting natural and cultural resources while providing sustainable public access to recreation[27]. The organization provides training, technical guidance, and networking. The 2021-2025 Strategic Plan for the Society of Outdoor Recreational Professionals outlines goals and objectives to provide justice, equity, diversity, and inclusion in sustainable outdoor recreation opportunities that contribute to the overall sustainability of communities, ecosystems, and economies. A library collection of technical resources for topics from diversity, equity, inclusion, and accessibility to environmental education, responsible recreation, recreation conflict, heritage recreation, visitor use management, and access to public lands is available[28].

STATE EXAMPLES AND OPPORTUNITIES PROVIDING INFORMATION ON STATE AND REGIONAL PRIORITIES

State Fish and Wildlife Agencies have jurisdiction for and are repositories for state-level fish and wildlife conservation data. These data are used to inform many state, local, and federal planning, conservation, and regulatory entities as well as the public. State Wildlife Action Plans provide detailed science-based information on SGCN. Each Northeast State revises its plan every ten years and can be accessed through the respective **Northeast SWAP Website links:**

- Connecticut
- D.C.
- Delaware
- Maine
- Maryland
- Massachusetts
- New Hampshire
- New Jersey
- New York
- Pennsylvania - Fish
- Pennsylvania - Game
- Rhode Island
- Vermont
- Virginia
- West Virginia

The **NEAFWA** website[5] hosts the Northeast **SWAP Database** containing key data from all 14 Northeast SWAPs. This database was initiated by NEAFWA's Northeast Fish and Wildlife Diversity Technical Committee and developed by Terwilliger Consulting, Inc. This project was supported by State Wildlife Grant funding awarded through the Northeast Regional Conservation Needs Program which joins thirteen northeast states, the District of Columbia, and the U.S. Fish and Wildlife Service. It is administered by the Wildlife Management Institute in a partnership to address landscape-scale, regional wildlife conservation issues. Progress on these regional issues is achieved by combining resources, leveraging funds, and prioritizing conservation actions identified in the SWAPs. The RCN Program is an initiative of the Northeast Association of Fish and Wildlife Agencies.

State fish and wildlife agencies have developed more accessible data and web portals that depict the status and distribution of rare species and their habitats. State fish and wildlife agencies provide the most current data on fish and wildlife in their state that can be accessed by the public and used for environmental review and other uses. PA Wildlife Conservation Opportunity Area Tool; State Fish and Wildlife agencies/NHPs data; BioMap in Massachusetts; Beginning with Habitat in Maine; Taking Action for Wildlife in New Hampshire; and New Jersey's Landscape tool are just a few of these state programs that provide information to planners and developers for strategic planning and to minimize the impacts of development. State examples are listed below:

Massachusetts BioMap3[29]. A short video[30] presents the basics of BioMap3. The Massachusetts SWAP used Key Sites, based on BioMap2, to identify and target the most important sites for biodiversity protection and habitat management. The clear selection criteria, strategic approach, and limited spatial extent of the project (key sites account for about 10% of Massachusetts) help focus conservation efforts for states and partners. Actions taken in key sites are typical land protection or restoration steps, and they tend to lessen the impact of threats like development, climate change, and vegetative succession.

Rhode Island SWAP Community Guide provides recommendations, examples, and resources for local planners, such as the use of compliant LEDs and fixtures to reduce the impact of artificial lights on nocturnal species (RI Department of Environmental Management 2015). **Rhode Island Woodland Partnership**[31]: information about this partnership can be found online through the Partnership's website.

Maine Land Trust Network[32]. The Southern Maine Regional Planning Commission[33] is likely the best example of a multi-jurisdictional entity. **Maine Beginning with Habitat[34]** is another. Both offer valuable service to local level planning boards, regional planning commissions.

Vermont's Community Wildlife. Works with realtors to make sure that habitat value is a consideration whenever properties are sold. This manual offers choices and opportunities to **Vermont** communities and others who engage in land use and conservation planning efforts (Austin et al. 2013).

Virginia Department of Wildlife Resources Fish and Wildlife Information System is a public portal information to search current information on any species and habitats in Virginia[35]. The **Virginia Natural Landscape Assessment** 2022 GIS layers map the statewide network of natural lands, ecological cores, and landscape corridors in the state[36].

New Jersey's Conservation Blueprint is a data-driven, interactive mapping tool made possible through a partnership between The Nature Conservancy, Rowan University, and the New Jersey Conservation Foundation, together with a collective of 21 conservation-focused government and non-profit groups[37]. **Time for CHANJ.** Connecting Habitat Across New Jersey (CHANJ) is an effort to make NJ landscapes and roadways more permeable for terrestrial wildlife by identifying key areas and actions needed to achieve habitat connectivity across the state. CHANJ offers two main products – an interactive Mapping tool and a Guidance Document – to help prioritize land protection, inform habitat restoration and management, and guide mitigation of road barrier effects on wildlife and their habitats[38].

New Hampshire's Taking Action Together: Taking Action for Wildlife supports communities, conservation groups, and individuals with resources, tools, and training focused on conserving New Hampshire's wildlife and habitats[39].

PA Conservation Opportunity Area Tool: The 2015-2025 Pennsylvania Wildlife Action Plan is now available through a web-based map showing Species of Greatest Conservation Need within a user-defined area of interest[40]. Users can develop output reports that include actions to support the species and habitats in an area of interest. They can also generate lists of SGCN by county or watershed. See range maps for most Species of Greatest Conservation Need.

Maryland's Environmental Resources and Land Information Network
MERLIN Online is part of the Maryland iMAP mapping system was developed in the late 1990s to allow users to view spatial data and to use that information to make better informed decisions[41]. It allows users to produce a custom map of any location in Maryland, including their choice of base maps and data layers. For the advanced user, MERLIN Online data is available as Web Map Services (WMS) that can be incorporated into many desktop GIS applications and other online mapping tools. More information can be found at the Maryland iMAP Portal[42]. Maryland Department of Natural Resources website provide additional information on species in the state[43].

State Natural Heritage Programs are also a source for rare species and natural community information. In some states they are within the State Fish and Wildlife Agency. The **Massachusetts Natural Heritage Program of MA Fish and Wildlife** developed BioMap3. The Massachusetts SWAP used Key Sites, based on BioMap2, to identify and target the most important sites for biodiversity protection and habitat management. These included sites with a concentration of co-occurring rare species listed under the Massachusetts Endangered Species Act (MESA), those with the best-quality occurrences of high-priority species or natural communities (e.g., globally rare species), and those with multiple, co-occurring, landscape-level resources as identified by BioMap2. The clear selection criteria, strategic approach, and limited geographic scope (key sites account for about 10% of Massachusetts) help justify conservation efforts by states and partners. Actions taken in key sites are typical for other land protection or restoration strategies and are intended to limit the impact of threats like development, climate change, and vegetative succession. One approach to prioritizing biodiversity hotspots that promise to be resilient under changing climates is to preserve geodiversity across landscapes. When these geologically diverse places are protected, the result acts to preserve nature's "stage" for continued but shifting biodiversity "actors" (e.g. Beier et al. 2015, Anderson et al. 2015, Anderson et al. 2023b).

KEY REGIONAL PARTNER EXAMPLES AND OPPORTUNITIES.

For additional information and partners, please see *Chapter 7*.

NE Climate Adaptation Science Center (UMass Amherst and USGS)[44]. NECASC's robust scientific contributions have produced valuable tools and information on addressing climate change in the Northeast. Collaboration with natural and cultural resource managers has provided the climate change science to help inform fish and wildlife management decision-making and produce actionable products and results including more than 160 research projects and tools to facilitate climate change adaptation strategies for the Northeast.

One of the most significant contributions was the 2015 Northeast Climate Change Synthesis to support the 2015 Northeast SWAP revisions (Staudinger et al. 2015). Staudinger et al. (2015) provided a wealth of information on the state of knowledge of impacts, vulnerabilities, and adaptive management of Northeast RSGCN and their key habitats for the 2015 SWAP revisions. NECASC has initiated a project to update the 2015 synthesis and assist the 2025 SWAP revision process (Staudinger et al. 2023). The 2023 Northeast Climate Change Synthesis revision provides additional, current data including more detailed climate change predictions across the region, information on the different assessments and indices, and multiple case studies on current and projected conditions for RSGCN and their habitats. NECASC established a Northeast Climate Change Working Group to share information on Northeast efforts among key partners as well as to solicit information leading to a better understanding of the climate change-related needs of state fish and wildlife agencies and their key partners, and then to develop and deliver science to meet those needs. Please see *Section 4.6* for additional information on specific projects, resources, and references on climate change.

JOINT VENTURES IN THE NORTHEAST

Atlantic Coast Joint Venture (ACJV)[45]. The Atlantic Coast Joint Venture (ACJV) is a regional partnership to restore and sustain native bird populations and habitats throughout the ACJV region. The ACJV is comprised of 16 state wildlife agencies from Maine to Florida and the territory of Puerto Rico; federal and regional habitat conservation agencies; and other organizations. The partnership is currently focused on one of the most imperiled habitats in the ACJV region – coastal marshes and the suite of vulnerable birds that depend on them. The ACJV is leading a coordinated marsh restoration and protection effort across the flyway to ensure that the partnership can achieve its vision. ACJV approaches its coastal marsh conservation goals by focusing on three flagship species that represent this habitat: American Black Duck, Black Rail and Saltmarsh Sparrow. The partnership is working to develop species-specific population and habitat objectives, prioritize potential threats facing each species, and craft actions to remove or reduce those threats. ACJV works to protect, restore, and enhance critical habitats that sustain populations of these and other marsh-dependent fish and wildlife species. Its habitat work provides many strong and direct benefits to people by reducing flooding, improving water quality, and supporting tourism, recreation, hunting, and fishing.

ACJV's science-based tools help direct the most appropriate conservation actions to strategic places on the ground and include:

- Population and habitat objectives for our focal species and habitats.
- Decision-support tools and priority area maps to target conservation action.
- Conservation planning documents for focal species and coastal marsh habitat to guide work on the ground.

ACJV works through partnerships and through federal and other grant programs like the North American Wetland Conservation Act (NAWCA), National Coastal Wetlands Grants Program, National Fish & Wildlife Foundation, State Wildlife Grants, and Great Lakes Restoration Initiative grants to help partners obtain a five-year average of approximately $20 Million per year. This funding helps to conserve more than 46,500 acres per year and leverages an additional $47 Million annually for land protection and habitat restoration projects.

Appalachian Mountains Joint Venture (AMJV)'s mission is to restore and sustain viable populations of native birds and their habitats in the Appalachian Mountains Joint Venture[46] region through effective, collaborative partnerships. Its focus is on Bird Conservation, but this work also benefits the diversity of wildlife and habitats throughout the Appalachians. Much of AMJV's work revolves around improving the health, resilience, and structure of Appalachian Forests. AMJV works across the range of land ownerships, including federal lands (e.g., National Forests), state lands (state forests and wildlife management areas), industrially owned properties, and Private Lands. ACJV highlights a "working landscapes" approach that balances landowners' needs with conservation potential, one that typically results in win-win results for both birds and people.

Brook Trout Joint Venture (EBTJV)[47]. The Eastern Brook Trout Joint Venture (EBTJV) is a geographically focused, locally driven, and scientifically based effort to protect, restore and enhance aquatic habitat throughout the brook trout's Eastern US native range. Its mission is to secure resilient populations of wild Brook Trout by protecting, enhancing, and restoring aquatic habitat and increasing human connections to, and stewardship of, the natural environment. EBTJV fills a need for collaborative, coordinated management of brook trout habitat across jurisdictional lines, especially by providing science and data, collaboration and information sharing, funding results-oriented habitat projects, and promoting the story of native, wild brook trout.

Atlantic Coast Fish Habitat Partnership (ACFHP)[48]. Species-Habitat Matrix The Species-Habitat Matrix is an evaluation of the importance of benthic habitats as space for shelter, feeding, and breeding by coastal fishes and motile invertebrates in ACFHP's four subregions. ACFHP's analysis quantified the relationship between more than 100 different species across four life stages and 26 different habitats. To access the data and published results, visit the ACFHP website. **ACFHP's Assessment of Existing Information.** The Assessment of Existing Information was completed in 2009 with the primary purpose of informing and enabling conservation planning for ACFHP. It includes three components: 1) a representative bibliographic and assessment database; 2) a GIS spatial framework; and 3) a summary document with a description of methods, analyses of results, and recommendations for future work. The results supported development of priorities for ACFHP's conservation efforts within its boundaries.

Partners in Flight (PIF) databases[49] were developed through the voluntary collaboration of more than one hundred ornithological experts working to provide a standardized and transparent system for estimating the population size and conservation status of North American birds at multiple geographic scales. Additional data can be accessed from our partners via the Avian Knowledge Network (AKN)[50], a partnership of people, institutions and government agencies supporting the conservation of birds and their habitats based on current data, the adaptive management paradigm, and the best available science. AKN partners act to improve awareness, purpose, access to, and use of data and tools at scales ranging from individual locations to administrative regions (e.g., management areas, states, countries) and species ranges. The two distinct PIF databases are housed and managed by Bird Conservancy of the Rockies[51]. The **Population Estimates Database** (PED) provides breeding adult population size estimates for U.S. and Canadian land birds at continental, state/province, and Bird Conservation Region (BCR) scales. The **Avian Conservation Assessment Database** (ACAD) provides a wealth of information useful for assessing the conservation vulnerability and status of all bird taxa (waterfowl, waterbirds, shorebirds, and land birds) from Canada through Panama.

Xerces Society's Guidelines for Protecting Fireflies of the US and Canada provides conservation actions that address their key threats including habitat loss/degradation, pesticides, human disturbance, and light pollution(Fallon et al. 2019). They also provide habitat restoration and protection recommendations as well as protocols for surveying and monitoring, research needs, and outreach and advocacy recommendations. Xerces is a valuable resource for additional invertebrate species conservation expertise and information.

The Carnegie Museums' Online Invertebrate Database provides a wealth of information on these taxa (Fetzner 2011). NEAFWA's RCN program sponsored a 2016 Land Snail Project to assess the status and distribution of land snails in the Northeast as a first step in their conservation (Hotepp et al. 2013). Since then, almost 30 species of land snails have been identified as RSGCN or Watchlist species. A similar assessment of the dragonflies and damselflies of the Northeast serves as the foundation of RSGCN data for these species.

Shorebird Conservation Partners: At Virginia Tech, recent community-based social marketing research produced a guide to changing human behavior relative to shorebird disturbance (Mengak et al. 2019, Mengak and Dayer 2022). With the support of National Fish and Wildlife Foundation (NFWF), Community of Practice, various partner organizations, and some state offices/wildlife Refuges, campaigns to change behavior were developed and piloted at key sites. Analyses on the impacts of the Community of Practice's efforts are being evaluated using social and ecological science methods. This will result in an online toolkit to be published in spring of 2023, the final phase of a larger project on the Atlantic Flyway[52]. These efforts, in turn, will support development and implementation of even broader campaigns to change human behavior and protect shorebirds across the US and Canada.

The Wildlife Society (TWS) is comprised of national, regional, and state Chapters and Working Groups that serve multiple roles in wildlife conservation. Their publications, white papers, and position statements provide cutting edge scientific information and techniques across the region. The **Conservation Affairs Network** under TWS sets conservation priorities and actions geared toward outreach and support for conservation policy.

American Fisheries Society (AFS) is dedicated to strengthening the fisheries profession, advancing fisheries science, and conserving fisheries resources. Its publications include scientific articles, journals, and magazine. These include "**Common and Scientific Names of Fishes from the United States, Canada, and Mexico, 7th edition**" as well as the **Conservation Status of Imperiled**

North American Freshwater and Diadromous Fishes (Jelks et al. 2008). AFS is an active professional society producing a wide range of publications, white papers, and positions on many important issues facing fisheries today.

Eagle Hill Institute, sponsor of the Northeast Natural History Conference[53]. The Eagle Hill Institute (a 501(c)(3) scientific and literary nonprofit organization) is dedicated to contributing to a greater interest in scholarly and educational pursuits in the natural history sciences. The Institute has been providing natural history science summer seminars and fall workshops since1987 and has hosted the annual Northeast Natural History Science Conference since 2011. Its work has expanded over time to include the publication of a number of peer-reviewed scientific journals. It maintains a natural history and art history library, hosts occasional resident scholars, and offers chamber concerts, lectures, and discussion Forums.

The Northeastern Naturalist[54]. The *Northeastern Naturalist* covers all aspects of the natural history sciences focusing on terrestrial, freshwater, and marine organisms and the environments of the region from Virginia to Missouri, north to Minnesota and Nunavut, east to Newfoundland, and south back to Virginia. Manuscripts based on field studies outside of this region that provide information on species within this region may be considered at the Editor's discretion. The journal welcomes manuscripts based on observations and research focused on the biology of terrestrial, freshwater, and marine organisms and communities. Such studies may encompass measurements, surveys, and/or experiments in the field, under lab conditions, or utilizing museum and herbarium specimens. Subject areas include, but are not limited to, anatomy, behavior, biogeography, biology, conservation, evolution, ecology, genetics, parasitology, physiology, population biology, and taxonomy. Laboratory, modeling, and simulation studies on natural history of the region, without any field component, are considered for publication as long as the research has direct and clear significance to field naturalists and the manuscript discusses these implications.

These next four regional conservation actions specifically address the top regional threats identified in the 2005 and 2015 SWAPS and 2023 RSGCN and their habitats in the Northeast. Detailed information on these top threats, the RSGCN species they impact, and additional tools and resources are provided in *Chapter 3*.

These overarching actions prioritized in the Northeast region address key goals and targets of partner plans at multiple scales, including the most recent Global Diversity Framework from the "Kunming-Montreal" Convention on Biological Diversity3, the National Fish, Wildlife and Plants Climate Change Adaptation Strategy recommendations (National Fish, Wildlife, and Plants Climate Adaptation Network. 2021) and reflect a diversity of other partner plans from the global to local scale.

4.3 CONSERVE NORTHEAST RSGCN AND THEIR HABITATS BY ADDRESSING HABITAT LOSS AND DEGRADATION (FROM DEVELOPMENT, NATURAL SYSTEM MODIFICATION AND BIOLOGICAL RESOURCE USE)

4.3.1 REGIONAL NEED AND PRIORITY ACTIONS

Regional Need: The 2005 and 2015 SWAPs, the 2017 SWAP Synthesis, and the 2023 RSGCN process consistently identified that habitat loss and degradation from development, natural systems modification, and biological resource use as top threats facing Northeast RSGCN and their habitats. The Northeast region is among the most developed and modified areas in the United States, impacting RSGCN species and their associated habitats. A coordinated, regional approach and set of tools and guidelines to address land and resource use on Northeast landscapes and waters are needed, especially in the face of increasing impacts from climate change.

Priority Actions: Provide and encourage incorporation of SWAP and regional priorities into land, water and natural resource use plans, decisions, and management programs across the Northeast. Provide information and guidance with best practices and consistent protocols for RSGCN and their key habitats. Work with agencies and entities that regulate impacts to fish and wildlife habitats to develop and implement holistic, effective, consistent policies and approaches that incorporate climate projections into risk assessments across Northeast lands and waters to conserve and restore RSGCN and their habitats.

See Priority Species in Chapter 1, Priority Habitats in Chapter 2, Priority Threats in Chapter 3, each with partner and program opportunities and examples. See Table 4.1.1 and Appendix 4A for priority projects completed and Appendix 4B, the SWAP Synthesis, and individual SWAPs for additional priority Conservation Actions that address habitat loss and degradation across the Northeast.

4.3.2 APPROACH

From the global perspective, habitat destruction and over-exploitation are at the top of the list of global threats to biodiversity, although the relative ranking of these threats often depends on local context and the metrics used (Bellard et al. 2022). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

(IPBES), International Union for Conservation of Nature (IUCN), and World Wide Fund for Nature (WWF) recently ranked these global threat categories in terms of their estimated contribution to biodiversity loss. The IPBES ranking of these threats identified habitat change as the most important, followed by overexploitation, climate change, pollution, and biological invasions. See Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services[55]; and the United Nations Convention on Biological Diversity[56]. A synthesis of recent driver impacts indicated that land/sea use change has been the dominant direct driver of recent biodiversity loss worldwide. Direct exploitation of natural resources ranks second and pollution ranks third, followed by climate change and invasive alien species (Jaureguiberry et al. 2022). Although the ranking of threats at the global scale varies depending on the system used, the same threats consistently rise to the top. Addressing global biodiversity loss requires tackling all these major drivers as well as their many interactions.

The December 2022 Convention on Biological Diversity set targets for land and water conservation that aim to reverse the unprecedented losses caused by development at the national and global scales. One of the agreement's twenty-three targets aims to protect at least 30 percent of the planet's land and water by 2030. Thirty-by-thirty (30×30) refers to efforts by the global community to conserve 30% of terrestrial and marine habitat by 2030. This became official policy in the U.S. in 2021. See the **IUCN Green List of Protected and Conserved Areas**[57] and **Protected Areas Database of the US (PAD-US)**[58]. TNC is augmenting the PAD-US dataset as part of the RCN Northeast Habitat Condition Analysis project by reaching out to its state chapters in the Northeast for the best available information (Anderson et al. 2023a).

EPA's Report on the Environment[59], The National Climate Assessment[60], the Socioeconomic Data and Applications Center (SEDAC), CIESIN-The Earth Institute at Columbia University[61], and NASA's Earth Observing System Data and Information System (EOSDIS) Distributed Active Archive Centers[62] provide detailed information on the status of environmental health and biodiversity nationwide. Again, the same threats rise to the top, and are all anthropogenic in their origin. The first iteration of the SWAP Synthesis (TCI 2007) listed the same top threats as did the 2015 SWAPs and the 2023 RSGCN analysis (see Chapter 3 for detailed threat descriptions, impacts and examples in the Northeast).

Biological resource use of animals and plants continues to impact RSGCN and their key habitats in the Northeast in multiple ways (see Chapters 1 and 2). See Chapter 3 for detailed threat descriptions, RSGCN impacts, and additional resources for responding to this threat. Reducing it requires working closely with regulatory agencies and divisions that regulate harvest of animals or plants. In some states the jurisdiction of some animals and plants is shared with other agencies. Some state fish and wildlife agencies may not have authority for all invertebrates or plants. Close coordination with all regulatory authorities is critical (e.g., state Department of Agriculture) and states often develop cooperative agreements between agencies for this purpose.

State marine programs usually have jurisdiction over marine plants and animals, though diadromous fish are often shared responsibilities. For conservation of marine RSGCN, agency counterparts include NOAA's National Marine Fisheries Service (NMFS), as well as regional fisheries Councils and Commissions. NOAA's current Strategic plan for New England and the Mid-Atlantic region outlines approaches to managing fisheries and marine resources (NMFS 2022). The plan states that effective science-based management is essential to reaching optimum yield while preventing overfishing. Close collaboration with the New England and Mid-Atlantic Fishery Management Councils, Atlantic States Marine Fisheries Commission, state and fishing industry partners, the Northwest Atlantic Fisheries Organization, and local organizations and stakeholders should continue to address impacts on RSGCN and their habitats. Halpern et al. (2019) describes the status and recent changes to ocean environments. The current NOAA National Strategy can be accessed through the NOAA Fisheries website (NMFW 2022).

Development, natural systems modifications, and biological resource use have long been identified as top regional threats to RSGCN and their habitats in the Northeast, beginning with the original SWAPS in 2005 (TCI 2007). See *Chapter 3* for detailed threat descriptions, RSGCN impacts, and additional resources for each threat. It is important to note that most actions are ultimately taken at the local and state levels, even though they are identified as important at regional or broader scales. Regional implementation can include the development of consistent tools and data to inform customized state-level implementation. A coordinated approach between and among the states to share their advancements in the development of broader, regional tools and guidelines is more efficient and effective than 14 states working independently toward the same goal.

Together, the fourteen 2015 Northeast SWAPs cited more than 800 unique actions to address the severe, irreversible threat posed by development. More than 75% of the recommendations pertained specifically to residential development, but some of the recommended actions were more broadly focused.

The most commonly shared and frequently cited action categories to address habitat loss and degradation listed by SWAPS are (in descending order):

1) **direct management of natural resources;**
2) **data collection and analysis;**
3) **land and water acquisition and protection;**

4) **outreach, planning, species management/reintroduction, coordination and administration; and**
5) **partnerships, technical assistance, and law enforcement.**

All were identified as critical to strategically addressing the threat of development (TCI and NEFWDTC 2017) (see *Appendix 4B*, the 2017 SWAP Synthesis and individual SWAPS for additional actions in each category.

Numerous efforts have been undertaken to **inform local and state land use planning and development**. Each state's Fish and Wildlife agency and Natural Heritage Program provides detailed information on the status, occurrence, and distribution of rare and endangered species, their habitats and associated natural communities. Ensuring that local, state, and regional planning and development are informed by SWAP SGCN and RSGCN species and habitat information is the critical first step toward ensuring that they are considered in each local and regional plan and project. Along with the environmental review process for each state and locality, providing SWAP and regional key habitat and COA information that identifies important areas and considerations allows local planning boards and commissions to be more strategic in their design and placement of projects.

This includes **identifying important lands and waters to be protected as cores with corridors** that allow healthy movement of fish and wildlife populations and enough conserved habitat on public and private lands to make this movement possible. The restoration of functioning ecosystems in targeted areas to connect and enhance the matrix of conserved habitat is a key conservation priority. Environmental review and restoration should not only consider the historical impacts on a species and system, but also incorporate climate change projections to help determine whether future conditions will support the species or system and to prioritize areas that offer climate refugia and suitable habitat.

A common thread in SWAPs was the need to inform land use decision-makers in both the public and private sectors about the importance of incorporating SWAP priorities (RSGCN, SGCN, COAs and key habitats) into their plans and programs.

State fish and wildlife agencies and their partners with direct knowledge of SGCN and their habitats can **provide technical assistance to landowners, land managers, and decision-makers** on the most appropriate strategies and best practices for incorporating wildlife diversity into land use planning at the local, state, and regional levels. State agencies can engage partners for effective conservation and to inform stakeholders and the public about the importance of SGCN and their role as sentinel species for functioning ecosystems, as well as in protecting clean air and water and quality of life for human communities. Proactive conservation is also a more ecologically, socially, and economically beneficial approach to resource management. Smart growth planning can avoid significant costs, such as the destruction along developed coasts caused by hurricanes and other coastal storms. Additional actions and resources can be found in the 2017 SWAP Synthesis and action matrix in *Appendix 4B, Chapter 2* (by habitat) and *Chapter 3* (by threat).

As development, natural system modification, and biological resource use continue to impact Northeast wildlife and its habitats, **providing access to SWAP and regional data** and encouraging its use in strategic growth planning, transportation, and green infrastructure initiatives is key. New tools are being developed at the regional, state, and local levels to facilitate incorporation of regional data and priorities into resource management and planning (see Table 4.1.1 and Appendix 4A and Chapter 2 for habitat management information and examples). Development for commercial, industrial, recreational, and residential purposes is a longstanding threat to many wildlife species. It fragments habitats and reduces wildlife populations, either directly through events like construction and road mortality, or indirectly via the introduction of invasive species or diseases. As climates changes in coastal areas, human populations will expand into other areas, displacing or adversely impacting native wildlife in the process. See *Chapter 3* for detailed threat descriptions, RSGCN impacts, and additional resources for these threats.

Planning should prioritize landscape connectivity and include actions that support migration corridors and facilitate movement of multiple species in terrestrial, aquatic, and coastal habitats. In terrestrial systems, The Nature Conservancy's resilient and permeable landscapes tools can be used to identify climate-resilient sites and corridors (Anderson et al. 2016a, 2016b). Designing Sustainable Landscapes[63] and Nature's Network[64] can be used to evaluate development scenarios with information and RSGCN data, prioritizing areas for conservation, restoration, and land acquisition as a way to increase connectivity and preserve refugia. The U.S. Geological Survey's Coastal Response data layers[65] and TNC's Resilient Coastal Sites[66] can be used to identify locations that support and protect coastal resiliency and to prioritize areas for land acquisition and restoration that allow upslope and inland migration (Anderson et al. 2016b).

Many states and partners identified the need to **determine priority areas for protection and conservation**. Many SWAPs identified Conservation Opportunity Areas and Nature's Network/Database by NALCC and its partners addressed this at the regional scale. Planning, outreach, and technical assistance encourage the use of incentives and improvement of land use practices by working with both public and private sector partners. SWAPS identified specific habitats where voluntary incentives could be used. These include wetland and riparian buffers, vernal pools, northern and south-central forest and swamps, pine barrens, wetlands, and coastal dune and marsh habitats. A key objective is to improve connectivity of the human/built landscape to mitigate the effects of sprawl and limit additional habitat fragmentation. Several RCN projects developed BMPs to specifically address development, natural systems modification, and biological resource use (see Table 4.1.1 and Appendix 4A).

Education and Outreach actions included development and dissemination of a variety of wildlife-friendly tools and information for localities, homeowner associations, etc. Providing technical assistance to landowners, planners, developers, and other land users was cited by the SWAPS as crucial to protecting SGCN and their habitats.

Law and Policy recommendations focused on the need to improve buffers around important wetlands; wildlife friendly zoning; and incentives for public and private sector conservation and stewardship. These include green infrastructure, land tax programs, long term easement incentives, and policy as well as private sector standards and incentives for wildlife-friendly lawn care and better water management through the reduction of semi-impervious surfaces. See *Chapter 7* for additional information on Northeast partners and *Chapter 3* for more detailed threat information.

4.3.3 REGIONAL PROJECTS ADDRESSING HABITAT LOSS AND DEGRADATION FROM DEVELOPMENT, NATURAL SYSTEMS MODIFICATION AND BIOLOGICAL RESOURCE USE

The NEFWDTC and SWAP Synthesis identified Development, Natural Systems Modification and Biological Resource Use as top regional threats in the 2005 and 2015 SWAPs. To address them, NEAFWA's RCN and key partner programs prioritized and funded multiple projects to provide management guidelines and Best Management Practices (BMPs) that will help restore and improve habitat quality, function, and connectivity for RSGCN in the region. For a complete list of these projects, see Table 4.1.1 and *Appendix 4A*; for additional partner information see *Chapter 7*.

See Priority Species in Chapter 1, Priority Habitats in Chapter 2, Priority Threats in Chapter 3, each with partner and program opportunities and examples. See Table 4.1.1 and Appendix 4A for priority projects completed and Appendix 4B, the SWAP Synthesis, and individual SWAPs for additional priority Conservation Actions.

Appendix 4A provides a list of projects that have advanced the conservation of these regional species and habitats through the RCN, CSWG, SA programs from 2007 to 2023. This Chapter provides a list (Table 4.1.1) and summaries of those projects implemented since the 2013 Synthesis, organized by the predominant information or tool and SWAP element they address. The key RCN and CSWG projects addressing Development, Natural Systems Modification, and Biological Resource Use are summarized below.

Development of Model Guidelines for Assisting Local Planning Boards with Conservation of Species of Greatest Conservation Need and their Key Habitats through Local Land Use Planning (2008) (RCN). This project focused on integrating conservation information on SGCN and their habitats with land use planning decisions. The intended audience was decision-makers, particularly those at a local scale, and volunteers needing access to information. The goal in many instances was to answer their questions with a few simple keystrokes. The project developed an initial toolkit for planners that provides a) easy access to SGCN and habitat information; b) access to funding sources that support wildlife conservation planning; c) legal frameworks in each state that address SGCN; d) BMPs; and e) mechanisms that can deliver this information efficiently and effectively. A regional and state-by-state overview of wildlife conservation practices in the Northeast helps to identify priorities for future studies, reveals gaps in information, and highlights successful programs. The study also builds on a wealth of information previously compiled by each partner and offers an inventory of existing delivery mechanisms, legal requirements, BMPs, funding sources, and key networking and dissemination opportunities available in the Northeast region. Through in-depth interviews with representatives of state wildlife agencies, selected land trusts, and municipalities, the study identifies gaps in the existing delivery system that may be filled through an expanded toolkit. This project includes a) an overview of wildlife and conservation information available from a national / regional and state- level sources, as well as detailed information in an Excel spreadsheet format ; b) case studies showing how biodiversity conservation was incorporated into planning in Virginia and Pennsylvania; c) legal conservation frameworks for each state ; d) funding sources for conservation by state; and e) links to a demonstration toolkit for three states (Virginia, Pennsylvania, and New Hampshire). This toolkit is available on NatureServe's LandScope America. It brings together maps, data, and stories about natural places and presents them in dynamic and accessible formats (Sneddon et al. 2012).

Staying Connected in the Northern Appalachians (2008) (CSWG). This project implemented top priority actions from the Maine, New Hampshire, New York and Vermont Wildlife Action Plans to restore, maintain and enhance the six most important habitat linkages in the Northern Appalachian Ecoregion, benefitting at least

41 wide-ranging and forest-dwelling SGCN. Benefits to SGCN will accrue through protecting the ability of species to move regionally in response to changing climate and by protecting and/or restoring opportunities for regional genetic interchange. States will integrate conservation planning at the ecoregional, state and local scales with land protection (at least 18,250 acres) and technical assistance activities targeted to municipalities where most land use decisions in the Northeast are made. The work of this partnership of eight state agencies in four states and 13 non-profit organizations will be complimented by similar conservation activities in the neighboring four Canadian provinces. International coordination will be provided by Two Countries, One Forest.

The Staying Connected in the Northern Appalachians Initiative, also referred to as the "Staying Connected Initiative" or SCI[67], was supported by a Competitive State Wildlife Grant awarded in 2009 and by other funding sources. Staying Connected advanced landscape-scale conservation across the Northern Appalachian Ecoregion by maintaining, enhancing, and restoring habitat connectivity for a variety of SGCN. The SCI partnership concentrated its work in eight key areas, focusing on connectivity and the blending of conservation science, land protection, technical assistance for land use planning and community action, and road barrier mitigation.
The final report includes separate reports on each of twelve component projects supported by SCI's Competitive State Wildlife Grant (CSWG). The other essential piece of this report is the extensive body of supplemental materials provided in the attachments.

Best Management Practices for RSGCN In Northeast Forests (RCN). This project provides BMPs for the biological resource use of forested habitats. Northeastern forests are considered key habitat for a large suite of wildlife, including several habitat specialists listed as SGCN in multiple states. Their vulnerability to various stressors has prompted the formation of several species--level conservation and research initiatives. This RCN project collaborated with key forest stewards to integrate current ecological and biogeographic information into on-the-ground habitat enhancement. This collaboration produced spatially explicit management and conservation support for five regional SGCN: Bicknell's Thrush, Wood Thrush, Canada Warbler, Rusty Blackbird, and American Marten. For each of these species, the report contains a species profile, conservation status, habitat landscape characteristics, desired habitat conditions, recommended management/conservation practices, and ecosystem services and comprehensive planning. The project engaged both experts and end users to produce scientifically sound and practical guidelines for conserving these species and other SGCN in their guilds. Available occurrence data, distribution models, and stakeholder input delineated and prioritized areas with high management and conservation potential. Working directly with habitat stewards ensured that the recommended practices are implemented in management and conservation opportunity areas. Results include field guides and guidelines for managing habitat for RSGCN in the Northeast and Mid-Atlantic Forests, a final report, and spatial prioritization for implementing these guidelines for RSGCN (Lambert and Reitsma 2017, Lambert et al. 2017).

Implementing Bird Action Plans for Shrubland Dependents in the Northeast (2007-2012) (RCN). This project enhanced the conservation status and increased awareness of shrubland habitat-dependent SGCN in the Northeast, with a focus on the Appalachian Mountains. SWAPs in VA, MD, WV, PA and NY collectively identify 87 SGCN that are dependent upon shrubland habitats in Bird Conservation Region 28 – Appalachian Mountains. Among the 87 shrubland- dependent SGCN, there are 40 birds, 16 mammals, 16 amphibians/reptiles, and 15 invertebrates. Shrubland habitats in BCR 28 have declined due to loss of land to development, maturation of successional habitats, suppression of natural disturbance, and lack of active management. To address the decline in shrubland habitat-dependent SGCN, this project was designed to increase the conservation status of shrubland habitats on public and private lands through the development of Best Management Practices (BMPs), establishment of BMP demonstration areas, monitoring the response of selected shrubland species to habitat management, and outreach to public land managers and private landowners. Restoration of shrubland habitats depends on private landowner awareness, knowledge, and engagement in providing conservation benefits to the suite of species. Short-term conservation benefits included an increase in shrubland habitats. Long-term benefits will accrue from a growing awareness among private landowners that current and future actions taken on their land will determine if this suite of species remains imperiled. Final products include a report *Implementing Bird Action Plans for Shrubland Dependents in the Northeast* as well as the following publications: *Implementing the American Woodcock Conservation Plan, American Woodcock Habitat: Best Management Practices for the Central Appalachian Mountains Region* and *Under Cover: Wildlife of Shrublands and Young Forest*. A web site[68] was developed and populated with documentation of BMPs, demonstration areas, and opportunities for technical assistance (McDowell 2011, Gilbart 2012).

Establishing a Regional Initiative for Biomass Energy Development for Early-Succession SGCN in the Northeast (RCN). This project outlined the costs and benefits that biomass energy systems pose for SGCN in the Northeast. This information can be used to identify opportunities that certain biomass energy applications present for managing SGCN. It can also provide an impetus to work with biomass developers for mutual benefit. For example, some biomass energy systems have the potential to provide habitat favorable to early successional SGCN. In nearly all 13 states, early successional species are included in the list of SGCN but the tools available to wildlife managers for creating and maintaining these habitats are dwindling. Biomass energy systems provide a clear opportunity for early successional species habitat management. Public demand for green energy alternatives is increasing and the amount of land needed to supply these facilities is substantial. There are many types of biomass systems, either in-place or proposed, for the region. The project team investigated only those systems that utilize native species and assigned each of the SGCN to a general habitat class based on life history information. Potential interaction responses of positive, negative, no effect, or not applicable were assigned to each combination of biomass system and SGCN; and the net potential impacts of specific biomass system implementation on SGCN were summarized.

Overall, the results of this project show that biomass energy development will impact SGCN at the state and regional levels. Results, in general, indicated that biomass systems that utilize wood from existing mature forests will result in a net negative impact to SGCN as these forests are converted to a younger state. Biomass systems sited on existing agricultural land would have a larger potential net positive for SGCN regardless of which biomass system was implemented. Some of the biomass systems presently under discussion have structural or floristic components similar to those provided in these species' natural habitats. This is particularly true for "early successional species" that utilize habitats maintained through frequent disturbance. Ultimately, the interest in biomass energy development may supply the only real landscape-level alternative for addressing the shortage of shrub and grassland habitat in the region. The study recommends that wildlife resource management agencies become active participants in the planning and implementation phases of biomass energy project development, to mitigate potential negatives and maximize potential benefits (Klopfer 2011).

Best Management Practices for Wetland Butterflies (RCN). This project provided BMPs for the management of wetland habitats. It also addressed the uncertain status and distribution of many wetland butterfly species in several Mid-Atlantic States, including SGCN and RSGCN species in the Northeast. Some species declines may be due in part to threats impacting groundwater wetlands, including outright destruction, habitat degradation, and the succession of open wetland habitats to forest or dense shrubland. Climate change and habitat fragmentation may further impact these species and leave them vulnerable to local extirpations. The primary objective of this effort was to enhance and expand populations of wetland butterfly SGCN through developing a greater understanding of the distribution and habitat requirements for these species, and by implementing habitat enhancement projects where needed. Project goals were to: 1) update distribution data for 14 butterfly SGCN in the region; 2) model species distribution and climate conditions for each species; 3) identify and prioritize wetlands that support one or more of these 14 species; 4) implement wetland enhancement and improvement projects; and 5) develop BMPs for species distribution and climate modeling and for wetland enhancement projects. Results should guide targeted survey work for these species and prioritize wetlands for enhancement projects. In the long-term, results may also improve habitats for these species, increase populations of butterfly SGCN, and promote connectivity between populations through increased habitat availability. Fourteen species of wetland-inhabiting butterflies with SGCN status were surveyed at multiple sites across four states – Maryland, New Jersey, Pennsylvania, and West Virginia—in 2016-17. Survey data was used to evaluate the status of each species in all states where they occurred, as well as to refine the distribution data for each species across the region. All data points were mapped in ArcGIS and used to model species distribution in terms of both habitat and climate. BMPs were developed, and habitat enhancement projects were initiated in Maryland and Pennsylvania. The report includes Life History Guides to the 14 species, the Pennsylvania Habitat Management Guide for Pollinators, Wetland Butterfly Habitat Enhancement BMPs, and additional resources including a model Wetland Restoration Report (Frye et al. 2018).

Conservation Plans for Blanding's, Bog, Wood, Spotted, and Box Turtles and Associated Wetland-Dependent SGCNs (RCN, CSWG). Over the past decade, significant advancements have been made in addressing the information and conservation needs of RSGCN turtles through the RCN and CSWG grants. Multiple partners and grants (RCN and CSWG) have resulted in robust conservation plans, protocols, and best management practices to be implemented regionally for these important RSGCN. See *Appendix 4A* and summaries presented in *section 4.2.3*. For additional information on the BMPS, protocols and conservation actions that address development and biological resource use see the Conservation Planning for Northeast Turtles website[15].

The SA ARS program 2022 efforts for the Northeast Turtles (Blanding's, Spotted, and Wood Turtle) Conservation. The At-Risk Turtle team worked with the states to implement conservation plans that are informed by standardized monitoring and genetic analysis. Specifically, this work has focused on: 1) securing viable populations through land conservation (using grant programs like LWCA, DE Bay, Chesapeake Wild, and America the Beautiful, and NRCS's Wetland Reserve Easement program); 2) enhancing populations through restoration of habitat (work on refuge lands, DoD lands, and working with NRCS on private lands); 3) decreasing road mortality in areas with high mortality rates (work on refuges and with individual states using DOT funds); 4) addressing illegal trade in turtles. The team continues to provide leadership on the Collaborative to Combat Illegal Trade in Turtles, to support Law Enforcement by identifying housing for confiscated turtles, and to help states get turtles back to the wild through genetic and disease screening. Development of outreach tools is part of a long-term strategy to address illegal trade in turtles continues. The ARS program assesses population status on refuges and DoD lands, and through projects with NAFO, and is the lead for spotted and wood SSA and assists on the Blanding's SSA.

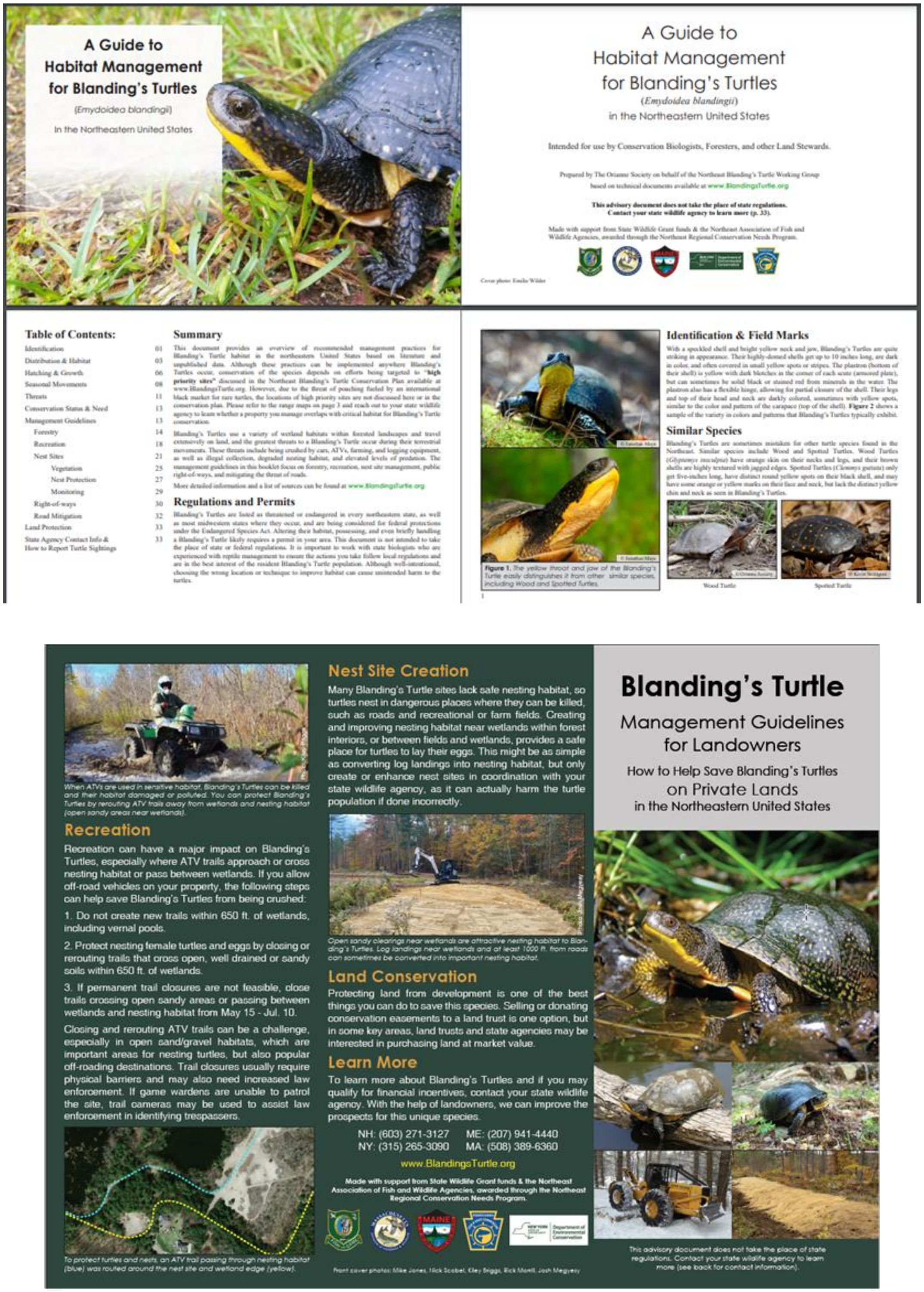

Figure 4.3.1. Management guidelines for RSGCN Turtles (see northeastturtles.org).

Population Declines Due to Loss of Adult and Juvenile Turtles to Illegal Wildlife Trade in 2021 (CSWG). The goals of this project were to: 1) assess recently developed health and disease testing protocols and 2) determine the best method and use of genetic information to determine the place of origin of confiscated animals. These two actions are designed to slow the rates of decline in eastern, native SGCN turtle populations due to wildlife trafficking by providing states with the information needed to make an informed decisions regarding repatriation.

Young Forest and England Cottontail Conservation Initiative (2007-14) (CSWG, SA, RCN). As part of its young forest project, NEAFWA's Habitat Technical Committee developed a manual providing information and recommendations on managing and renewing young-forest habitats in the Northeast: Managing Grasslands, Shrublands and Young Forests for Wildlife (Oehler et al. 2006). Multiple resources, including articles, brochures, guidebooks and manuals, presentations, etc. are available on this site. A Conservation Strategy (Fuller and Tur 2012), and a recent outreach plan for the New England Cottontail (New England Cottontail Outreach Strategy 2018) are also available to help partners implement the conservation strategy for New England cottontail rabbit (*Sylvilagus transitionalis*).

The goal of the initiative in the short-term is to restore 1200 acres of New England cottontail habitat, creating 50 new habitat patches across the species range, with an expected long-term population increase of 720 animals. The goal in the long-term is to avert federal listing by increasing the rate of colonization of habitat patches, thereby stabilizing metapopulation viability. Objectives included: 1) convene a range-wide recovery steering committee comprised of partnering state wildlife agencies, NRCS, and USFWS; 2) evaluate target properties for habitat restoration and draft a spatially explicit habitat restoration plan; 3) disseminate restoration plans to local stakeholders and partnering agencies; 4) prescribe and implement habitat restoration activities in an adaptive management framework; 5) monitor performance to determine the relative efficacy of implemented actions; and 6) provide technical and administrative support to the states and partnering entities.

The range wide "Conservation Strategy for the New England Cottontail" was completed in 2012 by a multi-agency working group. State conservation summaries were completed for all six states and included in the regional conservation strategy that was peer reviewed in June 2012. A comprehensive landscape analysis of all parcels in the species range supported the design of landscapes to support NEC populations and the identification of target sites. Across 6 states, 12,439 parcels were ranked as the most likely to be suitable. The best ranked parcels have been adopted as targets for range-wide NEC conservation. The formation of a private lands working group has increased the number of private parcels that are visited for evaluation, and resulted in contracts with NRCS, WMI, and USFWS Partners for Fish and Wildlife. More than 950 acres have been treated on state lands across all six states since 2009, and the target of 1,200 acres was met by May 2014. The **ARS Team supports the New England Cottontail rabbit conservation (SA)** throughout the region. In 2012, state wildlife agencies from Connecticut, Maine, Massachusetts, New Hampshire, New York, and Rhode Island worked with U.S Fish and Wildlife Service and the Natural Resources Conservation Service to finalize a conservation strategy to conserve the New England cottontail throughout its current range.

Pollinator Habitat in Xeric Grasslands, Barrens, and Woodlands (2018-22) (RCN) [22]**.** NEFWDTC prioritized another key regional habitat supporting multiple RSGCN taxa and focused on conservation of the fire-adapted xeric habitats that support a diverse fauna including pollinators. This RCN project developed a regional network of experimental adaptive management sites where coordinated management and monitoring leads to improvements in management over time. This includes ensuring adequate representation of forbs, bare soil, and other key pollinator habitat features; improving habitat for other RSGCN; and lowering management costs and treatment frequency to the greatest extent practical. The project also resulted in improved coordination and sharing of early successional habitat management expertise among states. Standardized, regional vegetation and pollinator monitoring protocols were developed, enabling more effective pooling of data and providing a framework for informed, science-based management decisions. The project improved understanding of the abundance and distribution of select, vulnerable pollinator taxa (e.g., bees and butterflies), and of how these species respond to habitat management over time. Results informed and improved on-the-ground management of at least 500 acres of habitat at regionally significant sites. The project served as a framework for longer-term monitoring and experimental adaptive management practices to improve overall management for these complex, fire-influenced systems (Milam 2018).

This Xeric Habitat for Pollinators Project focused on fire-adapted habitats (xeric grasslands, barrens, and woodlands) as a way to improve the ability of Northeast states to implement cost-effective habitat management for the benefit of native pollinators and other RSGCN that depend upon these priority habitat types. Templates for data collection and reporting were developed along with the vegetation monitoring project protocol, which seeks to provide data consistent with the longstanding monitoring programs at some of the more established sites. A key variable, the percent of vegetative cover, is expected to respond to treatments and to indicate habitat suitability for ground-nesting bees.

4.3.4 REGIONAL EXAMPLES AND OPPORTUNITIES TO ADDRESS DEVELOPMENT, NATURAL SYSTEMS MODIFICATION, AND BIOLOGICAL RESOURCE USE

Please see *Chapter 3* for detailed threat descriptions, impacts to RSGCN, and additional resources, tools and examples for each threat.

Habitat Management Guidelines and Best Practices for Reptiles and Amphibians. The RCN, CSWG and SA projects listed in Table 4.1.1 and summarized above on rare wetland turtles in the Northeast provide robust conservation plans, guidelines and resources. Additional Habitat Management Guidelines for Northeast Amphibians and Reptiles are available from PARC/NEPARC since habitat alteration, fragmentation and loss are collectively considered to be the primary challenge in the region. With herpetofauna populations declining and human populations expanding across more land, PARC developed a series of regionally specific best management practices, or Habitat Management Guidelines, to provide proactive guidance for improving the compatibility of land management practices with the conservation needs of these animals. These guidelines are not regulations and should be regarded instead as recommendations helping landowners and managers to consider the needs of amphibians and reptiles during their management activities. They are directed toward resource managers and private landowners who have a desire to help protect amphibians and reptiles. These are regionally specific guidelines for managing habitats with the goals of keeping common species common, stemming the decline of imperiled species, and reducing the likelihood that these species will become listed as threatened or endangered. More specific conservation and management plans containing more specific recommendations for turtle species, including the spotted, wood, box, and Blanding turtles, can be found on the Conservation Planning for Northeast Turtles website[15]. Mitchell et al. (2006) describe habitat management guidelines for herptiles in the Northeast. MacNeil et al. (2013) provides forest management guidelines for the Midwest.

Working with Urban areas and Infrastructure has provided a diversity of conservation and education opportunities. Sparks et al. (2019) attempt to "bridge the gap" between **Bats and Transportation Projects** in their Manual of Best Management Practices for Bridges, Artificial Roosts, and Other Mitigation Approaches for North American Bats. McCance et al. (2017) describe the importance of urban wildlife management in the U.S. and Canada. Many partners efforts seek to promote wildlife conservation and education in urban environments and have found opportunities to work with diverse development partners across the region (see *Chapters 2 and 7* for more details).

Wildlife Habitat Council (WHC)[69] empowers companies to advance biodiversity, sustainability, employee engagement and community relations goals. Its mission is to recognize, inspire, engage and support businesses to achieve wins for nature and vision is a world in which nature is fully integrated into all aspects of business (operations, corporate citizenship and management). WHC programs translate corporate sustainability goals and objectives into tangible and measurable on-the-ground actions. Through a focus on building collaboration for conservation with corporate employees, other conservation organizations, government agencies and community members, WHC programs focus on healthy ecosystems and connected communities.

Designing Sustainable Landscapes (DSL)[63]**.** Multiple tools to Design Sustainable, Permeable, Resilient Landscapes have been developed in the Northeast. Designing Sustainable Landscapes (DSL) is a landscape conservation project focusing on the Northeast region. Its purpose is to offer guidance for strategic habitat conservation by assessing ecological integrity and landscape capability for a suite of focal species across the landscape. Assessments are done for both the current landscape and potential future landscapes, as modified by models of urban growth, climate change, and sea level rise. Indices of ecological integrity were used as part of the modelling (McGarigal 2018a, 2018b).

For global and national context, The December **2022 Convention on Biological Diversity** set targets for land and water conservation that aim to reverse the unprecedented loss of nature to development. One of the agreement's twenty-three targets aims to protect at least 30 percent of the planet's land and water by 2030. Thirty-by-thirty (30×30) refers to efforts by the global community to conserve 30% of terrestrial and marine habitat by 2030. This became official policy in the U.S. in 2021. The IUCN Green List of Protected and Conserved Areas[57]and Protected Areas Database of the US (PAD-US)[58] are spatial resources available at the global and national scales. TNC is augmenting the PAD-US dataset as part of the RCN Northeast Habitat Condition Analysis project by reaching out to NE state TNC chapters for the best available information. See Anderson et al. (2023a).

The 30x30 Initiative is an inclusive model of conservation that is science-based, locally driven, and engages all stakeholders, from tribal and Indigenous communities to farmers, ranchers, and outdoors enthusiasts. The first annual progress report on the America the Beautiful initiative[70] highlights steps the Administration has taken over the past year to support locally-led and voluntary efforts to conserve, connect, and restore lands and waters across the nation that sustain the health of our communities, power local economies, and help combat climate change (America the Beautiful Interagency Working Group 2021). The report outlines the collective work to pursue the national conservation goal by the US Departments of the Interior, Agriculture and Commerce, and the White House Council on Environmental Quality. The federal actions described in the progress report align with the America the Beautiful initiative's guiding principles and build upon the existing investments made through the Great American Outdoors Act[71] to support the creation of more parks and increased access to the outdoors and nature-based recreation in historically underrepresented communities while creating jobs that support restoration and resilience. The initiative also prioritizes supporting Tribally led conservation and restoration priorities, as well as expanding collaborative conservation of fish and wildlife habitats and corridors.

Wildlife Corridors. The Wildlife Corridors Conservation Act of 2019 establishes a National Wildlife Corridors System to designate wildlife corridors on federal public lands. It also provides funding for states, tribes, and other entities to protect wildlife corridors on nonfederal lands. The new grant program would provide up to $100 million a year over the next five years through competitive grants to states, Tribes, and/or other land managers to construct wildlife crossings over or under their highways. This will ensure that fish, wildlife, and plants can migrate between habitats for genetic exchange and climate adaptation. The bill directs federal land and water management agencies to collaborate with each other, as well as with states, tribes, local governments, and private landowners, to manage national wildlife corridors according to the habitat connectivity needs of native species. The bill also creates a publicly available National Wildlife Corridors Database[72] to inform corridor protection. Establishing this program is a critical step forward in protecting and restoring fish, wildlife, and plant species populations across our nation's lands and waters. Collisions between vehicles and animals result in more than 200 human deaths and 26,000 injuries, as well as the deaths of more than 1 million large animals each year. Currently, VA and NH are the Northeast states that have passed enabling state laws to address this problem.

Habitat Connectivity. Similar collaborative RCN projects undertaken by TNC evaluate and map the relative landscape permeability or "habitat connectivity," resilience, and site capacity across the Northeast region. These projects determine how permeability and resilience coincide with the locations and habitat of species of greatest conservation concern to identify where the most important regional conservation areas are, as well as movement concentrations, particularly those areas where movements may be funneled due to constriction in the landscape (Anderson et al. 2016a, 2016b, DeLuca2021). Using this information, TNC measured the amount of flow, permeability, and resistance present in the region's roads and in its secured-lands network. The projects are guided by a thirteen-state steering committee.

The DSL project provides much of the basis for the conservation planning tools used by **Nature's Network**[64] and **Connect the Connecticut**[73]. DSL is a project of the Landscape Ecology Lab at the University of Massachusetts and is supported primarily by the U.S. Fish and Wildlife Service North Atlantic-Appalachian Region, with additional support from the Northeast Climate Adaptation Science Center and the University of Massachusetts, Amherst. The most recent updates include revised 2020 data for species models and an Index of Ecological Integrity (IEI) to recreate the Nature's Network terrestrial cores and connectors. This phase also includes a new species model for Spotted Turtle. The new Spotted turtle Landscape Capability Model supported the development of Spotted Turtle conservation cores, showing connectivity among cores, and road vulnerability. Additional updates provide transportation and infrastructure data on culverts, dams, and beaches for improved habitat connectivity analyses.

North Atlantic Aquatic Connectivity Collaborative. New decision-making tools that consider climate change and other stressors (including barriers, pollution and land use change) have also been developed to aid managers in planning conservation actions for aquatic connectivity and flows in stream[74], river and lake[75] systems, including the USGS FishTail indices[76]. Other resources, like the US Climate Resilience Toolkit[77] and the Massachusetts Wildlife Climate Action Tool[78], allow managers to explore information, tools, and case studies for a growing number of species, habitats, and sectors.

Development has reduced the quantity and suitability of fish and wildlife habitat across the region. This has put additional pressure on conserved or protected habitat, including management activities in those dwindling managed conservation areas. Many localities and states have adopted the most current Global Diversity Framework[3] target of conserving 30% of their lands and waters.

Northeast Climate Adaptation and Science Center (NECASC)[44]. NECASC has conducted multiple projects informing land and water planning and use, including refugia and connectivity projects. See Staudinger et al. (2023) for a synthesis of climate change information and tools. Their website profiles 165 projects addressing multiple aspects of fish and wildlife conservation in relation to climate change.

Atlantic Coast Fish Habitat Partnership[48] The Assessment of Existing Information was completed in 2009 with the primary purpose of informing and enabling conservation planning for ACFHP. It includes three components: 1) a representative bibliographic and assessment database; 2) a GIS spatial framework; and 3) a summary document with a description of methods, analyses of results, and recommendations for future work. The results supported development of priorities for ACFHP's conservation efforts within its boundaries. The Species-Habitat Matrix is an evaluation of the importance of benthic habitats as space for shelter, feeding, and breeding by coastal fishes and motile invertebrates in ACFHP's four subregions. The analysis quantified the relationship between more than 100 different species across four life stages and 26 different habitats.

The NOAA Marine Protected Area (MPA) Inventory identified protected areas of Estuaries, Marine Nearshore, Marine Offshore, and Oceanic habitats in the US that in 2020 met the IUCN definition for international protected areas. An interactive map of the MPA Inventory is available online[79]. Protected waters include National Estuarine Research Reserves (NERRs), National Marine Sanctuaries, and waters within the boundaries of state and federal parks, wildlife management areas, refuges, and preserves. In the Northeast, 218,388 acres of Estuaries and connected Marine Nearshore waters were protected as of 2020, including the nine NERRs (Table 2.19.1). There are two MPAs in the Marine Offshore and Oceanic habitat of the Northeast. The Northeast Canyons and Seamounts Marine National Monument includes 12,699 square miles of Marine Offshore and Oceanic habitat located approximately 130 miles east-southeast of Cape Cod in federal waters off New York and New Jersey. The Marine National Monument is approximately the size of the state of Connecticut in two disjunct but adjacent areas, one protecting three submarine canyons and one protecting four seamounts. The Gerry E. Studds / Stellwagen Bank National Marine Sanctuary protects approximately 847 square miles of Marine Offshore and Oceanic habitat and is located east of Boston between Cape Ann and Cape Cod, Massachusetts. Both MPAs are managed by NOAA.

Other protection measures for Marine Offshore and Oceanic habitats are regulatory in nature. These include the designation of Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) by NOAA Fisheries and the protection of coral areas from fisheries impacts by the regional Fishery Management Councils. Virtually the entire Marine Offshore and Oceanic areas of the Northeast have been designated EFH for at least one species at one life stage or another, including Atlantic HMS and multiple other managed species[80].

NOAA's current Strategic plan for New England and the Mid-Atlantic. The plan states that effective science-based management is essential to reaching optimum yield while preventing overfishing (National Marine Fisheries Service 2020). Annual commercial landings revenues total nearly $2 billion, and recreational fisheries generate more than $5.8 billion in trip expenditures. Close collaboration with the New England and Mid-Atlantic Fishery Management Councils, Atlantic States Marine Fisheries Commission, state and fishing industry partners, the Northwest Atlantic Fisheries Organization, and local organizations and stakeholders will continue.

Forest and Woodlands are managed at the state level with a State Forest Action Plan (SFAP). State Forest Action Plans present Sustainable Forest

Management as one of the issues in their Regional Summary of the 2020 State Forest Action Plans in the Northeast and Midwest Forests (USDA Forest Service and Northeast-Midwest State Foresters Alliance 2022a).
These plans outline conservation strategies and priorities like those found in SWAPs, making the states eligible to receive federal funding as authorized by the Cooperative Forestry Assistance Act[81] . State Forest Action Plans are required to incorporate SWAP information, including their habitat assessments, strategies, and shared priorities or goals. The State Forest Action Plans of the Northeast were updated in 2020. The US Forest Service and Northeast-Midwest State Foresters Alliance synthesized the 2020 State Forest Action Plans of the Northeast and Midwest and released a regional summary report in 2022 (USFS and Northeast-Midwest State Foresters Alliance 2022a).

State Forest Action Plans are updated on a 10-year cycle that falls halfway between the 10-year cycle of SWAP; and, the regional summary report identified "tremendous opportunities for further collaboration on wildlife habitat strategies with state and regional wildlife and forestry agencies, organizations, and other partners" (USFS and Northeast-Midwest State Foresters Alliance 2022a). The regional summary report identifies 14 common themes across the 21 State Forest Action Plans, including wildlife habitat, adaptation to climate change, carbon management, forest health, clean water, wildfire and prescribed fire, sustainable forest management on public and private lands, and forest-based recreation, among others. The US Forest Service and Northeast-Midwest State Foresters Alliance produced an accompanying Landscape-Scale Conservation Interactive Web Map that displays multi-state priorities identified in the 2020 State Forest Action Plans. There are 15 landscape-scale priority areas in the Northeast and 18 in the Mid-Atlantic, with five of them shared across the subregions (USFS and Northeast-Midwest State Foresters Alliance 2022b). Individual State Forest Action Plans are available through the National Association of State Foresters[24].

State Comprehensive Outdoor Recreation Plans (SCORPs) are plans that describe a state's goals and priorities for outdoor recreation. They are updated every five years as required by the federal Land and Water Conservation Fund. Outdoor Recreation is an important activity that impacts Northeast fish, wildlife, and habitats, including RSGCN, and coordination to incorporate SWAP and regional priorities is encouraged. Individual SCORPs are not updated on the same revision cycle across the Northeast: the current plans cover 2017-2022 for some states and 2020-2025 for others. There is extensive public engagement in the development of SCORPs often with polls, surveys and focus groups used to determine the public's outdoor recreation needs and wants. Detailed information includes demographic and public participation data on outdoor recreation in the state. The priorities outlined in a SCORP may be implemented at the local level through state and federal grant programs for parks, trails, and a variety of outdoor recreation related projects. The Society of Outdoor Recreational

Professionals maintains a directory of SCORPs[26]. The 2020 update of the Pennsylvania SCORP, for example, includes the results of a project undertaken by The Trust for Public Land to map public access to the state's outdoor recreation areas, waterways, and trails with demographic data, spatially identifying areas of the greatest need for improved public access. Collaboration and coordination between SWAPs and SCORPs present an opportunity to address both the needs and the potential threats of public access to wild spaces.

Landowner Incentive Programs. There is both a need and an opportunity to encourage land/water/resource conservation through voluntary incentives, landowner and partner agreements, and easements. Federal and state conservation agencies, including the Departments of Agriculture and the Interior, have a diversity of programs with technical and financial assistance available across the Northeast. Examples of habitat management action that attempt to mitigate development impacts include providing for wildlife movement (notably turtles and other reptiles and amphibians) across habitat types. Several RCN projects described above provide BMPs and conservation recommendations, specifically to prevent road mortality and habitat loss; develop more cost-effective and green infrastructure designs; install road crossing structures and fencing; protect nesting areas; and improve buffers. Multiple federal, state, and local programs support key habitat conservation across the Northeast. Coordination with these partner agencies---including USFWS, NOAA, Department of Transportation, Federal Emergency Management Agency (FEMA), Environmental Protection Agency (EPA), Federal Energy Regulatory Commission (FERC), Department of Agriculture and Consumer Services (DOA), Natural resources Conservation Service (NRCS), and their implementing agency counterparts at the state and local levels---to incorporate regional species and habitat priorities into their programs and projects is essential. NRCS implements on- the-ground conservation through its Working Lands for Wildlife Program[10]; USFWS offers landowner assistance programs[82]; and state fish and wildlife agencies and forestry agencies also provide landowner assistance for conservation. Natural processes and flow could be restored to impacted aquatic systems by working with localities and regulatory as well as non-regulatory partners to restore land connections, water quality and quantity, and reconnect aquatic networks for fish and wildlife movement (see *Appendix 4A*).

Additional actions to address or mitigate development include providing pollinator habitat (information and land/yard management techniques) at rural, suburban, and urban sites. Because some RSGCN have been able to adapt to developed areas (chimney swifts, swallows, night hawks, eagles, osprey, falcons, and a range of pollinators, for example), there is both a need and an opportunity to manage these urban species and their habitat through green infrastructure and artificial nesting structures.

Nongovernmental organizations (NGOs) and land trusts[83] are also important partners in local land conservation, assisting and acquiring voluntary conservation easements donated by landowners. There are hundreds of land trusts and conservation groups across the Northeast, and in many places, these local, state, and regional groups are leading the way forward in the protection of habitat and wildlife corridors, contributing 70% of the growth in land protected since 2015.

Numerous techniques and programs are available to improve the condition of Developed Areas for wildlife. Urban wildlife management is of increasing importance and takes many forms (McCance et al. 2017). Multiple partner organizations offer guidance and certification of developed spaces as improved habitats for birds and pollinators. Others offer programs for urban forestry and canopy trees. Some address specific hazards such as light pollution; collisions with glass, aircraft, or vehicles; and the use of transportation infrastructure by bats.

The National Wildlife Federation (NWF) Certify Wildlife Habitat program offers guidance for improving suburban and urban yards, gardens, schoolyards, commercial spaces, and roadside greenspaces for wildlife[84]. Certification requirements including providing wildlife food, water, cover, places to raise young, and the use of sustainable maintenance practices (i.e., soil and water conservation, controlling exotic species, organic practices). The program offers signage to be installed at certified spaces as education and outreach tools to the public.

The North American Butterfly Association offers a public Butterfly Garden Certification program to improve garden habitats for butterflies[85]. To be certified as a North American Butterfly Association Butterfly Garden, the garden must contain at least three species of caterpillar food plants, at least three species of nectar plants, and avoid of the use of pesticides. Multiple types of educational signs are available for installation in certified gardens.

The Xerces Society has developed a Pollinator Protection Pledge that outlines four steps for improving pollinator habitat in Developed Areas and agricultural areas[86]. The four recommended steps include growing pollinator-friendly flowers, providing nest sites, avoiding the use of pesticides, and spreading the word to others about the need to improve pollinator habitat. Pollinator Habitat signs are available as well as recommendations for sharing on social media.

Developed spaces can be certified as **Monarch Waystations by Monarch Watch** through a program to create, conserve and protect habitat for the RSGCN Monarch Butterfly[87]. Guidance is available for the public to create waystations or to certify existing spaces that meet the requirements for certification. Waystations must be at least 100 square feet in size, receive at least six hours of sun a day; have soil types and drainage suitable for growing milkweed and nectar plants; provide shelter from predators and the elements; have at least 10 milkweed plants of at least two species; provide a mix of nectar plants across multiple seasons; and include a plan for conducting regular maintenance of the space with activities like watering, removing invasive plants, and eliminating the use of insecticides. Monarch Waystation signs are available to increase education and outreach to the public.

The National Audubon Society manages Plants for Birds[88] and Bird-Friendly Building[89] programs, which together can create Bird-friendly Communities[90]. The Plants for Birds program encourages the public to improve developed spaces as bird habitat by creating native plant gardens. The Bird-Friendly Building program addresses the threats of light pollution and collisions with glass through a Lights Out network of cities and states.

The USFS Urban and Community Forestry Program provides technical, financial and educational assistance to developed communities with the goal of improving the tree canopy in Developed Areas in the Northeast and beyond[91]. The program is overseen by the National Urban and Community Forestry Advisory Council and guided by a Ten-Year Urban Forestry Action Plan with the current version spanning the decade from 2016 to 2026. Educational and scientific resources are provided on the Vibrant Cities Lab website[92], which includes an Urban Forestry Toolkit, and through a National Webinar Series. The NEAFWA region falls within the Eastern administrative region of the USFS. The exception is Virginia, which is within the Southern region.

Staying Connected Initiative (SCI). The Staying Connected Initiative[67] is a regional partnership between public agencies and non-profit organizations working to protect functional habitat linkages that mitigate the impacts of habitat fragmentation and climate change for many SGCN across the Northern Forest (Maine, New Hampshire, New York and Vermont and Canada). Wildlife in this region stay connected thanks to an extensive network of forest, wetland, and riverine habitats that enables far-ranging mammals to reach suitable habitat and helps maintain the genetic diversity as well as the overall health and vitality of wildlife populations.

Since 2009, SCI partners have completed permanent land protection projects that enhance connectivity in the linkage areas covering more than 50,000 acres. Approximately 40,000 additional acres of important connectivity lands are in various stages of development. SCI has provided direct assistance to dozens of localities, helping to secure or initiate meaningful improvements in the land use plans and/or policies of nearly 20 communities and at least three regional planning commissions. SCI has also identified road segments important for landscape connectivity and is collaborating with state departments of transportation (DOTs) to improve connectivity during road maintenance/upgrade projects. Within the SCI region, 13 towns have added connectivity provisions to their local plans; more towns are considering them; and another town has created a new Conservation Fund. In Vermont, one RPC has incorporated connectivity provisions into its regional plan, which covers 19 linkage-area towns and eight others outside the linkage boundary. Three additional RPCs are now working on similar provisions. Six towns have revised their zoning and subdivision bylaws/regulations to address habitat and connectivity priorities; and two towns have established new Conservation Commissions.

Adirondacks Program for Residential Development. The Wildlife Conservation Society's Adirondacks Program identified best practices and case studies for implementing conservation design ordinances that govern residential development, thereby helping communities and planning boards to adopt and implement land use practices that protect wildlife connectivity.

SCI focuses on the top priority actions identified in partner states' Wildlife Action Plans, providing land protection and technical assistance targeted to the places where most land use decisions in the Northeast are made. Primary objectives are:

1. To develop conservation science information and analyses on ecological features, wildlife movement zones, community conservation values, and wildlife road crossing locations, using these to inform land protection, land-use and transportation planning, barrier mitigation, and technical assistance for local groups and decision makers.
2. To protect important habitat connectivity "steppingstones" at key road crossings and other high priority areas through technical and financial support to land trusts.
3. To support local land-use planning through technical assistance that municipalities can incorporate into their town plans, land use planning, and zoning ordinances.
4. To provide local organizations with technical assistance designed to enhance the knowledge and skills of local groups so they can more effectively implement wildlife and connectivity conservation activities.
5. To increase the permeability of roads and highways by offering technical assistance to state transportation agencies as part of planned road maintenance/upgrades on priority wildlife linkage segments.

IUCN Green List of Protected and Conserved Areas[57] and

Protected Areas Database of the US (PAD-US)[58]. TNC is augmenting this dataset as part of the Northeast Habitat Condition Analysis project by reaching out to NE state TNC chapters for the best available information. See Anderson et al (2023a).

Other resources displaying regional conservation partnerships are available through **the RCP Network**[93] **and the ALPINE Network**[94].

The National Wildlife Federation encourages wildlife habitat on private lands through an assortment of programs, including the wildlife Habitat Certification Program[84].

Rapid and large-scale changes to lands and waters mean that wildlife are losing the habitats they once knew. Every habitat garden is a step toward replenishing resources for wildlife such as bees, butterflies, birds, and amphibians—both locally and along migratory corridors. By adding pollinator-friendly and monarch-friendly plants, gardens also count toward the Million Pollinator Garden Challenge[95].

See *Chapter 2* (for habitat development or resource use) and *Chapters 3* and *7* for additional partners and projects addressing development, natural systems modification and biological resource use.

STATE OPPORTUNITIES FOR IMPLEMENTATION

State fish and wildlife agencies have developed more accessible data and web portals that depict the status and distribution of rare species and their habitats. PA Wildlife Conservation Opportunity Area Tool; State fish and wildlife agencies/NHPs data; BioMap in Massachusetts; Beginning with Habitat in Maine; Taking Action for Wildlife in New Hampshire; and New Jersey's Landscape tool are just a few of these state programs that provide information to planners and developers for strategic planning and to minimize the impacts of development. State examples are listed below:

Massachusetts BioMap3[33]. The Massachusetts SWAP used Key Sites, based on BioMap2, to identify and target the most important sites for biodiversity protection and habitat management. The clear selection criteria, strategic approach, and limited spatial extent of the project (key sites account for about 10% of Massachusetts) help focus conservation efforts for states and partners. Actions taken in key sites are typical land protection or restoration steps, and they tend to lessen the impact of threats like development, climate change, and vegetative succession.

Rhode Island SWAP Community Guide provides recommendations, examples, and resources for local planners, such as the use of compliant LEDs and fixtures to reduce the impact of artificial lights on nocturnal species (RI Department of Environmental Management 2015). **Rhode Island Woodland Partnership**[96]: information about this partnership can be found online through the Partnership's website.

Maine Land Trust Network[32]. The Southern Maine Regional Planning Commission[33] is a good example of a multi-jurisdictional entity. **Maine Beginning with Habitat**[34] is another. Both offer valuable service to local level planning boards, regional planning commissions.

Vermont's Community Wildlife. Works with realtors to make sure that habitat value is considered whenever properties are sold. This manual offers choices and opportunities to Vermont communities and others who engage in land use and conservation planning efforts (Austin et al. 2013).

Virginia Natural Landscape Assessment[36]. 2022 — GIS layers map the statewide network of natural lands, ecological cores, and landscape corridors.

New Jersey's Conservation Blueprint[37] is a data-driven, interactive mapping tool made possible through a partnership between The Nature Conservancy, Rowan University, and the New Jersey Conservation Foundation, working with a collective of 21 conservation-focused government and non-profit groups. **Time for CHANJ.** Connecting Habitat Across New Jersey (CHANJ)[38] is an effort to make NJ landscapes and roadways more permeable for terrestrial wildlife by identifying key areas and actions needed to achieve habitat connectivity across the state. CHANJ offers two main products – an interactive Mapping tool and a Guidance Document – to help prioritize land protection, inform habitat restoration and management, and guide mitigation of road barrier effects on wildlife and their habitats.

New Hampshire's Taking Action Together[39]: Taking Action for Wildlife supports communities, conservation groups, and individuals with resources, tools, and training focused on conserving New Hampshire's wildlife and habitats.

PA Conservation Opportunity Area Tool[40]: The 2015-2025 Pennsylvania Wildlife Action Plan is now available through a web-based map showing SGCN within a user-defined area of interest. Users can develop output reports that include actions to support the species and habitats in an area of interest. They can also generate lists of SGCN by county or watershed. See range maps for most Species of Greatest Conservation Need.

4.4 PROTECT NATIVE NORTHEAST SPECIES AND THEIR HABITATS FROM THE INTRODUCTION AND SPREAD OF INVASIVE SPECIES AND DISEASE

4.4.1 REGIONAL NEED AND PRIORITY ACTIONS

Regional Need: The 14 Northeast 2005 and 2015 SWAPS, the 2017 SWAP Synthesis, and the 2023 RSGCN process identified Invasives and Disease as top regional threats to fish and wildlife diversity in the Northeast. imperiled species and habitats can be severely impacted or lost due to invasive species or disease, even if all other conservation objectives are met. Invasive species may be less negatively impacted by climate change than native species; or may even benefit from these changes. To effectively prevent or address these impacts, an effective, collaborative regional scale effort is required.

Priority Actions: Develop regionally coordinated and targeted early detection and rapid response strategies for the control and management of invasive, non-native species that pose threats to native wildlife or communities. Work with and through Northeast partners and networks for effective, inclusive, regional conservation. Use climate projections to estimate timelines and locations most vulnerable to invasive species spread and establishment. Coordinate with agencies and entities that regulate impacts to fish and wildlife habitats to develop and implement effective, consistent policies, incentives, and approaches to address invasives and disease across Northeast lands and waters.

See Priority Species in Chapter 1, Priority Habitats in Chapter 2, Priority Threats in Chapter 3, each with partner and program opportunities and examples. See Table 4.1.1 and Appendix 4A for priority projects completed and Appendix 4B, the SWAP Synthesis, and individual SWAPs for additional priority Conservation Actions that address invasive species and disease.

4.4.2 APPROACH

Prevention and documentation are critical to addressing the pervasive threat of invasive species and diseases. Once invasive species and diseases are established, whether through introduction or extension of their former range, control measures can be difficult to implement, and eradication may be impractical or prohibitively expensive. For more information on the impacts of invasive species and disease, see Chapter 3. Targeted outreach (e.g., to anglers, boaters, hunters, landscapers, outdoor recreationists) that provides information about the impact of invasive species and diseases and how to identify these emerging threats in the field is critically important. Working closely with the Wildlife Disease Cooperatives, state and regional Invasive Species Council, and other partners ensures up-to-date information and regional coordination.

In general, when prioritizing threats and actions, the cost, likelihood of success, severity of impacts, and urgency are all factors that need to be considered. In the case of invasive species, treatment is expensive and successful eradication can be difficult to achieve. Therefore, many of the proposed actions focus on prevention and monitoring. Addressing pollution and aquatic connectivity can help increase resilience to climate change and increase the adaptive capacity of native species and populations to future risk. Priority actions identified in 2015 SWAPS, presented in the 2017 SWAP Synthesis, and prioritized by the NEFWDTC and their Threat Working Groups include:

- **Develop regionally coordinated and targeted mechanisms for early detection and rapid response**, deploying control/management strategies and response plans that reduce the impacts and/or limit the distribution of invasive, non-native species (wildlife and plants) and disease.
- **Customize the existing National Invasive Species Strategy** based on - 1) prevention 2) early detection and rapid response 3) control and management, and 4) rehabilitation and restoration.
- **Develop and implement regional tools, incentives and BMPs** to maximize the effectiveness of these strategies while avoiding excessive harm to non-target species.
- **Identify Priority Areas**: Work with RISCC and other key partners to identify targeted locations for research, survey, management, eradication, and monitoring in the Northeast.
- **Develop effective and coordinated messaging and communication** about the threat, and actions to address this threat of disease and invasive species in the Northeast.
- **Develop and improve consistent protocols and policies**, incentives, and regulations in Northeastern states to prevent introduction and spread of disease and invasives.

The NEFWDTC and SWAP Synthesis identified Invasive Species and Disease as top regional threats in the 2005 and 2015 SWAPs. NEAFWA's RCN and key partner programs prioritized and funded multiple projects to provide information, management guidelines, and Best Management Practices (BMPs) and protocols to address the impacts of these threats on RSGCN and their habitats in the region. Some of the key projects are listed below as resources. For a complete list, see Table 4.1.1 and *Appendix*

4A; and for additional partner information see *Chapter 7*. For more detailed information on RSGCN and habitats, see *Chapters 1 and 2* respectively. *Chapter 2* provides information on Northeast habitat status and condition as well as RSGCN supported by each habitat. It also provides examples of management and conservation plans and efforts that address these threats in the region. ***Chapter 3* provides detailed threat descriptions, impacts on RSGCN, and additional resources and examples that may help in addressing this threat in the Northeast.**

4.4.3 INVASIVE SPECIES

Key state and regional partners have been monitoring invasive plants over the past decade (Bradley et al. 2022a, Allen et al. 2022). Invasive plants are a common focus of habitat management. A recent survey of natural resource managers in the Northeast found that 70% of the more than 200 respondents focused much of their time on invasive plants (Beaury et al. 2020). Chapter 3 provides more detailed threat descriptions, impacts on RSGCN, and additional resources and examples for this threat in the Northeast.

Invasive plant management is most successful during the early stages of invasion, when eradication is still feasible (Rejmánek & Pitcairn 2002). Proactive management at the early stages of invasion involves preventing species from being introduced through policy mechanisms such as state noxious weed lists. Proactive management also involves monitoring for new invasions and quickly eradicating the invaders before they spread – a practice known as early detection and rapid response (Westbrooks 2004). Preventing or detecting and then eradicating invasions early are much more cost effective than controlling invasions after the species has become established (Leung et al. 2002, Keller et al. 2007). Moreover, preventing plants from invading and reaching high abundance reduces environmental impacts (Tekiela & Barney 2017, Bradley et al. 2019).

Although proactive prevention, early detection and rapid response are the most effective tools for invasive plant management, controlling populations at any stage can benefit wildlife habitat. In a meta-analysis of studies from more than 200 papers, Bradley et al. (2019) showed that there is a significant negative, linear relationship between invasive plant abundance (e.g., percent cover, stem count, biomass) and native species diversity. From a management standpoint, this suggests that environmental harm continues to accrue linearly as plant invasions progress. Therefore, reducing invasive plant abundance at any stage of invasion reduces corresponding ecological harm.

Focusing on the current population of invasive plants in the Northeast, the first key management need is to reduce the continued introduction of known invasive species. Most invasive plants are introduced as ornamentals (Lehan et al. 2013) and lag times between introduction and invasion (Aikio et al. 2010) leads to the persistent sale of known invasive plants across the U.S. (Beaury et al. 2021a). The ongoing sale of invasive plants both perpetuates and expands current invasions (Beaury et al. 2021a). It also has the potential to seed new plant invasions as climate change makes conditions more suitable for novel species to invade (Allen et al. 2022; Bradley et al. 2022a).

One of the primary tools states can use to reduce the number of invasive plants introduced as ornamentals is the development and use of incentives and "green light" alternatives. Encouraging the use of native species by local nurseries and seed banks provides industry incentives and important outreach and messaging, as does the use of "green lists" of native species alternatives. Dumroese (2009) provides a manual of native plants to nurseries (see examples in the next section).

Another tool available to states is the regulation of the species as noxious weeds, and thus prohibiting their sale. States can provide incentives for the use of native seed banks, and "Green lists" for native species. They can also improve coordination and consistency of regulation across state borders (Lakoba et al. 2020, Beaury et al. 2021b). In a survey of the lower 48 states, Beaury et al. (2021b) found only a 17% overlap in regulated plants between adjacent states. Focusing on six northeastern states (CT, MA, ME, NH, NY, VT), Bradley et al. (2022b) showed that such inconsistencies are largely due to differences between the pools of species evaluated by each state rather than to different outcomes among state risk assessment protocols. Regulatory inconsistencies across state borders are likely due to the lack of state capacity to evaluate and recommend invasive plants for regulation. To increase consistency, northeastern states should first evaluate risk from plants already regulated by adjacent states. A taxonomically standardized list of regulated plants (as of April 2021) is available as supplementary material in Beaury et al. (2021b) and updated lists are posted through the National Plant Board[97]. Increasing coordination and sharing risk assessment resources across state borders could improve consistency and reduce the ongoing sale of known invasive plants (Bradley et al. 2022a, 2022b). The Northeast Regional Invasive Species & Climate Change network (NE RISCC)[98] hosts a biannual working group of invasive plant council representatives spanning states from Pennsylvania to Maine to improve information exchange. However, a second key challenge for most states is the lack of resources to conduct regulatory assessments. The lack of funding and capacity for risk assessment impedes consistent regulation and leads to the continued introduction and spread of known invasive plants.

Managing for the combined threats of invasive species and climate change is daunting. AFWA surveys of threats to climate adaptation consistently point to range-shifting invasive species as the top threat (Ernest Johnson 2020). Proactively preventing the introduction (by regulated sales through noxious weed laws) and expanding monitoring and EDRR for range-shifting invasive plants are critical tools for climate-smart invasive species management.

To **develop consistent and proactive invasive species management**, states can:

- Share information across borders (what's coming and how to manage it)
- Increase capacity for multi-state working groups of invasive species officials.
- Provide information, incentives, and alternatives to all sectors involved
- Develop consistent protocols, policies, incentives, and regulations for invasives sold/traded, especially those already regulated by neighboring states.
- Increase capacity for risk assessment with state invasive species networks.
- Increase the development and use of incentives and "green light" alternatives
- Use the resources provided by research from NE RISCC to identify high impact range-shifting species
- Monitor and manage new infestations of invasive species.
- Fund rapid response teams

The same well-established, coordinated efforts to address invasive plants in the region are also being applied to animals, specifically in aquatic environments. Introduction of non-native species, which may result in hybridization, competition, and predation, has also impacted many native species including RSGCN. Examples include the Northern snakehead (now established in the Potomac River), the rusty crayfish, fishhook water flea, and diatoms such as didymo. These and other non-native species can alter freshwater aquatic environments, which in turn effects all species in the system including RSGCN. Parasitism and diseases such as whirling disease (introduced from Europe) have affected many wild and hatchery populations of trout and salmon species in the United States and Canada.

Some species, such as the Northern Snakehead, Zebra Mussel, Spongy Moth and Emerald Ash Borer, are the focus of significant ongoing management efforts, whereas others remain an unmet challenge. Species that are used in recreational activities including fishing (such as crayfish, salamanders, and other "bait") have conservation efforts underway to prevent the spread of invasives or exploitation of native species. Maryland, Pennsylvania, and Virginia have active outreach campaigns to prevent the spread of invasive crayfish and other "bait" species. The release of live, unused bait into Maryland waters is a common practice among Maryland anglers. The use and release of live crayfishes as bait by anglers has resulted in the introduction of five non-native crayfish in Maryland waters. Three of these – Rusty Crayfish, Virile Crayfish, and Red Swamp Crawfish – are considered invasive due to their adverse effects on aquatic ecosystem function and native biodiversity. The rapid spread of this species is the result of bait bucket introductions – the transfer of live crayfish from one watershed to another and their release by anglers. The introduction of invasive crayfish is thought to be one of the most pressing threats to native crayfish diversity worldwide.

In the Mid-Atlantic region, the spread of invasive crayfishes through their use as bait has been followed by declines of native crayfishes in Maryland, Pennsylvania, and West Virginia. Due to their ability to achieve high densities and their importance as both prey and predator, invasive crayfishes have the capacity to affect more than just native crayfish diversity. They are known to adversely affect stream insects, mussels, snails, amphibians, reptiles, fishes, and sport fisheries. In recognition of the threats posed by invasive crayfish, several U.S. states and Canadian provinces have banned the use of live crayfishes as bait and many others have restricted their use in some way. In response to the discovery of Rusty Crayfish in 2008, Maryland prohibited the catch, use, or possession of crayfish in the Upper Potomac, Middle Potomac, and Lower Susquehanna River basins unless the head is removed immediately upon capture. This regulation aimed to prevent the catch and transfer of Rusty Crayfish from these basins into other Maryland waters. MDNR is considering expanding this regulation to include all river basins. A statewide ban on the catch, use, or possession of live crayfish would be more enforceable, more easily interpreted by anglers, and would protect all Maryland waters against the spread of invasive crayfishes (MD DNR, unpublished 2014).

The impacts of multiple insect invaders on Northeast habitats have been well documented (Staudinger et al 2023). NE CASC climate change synthesis provides current information on the impacts and vulnerabilities of many Northeast RSGCN and their habitats. A list of top 100 aquatic invaders was developed by NECASC and will help focus and coordinate consistent efforts to minimize their impacts (Allen et al. 2022).

Over the past decade, NEAFWA NEFWDTC has prioritized and addressed the problem of invasive species through a strategic approach, collaborating with its partners in the Northeast. Exotic invasive species pose significant threats to SGCN throughout the region. SWAPs have identified wildlife species within each state that warrant some level of management concern. Most of the RCN projects listed in Table 4.1.1 also mention or address invasive species and disease as issues in their conservation of specific species or habitats.

The goal of an early RCN project, **Identifying Relationships of Invasives Species with SGCN,** was to produce a list of invasive species that posed the most significant threats to SGCNs in the Northeast Region. However, during the project it became evident that the true value in this effort lay in the data assembled and the ability of future users to customize it for their specific needs. The goal of the project was therefore amended to focus on the provision of these data tables and on developing a process that would allow users to modify them and generate lists reflecting their own importance criteria. Since there are different ways to evaluate the impacts of invasive species, several metrics were compiled to give users a way to create ranked lists that can be used individually or together (e.g., sum of ranks). Users can understand how each metric is calculated, what information is included, and which metric is the most appropriate one to use. The metrics can be easily modified in MS Excel to produce custom values keyed to specific needs. The final report provides background information on how the SGCN data tables of SGCN were developed and how they should be interpreted for prioritizing and ranking invasive species threats. Also provided is an example of how this information can be used to generate specific ranked lists of invasive terrestrial species in Pennsylvania.

4.4.4 REGIONAL EXAMPLES AND OPPORTUNITIES THAT ADDRESS INVASIVE SPECIES

Many partners and networks have formed to address this pressing threat across the Northeast. Key examples are provided below.

Northeast RISCC Management Network[98]**.** The Northeast Regional Invasive Species & Climate Change (RISCC) Management Network aims to reduce the compounding effects of invasive species and climate change by synthesizing relevant science, sharing the needs and knowledge of managers, building stronger scientist-manager communities, and conducting priority research. The network includes invasion scientists, climate scientists, natural resource managers, policymakers, and stakeholders from the broader public. The website provides a listserv and multiple resources including “Management challenges”—a series of two-page documents that synthesize the current state of knowledge about a topic related to invasive species and climate change. These management challenges are designed to help share knowledge about these topics to managers and stakeholders.

Many watersheds have active efforts that include the monitoring and management of Invasive species. The Chesapeake Bay Watershed is one example of an active partnership to assess and address aquatic invasive species. The U.S. Geological Survey (USGS) revised the Chesapeake Bay-based science plan and reported that all 13 agencies and organizations in the Bay region identified Aquatic Invasive Species (AIS) as being of general concern, with most stakeholder groups reporting AIS-related issues to be of high priority (Densmore 2020). Species in this category include fishes, invertebrates, invasive plants, and microbes including aquatic animal pathogens.

The **USGS** maintains records of Nonindigenous Aquatic Species that can be queried by species, location, and other key data fields[99]. Figure 4.4.3 depicts the locations of the

Zebra mussel (*Dreissena polymorpha*) in the US. Most states have active programs to prevent the introduction and spared of this formidable invasive mussel, and these active management and outreach efforts can be used for other aquatics as well.

EDDMapS hosts the invasive range expanders listing tool[100] based on spatial models of climate-change-driven range shifts for 896 non-native, invasive plants (Allen and Bradley 2016). This tool allows users to generate a list of invasive plants that are not currently found in their state (or county) but that could expand into the region as a result of climate change (models are based on distribution data compiled in 2015). Hundreds of new invasive plants are projected to expand into Northeast states by mid-century. However, some of these species are likely to cause greater ecological impacts than others.

Using the **invasive range expanders listing tool,** Rockwell-Postel et al. (2020) and Coville et al. (2021) evaluated the ecological and socioeconomic impacts of invasive plants likely to expand into southern and northern New England, respectively. Both studies used the IUCN Environmental Impacts Assessment of Alien Taxa protocol (EICAT; Hawkins et al. 2015). The EICAT protocol involves compiling all scientific literature describing ecological impacts of the target taxon and scoring those impacts on a scale of 1-4, where negative impacts on native species populations are scored as a 3 (moderate impacts) and negative impact on native species diversity or on the populations of multiple native species are scored as a 4 (major impacts).

Rockwell-Postel et al. (2020) evaluated 100 range-shifting invasive plants that are not currently present but are deemed likely to expand in Connecticut, Massachusetts, New York, and/or Rhode Island. They identified 20 species with major impacts on native communities. Bradley et al. (2020) later narrowed this list to five species most likely to affect northeastern ecosystems: *Anthriscus caucalis, Arundo donax, Avena barbata, Ludwigia grandiflora,* and *Rubus ulmifolius*. Similarly, Coville et al. (2021) evaluated 87 range-shifting invasive plants not currently present but likely to expand in Maine, New Hampshire, and/or Vermont and identified 24 species with major impacts on native communities (see Table 1 from Coville et al. 2021). Combining these high-impact, range shifting species for New York and the New England states, Allen et al. (2022) created a list of 24 species that are also commonly offered for sale as ornamental plants. This 'Do Not Sell' list (Allen et al. 2022) comprises priority species that could quickly invade the mid-Atlantic and New England due to the combination of climate change and horticulture introduction. These species are priorities for proactive coordination and regulation.

Following the same methods as Rockwell-Postel et al. (2020) and Coville et al. (2021), Salva and Bradley (*in prep.*) have completed EICAT assessments for species projected to expand into Delaware, Kentucky, Maryland, Ohio, New Jersey, Pennsylvania, Virginia, and West Virginia. Salva and Bradley (*in prep*.) have evaluated 108 range-shifting species and identified 32 species with major impacts. These species have not yet been further evaluated for vulnerability of northeastern habitats or for their likely introduction as ornamental plants. However, this list, together with the synthesis by Allen et al. (2022) provides a starting point for proactive invasive plant regulation across the Northeast.

Great Lakes and Lake Champlain Invasive Species Program. EPA's Great Lakes National Program[101] is a synthesis of readily available information from many partners, including federal, state, and tribal entities, to "inventory" the degree to which the eight stated purposes of the Program are currently being met (Great Lakes National Program Office 2019). This inventory was done in collaboration with Great Lakes states and tribes, EPA Regions 1 and 2, and the Lake Champlain Basin Program[102].

To help inform recreational fishers, the general public, and students about the dangers of invasive species, **Delaware Sea Grant (DESG)** developed a three-pronged informational approach on how to identify and what to do when encountering invasive species. The project was funded by the Mid-Atlantic panel on Aquatic Invasive Species and involved DESG's Marine Advisory Service. Members of a local recreational fishing club were given waterproof rack cards with information on invasive fish and how to report them to local management agencies. The rack cards highlight three invasive fish—northern snakehead, flathead catfish and blue catfish—and their similar looking counterparts, bowfin and channel catfish. The card a QR code, email, and phone contact information where users can report invasive species to the Delaware Department of Natural Resources and Environmental Control (DNREC). A similar program focuses on the European Green Crab, the Asian Shore Crab and the Chinese Mitten Crab[103].

The invasive mussel collaborative connects people, science, and management to advance technology for invasive mussel control. The collaborative maintains a directory, a library, and a wide variety of resources for mangers, property owners, recreational users, etc. Control methods, management and research projects are compiled[104].

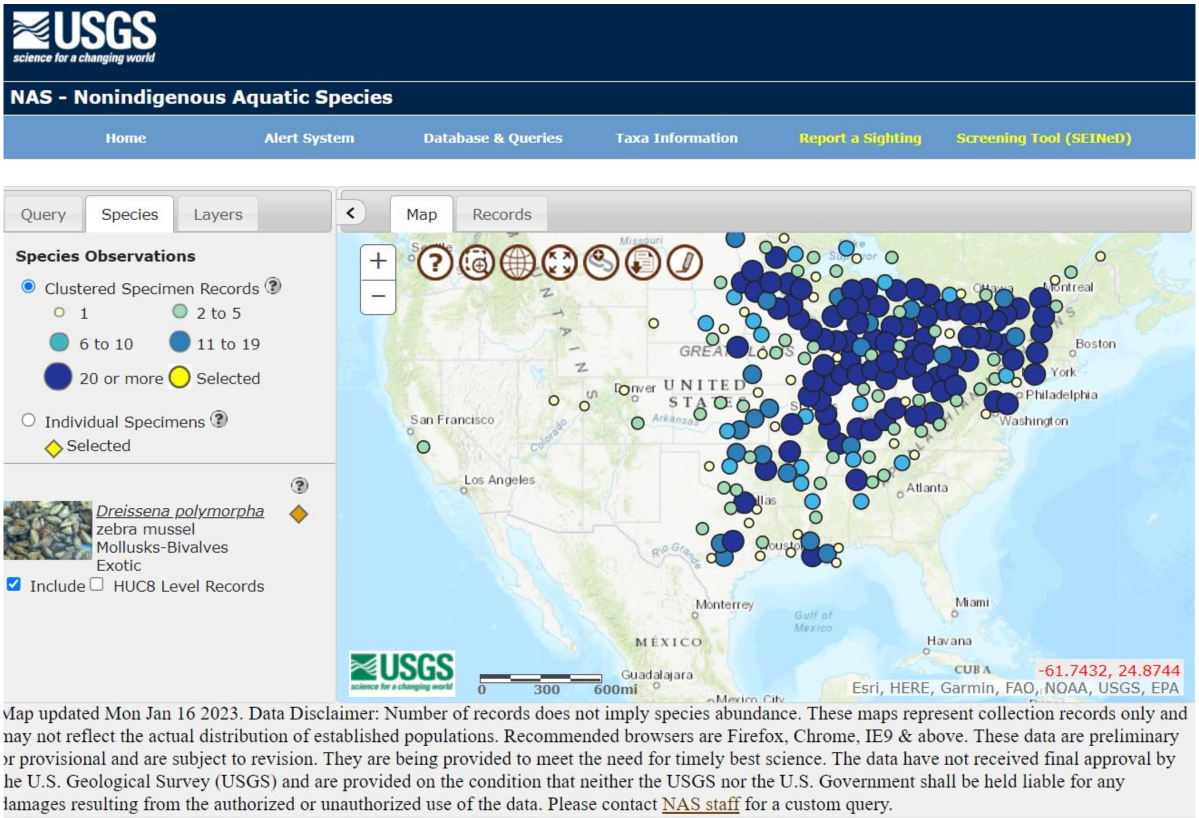

Figure 4.4.1 USGS Mapped Query Results for Zebra Mussel (USGS 2023).

The USDA Natural Resources Conservation Service's multiple programs assist landowners in addressing invasive species and pests and provide services, technical support, and financial assistance, as well as many resources[105].

Terrestrial Invaders. The Northeast U.S. has been identified as a hotspot for future invasion risk because of climate change (Allen and Bradley 2016). Up to 100 invasive plant species are projected to expand into the region, threatening native ecosystems, agricultural systems, and economies. Because the identity of these range-shifting species is known (Allen and Bradley 2017), there is currently a unique and perhaps fleeting opportunity to prevent the introduction and spread of high-impact species into this increasingly vulnerable region. The large number of range-shifting invasive plants, coupled with limited resources, makes early detection and a rapid *comprehensive* response for all 100 species a challenge. Therefore, prioritizing range-shifting invasive plants is a critical step in developing informed and effective prevention strategies. Getting a step ahead of the expected invasions by targeting high-impact species will not only allow states to use resources most effectively, but also increase the likelihood of success. This study illustrates how the combination of watch lists and impact assessments creates an effective tool for proactive management of invasive plants in the context of climate change. From a list of 100 species, five were identified as high priority due to reported impacts in ecological communities and invading ecosystems like those found in New York and southern New England. Aside from reported impacts, these five species are deemed likely to invade the Northeast, either due to recent establishment in this region or to the existence of known introduction pathways that could lead to quick establishment and rapid spread (Bradley et al. 2019).

Landscape-scale Changes to Plant Communities. Invasive species establish outside of their native range, spread, and negatively impact ecosystems and economies. As temperatures rise, many invasive plants can spread into regions that were previously too cold for their survival. The Northeast Climate Adaptation Science Center and University of Massachusetts continue to model landscape-scale changes to Northeastern plant communities under climate change scenarios, providing natural resource managers with site-specific lists of native plant species likely to be resilient to novel future climates. A recent survey of 200 natural resource managers in the Northeast indicated that the top research priority was specific information to support the management of climate-resilient native communities. But less than 10% of respondents reported that planting species adapted to climate change in restoration or adaptation projects was part of their management portfolio (Beaury et al. 2020). Scientific outcomes will be translated into action through collaboration with the Northeast RISCC Management Network (co-founded by co-PI Bradley) and RISCC-supported Invasive Plant Councils working group (state officials from CT, MA, ME, NH, NJ, NY, PA, RI, and VT) as well as managers from the US Fish & Wildlife Service and the National Park Service. The project will generate spatially explicit, joint predictions of plant communities at any location within the Northeast region under published climate scenarios (Abatzoglou et al. 2018). It will also provide natural resource managers with site-specific lists of climate-adapted species to inform the creation of climate-smart vegetative communities across the Northeast CASC region[106].

Aquatic Invaders of the Northeast[107]. Currently, hundreds of invasive aquatic species occur in the Southeast and the Western U.S. and have the potential to move into the Northeast region. This project will help guide future monitoring efforts and bring attention to high-risk areas that could be invaded by southern and western aquatic species. In 2022, NECASC developed a list of the top 100 aquatic species that naturally occur in the southeast and the western U.S. and have the potential to invade the Northeast. The research team selected these species based on input from a regional stakeholder workshop to ensure that priority management species are considered. Early detection and rapid response are essential to minimize the impact of invasive species, and this research is a critical first step to ensure that these responses are informed and based on the best available science.

Regulations to Reduce Spread of Invasive Plants. Consistent and proactive regulation to prevent the introduction and spread of new invasive plants is most effective when applied consistently across jurisdictional boundaries and proactively, either to prohibit non-native species from arriving in the first place or to sequester and, if possible, eradicate them in the earliest stages of invasion. Recent analyses of state regulated plant lists in the Northeast show that regulations are neither consistent nor proactive. A NECASC project that focused on invasive plant regulation across six northeastern states (Connecticut, Maine, Massachusetts, New Hampshire, New York, and Vermont) confirms previous findings that invasive plant regulations are inconsistent and reactive, and driven by different sets of information and variations in the lists of species being evaluated. Risk assessment protocols varied considerably across states, but they consistently included criteria related to ecological impact, potential to establish, dispersal mechanisms, and life history traits. While none of the assessments explicitly considers climate change, they also did not contain language that would preclude regulating species that have not yet arrived in the state. To increase consistency and proactivity, the project recommends a two-pronged approach in which states would: 1) focus on high-risk, range-shifting invasive species identified in neighboring states; and 2) explicitly consider climate change when assessing "potential distribution" or "potential impact" of target species. Lists of these high-risk, range-shifting invasive species are compiled by Bradley et al. (2022a).

The Native Plant Trust[108]. The Native Plant Trust (the nation's first plant conservation organization) focuses on New England's native plants with the mission to conserve and promote these species in order to ensure healthy, biologically diverse landscapes. They save native plants in the wild, grow them for gardens and restorations, educate others on their value and use, create cutting-edge tools, and foster collaborations that advance plant conservation. Based in Massachusetts at Garden in the Woods, the Trust operates a native plant nursery at Nasami Farm as well as six rare plant sanctuaries in Maine, New Hampshire, and Vermont. Native Plant Trust has paid staff and 1,500 trained volunteers who work throughout New England to monitor, protect, and restore rare and endangered plants; collect and bank seeds for biological diversity; detect and control invasive species; conduct botanical and horticultural research; and educate the public, from home gardeners to professional land managers. Native Plant Trust is leading the Northeast region's conservation community in its effort to save native plants. It is the largest organization in New England dedicated solely to protecting and restoring rare plant species, and to keeping common plant species common. The Native Plant Trust also provides resources and technical assistance on their website.

Mid-Atlantic Early Detection Network. The Mid-Atlantic Early Detection Network (MAEDN) powered by EDDMapS (Early Detection & Distribution Mapping System) tracks more than 400 species of invasive plants[109]. High priority invasive insects and pathogens are also included. Invasive species observations can be reported using the

Early Detection and Distribution Mapping System (EDDMapS) developed by the University of Georgia's Center for Invasive Species and Ecosystem Health. Reporting can be done on a laptop or desktop computer or via smartphone. Because of the extent of invasion in Washington, D.C., National Capitol Region PRISM[110] and Invasive Species provide information on early detection and rapid response. Habitats that are otherwise high quality are a high priority for treatment. Small patches of invasive species are also targeted to prevent their spread into otherwise untouched habitat. Partnerships with the National Park Service are important because the region has so much edge habitat where invasions begin at the boundary of land management[111].

U.S. Forest Service and Intertribal Nursery Council[112]. Multiple programs, projects, and initiatives of the US Forest Service offer partnership opportunities to conserve forests and woodlands in the Northeast. The federal agency manages the tribally guided Intertribal Nursery Council to advance the interests of Indigenous peoples involved with plant production in nurseries. The goals of the Intertribal Nursery Council are to share information and technology transfer, preserve ecological knowledge, provide nursery training, conduct conservation education, and contribute to reforestation and habitat restoration projects by propagating native plants. The *Nursery Manual for Native Plants: A Guide for Tribal Nurseries* handbook contains detailed information on native plant propagation from seed collection to holistic pest management (Dumroese et al. 2009).

The US Forest Service maintains a National Seed Laboratory that propagates seeds of native plants for conservation and restoration projects and conducts research on restoring and sustaining native plant communities[113]. The Laboratory has developed a Native Plant Protocol for handling, germinating, and storing seeds. It also provides training materials to transfer technology and conserves seeds for genetic diversity. The Reforestation, Nurseries and Genetic Resources Program is a collaborative partnership sponsored by the US Forest Service to share technical information with land managers and nurseries related to the production and planting of trees and other native plant species for reforestation, restoration and conservation of forests and woodlands[114]. Numerous guidelines and resources have been developed by the Program and its partners, including a Propagation Protocol Database and the Native Plant Network.

The US Forest Service Landscape Scale Restoration Grant Program is a competitive grant program to address landscape-level issues affecting state, tribal, and private Forests and Woodlands such as watershed protection and restoration, the spread of invasive species, disease, insect infestation, and wildfire risk reduction. Conservation strategies of State Forest Action Plans are prioritized, and projects are evaluated and grants awarded regionally. A Landscape Scale Restoration Manual and Landscape Scale

Restoration Project Planning Tool are available to guide conservation projects. An inventory of landscape-scale restoration projects is available[115].

The Northeast-Midwest State Foresters Alliance is a partnership of state forestry agencies across 20 states in the Northeast, Midwest, and the District of Columbia[116]. The mission of the organization is to collaboratively protect, conserve, and manage the Forests and Woodlands of the region. Forestry-related BMPs have been developed to protect water quality in adjacent aquatic habitats and are available through the National Association of State Foresters[117].

Invasive Plant Atlas of New England. The mission of the Invasive Plant Atlas of New England (IPANE)[118] is to provide a comprehensive web-accessible database of invasive plants to facilitate education and research that will be continually updated by a network of professionals and trained volunteers. The database will facilitate education and research that will in turn lead to a greater understanding of invasive plant ecology and support informed conservation management. An important focus of the project is the early detection of, and rapid response to, new invasions.

New England examples of incentives and projects to increase the supply of wild, native plant seeds and promote their use include a ReSeeding Rhode Island project, Connecticut's NOFA's EcoType Project[119], and the New England Transportation Consortium's seed project[120].

Garden for Wildlife. National Wildlife Federation (NWF)'s Garden for Wildlife[121] promotes and sources local, native plant species at the National level. Their website provides information on the threats to wildlife, including invasive species, and provides a wealth of educational resources. The National Wildlife Federation, one of America's largest and most trusted conservation organization, works across the country to unite Americans in giving wildlife a voice. NWF has been on the front lines for wildlife since 1936, fighting for the conservation values that are woven into the fabric of the nation's collective heritage[122].

Aquatic Invasive Species in the Chesapeake Bay Drainage—Research-Based Needs and Priorities of U.S. Geological Survey Partners and Collaborators. The U.S. Geological Survey (USGS) revised the Chesapeake Bay science plan and reported that all 13 agencies and organizations located in the Bay region identified Aquatic Invasive Species (AIS) as being of general concern, with most stakeholder groups reporting AIS-related issues to be of high priority (Densmore 2020). Species in this category include fishes, invertebrates, invasive plants, and microbes including aquatic animal pathogens.

Education and Outreach

Effective regional conservation depends on clear and consistent Information about state and regional conservation targets, specifically SGCN in SWAP and COAs, RSGCN, and Regional Conservation Opportunity Area (RCOA) habitats. When engaging partners, stakeholders, and the public, one important role for the state fish and wildlife agencies will be to clearly state how top threats impair populations of SGCN and explain how conservation actions can address those impacts.

Education and Outreach actions should include current regionally consistent messaging of SWAP SGCN/RSGCN priorities and conservation needs. The RSGCN list has recently been updated and offers current opportunities for these regional messages to be shared. Improved communication and technical assistance approaches should target key audiences that include land use decision-makers, stakeholders, and the public to address this important threat to SGCN and key habitats. Communication and messaging efforts should include benefits and risks to species and humans (i.e., why should people care?). These outreach and education messages and actions should be distributed/communicated to target audiences through accurate, clear definitions, lists, and best practices (including lists and benefits of using locally adapted native species).

Multiple state/regional/subregional invasive species expert groups, councils, and networks exist in each state and across the Northeast; and coordination among these groups is critical. This coordination should communicate current SWAP/RSGCN species and habitat priorities and encourage the development of best practices for these targets. Many of these invasive species' groups are listed below as examples of partnership efforts within the RISCC Management Networks. These networks reduce the joint effects of climate change and invasive species by synthesizing relevant science, sharing the needs and knowledge of managers, building stronger scientist-manager communities, and conducting priority research. The Northeast Region RISCC[98] website contains research and tool summaries, management challenges, guiding principles, and current news and events. Tools include:

- Climate Voyager Map-with climate projections and visualizations,
- Resilient Land Mapping Tool for planning and decision-making considering resiliency and range shifts,
- Don't Move Firewood – outreach and education for preventing the spread of invasive species,
- Invasive Range Expanders Listing Tool for stakeholder engagement in range-shift and climate change impacts,
- New England landscape Future Explorer for land use projections and decision-making,

- Nonindigenous Aquatic Species (NAS) a database for mapping and alerts for aquatic species,
- Xerces partnership with Bee City/Bee Campus USA[123] uses regionally specific native plant guides,
- Homegrown National Park[124] additional plant guides, and
- Pollinator Pathways[125] is another project that promotes the idea of corridors through entire neighborhoods, encouraging broad participation.

Theodore Roosevelt Conservation Partnership (TRCP)[126]. Members of the $689-billion outdoor recreation industry have established a blue-ribbon commission to stop and reverse the spread of aquatic invasive species in the U.S. The commission will convene leading biologists, environmentalists, policymakers, and resource managers to assess existing mitigation efforts and identify more effective eradication solutions. Findings from the analysis will be presented to Congress and the Administration in 2023, with the goal of passing comprehensive legislation to better manage and eliminate aquatic invasive species.

STATE EXAMPLES AND OPPORTUNITIES

- **Maryland** DNR promotes a citizen science program called "Statewide Eyes" to identify and report invasive species using a free mobile application called the Mid-Atlantic Early Detection Network (MAEDN). Use of the MAEDN increased fourfold between 2015 and 2016, and Maryland users have submitted more records than any other state in the region, with Virginia a close second. Invasive plants new to the area have been found and reported by MAEDN users (e.g., *Cardamine impatiens* and *Corydalis incisa*). In 2016, Maryland banned the sale of three ornamental invasive plants: Shining Canesbill, Yellow Flag Iris, and Fig Buttercup. Warnings are also required to be posted on Burning Bush, Border Privet, and three invasive vines that are non-native members of the wisteria family. Atlases, BioBlitz, other surveys, and citizen science all provide significant contributions to public knowledge about status and distribution of multiple taxa, both native and non-native.
- Partnerships for Regional Invasive Species Management (PRISM) in **New York** is a program to coordinate treatment and prevention of invasive species outbreaks. NY's Adirondack Park Invasive Plant Project, Cornell Invasive Plants, and iMapInvasives[127] are online tools for reporting invasive species and data management. New York State's Department of Environmental Conservation (NYS DEC) lists regulated species and provided guidelines with their education and outreach initiatives:

    - Nuisance & Invasive Species List[128]
    - Prohibited and Regulated Invasive Plants (NYS DEC and NYS DAA 2014)
    - Long Island Sound Study to restore and protect the Sound[129]
- In 2020 the **Maine** Forest Service and Maine Natural Areas Program were awarded Landscape Scale Restoration Grant funding for the Mapping, Prioritizing, and Controlling Invasive Plants in Maine Woodlands project. This project will develop an invasive plant landscape plan; publish a manual of science-based strategies detailing how to survey, map, prioritize, and control invasive plants; and conduct in-depth training. Financial incentives for private landowners to prepare Invasive Plant Control Practice Plans will be competitively funded, with follow-up monitoring of treatment efficacy.
- **Maryland Crayfish regulations.** The release of live, unused bait into Maryland waters is a common practice among Maryland anglers. Based on a survey of Maryland's freshwater anglers conducted in 2008: 1) approximately 20% of freshwater anglers use live crayfish as bait; and 2) 69% reported releasing unused crayfish alive into streams and lakes at the end of their fishing trips. Most anglers (72%) reported that they caught their own crayfish while 26% reported that they purchased crayfish from bait shops. The use and release of live crayfishes as bait by anglers has resulted in the introduction of five non-native crayfish in Maryland waters. Three of these – Rusty Crayfish, Virile Crayfish, and Red Swamp Crawfish – are considered invasive due to their adverse effects on aquatic ecosystem function and native biodiversity. Virile Crayfish, first introduced in the Patapsco River in the late 1950s, is now the most widespread invasive crayfish – currently found in 11 river basins in Central and Western Maryland. MD DNR is considering expanding its regulations to address this.
- **Delaware**: **Homegrown National Park**[124] is a grassroots call-to-action to regenerate biodiversity and ecosystem function by planting native plants and creating new ecological networks cofounded in Delaware.
- **Rhode Island's Wild Plant Society**[130] works at the state scale, providing education and propagation of native plants for sale and partnering with farmers and land trusts statwide. ReSeeding RI is a new project of the RI Wild Plant Society, building on lessons learned from RhodyNative and the EcoType Project/Eco59 retail counterpart model to create a sustainable approach to promoting wild, native plants[131].

4.4.5 WILDLIFE DISEASE

Chapter 3 provides more detailed descriptions, impacts on RSGCN, and additional resources and examples for this threat in the Northeast. Wildlife diseases have the potential to imperil a broad range of both terrestrial and aquatic wildlife and have been identified as one of the top regional threats. The SWAP Synthesis and Limiting Factors reports (TCI and NEFWDTC 2017, 2020a) summarized additional information and actions needed to address the threat of disease in the Northeast as prioritized by NEFWDTC and SWAP coordinators. Actions to address data gaps and concerns about the introduction and spread of disease in fish and other aquatic taxa includes employing the experience and techniques learned from WNS, CWD, Rana Virus, Avian Flu, Bsal and other challenging efforts to combat wildlife diseases over the past decade.

Priority planning actions included the development of regionally coordinated Response Plans as well as targeted early detection and ways to implement rapid control/management strategies that will reduce the impacts to native wildlife or communities. Customizing the National Invasive Species Strategy with regional tools and BMPs to maximize the effectiveness of these strategies while avoiding excessive harm to non-target species was recommended. Additional recommended actions include developing treatment, containment, and mitigation options and protocols; and improving prevention through quarantine, risk assessments, and improved, consistent regulation.

Little is known about invertebrate pollinators compared to other taxonomic groups, but as implementation of SWAPs and focused RCN projects fill critical data gaps, knowledge about the importance of these species and their vulnerabilities has grown. Significantly more invertebrates have been listed as SGCN in the fourteen 2015 Northeast SWAPS; they now represent 71% of all SGCN listed in the region. Proactive work is needed to assess the status of these taxa and the threats facing them. Better understanding of the impact of disease on declining populations and of the loss of habitat for these regionally important species is crucial to avoid the potential for listing. While there are still many unknowns in pollinator conservation, coordinated monitoring of the effects of disease will help identify effective best practices that can be implemented for these species in all Northeast states.

Appendix 4A provides a list of projects that have advanced the conservation of these regional species and habitats through the RCN, CSWG, SA programs from 2007- 2023. This Chapter provides a list (Table 4.1.1) and summaries for those projects implemented since the 2013 Synthesis, organized by the predominant information or tool and SWAP element they address. The key RCN and CSWG projects to address Disease are summarized below.

Bats and White-Nose Syndrome (2007, 2008) (RCN, CSWG). The RCN Grant Program supported two projects to address the ongoing WNS crisis in Northeast bat populations (WNS; Reeder et al. 2011). The first studied the effects of the fungus that causes WNS on hibernating bats and demonstrated that bats infected by the fungus were aroused to normal body temperatures more frequently than uninfected bats

(Reeder et al. 2011). These arousals depleted the bats' fat stores and likely contributed to their subsequent mortality. The number of arousal events significantly predicted the bats' date of death; and the severity of fungal infection correlated with the number of arousal events.

The second project developed methodologies to combat WNS. Specific goals included: 1) testing potential treatments for efficacy against cultures of the fungal pathogen associated with WNS under laboratory conditions' 2) testing potential treatments for safety in healthy bats; and 3) testing potential treatments for efficacy against fungal infection in hibernating bats. The project tested formulations of terbinafine and other anti-fungal compounds. Research on WNS has also received support through the competitive SWG program.

A CSWG project supported this regional effort to address White Nose Syndrome through a Multi-state Coordination, investigation, and Rapid Response grant project. At the start of the 2008 grant, WNS was only known to be present in New York, Connecticut, Massachusetts, and Vermont. The hope was for the spread of the fungus to be limited to adjacent states the following year. Unfortunately, by the spring of 2009, it had swept south all the way to western Virginia. Although the sudden magnitude of the problem was unexpected, this grant was critical to preventing state agencies from being completely overwhelmed by the crisis. Eleven states participated in this grant: Pennsylvania, New Hampshire, Vermont, Connecticut, New Jersey, Delaware, Maryland, West Virginia, Virginia, Wisconsin, and New York. All of these states except, Wisconsin, felt the impact of WNS on their bat populations during the grant period. Common goals of developing a public reporting system, improving public outreach, coordinating sample requests, and improving ability to monitor and track bat populations were developed and shared. The group cooperated in identifying and selecting research priorities that were most important to states already experiencing heavy bat mortalities associated with WNS.

The **New England Cottontail Conservation Strategy (2007-14) (CSWG, SA, RCN)** and initiative addresses the potential impact of disease (including Rabbit Hemorrhagic Disease) on this important Northeast species**.** To help avoid and minimize the spread of the rabbit hemorrhagic disease, USFWS (CSWG, SA) and its partners have developed a conservation strategy and noninvasive monitoring tools focusing on New England Cottontail populations. The CSWG grants and At-Risk Species Team have worked through the New England Cottontail Conservation Initiative for decades, and their Conservation Strategy and extensive efforts include preventing and addressing disease (Tur and Fuller 2012).

Ranavirus in Amphibian Populations (2014) (RCN). In 2014, NEAFWA RCN funded a project investigating Ranavirus in amphibian populations. NEFWDTC developed an initial set of priority actions that respond to this disease in the Northeast. In 2017 SWAP Synthesis and NEFWDTC also identified Ranavirus and related diseases in herpetofauna as a regional priority. The Committee sponsored several regional projects to address this threat and identified both an action framework and partnerships for implementation. Protection efforts targeted native SGCN and RSGCN by preventing the introduction and spread of Ranavirus, Bsal and other diseases of reptiles and amphibians. In the Northeast, some actions focused on working with the pet industry advisory council and Disease Cooperatives to prevent introduction of diseases through the pet trade. This included early detection at ports of entry, development of a rapid assessment tool, and species health profiles. Additional RCN projects were prioritized to address this serious threat and are summarized below.

In order to better understand the extent to which Ranavirus is impacting amphibian and reptile populations in the Northeast, and to develop a sampling protocol for the region, this RCN project led by MD DNR staff with EFWDTC and NEPARC participation conducted a survey of amphibian larvae at randomly selected wood frog breeding ponds. The study area encompassed parts of Delaware, Maryland, New Jersey, Pennsylvania, and Virginia. In 2013 and 2014, a total of 4,306 individual wood frog larvae were collected for quantitative PCR analysis by Montclair State University in New Jersey. Individuals representing seven amphibian species that are subject to active die-offs were collected for analysis by the USGS National Wildlife Health Center (NWHC), representing both the largest geographic area and the greatest sample size ever screened for Ranavirus. A regional survey, diagnostic lab reports, and published scientific literature indicated that Ranavirus has been lab-confirmed in 33 herpetofauna species in at least 64 counties in the Northeast region. It was found most frequently in Wood Frog larvae, Eastern Box Turtles, and the larvae of Spotted Salamanders, Green Frogs, and American Bullfrogs (Smith et al. 2016).

Scientists and conservation groups in the Northeast continue to address the challenge of how to best respond to the threat posed by Ranavirus, as the study indicated that state response capacity varied across the region. Most states (11 of the 14) make use of the diagnostic services of the NWHC. The study developed and applied field protocols and recommended that disinfection protocols become standard operating procedure for all land management agencies as they work with groups like PARC to develop strategies to address the threat of emerging diseases.

Preventing Bsal in Amphibian Populations (2016) (RCN, CSWG, SA). The SWAP Synthesis also prioritized prevention and spread of Disease: *Batrachochytrium salamandrivorans* (Bsal). In 2016, the NEFWDTC and NEPARC reached out through the Northeast and Southeast Wildlife Disease Cooperatives to help protect wild populations of amphibians by preventing the introduction of *B. salamandrivorans* from imported amphibians. Collaborators, working with the Disease Cooperatives, developed methods for early detection that require swabbing individual animals and then testing the samples. Practical approaches to implementing these diagnostic tests are still to be developed. Ideally, animals should be tested before leaving the country of origin. If imported, individuals would need to be held for a few days until results were returned or tracked and retrieved if testing positive. NEPARC's Website provides information and resources and multiple protocols on preventing the introduction and spread of this disease in the Northeast. A North American Bsal Task Force has been established and a North American Strategic Plan to Prevent and Control Invasions of the Lethal Salamander Pathogen *Batrachochytrium salamandrivorans* has been developed (North American Bsal Task Force 2022).

Snake Fungal Dermatitis in New England Timber Rattlesnakes (2014) (RCN, CSWG). In 2014, NEAFWA RCN also funded a project investigating snake fungal dermatitis in New England Timber Rattlesnakes. The NEFWDTC identified this as a priority and specifically identified actions to address disease response in the Northeast. The Timber Rattlesnake is a RSGCN, a species of 'Severe Concern' by NEPARC (2010) and is listed as a Species of Greatest Conservation Need in 12 Northeast states. It is believed to be extant in only 10 of those states. In 2009, Timber Rattlesnakes were found to have a significant fungal dermatitis, which has been shown to cause mortality in Viperidae snakes. Due to the low population numbers of the Timber Rattlesnake in New England, the study was prioritized for RCN funding and led by the Roger Williams Park Zoo. It provides a baseline health assessment of multiple New England populations of the Timber Rattlesnakes in 2014. Ninety-eight individuals from nine Timber Rattlesnake populations in New England were captured (and released) for the study across four seasons. Data gathered on the snakes included morphological measurements, gender, and estimated age. Individuals were visually examined for dermatitis lesions or external abnormalities; blood was drawn for hematology, serum biochemistry, and heavy metal analysis; and two cloacal swabs were obtained for paramyxovirus testing. The study provides an initial prevalence rate of fungal dermatitis in these nine populations that can be used for comparison in future years to determine if the prevalence of the disease is increasing. The overall prevalence among snakes studied was 33% and found to be higher in the spring than summer. The analyses showed no evidence that the disease is an opportunistic infection in snakes with suppressed immunity, and in fact the sampled snakes appeared to be in overall good health (McBride et al. 2015).

A CSWG Project **Conserving Snake Species of Greatest Conservation Need Threatened by an Emerging Fungal Skin Disease supplemented this project throughout the region.** Using data obtained from the regional snake species assessment, state partners used an adaptive management framework for development of long-term conservation strategies for up to 40 snake species potentially impacted by the disease. Other conservation actions include evaluation of treatment options, experimental treatment with antifungal agents, captive rearing, and monitoring.

4.4.6 REGIONAL EXAMPLES AND OPPORTUNITIES THAT ADDRESS WILDLIFE DISEASE

Much can be learned from recent challenges of and responses to WNS, Bsal, CWD and other prominent wildlife diseases over the past decade. Working closely with the Wildlife Disease Cooperatives ensures up-to-date information and regional coordination. The Northeast region worked quickly to respond to the discovery of White Nose Syndrome and learned a lot about how to respond to disease outbreaks through research, rapid response, and coordination. The RCN program funded several projects related to wildlife diseases that provided valuable protocols, standard operating procedures, and BMPs that were then employed across the region to minimize the introduction and spread of White Nose Syndrome in bats, Ranavirus in amphibians, and Fungal Dermatitis in Timber Rattlesnakes. See Table 4.1.1 and *Appendix 4B* for examples of RCN projects that developed handling protocols to contain, avoid, treat, and mitigate these diseases in RSGCN. See Chapter 7 for additional information on partners. Chapter 3 provides detailed threat descriptions, impacts on RSGCN, and additional resources and examples for this threat in the Northeast.

The **North American Bsal Strategic Plan** includes background information on Bsal and the ecological significance of salamanders in ecosystems, as well as a brief review of policy options aimed at preventing Bsal introduction in North America (North American Bsal Task Force 2022). The Task Force and its strategic goals are described, as are the roles of the Technical Advisory Committee and other working groups. These include goals for: Response & Control; Diagnostics; Research; Decision Science; Surveillance & Monitoring; Data Management; Outreach & Communication; and Clean Trade. **The Rapid Response Plan Template**, which provides guidance for field or captive activities, and the Bsal Implementation Plan, which outlines more specific goals and priorities of the Technical Advisory Committee and working groups, are provided as appendices. Both appendices are expected to evolve over time to include new information and updates posted on relevant websites (e.g., North American Bsal Task Force[132] and PARC's disease resources[133] websites).

Portal for Reporting Diseases in Herpetofauna. PARC has developed a national disease reporting portal[134]. The PARC Disease Task Team[135] has also created an amphibian and reptile disease alert email where people in the USA and Canada can report or learn about an incident of sick, dying, or multiple dead amphibians or reptiles. The PARC DTT maintains a current list of appropriate individuals to contact in both countries. PARC's website also has a resource page with recent publications and contacts.

Northeast Partners in Amphibian and Reptile Conservation. NEPARC has a Working Group that addresses Reptile and Amphibian Diseases[136]. NEPARC's working group published a scientific article in Herpetological Review describing best practices for decontaminating construction equipment (Julian et al. 2020). They developed a Three-Step Guide (NEPARC 2022) for a general audience and equipment operators as well as a short video on how to reduce the spread of disease in this taxon. The NEPARC website on emerging diseases has numerous other resources related to various herptile diseases, including Bd, Bsal, and ranavirus, including best practices, factsheets, and links to other resources.

USGS Wildlife Health Center. The National Wildlife Health Center (NWHC)[137] was established in 1975 as a biomedical laboratory dedicated to assessing the impact of disease on wildlife and identifying the role of various pathogens in contributing to wildlife losses. It provides information, technical assistance, and research on national and international wildlife health issues. The Center monitors and assesses the impact of disease on wildlife populations; defines ecological relationships leading to the occurrence of disease; transfers technology for disease prevention and control; and provides guidance, training, and on-site assistance for reducing wildlife losses. It provides multiple resources and tools, including WHISPers, a partner-driven, web-based repository for sharing basic information about historic and ongoing wildlife mortality (death) and morbidity (illness) events in North America[138].

Wildlife Disease Cooperatives and Support.

The **Southeast Wildlife Disease Cooperative**[139] conducts research on ecology of avian influenza virus in waterfowl and shorebirds; assessing and reducing the health risks posed by translocating wild animals; the ecology of tick-borne zoonoses; West Nile Virus infections in wild birds, and more.

The **Northeast Wildlife Disease Cooperative** (NEWDC) was affiliated with Tufts University from 2013 to 2020. This consortium of veterinary diagnostic laboratories provided educational opportunities, wildlife diagnostics, cutting-edge research, and collaboration with wildlife agencies in the region. It also disseminated current information regarding wildlife diseases to wildlife agencies and organizations in the Northeast United States. The cooperative entered a dormant phase when the Director of NEWDC transitioned to a new position. Henceforth, disease threats will be managed through a coordinator hired by the Northeast Association of Fish and Wildlife Agencies with additional funding from the US Fish and Wildlife Service and support from USGS. The **Northeast Regional Fish and Wildlife Health Coordinator** will support the work of fish and wildlife health practitioners to address zoonotic and other wildlife diseases. This position will work with Coordinators from other regions, encouraging nationwide collaboration, and will help develop regional strategies for the prevention, detection, control, and eradication of wildlife diseases.

Cornell Wildlife Health Lab[140]. The Cornell Wildlife Health Lab works to promote the health and long-term sustainability of wildlife populations through integration of the fields of wildlife ecology and veterinary medicine. The Lab conducts disease surveillance and collaborative research; develops diagnostic tools; and communicates findings through training, teaching and public outreach. The lab is based at the Cornell University College of Veterinary Medicine Animal Health Diagnostic Center (AHDC).

Penn State and the Wildlife Futures Program[141]. Penn State's Department of Veterinary and Biomedical Sciences' mission is to protect animal health, human health, and food safety through diagnostic laboratory services and professional expertise. Priorities include early detection and monitoring of animal diseases and providing support for animal owners and industries, veterinarians, animal research scientists and educators as well as state and federal animal health programs. The Animal Diagnostic Laboratory (ADL)[142] fulfills its mission by providing in-depth, rapid diagnostic information to support disease control, health management, and performance of livestock, poultry, wildlife, fish, and companion animals; and by ensuring the safety of foods of animal origin. Furthermore, ADL provides active surveillance of animal diseases and identification of emerging diseases through the development and application of new diagnostic methods, training, and education for new diagnosticians, veterinarians, and graduate students. These proactive measures are designed to ensure the viability of Pennsylvania's animal industries. Wild animals are frequently submitted for evaluation at ADL and wildlife submissions must be arranged through the PA Game Commission. It is a science-based, wildlife health program to increase disease surveillance, management, and research supporting the protection of wildlife across the Commonwealth of Pennsylvania and beyond. It is a partnership with the Pennsylvania Game Commission which provides information, resources and guidance on current wildlife disease issues including:

- **Threat Assessments**
- **Wildlife COVID-19 Resources**
- **Wildlife Disease Fact Sheets –** A compendium of fact sheets on various wildlife diseases, organized into the following groups: mammals, birds, reptiles & amphibians, and multiple species groups.
- **Additional Resources include Avian Flu and Rabbit Hemorrhagic Disease**

Reporting Bat Sightings film-outreach example. Outdoor enthusiasts including climbers and hikers can play and important role by reporting their bat sightings. A new film by **Ravenswood Media**[143], ***Explorers for Bats***[144], explains how climbers and hikers can help document their sightings while at the same time avoiding harm to the bats, including introducing disease. In the film, wildlife managers, bat experts and climbers are interviewed, each providing information about bat behavior, habitat use, populations in established climbing areas, and how those who want to conserve outdoor recreation are invested in bat conservation. Climbers are provided with guidelines for encountering bats, focusing in particular on how to climb in areas without contributing to the spread of the WNS fungus. The interviews take place in spectacular settings on Federal lands in Maine and Utah. Ravenswood Media produced ***Explorers for Bats*** in collaboration with the Colorado Natural Heritage Program, Climbers for Bat Conservation, the National Park Service, and Idaho Department of Fish and Game. The film was funded by a grant from the US Fish & Wildlife Service, administered by the Wildlife Management Institute.

4.5 CONSERVE AQUATIC HABITATS AND RSGCN BY ADDRESSING POLLUTION AND AQUATIC CONNECTIVITY IN NORTHEAST WATERS

4.5.1 REGIONAL NEED AND PRIORITY ACTIONS

Regional Need: The 2015 SWAPS, 2017 SWAP Synthesis, and NEFWDTC identified pollution and the loss of aquatic connectivity as top threats facing aquatic RSGCN and their habitats across the Northeast. Many RSGCNs are associated with aquatic habitats in the Northeast, but these habitats continue to be affected by pollution, water quantity and quality management challenges, and aquatic connectivity issues that can benefit from watershed-focused regional approaches. Climate change will exacerbate water quality issues, requiring environmental assessments and restoration actions to evaluate past management in light of these additional challenges to effectively address present and future conservation goals.

Priority Actions: Provide regional SWAP priorities for incorporation into local, state, and regional water management and watershed planning efforts, highlighting RSGCN and key habitats. Work with partners to improve aquatic connectivity, water management, and water quality for RSGCN and their habitats. Work with agencies and entities that regulate impacts to fish and wildlife habitats to develop and implement effective, consistent policies and approaches across Northeast lands and waters.

See Priority Species in Chapter 1, Priority Habitats in Chapter 2, Priority Threats in Chapter 3, each with partner and program opportunities and examples. See Table 4.1.1 and Appendix 4A for priority projects completed and Appendix 4B, the SWAP Synthesis, and individual SWAPs for additional priority Conservation Actions that address aquatic RSGCN habitat quality.

4.5.2 APPROACH

Chapter 3 provides detailed threat descriptions, impacts on RSGCN, and additional resources and examples for this threat in the Northeast. Continued development along the eastern seaboard is increasing the demand for freshwater, with upland resources being tapped to meet this demand. There is increasing awareness of the need to protect water rights for natural habitats and species. State fish and wildlife agencies have limited authority or capacity to prevent the creation of aquatic barriers or pollution resulting in degraded habitats downstream. This emphasizes the need to work with partners and regulatory agencies at the local, state, regional, and national levels to incorporate current information on SGCN and RSGCN as well as the impacts and benefits of pollution reduction and aquatic connectivity programs.

SWAPs identified dams and water management structures as a priority threat to aquatic fish and wildlife diversity regionally. Specific SWAP actions can be found in the NE SWAP Database and the 14 2015 SWAPs. The 2017 SWAP Synthesis compiled priority SWAP actions and information to address this threat[1]. These action priorities include direct management activities, data collection, partnership development, communications, focused planning, and coordination.

Actions to address these key water management threats are frequently confounded by problems in identifying responsibility for repairs, upgrading, or removal of dams and related structures. Even when ownership is known, repair or removal of these structures may be voluntary, or contingent on the consent of willing owners. Assessing species impacts and monitoring population responses are needed in order to provide informed guidance on conservation work in partnership with state Departments of Transportation and other entities. Restoring watershed buffers and guiding vegetation management and land use activities to restore natural ecosystem communities and functions for RSGCN wildlife and their habitats will help minimize pollution and the impact of extreme weather events. Important communication actions identified were those that effectively message aquatic connectivity and its benefits to SGCN; the costs and risks of degrading dams; best practices for dam/culvert upgrading or removal; and the importance of maintaining minimum flows or levels.

Direct management actions that improve aquatic connectivity by upgrading or removing barriers to restore passage and flow as well as improving buffer condition were identified as high priorities across the region. Applying SWAP, RCN, RSGCN, and key partner tools enhanced with state and local data provides a framework and critical guidance for prioritizing on-the-ground conservation in the Northeast. SWAP priorities need to be incorporated into standards of practice for residential and commercial development, service, and transportation to reduce the impacts of pollution (e.g., the lawn care, road salting).

Aquatic connectivity and pollution reduction are best accomplished with active support and engagement of public and private partners including Departments of Transportation, key Non-Governmental Organizations (NGO), and watershed groups. There is a continuing need to inventory and monitor barriers and water quality conditions and to document RSGCN vulnerabilities and responses to implemented actions. Likewise, there is a continuing need to implement effective, consistent BMPs that engage partners and landowners. Some relevant BMPs already exist; others need to be developed. Offering standardized buffer guidance that incorporates regional SWAP and partner priorities into local, state, and regional water and watershed planning efforts is also important in protecting RSGCN and their key habitats.

Outreach to large landowners such as military bases and corporate/industrial parks is also a priority, along with US Department of Agriculture programs to restore important grassland and early successional habitats and minimize pollution. Planning actions included those that consider SGCN requirements when regulating wells and dams, especially regarding flow release schedules and protocols and creating dam/water management regulations and policies that support biodiversity in or around RSGCN habitats. Measuring and monitoring species and habitat responses to water quality and quantity were likewise considered priority actions by Northeast SWAPs.

An important first and continuing step in aquatic conservation is **working with and informing watershed stakeholders,** providing them with current information on state and regional species and habitat conservation priorities and clearly explaining what is important and why. SWAPs are critical resources for this state-scale information. Regional priorities provided in the RSGCN and SWAP Databases can be found on the NEFWDTC website. **These priorities should be incorporated into local, state, and regional water quality and watershed planning efforts highlighting RSGCN and key habitats.** This includes working with private and NGO partners and stakeholders to incorporate these important conservation targets into their programs and planning processes. The 2017 SWAP Synthesis and Northeast SWAP Database contain detailed actions and information gathered from analysis of the 14 2015 Northeast SWAPs—information on the impacts of this top regional threat to SGCN and RSGCN and their habitats as well as strategies to improve aquatic connectivity and reduce pollution. Key actions identified to address these threats at the regional scale also include incorporating connectivity into transportation and infrastructure design and implementation (culverts, bridges, road crossings, water control structures, and fencing to protect key areas and habitats).

There is a need to **incorporate SWAP and RSGCN information and conservation into transportation, infrastructure, and other sources of pollution and barriers.** Some state and regional efforts (involving North Atlantic Aquatic Connectivity Collaborative[74], TNC, and other key partners) have mapped stream barriers while others have performed cursory condition assessments. These inventories and assessments help determine priorities for upgrades and removal, but additional criteria for assessing ecological conditions are needed. A related need is to develop and test cost-effective approaches to modifying and upgrading barriers that can still provide significant benefits to RSGCN and SGCN in streams. A wide range of improvements and replacement designs, including the use of “slip-line” culverts, are already available to minimize the impact of stream crossings on SGCN; but others can and should be developed.

There is a continuing need to **develop and disseminate consistent, regional BMPs and incentives for barrier removal, repair, and replacement that support conservation of RSGCN and SGCN**. Additional considerations in dam removal planning include invasive species and water temperature. Assessing the condition of the region’s 80,000 culverts and road crossings posed a difficult challenge. In a triage effort, 15,000 were identified as high priority, although it should be noted that this ranking does not include sufficient ecological assessment criteria. Not all dams can be removed, so other strategies must be developed to minimize impacts on SGCN. There is continued need for research leading to the development of improved fish passage structures. Where dams are large enough to require flow release schedules, ecologically appropriate practices should be used. The Federal Energy Regulatory Commission and state regulatory agency policies should be updated to include the conservation needs of SGCN. Classification and regulation of dams varies among states, with some states focusing only on larger dams, and others requiring annual inspection of much smaller dams. These differing regulations will need to be considered in any regional aquatic connectivity initiatives.

Improving the condition of stream and riparian buffers remains a priority in the Northeast. Degraded buffers along adjacent transportation corridors (e.g., roads and railroads), or where power and pipelines traverse rivers and streams, cause similar negative impacts. With consideration for other wildlife needs, careful selection of buffer plants can not only improve stream health and aquatic habitat; they can also provide suitable habitat for pollinators, help stabilize stream temperatures, and reduce pollutant run-off. BMPs for buffers are available, but more consistency in recommendations should specifically include the conservation needs of SGCN.

Significant aquatic connectivity and stream quality improvements can be achieved by **working with partners**. More coordination with State Departments of Transportation is recommended. USDA-NRCS and other partners have multiple wetland and riparian buffer programs (e.g., Wetland Reserve Program, Conservation Reserve Program) that can lead to improved water management practices, and RSGCN and SGCN conservation needs should be included in these, as well. Working with regional partners such as Trout Unlimited, Eastern Brook Trout Joint Venture, and National Fish Habitat Partnerships initiatives can also help incorporate scientific assessments and RSGCN priorities into a wide range of activities.

An emerging area of conservation action relates to **protecting groundwater for RSGCN and their key habitats**. This is especially important in late summer when risk of severe drought is greatest. The effect of water withdrawals on SGCN may increase with climate change because: 1) sea level rise is expected to result in saltwater intrusion near coasts where aquifer water is withdrawn; 2) warmer air temperatures will expose species in low-flow streams to much higher water temperatures; and 3) higher frequency and increased severity of drought in late summer could cause and/or exacerbate conflicts between the many demands for freshwater, including the need to maintain natural habitats for SGCN. Requirements to address RSGCN life-history for wells in proximity to their habitats should be considered. As sea level rise introduces salt water into shallow aquifers, coastal states need to consider and communicate the needs of RSGCN in local and state water management planning.

Over the past decade, it has become clear that Climate Change exacerbates water quality and quantity issues in the Northeast. NECASC has provided valuable research, information, and tools for better understanding and adaptation strategies[49] (Staudinger et al. 2023).

Multiple RCN, CSWG, and SA efforts address aquatic connectivity and water quality and quantity within species and habitat conservation strategies and plans, including the following RCN, CSWG and SA projects listed in Table 4.1.1and *Appendix 4B*: SWAP Database, RSGCN Database and List Development, 2017 SWAP Synthesis, 2020 Limiting Factors Report, Great Lakes ELOHA, Landlocked Alewives, Aquatic Connectivity Dam Assessment, Flow Models, Brook Floater, Chesapeake Logperch, Diadromous Fishes, Rare Wetland Turtles, Hellbender, Diamondback Terrapin Wetland Bird, Odonate Assessment, and Wetland Butterfly projects. See Table 4.1.1and *Appendix 4B*.

4.5.3 REGIONAL PROJECTS ADDRESSING AQUATIC HABITAT CONSERVATION

The 14 Northeast 2005 and 2015 SWAPS, the 2017 SWAP Synthesis, and the 2023 RSGCN process identified Pollution and Water Management as top regional threats to fish and wildlife diversity conservation in the Northeast. To address them, NEAFWA's RCN and key partner programs prioritized and funded multiple projects to assess and remove aquatic barriers and improve connectivity and water quantity and quality in the region. Some of the key projects are listed below as resources. For a complete list of these projects please see Table 4.1.1 and *Appendix 4*, for additional partner information see *Chapter 7*. For more detailed information on aquatic species and habitats, see *Chapters 1 and 2* respectively. *Chapter 2* provides information on Northeast aquatic habitat status and condition as well as RSGCN supported and provides examples of management and conservation plans and efforts in the region. *Chapter 3* provides detailed threat descriptions, impacts on RSGCN, and additional resources and examples for this threat in the Northeast.

An Interactive, GIS-Based Application to Estimate Continuous, Unimpacted Daily Streamflow at Ungauged Locations in the Connecticut River Basin (2007) (RCN). This project developed an interactive map-based decision-support tool to estimate continuous unimpacted daily streamflow at ungagged locations in the Connecticut River basin (Archfield et al. 2013). Work from this project allows users to identify a stream reach of interest in the Connecticut River basin and obtain estimated continuous daily, unregulated, or "natural" streamflow at the selected location. The

Connecticut River UnImpacted Streamflow Estimator (CRUISE) tool spans the entire Connecticut River basin, including the states of Connecticut, Massachusetts, New Hampshire, and Vermont. This work expands on a method developed for Massachusetts to estimate daily streamflow at ungagged locations. The CRUISE software tool and user manual are available through the USGS[145].

ELOHA Framework in the Great Lakes Drainage. (2008) (RCN). This RCN project applied the Ecological Limits of Hydrologic Alteration (ELOHA) framework in the Great Lakes drainage of New York and Pennsylvania to develop an objective, spatially explicit process for evaluating the ecological impacts of new withdrawals of water from the tributaries of Lakes Erie, Ontario, and the upper St. Lawrence River (Taylor et al. 2013). This provided the information necessary to develop and implement instream flow standards for managing the Great Lakes surface and ground-waters of New York and Pennsylvania under the terms of the **Great Lakes Compact** (see *Chapter 7*). Additional multi-state benefits include transferability of the holistic, ELOHA-based technique being developed from the Susquehanna Basin to the Great Lakes Basin; guiding implementation of the Great Lakes Compact in at least two states, with useful information for other states and provinces in the region (e.g., Vermont, Ontario, Quebec, Ohio); and assessing and documenting the transferability of the project methods and models to other NEAFWA states or watersheds. The project engaged technical advisors from agencies, universities, and other stakeholders in combining testable models of ecological responses to flow alterations with an assessment of current alterations in different types of streams. This combination enabled New York and Pennsylvania to determine the flows necessary to sustain aquatic life and to implement instream flow policies that balance human and ecosystem needs.

Determining the Effects of Landlocked Alewives on Anadromous Alewife Restoration. (2015) (RCN) Another RCN project funded dam removal and fish passage efforts that are critical components of anadromous Alewife restoration, reconnecting runs to prime spawning habitat in coastal lakes. Landlocked Alewife populations have become established in many coastal New England lakes, and the effects of landlocked Alewives on anadromous Alewife restoration were unknown. Specifically, this RCN project investigated the effects of landlocked Alewife presence on anadromous Alewife restoration in Rogers Lake, which once hosted one of the largest anadromous Alewife runs in Connecticut (Palkovacs et al. 2018). From 2015-2017, spawning anadromous adults were stocked and sampled. A novel set of microhaplotype genetic markers were developed to identify anadromous, landlocked, and hybrid juveniles. Estimates of spawning time showed that anadromous Alewives spawn earlier in the spring than landlocked Alewives, but that there is a period of overlap in spawning time, creating the potential for hybridization. Results of genetic monitoring indicate that anadromous Alewives are successfully spawning in Rogers Lake. The identification of anadromous juveniles indicates that anadromous Alewife are able to successfully spawn and juveniles to rear in a lake containing a landlocked population. The identification of hybrids indicates that the two life history forms can successfully spawn together and produce viable and competitive offspring. Estimates suggest that anadromous production is high enough to initiate anadromous Alewife restoration. They also show that landlocked Alewives are still substantially more common in the lake compared to anadromous or hybrids. Hybrids are less common than anadromous juveniles, but they are present at ecologically and evolutionarily relevant abundances. Future work continues to track the abundance of each life history form to better understand how anadromous production and hybridization are proceeding as the restoration project continues. A PowerPoint summary and the full report on the Restoration of Anadromous Alewife of Lakes of Connecticut can be found through the NEFWDTC website.

Chesapeake Logperch (Percina bimaculata) projects (2018) (CSWG, SA). The Chesapeake Logperch (*Percina bimaculata*) is listed as threatened in Pennsylvania and Maryland. Historically, this species was found in the Chesapeake Bay watershed in the District of Columbia, Maryland, Pennsylvania, and Virginia. It was limited to the lower sections of the Potomac and Susquehanna rivers and their tributaries, and a few direct tributaries to the Chesapeake Bay. It was thought to have been extirpated from the Potomac River drainage due to pollution and sedimentation. Threats to the Chesapeake Logperch are many: nutrient loading/sediment loading; Polychlorinated Biphenyls (PCBs) and Chlordane; pollution; habitat loss/modification of natural systems (*i.e.*, dams fragmenting riverine habitat, development, conversion to agricultural use); impingement (Peach Bottom Nuclear Facility intake structures); stranding in shallow pools (mid-summer months); and the introduction of hybrid aquatic species nd invasive aquatic species, such as the Northern Snakehead (*Channa argus)*, the Flathead Catfish (*Pylodictis olivaris*), and Zebra Mussels (*Dreissena polymorpha*).

The objectives of this CSWG project were to: 1) determine the extant distribution of the Chesapeake Logperch and identify any significant phenotypic variation among sub-populations occupying the mainstem river and tributary streams; 2) determine habitat characteristics, life history and behavioral aspects of the Chesapeake Logperch; 3) reintroduce Chesapeake Logperches; 4) develop a conservation action plan for Chesapeake Logperch in Maryland; and 5) ensure that progress on grant activities is tracked and communicated to all partners.

The ARS program efforts contributing to the conservation goals and actions include: 1) protect, conserve, and enhance viable extant populations in Maryland and Pennsylvania; 2) reintroduce this species to historical range (including the Potomac drainage), and augment existing populations; 3) monitor the species; 4) protect streams and habitat from agricultural and urban run-off; and 5) genetic characterization.

The ARS team is working with state and federal partners to implement a captive rearing operation (multiple facilities). State partners are working to complete the last year of a 5-year Comp-SWG study on the Logperch including determining life history, behavior, and habitat characteristics; identifying suitable release sites; releasing wild and propagated Logperch stocks; and developing a Conservation Action Plan for logperch in Maryland. Federal partners have initiated genetic analysis to determine the genetic diversity implications for propagation efforts. The Team also works with academia on behavior, predator avoidance, and other studies.

Aquatic Habitat Classification System and Map Guide. (2007, 2011) Important foundational RCN projects established classification and mapping of aquatic habitats in the Northeast. A classification system was developed for aquatic habitats with an accompanying guide to the Northeast Aquatic Habitat Map. These serve as a companion to the terrestrial and aquatic habitat maps. The goal of this project was to ensure the understanding and widespread use of the **Northeast Aquatic Habitat classification system** by creating a printable web-based guide to the Northeast Aquatic Habitat Classification and GIS database (Olivero and Anderson 2008, Olivero Sheldon et al. 2015). The guide includes descriptions of the habitat types, sample photographs, statistics and distribution patterns, guidance for using crosswalks to other (state) classification schemes, and, when available, wildlife associations for Northeast fish and mussels. A steering committee developed a classification scheme that simplifies the full classification into logical stream types. Most recent classification systems for lakes and ponds and marine systems have also been updated and completed (Olivero and Anderson 2008, Olivero at al. 2015, Olivero Sheldon and Anderson 2016).

Diadromous Fishes (Alewife, Blueback Herring) (2022) (SA). Alewife (*Alosa pseudoharengus*) and Blueback herring (*Alosa aestivalis*), collectively known as River Herring, are categorized as SGCN in all New England states, New York, Pennsylvania, New Jersey, Delaware, and Virginia. Blueback herring are additionally categorized as SGCN in South Carolina and Florida. River Herring Conservation Plans have been released by NOAA Fisheries and the Atlantic States Marine Fisheries Commission (ASMFC) within the last decade. Threats to River Herring populations include exclusion from or reduced access to historic freshwater spawning and nursery habitats; barriers with inadequate fish passage measures; freshwater and estuarine habitat/water quality degradation; climate change impacts; and indirect (bycatch) fishing pressure. In both the marine and freshwater environments, shifts in water temperature, related temporal/spatial shifts in environmental conditions, prey availability, and predators may be negatively influencing River Herring populations. Conservation goals for River

Herring are aligned with those established in the ASMFC Amendment 2 to the Interstate Fishery Management Plan for American Shad and River Herring (River Herring Management) (ASMFC Shad and River Herring Plan Development Team 2009): *"Protect, enhance, and restore East Coast migratory spawning stocks of . . . alewife (*Alosa pseudoharengus*), and blueback herring (Alosa aestivalis) in order to achieve stock restoration and maintain sustainable levels of spawning stock biomass."* Priority objectives include: 1) preventing further declines in population abundance; 2) promoting improvements in degraded or historic habitat throughout the species range; 3) improving access to historic freshwater spawning and nursery habitat; and 4) increasing understanding of the influences of River Herring bycatch in commercial fisheries as well as updating the status of stock dynamics and health.

Freshwater Mussels (Brook Floater, Cumberland Moccasinshell, Pheasantshell, Tennessee Clubshell, Tidewater Mucket, Yellow Lampmussel) (2012, 2016, 2022) (RCN, CSWG, SA). Across the continent, freshwater mussels have experienced drastic declines. More than 74 % of the 298 species found in North America are in some state of imperilment, with 93 species federally listed as endangered or threatened (Williams et al. 2017). Habitat degradation, which includes water pollution and impoundments, is by far the leading cause of these declines. Non-native species also have outcompeted some native species. Freshwater mussels also provide ecological and economic benefits to people and aquatic ecosystems. Like oysters, they filter millions of gallons of water and act as ecosystem engineers. They're crucial to a multi-billion-dollar pearl jewelry industry, and harvest of mussels is a reserved treaty right for some Native American tribes. Without intervention, freshwater mussels will continue to disappear within their range, with the risk of also losing the valuable ecosystem services they provide.

An RCN project assessed the conservation status of the brook floater mussel, *Alasmidonta varicosa,* in the United States and established the trends in distribution, occurrence, and condition of populations (Wicklow et al. 2017). They reported on: 1) its biology and life history; 2) the distribution and condition of all known populations from Maine to Georgia; (3) the human impacts on populations; 4) the results of models using environmental factors at both the HUC 12 level and stream level as predictors of population condition; and 5) the results of a survey concerning threats to this species that was sent to mussel biologists from Maine to Georgia.

Using adaptive management and working at landscape scales in partnership with states and Tribes, partners work together to restore and conserve these at-risk species of mussels and proactively address threats in an effort to avoid the need to list these species under the Endangered Species Act. With input from partners, the ARS program has been building a conservation plan called the **Northeast Region Conservation**

Strategy for Freshwater Mussels. It provides a framework and strategies for conserving and restoring at-risk species of freshwater mussels and their habitats from Maine to Virginia and West Virginia. This will inform decisions on feasible, cost-effective actions that Service programs can take with partner support over the next five years to increase representation, redundancy, and resiliency (3 Rs) of each species, and ensure their long-term viability.

In 2022, biologists from 12 States, the Partnership for Delaware Estuary, USGS, and representatives from the Penobscot Nation were interviewed. A suite of questions aimed at identifying priority areas and management and science needs for conservation of mussels. This information is being synthesized into maps and tables which will highlight priority areas for conducting surveys, habitat restoration, land protection, propagation and stocking, and science needs. Discussions held in 2021 with the Rappahannock, Chickahominy, and Upper Mattaponi Indian Tribes in Virginia are also informing priority areas for conservation of at-risk mussels and their host fish, as described in the *Northeast Region Conservation Strategy for Freshwater Mussels*. Interviews with Tribal partners continue to further identify priority areas for mussel conservation efforts. The strategy will be distributed to State and Tribal partners and to other Service offices for review and comment, and the result will be a comprehensive At-Risk Conservation Strategy. Continuing program efforts will work to build local action plans within target watershed and implement projects. Priority science needs for mussels were also identified and included in the request for proposals through the USGS as well as priority projects for BIL funding.

Brook Floater Rangewide Conservation and Restoration Initiative (CSWG). This project developed protocols to estimate the occupancy and detection rates of Brook Floater within the watershed; estimate how environmental and observational covariates influence these rates; and standardize methods for capture-mark and recapture of Brook floater at high-priority conservation sites.

The Gulf of Maine Coastal Marine Ecosystem Survey: Mapping Biological Hotspots (2013) (CSWG). The goal of this project was to fill critical knowledge gaps on the basic ecology, distribution, and abundance of 27 SGCN that inhabit the region's coastal marine ecosystem. Using distribution and abundance data, the partners calculate biological hotspot index values and develop digital maps based on habitat use model predictions. This critical information helps the partners develop effective conservation programs for these species within the Gulf of Maine and provide technical assistance for siting of offshore energy development projects in ways that minimize their impacts on marine habitats.

4.5.4 REGIONAL EXAMPLES AND OPPORTUNITIES

Chapter 3 provides detailed threat descriptions, impacts on RSGCN, and additional resources and examples for this threat in the Northeast. Many estuary and watershed programs in the Northeast are working to reduce non-point source pollutants. For example, the Chesapeake Bay Program's Total Maximum Daily Load limits on nutrients and sediment set in 2010 by US Environmental Protection Agency (EPA) were written into Watershed Implementation Plans that detail how and when each of the Bay jurisdictions will meet the goals[146]. Other such programs across the Northeast include the Hudson River Estuary Program, Delaware Bay Program, Lake Champlain Basin Program, Great Lakes Restoration Initiative, Long Island Sound Program, and Riverkeeper Programs, etc. (see *Chapter 2* and *7* for additional partners' programs).

North Atlantic Connectivity Collaborative. The aquatic connectivity portal maintained by the North Atlantic Aquatic Connectivity Collaborative is a one-stop source for tools and regional collaboratives focused on aquatic organism passage ("fish passage") and the fragmentation of river and stream ecosystems. It is a starting place for stakeholders, users, and tool developers looking to keep track of the latest initiatives and identify opportunities for collaboration and action[84]. Examples of this site's contents include:

- **TNC HUC12 Prioritization Tool**[147], spanning the 13 North Atlantic states from Maine to West Virginia helps identify sub-watersheds that may have priority for field survey and crossing assessments.
- **TNC Aquatic Barriers Prioritization Tool**[148], for the 13 North Atlantic states from Maine to West Virginia explores barriers to aquatic connectivity — dams and road stream crossings, using GIS.
- **Fishwerks**[149], is a Web-based GIS platform that uses sophisticated optimization tools to help maximize the efficiency of habitat improvement projects for migratory fish in the Great Lakes basin.
- **Freshwater Network – Chesapeake Region**[150], allows users to explore barriers to aquatic connectivity — dams – and identify high priorities for removal or improved fish passage. It also supports custom analyses in the Chesapeake Bay watershed states of Virginia, Maryland, and Pennsylvania.
- **Coastal Resilience Maine**[151]**,** allows users to explore barriers to aquatic connectivity — dams and road-stream crossings– in the Penobscot River Watershed and identify high priorities for removal and/or improved fish passage. It also supports a range of custom analyses.
- **Southeast Aquatic Barrier Prioritization Tool**[152], Atlantic Drainages from the Roanoke River in VA to Mobile Bay allows users to explore barriers to aquatic connectivity — dams – and identify likely high priorities for removal or improved fish passage. It also supports a range of custom analyses.

NRCS Wetland Reserve Easements Program. The Natural Resources Conservation Service (NRCS) Wetland Reserve Easements Program (one part of the Agricultural Conservation Easement Program) provides funds to purchase development rights in connected riparian areas. Land eligible for Wetland Reserve Easements includes farmed or converted wetland that can be successfully and cost-effectively restored. NRCS prioritizes applications based the easement's potential for protecting and enhancing habitat for migratory birds and other wildlife. In many cases NRCS has included the SWAP SGCN species in their priority ranking system. An example is its use in habitat protection of saltmarshes to support Saltmarsh Sparrow. Working with experienced partners, NRCS funds the enlargement of stream buffers, an example of conservation stewardship design[153].

Environmental Protection Agency's Report on the Environment[154] includes five indicators of ecological condition that address the state of the nation's ecological systems, providing insight into the degree to which the natural environment is being protected:

- **Extent and Distribution.** This indicator examines trends in the overall extent (area and location) of different kinds of ecological systems. It also examines spatial patterns in the distribution of ecological systems that affect interactions of nutrients, energy, and organisms, considering Ecological Connectivity, Forest Extent and Type, Forest Fragmentation, Land Cover, Land Use, Urbanization and Population Change, and Wetlands
- **Diversity and Biological Balance.** These indicators identify trends in the types and numbers of species that live within ecological systems and how they interact with each other. Examples include: Benthic Macroinvertebrates in Wadeable Streams, Bird Populations, Coastal Benthic Communities, Cyanobacteria in Lakes, Fish Faunal Intactness, Non-Indigenous Estuarine Species in Pacific Northwest, Submerged Aquatic Vegetation in Chesapeake Bay
- **Ecological Processes.** These indicators focus on trends in the critical processes that sustain ecological systems, such as primary and secondary productivity, nutrient cycling, decomposition, and reproduction: Carbon Storage in Forests, for example
- **Physical and Chemical Attributes.** *Physical attributes* can include temperature, hydrology, and physical habitat, as well as major physical events that reshape ecological systems, such as fires, floods, and windstorms. *Chemical attributes* can include pH, dissolved oxygen concentrations, and nutrients (e.g., nitrogen and phosphorus). These indicators include: Acidity in Lakes and Streams, Hypoxia in Gulf of Mexico and Long Island Sound, Nitrogen and Phosphorus in Agricultural Streams, Nitrogen and Phosphorus in Large Rivers, Nitrogen and Phosphorus in Wadeable Streams, Sea Level, Sea Surface

Temperature, Stream Flows, Streambed Stability, and Temperature and Precipitation

- **Ecological Exposure to Contaminants.** This indicator set provides information on biomarkers of exposure to contaminants that are particularly important with respect to the health of plants and animals, as well as to humans who might consume them: Coastal Fish Tissue and Lake Fish Tissue, for example.

The New England District of the U S Army Corps of Engineers developed **Stream Crossing Best Management Practices** (USACE 2015).

DAMS AND WATER MANAGEMENT

Most states' experience with this threat involves dam removal or culvert replacement. Efforts have focused on priority structures for which removal can significantly lengthen connected stream segments and restore RSGCN/ SGCN habitats and populations by facilitating aquatic organism passage.

Nationwide, the USFWS has been involved in the removal of 1600 barriers to fish passage over the past two decades. USDA-NRCS and the National Fish Passage Program are other national partners. In each state, environmental protection agencies, power utility companies, departments of transportation, and Watershed protection NGO's (including Trout Unlimited, American Rivers, etc.) are potential partners, as well. American Rivers summarizes the state of dam removal throughout the US on its website[155].

States reported that the ability to cite economic benefits of dam removal or fish passage is important in justifying this conservation work. A 2010 USFWS report estimated the annual economic contributions attributable to the focus areas detailed in the National Fisheries Program Strategic Plan (Charbonneau & Caudill 2010). Aquatic Habitat & Species Conservation and Public Use were focus areas of the report and included case studies of dam removal and improvements.

Most watersheds in the Northeast address invasives and disease in their plans and programs. The Connecticut River is one example of the many active watershed partnerships in the region.

Connecticut River Watershed Council[156]. The Connecticut River Watershed Council works to protect the watershed from source to sea, The Connecticut River watershed unites a diversity of habitats, communities, and resources from Alpine forests to tidal estuaries, rural farmlands to urban riverfronts, salamanders to bald eagles, and mussels to salmon.

Economic Impacts of Habitat Improvements. Gentner Consulting Group developed a tool allowing users of the National Fish Habitat Action Plan to calculate economic impacts of fresh and saltwater habitat improvements (Gentner 2013). The **Atlantic Coastal Fish Habitat Partnership (ACFHP) Plans** incorporate water quality and connectivity in their Conservation Strategic Plan which is updated every five years and used as a guidance document by the ACFHP Steering Committee, the Partnership-At-Large, state and federal agencies, and restoration practitioners (ACFHP 2017). The Plan is designed to address goals, objectives, and strategies that the Atlantic Coast Fish Habitat Partnership will focus on to improve the condition of Atlantic coastal fish habitat. A more specific set of priority actions is presented in the 2020-21 Action Plan (ACFHP 2020). The current NOAA National Strategy can be accessed through the NOAA Fisheries website (NMFW 2022).

Northeast Climate Adaptation and Science Center. NECASC provides a wealth of information and tools on how climate change exacerbates the issues of water quality and quantity in the Northeast. Their website[50] includes a list of projects, publications, and examples, several of which are presented below:

- **Determining the Skill and Value of Incorporating Streamflow Forecasts into an Early Drought Detection System -** This research investigates success in forecasting or predicting the onset and severity of drought. One of the unique features of NECASC's research agenda is the active engagement of water supply utilities. Another is the evaluation of how climate informs short-term stream flow forecasts.
- **Science to Inform the Reconnection of Floodplains and Restoration of Green Space to Minimize Risk in the Future -** This project identifies opportunities to manage flows, connections, and landscapes in ways that increase the resilience of human communities and ecosystems. This research identifies dynamic and adaptive solutions to managing river flows that support continuation of valuable infrastructure services.
- **An Assessment of Midwestern Lake and Stream Temperatures under Climate Change -** Water temperatures are warming in lakes and streams, resulting in the loss of many native fish. Given clear passage, cold water stream fishes can take refuge upstream when larger streams become too warm. Likewise, many Midwestern lakes "thermally stratify," with warmer waters closer to the surface.
- **Small dam removal as a tool for climate change resilience -** Across the United States, millions of small dams fragment the landscape and alter stream ecosystems. Removal of obsolete dams and related structures is a way to eliminate or reverse the negative impacts on humans and ecosystems.

- **Science to Inform Management of Floodplain Conservation Lands in a Changing World -** Recent extreme floods on the Mississippi and Missouri Rivers have motivated decision-makers and resource managers to expand the inventory of floodplain conservation lands. Within Missouri, there are currently more than 85,000 acres of public conservation lands in large-river floodplains.
- **Framework for Protecting Aquatic Biodiversity in the Northeast Under Changing Climates -** This project uses an analytical, iterative process to evaluate aquatic biodiversity protection and management scenarios across four Northeastern states (Connecticut, Massachusetts, New Hampshire, and Vermont). It integrates climate change and management to identify land protection and restoration actions that optimize aquatic biodiversity protection into the future. Ultimately, the results will help managers to promote aquatic ecosystem health and prioritize climate adaptations.
- **Rethinking Lake Management for Invasive Plants Under Future Climate: Sensitivity of Lake Ecosystems to Winter Water Level Drawdowns -** Small lakes are important to local economies as sources of water and places of recreation. Commonly, lakes are considered more desirable for recreation if they are free of the thick weedy vegetation, often comprised of invasive species, that grows around the lake edge.
- **Mapping Salt Marsh Response to Sea Level Rise and Evaluating 'Runneling' as an Adaptation Technique to Inform Wildlife Habitat Management in New England -** Loss of saltmarsh habitat is one of the greatest threats to coastal sustainability in the Northeast. Salt marsh has been identified as an essential fish and wildlife habitat, and loss of saltmarsh corresponds with precipitous declines in marsh-dependent wildlife.
- **Mapping Connections Across Ecosystems in the Northeast to Inform Climate Refugia Networks**. As the climate continues to change, vulnerable wildlife species will need specific management strategies to help them adapt to these changes. One such strategy is based on the idea that some locations a species inhabits today will remain suitable over time and should be protected.
- **Mapping Connections across Ecosystems in the Northeast to Inform Climate Refugia Networks**

The New England District of the U S Army Corps of Engineers developed Stream Crossing Best Management Practices (USACE 2015).

STATE EXAMPLES AND OPPORTUNITIES

Connecticut: Connecticut has imposed a fine of up to $1000/day for dams that are not maintained or that are deemed unsafe. Keeping dams free of tree growth and maintaining structural integrity are high priorities. While many dams have been removed, the impact of coincident threats like rising water temperatures, inadequate buffer vegetation, and pollution may have limited species responses. In one example, the Zemko Dam was removed from the Eightmile River system in Salem, CT. Fish populations responded positively to the dam's removal; however a complete shift from lentic to lotic fishes did not occur within a 3 year sampling period (Poulos et al. 2014; Poulos & Chernoff 2017).

Maine: The Penobscot River Restoration Project[157] is a collaboration between the Penobscot Indian Nation, seven conservation groups, hydropower companies PPL Corporation and Black Bear Hydro LLC, and state and federal agencies. Its purpose is to restore 11 species of sea-run fish to the Penobscot River while maintaining energy production. This was accomplished by removing dams, installing fish lifts and bypasses, and replacing water intakes.

- **Penobscot River-** Penobscot River Restoration Project (Natural Resources Council of Maine)[184] and Restoring the Penobscot River (The Nature Conservancy)[158]
- The Penobscot Nation[159] provides information on water management, mud gates and invasive species affecting their lands and waters.
- Maine has been surveying stream crossings for 11 years and has nearly completed its inventory. The Maine Stream Habitat Viewer was made available in 2012 and is a powerful tool to access habitat and barrier data. In 2014, TNC, Maine Audubon, and the Maine State Chamber of Commerce lobbied for, and voters approved, a bond to fund improvements to stream crossings that would protect public safety, improve aquatic habitat connectivity, and allow for resiliency in the face of more frequent and intense storms. Priority projects begin with a full Aquatic Organism Passage study. There is still a need to improve the cost-effectiveness of these road crossing improvement projects.
- **Kennebec River (Edwards Dam) removal is documented here:**
    - Twenty years of dam removal successes – and what's up next[160] (American Rivers)
    - How Removing One Maine Dam 20 Years Ago Changed Everything[161] (The Revelator)
    - River Rebirth: Removing Edwards Dam on Maine's Kennebec River[162] (National Geographic)
    - Edwards Dam and Kennebec River Restoration[163] (Natural Resources Council of Maine)

Maryland: A 2014 publication reported links between chloride concentration in streams, mayfly abundance, the benthic macroinvertebrate index of biotic integrity, brook trout density, and salamander and mussel populations (Ashton et al. 2014). In all cases, streams with high chloride concentrations had low measured populations and were more likely to be listed as “impaired” streams in Maryland. This report also provides an extensive bibliography including measurements of chloride impacts on other species. For example, amphibians are particularly sensitive to road salt run-off due to their permeable skin. Spotted Salamanders (*Ambystoma maculatum*) were especially sensitive; Anurans in the genera of *Bufo, Rana, and Xenopus* were more tolerant; and salamanders in the genera *Aneides* and *Batrachoseps* were the most tolerant of all the species surveyed (Karraker et al. 2008).

Maryland is working with the State Highway Administration to monitor impacts of road salt application in a study that began in 2016.

Massachusetts:

- **Nissitisit River, Rattlesnake Brook, Shawsheen River, Cotley River, Housatonic River West Branch, Ipswich River**
  River Run – A Story of Dam Removal in Massachusetts[164] (MA Division of Ecological Restoration [MA DER] film series)
- **Removal** of the dilapidated **dam** and reconnecting 40 upstream river miles on a beautiful trout stream in **northeastern** Massachusetts
- **Stream Crossing Explorer - Deerfield River Watershed[165]**, Massachusetts and Vermont. Provides a data visualization and decision support tool that was developed to assist with locating and prioritizing stream crossings that meet user-defined criteria.
- **MA DER Restoration Potential Model Tool[166]**, An RPM Tool displays information that can be used to evaluate the relative ecological benefits of removing any known dam in Massachusetts.

New Hampshire:

- **NH Aquatic Restoration Mapper[167]** provides an Interactive tool allowing users to explore stream crossing, flood hazards, and aquatic habitat data to identify restoration opportunities in New Hampshire Communities.
- **Mill Pond Dam in Durham, NH[168].** Restoring Our Water and Food Ways of N’dakinna (Our Homelands) (2021 video by Ellen Ervin, Indigenous New Hampshire Collaborative Collective)[169]
- **Exeter River (Great Dam, Exeter NH), -** Great Dam Removal Project (Town of Exeter)[170], Documentary on the Exeter Dam (Exeter Historical Society)[171], Dam Removal and Habitat Restoration on the Exeter/Squamscott River, New Hampshire (Atlantic Coastal Fish Habitat Partnership)[172]

- **Bellamy River (Sawyer Mills Dams, Dover NH)-**A River's Freedom (The Nature Conservancy)[173] and Sawyer Mills dams being removed from Bellamy River (Foster's Daily Democrat)[174]
- New Hampshire River Restoration Task Force[175]
- **Gale River (White Mountains NH)-**Partners celebrate restoration of New Hampshire's Gale River (American Rivers)[176]

New York: Since the 1980s, the Adirondack Lakes Survey Corporation has worked to monitor acid deposition and its related ecological impacts in the Adirondack Mountains of New York. As the effects of acid deposition on aquatic and forest ecosystems have become well documented, environmental groups have successfully advocated for regulation of air-borne pollution to prevent acid rain and/or mitigate its impacts on Northeastern lakes and forests. The regulatory and monitoring work has reduced airborne acid pollutant loading and documented the ecological response.

- There are many examples of attempts to reduce road-salt use to benefit surface waters in New York. Specifically, there are documented increases in chloride in Lake Champlain[177]. NYSDOT is implementing salt reduction projects in the Adirondacks. Several ongoing studies explore the impact in the Lake George area. Vermont is also exploring road salt reduction.

Rhode Island: The White Rock Dam on the Pawcatuck is an example of interstate collaboration in dam removal (between Rhode Island and Vermont in this case)[178]. Other removals are underway, including a second one on the Pawcatucket River. Currently, there are anadromous fish passage projects on the Ten Mile, Blackstone, Wood/Pawcatuck, and Woonasquatucket River systems. They include full or partial dam removals and the installation of fishways/eel ramps. Some of these efforts provoked resistance to removal where the dams are considered cultural/historic landmarks. Horseshoe Falls, also on the Pawcatuck, is an example of this. Improving fish passage in RI is probably one of the best examples of collaborative partnering and urban restoration in the state (both of which were highlighted on p. 25 of the RI WAP Companion Guide[35]).

Vermont: In 2012, six farms in the Lake Champlain watershed participated in a study comparing edge-of-field treatments (Braun et al. 2016). The farms were enrolled in NRCS pollution reduction programs. Practices included cover cropping; manure injection and conservation tillage; soil aeration prior to manure application; adding waste and sediment control basins; and creating grassed waterways. Parameters that were monitored in the study include total phosphorus, total dissolved phosphorus, total nitrogen, total dissolved nitrogen, chloride, total suspended solid, soluble reactive phosphorus, and total event discharge. Precipitation, air temperature, runoff-specific conductance, and runoff temperature were also monitored.

Virginia and West Virginia: During the summer of 2016, three dams were removed in the West Fork River watershed in West Virginia[179]. The dams were between 85 and 105 years old. They were originally built for water supply purposes and were deemed to be both obsolete and safety liabilities. Removal of the dams reconnected 491 miles of streams and tributaries upstream of the Hartland Dam and benefited Clubshell and Snuffbox freshwater mussels. The National Park Service approved a Water Trail on the river. Plans are in place to extend the connected stream distance by installing passage for fish and non-motorized boaters at the Hartland Dam.

- As water levels dropped upstream of the dams, there was some sloughing of riverbanks and collapse of roads beside the banks. (West Virginia Division of Highways worked to stabilize these situations.) Volunteers and contractors relocated 1430 stranded mussels (representing 9 different species) into newly established riffle/run habitat. The declining water levels exposed a large amount of trash that had been submerged and had to be removed. At the same time, the local water utility realized between $40,000-and $50,000 in savings, in part because the incoming water was much cleaner and fewer treatment chemicals were needed.
- In Virginia, dams are being removed on the Upper Tennessee River Basin to benefit Yellowfin Madtom, Slender Chub, Spotfin Chub, Tan Riffleshell, Fluted Kidneyshell, Shiny Pigtoe, and dozens of other SGCN. Communities are supporting these efforts and have expressed interest in creating blueways or organized boating paths, enhancing local recreation and tourism opportunities once flow is restored.

OTHER RESOURCES

- **Connecticut River project:** Reconnecting Habitat for Fish (Connecticut River Conservancy)[180]
- **National Oceanic and Atmospheric Administration**: "Dam Removals in New Hampshire Benefit Public Safety, Fish Migration"[181]
- **New England Sustainability Consortium**: The Future of Dams Project[182]
- **The Nature Conservancy**
  "Unleashing Rivers": feature article[183] on dam removal in New England and "Removing Barriers to River Health and Fisheries", Provides overview of the Nature Conservancy's work restoring river ecosystems through dam removal[184]
- "The river is us; the river is in our veins": re-defining river restoration in three Indigenous communities (Fox et al. 2017).
  This resource uses three case studies in the US, New Zealand, and Canada, to

explore how Indigenous knowledge is expressed through Native participation in river restoration and how these practices affect restoration outcomes. It shows why cultural approaches to restoration are important, and the kinds of opportunities they create.
"Dam Removal: Case Studies on the Fiscal, Economic, Social, and Environmental Benefits of Dam Removal" (Headwaters Economics 2016). Report compiled by an independent, nonprofit research group summarizing fiscal, economic, social, and environmental benefits of dam removal. Formatted by case studies, including dam removals in Massachusetts, Maine, Connecticut, and Rhode Island.

- "Centuries of Anadromous Forage Fish Loss: Consequences for Ecosystem Connectivity and Productivity" (Hall et al. 2012). Analyzes dam records of Maine rivers to find where fish populations were prevented from accessing their native habitat by dams built between 1600 and 1900. Concludes that successful restoration of ecologically important fish species can occur in places where dams are removed.
- "Effects of Dam Removal on Fish Community Interactions and Stability in the Eightmile River System, Connecticut, USA" (Poulos and Chernoff 2017). Tracks the temporal effects of dam removal on fish community interactions in the Eightmile River system of Connecticut. Suggests that, following dam removals, it may take decades or even centuries for restored sites to approximate the eco-community structure of nearby undisturbed sites.
- "Shortnose Sturgeon in the Gulf of Maine: Use of Spawning Habitat in the Kennebec System and Response to Dam Removal" (Wippelhauser et al. 2015). Provides the first evidence that Shortnose Sturgeon began to spawn in the restored Kennebec River after the Edwards Dam was removed in 1999. Highlights the importance of the Kennebec system to Shortnose Sturgeon throughout the Gulf of Maine and the role of dam removal in river ecosystem restoration.
- "Opening the tap: Increased riverine connectivity strengthens marine food web pathways" (Dias et al. 2019)
  Models the increases in energy flow and population productivity resulting from improved ecosystem connectivity following dam removal. Suggests potential for biomass increase of several species with high economic value and a major increase for species of conservation concern. Emphasizes the benefits of increased connectivity between freshwater and ocean ecosystems.
- "Dam Removal Effects on Benthic Macroinvertebrate Dynamics: A New England Stream Case Study (Connecticut, USA)" (Poulos et al. 2019)
  Examines the effects of dam removal on the structure, function, and composition of benthic macroinvertebrate communities in a temperate New England stream. Indicates that the effects of stream restoration on benthic macroinvertebrate communities are site-specific and that interactions among benthic

macroinvertebrate taxa are important determinants of the post-dam removal community.

4.6 ADDRESS CLIMATE CHANGE IMPACTS TO NORTHEAST RSGCN AND THEIR HABITATS

4.6.1 REGIONAL NEED AND PRIORITY ACTIONS

Regional Need: The 2015 SWAPS, 2017 SWAP Synthesis, and NEFWDTC identified climate change as one of the top five threats facing Northeast RSGCN and their habitats. One of the largest current challenges related to climate change is uncertainty. As information related to climate change and its effects becomes more available, it is increasingly important to incorporate climate-change scenarios into conservation decisions for priority regional species and habitats and to develop climate-smart actions.

Priority Actions: Collaborate with key climate change partners to provide the best available scientific data for RSGCN and climate-related conservation issues to inform existing and new actions developed to address climate change as both a threat and threat amplifier. Incorporate climate projections and information to assess future scenarios of risk and use this information to develop climate-smart actions. Use existing climate vulnerability data when possible and conduct Climate Change Vulnerability Assessments to assess risk. Develop a regional Climate Adaptation Strategy guided by the 2021 national plan, NE CASC, and other key partners expertise and resources.

See Priority Species in Chapter 1, Priority Habitats in Chapter 2, Priority Threats in Chapter 3, each with partner and program opportunities and examples. See Table 4.1.1 and Appendix 4A for priority projects completed and Appendix 4B, the SWAP Synthesis, and individual SWAPs for additional priority Conservation Actions.

4.6.2 APPROACH

Since the 2013 Northeast Conservation Synthesis, additional information and resources have significantly advanced the state of knowledge and informed actions addressing the impacts of climate change on Northeast RSGCN and their habitats. One key advancement was the establishment of the Northeast Climate Adaptation Science Center in 2012. **The Climate Adaptation Science Centers** are US Geological Survey collaborations with academic institutions, bringing together climatologists, biologists, ecologists, and hydrologists with cutting-edge approaches to address major challenges posed by climate change[49]. **NECASC**'s robust scientific contributions have produced valuable tools and information on addressing climate change in the Northeast. Collaboration with natural and cultural resource managers has provided the climate change science to help inform fish and wildlife management decision-making and produce actionable products and results including more than 160 research projects and tools to facilitate climate change adaptation strategies for the Northeast[50]. **One of the most significant contributions was the 2015 Northeast Climate Change Synthesis to support the 2015 Northeast SWAP revisions (Staudinger et al. 2015). NECASC has initiated a project to update the 2015 synthesis and assist the 2025 SWAP revision process which will be available in late 2023 (Staudinger et al. 2023)**. NECASC established a Northeast Climate Change Working Group to solicit information leading to a better understanding of the climate change-related needs of state fish and wildlife agencies and their key partners; and then to develop and deliver science to meet those needs.

Resources, tools, information, and efforts that did not exist a decade ago are now available to inform and address climate change in the Northeast. Many climate change plans and assessments have been developed at the national, regional, subregional, landscape, and watershed levels. An important advancement has been the work of NEAFWA's NEFWDTC to document the climate change needs of RSGCN and their habitats in reports and databases. The following sections summarize these regional priority SWAP actions and advancements. See Staudinger et al. (2023) for more detailed information. In the revised 2023 NECASC Climate Change Synthesis. Chapter 3 provides detailed threat descriptions, impacts on RSGCN, and additional resources and examples for this threat in the Northeast.

The **Northern Institute of Applied Climate Science[185]** provides multiple resources for project planning and on the ground use and application (Janowiak et al. 2016). **The Adaptation Workbook was created for landowners and managers** unsure of how climate change might apply at the scales that are relevant to their work. Forest Adaptation Resources: Climate change tools and approaches for land managers, 2nd Edition (Swanston et al. 2016). The Workbook is also available for agriculture, which is described in Adaptation Resources for Agriculture: Responding to Climate Variability and Change in the Midwest and Northeast (Janowiak et al. 2014). The Workbook provides users with a flexible, logical process to consider climate change information and design customized management actions that can help achieve their management objectives. It is a structured process to consider the potential effects of climate change and design land management and conservation actions that can help prepare for changing conditions. The process is flexible to accommodate a wide variety of geographic locations, ownership types, ecosystems and land uses, management goals, and project sizes[186]. The Workbook consists of 5 basic steps:

1. **Define** goals and objectives
2. **Assess** climate impacts and vulnerabilities
3. **Evaluate** objectives considering climate impacts
4. **Identify** adaptation approaches and tactics for implementation
5. **Monitor** effectiveness of implemented actions

Oakes et al. (2021) provides a **rapid-assessment approach** to facilitate climate-informed conservation and nature-based solutions by using the 5Ws to help define project goals, consider climate risks, and brainstorm climate-informed actions and prescribes the following steps.

Step 1—Gather and examine the best-available information on current and projected climate change and its effects on nature and/or people that are the focus of the local planning effort (see Staudinger et al. 2023 for the most current Northeast climate projections).

Step 2—Consider how changes in climate could impact the effectiveness of traditional actions in meeting goals, as well as any ways in which those actions and goals may need to be modified to be more effective in a changing climate. Walk through the full suite of questions with respect to what, where, when, why, and who (the 5Ws) to make actions climate- informed:

- WHAT (modifying tactics)—Are there ways that traditional actions need to be modified to be effective at achieving goals under a changing climate? Are there new actions that will be needed to achieve goals, or address new or exacerbated challenges caused by climate change?
- WHERE (working in strategic locations)—Are there strategic places or sites to be prioritized in implementation, given potential climate change impacts (e.g., work in places that are more or less likely to be impacted, or places where the chances of successful outcomes may be greatest)?
- WHEN (shifting the timing and urgency)—Do the anticipated effects of changing climate increase the urgency of actions that are already being implemented? Would such climate-informed actions need to occur at different times of the year to be effective?
- WHY (embracing forward-looking goals)—Even with modifications in actions, is there a need to adjust the project goals to be more realistic or feasible as the climate changes (e.g., focus on different targets, or strive for different objectives)?
- WHO (reshaping project leadership, values, and stakeholder involvement)—Who leads design and implementation, and who needs to be involved for actions to be accepted, effective, enduring, and reflective of the needs and diverse values of

people and communities? Does climate change affect who benefits or should benefit from actions? Who might be harmed by actions or bear the costs?

Step 3—Document any changes to project goals and design. If after asking the above questions you do not feel that modifications to current goals and actions are needed, document the logic on how current actions will be adequate to achieve goals even as the climate changes.

REGIONAL SWAPS AND RSGCN CLIMATE CHANGE THEMES

Climate change differs from other direct threats identified in SWAPs because fish and wildlife agencies and their partners have little ability to prevent or reverse the impacts, and instead need to focus on understanding and responding to the resultant ecological changes. Securing species vulnerable to climate change threats requires a well-developed understanding of non-climate related stressors which are in turn recognized and addressed in SWAPs, as well as the potential effect of climatic changes on those species and their habitats. The added threat of climate change presents new challenges for fish and wildlife diversity. It also compounds the persistent problems posed by deficiencies in the resources needed to address other long-term challenges.

Compared to other threats, the full impacts of climate change, as well as its interactive and amplifying effects on other threats are uncertain. However, for some groups of species there are known vulnerabilities that have been documented through the NEFWDTC RSGCN process. In fact, taxa experts indicated that the majority of RSGCN are likely to be impacted by climate change across all taxa reviewed. Across all habitat types, life history requirements, and taxonomic groups, the following climate change themes emerged from the RSGCN process in the Northeast.

Coastal habitat resilience. In general, coastal RSGCN species are threatened by sea level rise and coastal storms, with impacts to habitat that affect shelter, nesting, and foraging – habitat uses across all life phases. Beaches and other coastal habitats remain a high priority for research and conservation action. Decades before the threats posed by climate change were known, loss or degradation of coastal habitat was responsible for population declines among birds, marine mammals, fishes, invertebrates, and sea turtles. Climate change exacerbates other threats in these coastal habitats, with impacts on RSGCN.

Over-wintering. Warming winters present unique challenges for different RSGCN taxa groups. Snake and other reptile brumation activity is interrupted on warm winter days, with potential health impacts and vulnerabilities to collection, disturbance, or killing at den sites. Bats and other species may also have temperature-dependent wintering strategies, and males and females may have different wintering behaviors or timing. Cave bats including the Tri-colored, Indiana, Northern Long-eared, Little brown, and Virginia Big-Eared bats are vulnerable to White Nose Syndrome, with growing evidence that cave temperature and humidity may influence fungal growth. Burrowing species, including small mammals, crayfish, mussels, and many reptiles and amphibians that rely on constant, undisturbed winter substrates and conditions are also becoming more vulnerable with the advent of increasingly severe weather events. In general, less is known about vulnerabilities and requirements during winter when species are less active and often harder to observe. Some species rely on winter snowpack to hide from predators or for protection from the cold (e.g., lynx, snowshoe hare and others). In the Northeast, winter temperatures may change more significantly than summer temperatures, so it is critical to understand winter vulnerabilities and climate change impacts.

Hydrologic conditions. More intense precipitation events and higher flood stages are predicted for the Northeast. Concerns for RSGCN freshwater mussels, stoneflies (and other EPT), and crayfish are primarily associated with the potential for scouring floods which have historically decimated populations in Northeast rivers, as have drought conditions which expose mussels or prevent crayfish from burrowing. These extreme river and stream conditions would also affect freshwater and diadromous fishes, Hellbenders, and Tiger Beetles which do not survive long periods of inundation. Other amphibians will also be affected by changes in hydrologic conditions, particularly if higher temperatures increase evapotranspiration, because of their reliance on vernal pools, wetlands, and high elevation habitats. Talus and other rocky habitats are important for snakes and amphibians, and soil moisture and humidity within the rocky spaces is important for these species and their invertebrate food sources. High elevation wetlands and hydrologic conditions below ground are likewise threatened by warming temperatures and drying. Burrowing crayfish, reptiles, amphibians, and small mammals require specific moisture and substrate conditions that will be impacted by storm events or intensified drought. Changes to temperature of headwaters and small streams.

Food resources. For most RSGCN taxa groups, the impacts of climate change on food resources are uncertain. We can surmise that climate change will impact food abundance through changes in temperature (e.g., insects or floral resources) and hydrology (e.g., aquatic insects and fish). Phenology mismatch is a concern in both terrestrial and aquatic species if prey populations and food supplies are not available during critical times of high energy demands. Red Knots (*Calidris canutus rufa*), Roseate Terns (*Sterna dougalii dougalii*), and North Atlantic Right Whales (*Eubalaena glacialis*) are among the coastal and marine species most likely to be affected, while bats and neotropical songbirds highlight this threat in relation to the hatch timing of forest insects. Offshore, initial research shows that the Gulf of Maine is one of the fastest warming bodies of water in the world (Seidov et al. 2021). In combination with the longstanding negative impacts of over-harvesting and the weakening influence of the Labrador Current, system-level climate changes are likely to induce corresponding changes in species distribution, prey availability, and disease risks. A reduction in zooplankton caused by warming ocean waters would have widespread impacts on all aspects of marine food webs.

Climate Change Information Needs Identified by RSGCN Taxonomic Teams
In 2019-2020, the 20 NEFWDTC taxonomic teams provided information on vulnerabilities and limiting factors for RSGCN. This information is summarized below, by taxa. Generally, additional RSGCN need climate vulnerability assessments that could be accomplished efficiently for taxonomic groups such as freshwater mussels, hibernating bats, and amphibians relying on vernal pools. Specific research topics are provided in the Limiting Factors report (TCI and NEFWDTC 2020a).

Birds. If birds' life cycles are regulated by daylight hours (unaffected by climate change) but prey lifecycles, particularly those of invertebrates, are regulated by water or air temperature (now warming earlier each year), many bird species may experience food scarcity in the years to come. Such phenology shifts have been noted for a number of migratory species. The Red Knot migration is triggered by daylight hours, but nesting and egg availability of Horseshoe Crab, an important food source for Red Knot, are primarily triggered by ocean temperature. For coastal birds, sea level rise and storm surge threaten nesting success and forage habitat suitability. Inland birds can respond to warming temperatures by shifting ranges northward and to higher elevations, but boreal species in the Northeast have little opportunity to seek refugia, and birds with higher site fidelity may also adapt more slowly. While birds are currently less affected by disease than other taxa, there is evidence that warmer, wetter conditions are increasing the threat of West Nile Virus for some species.

Mammals. The wintering, hydrologic concerns, and food uncertainties described above also apply to mammals. Some mammalian species may be adapting to climate change through range shifts, but increased survey efforts at the northern and southern edges of their ranges will be necessary to fully understand these shifts. Like other taxa found only at high elevations, coastal and lowlands species will also experience loss of suitable habitat with climate change. The North Atlantic Right Whale, one of the most endangered marine mammals, urgently requires research to understand the impacts of ocean warming and acidification on its food resources, shifts in migratory patterns, and how these interact with other issues that affect its survival such as entanglement and ship strikes.

Reptiles. Warming winter temperatures are affecting brumation in reptiles with unknown impacts for individuals or populations. Warming temperatures during nesting will cause shifting sex ratios for almost all RSGCN turtles. Northern Diamondback Terrapins in Maryland, for example, now have a sex ratio of 9 females per 1 male. (Higher proportions of males as bycatch in crab traps also partially explains these numbers.) Sea turtles and Northern Diamondback Terrapins have vulnerabilities during nesting due to sea level rise or storm surge as do freshwater turtles from flooding events. Reptiles may also be affected by changes in hydrologic regimes, particularly moisture in high elevation rocky habitats.

Amphibians. Most RSGCN salamanders have specific hydrologic requirements for vernal pools including soil moisture conditions and late summer refuges with high humidity. Traditional habitats for the high elevation *Plethodon* species are now at risk of warming or drying in late summer, and these species have little opportunity to seek alternative habitats. Coastal RSGCN (e.g., Eastern Mud Salamander and Atlantic Coast Leopard Frog) may also experience habitat degradation due to sea level rise.

Fish are affected by changes in water temperature, ocean acidification, extreme precipitation, or drought. All of these have the potential to affect mortality, health and fitness, food resources, and reproductive success. Climate vulnerability assessments are needed for most fish.

Aquatic invertebrates. Aquatic invertebrates are particularly vulnerable to flood scour and droughts. Temperature shifts may also affect aquatic invertebrates directly. If warming water temperatures affect host fish, mussel reproduction may be limited, and species ranges may retract from the southern edge. Dispersal upstream to cooler waters in response to rising temperatures may be more difficult for mussels and other less mobile aquatic invertebrates. For headwaters species, there is no more habitat further upstream to disperse to. Warming water temperatures can cause algal blooms and associated degradation of water quality which may in turn impact aquatic invertebrates. Near coasts, saltwater intrusion may make habitats unsuitable. Increased storm frequency and intensity will also increase sediment, nutrient and pollutant loads in runoff.

Butterflies. While the effects of climate on butterflies are still largely unknown, the high elevation butterflies of New Hampshire, Vermont, and Maine are vulnerable due to the absence of suitable alternative habitats into which they can disperse or migrate. Rising temperatures may lead to increased forest pest outbreaks, and the management of these pests via spraying will have negative impacts on many lepidopterans.

MANAGEMENT-RELATED INFORMATION NEEDS ACROSS TAXA

The Limiting Factors effort also showed that a common thread across taxa was the need for adequate research, surveys, and monitoring to determine baseline status and detect changes in populations before and after climate adaptation strategies are applied. Multiple taxa recommendations included the need for monitoring protocols that are consistent range-wide. A consistent, unified approach would improve status assessments and interventions as well as provide additional opportunities for conservation, thus avoiding the need to list these species at the federal level. A better understanding of the interaction between climate change and the top five regional direct threats and actions taken to address them would greatly inform management decisions across the region. These specific needs were expressed across the region and for all RSGCN taxa:

Invertebrate biomass. Because of the high number of vertebrate RSGCN relying on invertebrate food sources, there is a need to understand declines in invertebrate biomass within the context of climate change. This includes insects in terrestrial systems and plankton and krill in aquatic ones.

Wintering. Wintering vulnerabilities are an area of uncertainty across many taxonomic groups. Species may adapt to warming winters by changing the timing of wintering or the wintering strategies, but little is known currently about triggers for hibernation or migration, temperature-dependent activity states, or changes in energy demands associated with these changes in activity levels. The increase in installation of wind farms along common migration routes adds urgency to these questions, pointing specifically to the need to understand timing and other aspects of migration for birds and tree bats as well as impacts of the new infrastructure.

Changes in hydrologic regimes. Because of the large number of RSGCN associated with hydrologically defined habitats, anticipated changes in precipitation regimes and evapotranspiration will affect many RSGCN. Sedimentation, which has already changed substrate conditions in many streams, will need to be mitigated during extreme weather events. Some RSGCN are impacted by water management structures, which may also need to be redesigned as extreme precipitation events become more frequent.

Coastal habitats. These habitats have been degraded or reduced in size by intensive development along the coast and are now further threatened by sea level rise and storm surge. All RSGCN along the coast are affected by loss of habitat and intensified beach management. Some are affected by changing phenology of predator-prey relationships, ocean acidification, and warming temperatures, with uncertainty about their ability to shift inland or withstand flooding. Continued efforts are needed to improve habitat management and resiliency, to promote living shorelines as an adaptation, and monitor RSGCN.

Disease. There is an ongoing need to track the impacts of disease in reptiles and amphibians. There is also a need to learn if diseases of freshwater mussels or crayfish are responsible for population declines. Finally, West Nile Virus and Bird Flu are known to impact some birds but their effects on RSGCN birds in particular are unknown.

High-elevation species conservation. The Shenandoah Salamander illustrates the management challenges climate change presents for this high elevation species. During the past few decades, climatic changes have restricted the Shenandoah Salamander to a few isolated habitats at the tops of three mountains within Shenandoah National Park. Managers have struggled to assess the relative merits of monitoring a likely extinction event vs. putting those human resources to a different and perhaps better use elsewhere. Similar conditions exist for other endemic RSGCN species across the region, and management scenarios and decisions, including novel actions like assisted migration, need to be informed by sound climate change and adaptation science. It is important that these investments are made in places where species will also benefit over the long-term, and climate projections and scenario planning can help managers make informed decisions that have the highest likelihood of success under high levels of uncertainty.

Several NECASC projects aimed to identify and prioritize landscapes for conservation investment that benefits species and habitat long-term. These efforts can focus on single species or on multiple species conservation. Another focus for prioritization can be areas that are buffered from climate change and thus enable the persistence of biodiversity (Morelli et al. 2016). When these "climate change refugia" are mapped based on known habitat requirements and predicted climate and vegetation shifts, non-climate threats can be managed to conserve species. Such mapping is already being done for cold lakes and stream fishes in the Midwest and Massachusetts (e.g., ECOSHEDS for the Northeast[187], Hansen et al. 2017, Daniel et al. 2017). Other efforts focused on vernal pool salamanders[188] and on conifer forest mammals and birds. Mapping for coastal sand plains specialists is being coordinated by the Northeast Climate Adaptation Science Center.

Climate refugia. Landscape resiliency, connectivity, and the presence of habitat refugia are important geospatial considerations for climate planning. By developing this information, states can make other SWAP implementation actions more strategic and long-standing. For example, if good Blanding's Turtle habitat were filtered to identify those habitats that would be most suitable under future conditions, current restoration and protection efforts could be focused where a species (or suite of species) is most likely to persist over the long term.

Please see Staudinger et al. (2023) for a comprehensive synthesis of climate change and its impacts on RSGCN and their habitats in the Northeast.

4.6.3 REGIONAL EXAMPLES AND OPPORTUNITIES

By its nature, global climate change is a large-scale threat, and the Northeast states can benefit by coordinating to develop, share, and implement tools for adaptation and by planning together and with the many regional Northeast partners. The NECASC 2023 Northeast Climate Change Synthesis (Staudinger et al. 2023) contains more detailed information, analyses, and climate adaptation tools and strategies to reduce uncertainty and inform climate-smart guidance and actions to protect Northeast fish and wildlife and their habitats, including RSGCN.

The NEFWDTC and SWAP Synthesis identified Climate Change as a top regional threat in the 2005 and 2015 SWAPs. To address this threat, NEAFWA's RCN and key partner programs prioritized and funded multiple projects designed to provide information, management guidance for climate- smart actions to address impacts on RSGCN and their habitats in the region. Some of the key projects are listed below as resources. For a complete list of these projects, see Table 4.1.1 and *Appendix 4B*. For additional partner information, see *Chapter 7*; and to learn more about the threats themselves, see *Chapter 3*. More detailed information on RSGCN and habitats can be found in *Chapters 1* and *2* respectively. *Chapter 2* provides information on Northeast habitat status and condition as well as RSGCN supported by each and provides examples of management and conservation plans and efforts that address these threats in the region.

Appendix 4B provides a list of projects that have advanced the conservation of these regional species and habitats through the RCN, CSWG, SA programs from 2007- 2023. This Chapter provides a list (Table 4.1.1) and summaries for those projects implemented since the 2013 Synthesis, organized by the predominant information or tool and SWAP element they address. Key regional programs and resources developed by partners to inform and address regional climate adaptation strategies in the Northeast are presented below.

Regional Focal Areas for SGCN Based on Site Adaptive Capacity, Network Resilience and Connectivity (2007-11) (RCN). This project identified the most resilient examples of key geophysical settings (sand plains, granitic mountains, limestone valleys, etc.), in relation to SGCN, providing conservationists with a nuanced picture of the places where conservation is most likely to succeed under climate change. The central idea was that by mapping key geophysical settings and evaluating them for landscape characteristics that buffer against climate effects, it would be possible to identify the most resilient examples of each setting. This approach was based on observations that: 1) species diversity is highly correlated with geophysical diversity; 2) that species take advantage of the micro-climates available in complex landscapes; and 3) if the area is permeable, species can move to adjust to climatic changes. Developing a quantitative estimate of site resilience was the essence of the project, and this was accomplished by measuring the landscape complexity and permeability every 30 square meters of the region, creating comprehensive wall-to-wall data on the physical components of resilience. This information was applied to known species sites and compared the scores between sites with a similar geophysical composition to identify the most resilient sites for each setting. Further analysis of broad east-west and north-south permeability gradients identified areas where ecological flows and species movements potentially become concentrated. These areas may need conservation attention to allow the biota to adjust to a changing climate.

Impact of Climate Change on SGCN (2009-13) (RCN). In a project extending from Maine to the Virginias, the Northeastern Association of Fish and Wildlife Agencies (NEAFWA), **Manomet Center for Conservation Sciences** (Manomet)[189], and the **National Wildlife Federation** (NWF)[190] collaborated with other major northeastern stakeholders, including federal agencies and nonprofit organizations, to protect fish and wildlife and their habitats from climate change. Specifically, Manomet, NWF, and NEAFWA embarked on a three-year effort to evaluate the vulnerabilities of the northeast's key habitats and species, and to help increase the capabilities of state fish and wildlife agencies to respond to these challenges. The overarching goal of the project is to provide vulnerability and adaptation information that will help the Northeastern states to plan their conservation of fish and wildlife under a changing climate. The objectives of the project were:

1. To quantify the vulnerabilities to climate change of fish and wildlife and their habitats across the region and thereby identify those habitats and species that are likely to be more or less vulnerable, and how these vulnerabilities vary spatially.
2. To project how these habitats and species will change their status and distributions under climate change.
3. To identify potential adaptation options (including the mitigation of non-climate stressors) that can be used to safeguard vulnerable habitats and species.
4. To identify monitoring strategies that will help track the onset of climate change and the success, or otherwise, of adaptation actions.
5. To work with states to increase their institutional knowledge and capabilities to respond to climate change through educational and planning workshops and other events.

Three final reports were provided (through additional funding from the North Atlantic LCC).

- Climate Change and Cold-Water Fish Habitat in the Northeast: A Vulnerability Assessment (Manomet and NWF 2013a).
- The Vulnerability of Fish and Wildlife Habitats in the Northeast to Climate Change (Manomet and NWF 2013b).
- The Vulnerability of Northeastern Fish and Wildlife Habitats to Sea Level Rise (NWF and Manomet 2014).

The NEAFWA Habitat Vulnerability Assessment Model has been used by at least half of the Northeast states to complete their respective vulnerability assessments. In addition, the model has been used as an important component of training courses in vulnerability assessment for Federal and NGO practitioners.

Northeast Climate Adaptation Science Center (NECASC). NE CASC has developed more than 150 science projects with partners since its inception in 2012. Many of these address key northeast wildlife and their habitats and are listed with links below and on the NECASC website[50] . These will all be included in the 2023 Climate Change Synthesis (Staudinger et al. 2023).

- **Science to Support Marsh Conservation and Management Decisions in the Northeastern United States.** A synthesis of scientific and socio-economic perspectives on changing coastal systems is urgently needed. This project will develop a region-wide strategic capacity to provide timely scientific information and support for decision-makers dealing with climate-induced changes in coastal resilience and vulnerability.
- **Putting the sampling design to work: Enhancing species monitoring programs in the face of climate change.** The goal of this project is to develop statistical methods to enhance the ability of monitoring programs to understand climate effects on fish and wildlife. Project results will augment monitoring programs that are collecting critical data used to directly inform regulatory and policy decisions.
- **Understanding the Future of Red-Backed Salamanders as an Indicator of Future Forest Health.** Climate change will have sweeping impacts across the Northeast, yet there are key gaps in our understanding about whether species will be able to adapt to this changing environment. Results from this project will illuminate local and region-wide changes in forest ecosystems.
- **Future aquatic invaders of the Northeast U.S.: how climate change, human vectors, and natural history could bring southern and western species north.** Currently, hundreds of invasive aquatic species occur in the southeast and the western U.S. and can potentially move into the Northeast region. This project will help guide future monitoring efforts and bring attention

to high-risk areas that could be invaded by southern and western invasive aquatic species**.**

- **Effects of Urban Coastal "Armoring" on Salt Marsh Sediment Supplies and Resilience to Climate Change.** Along exposed coasts, humans have built seawalls and other structures to protect homes and infrastructure from erosion. Reduced erosion caused by this "coastal armoring" may have made it harder for salt marshes to thrive along urbanizing, armored shorelines.
- **Climate-Adaptive Population Supplementation (CAPS) to Enhance Fishery and Forestry Outcomes.** It is critical that population supplementation programs choose species that will thrive under future climate conditions while still promoting and maintaining genetic diversity. Climate-Adaptive Population Supplementation (CAPS) seeks to boost the efficiency of these programs.
- **A regional synthesis of climate data to inform the 2025 State Wildlife Action Plans in the Northeast U.S.** This project addresses the direct needs of Northeast states by developing a regional synthesis across four key areas of climate science, focused on the unique threats to RSGCN. It summarizes current data and information on regional climate changes, species' responses to climate change, climate vulnerabilities and risks, and scale-appropriate adaptation strategies and actions. Case studies of successful climate adaptation efforts and climate threat-to-action narratives provide illustrative examples of how climate change data has been integrated into decision-making processes. Lists of recent climate resources and partner projects will also be synthesized to help SWAP writing teams connect with existing regional efforts.
- **Refugia are Important but are they Connected? Mapping Well-Connected Climate Refugia for Species of Conservation Concern in the Northeastern U.S.** As the climate continues to change, vulnerable wildlife species will need management strategies to help them adapt to these changes. One specific management strategy is based on the idea that, in certain locations, climate conditions will allow native species to continue inhabiting those locations into the future. The main objective of this project was to provide maps of projected refugia networks at the end of the 21st century for each of 10 representative SGCN in the Northeastern U.S. A preliminary list of these species includes Canada Lynx, Saltmarsh Sparrow, Spotted Turtle, Wood Turtle, Bicknell's Thrush, Moose, Prairie Warbler, Cerulean Warbler, Blackpoll Warbler, and Virginia Rail. The list was compiled with input from stakeholders in the region. This information will support efforts of the USFWS Northeast Region to assess habitat needs for several species under federal consideration for listing as well as other SGCN. Maps of refugia connectivity will also support the development of priorities for on-the-ground habitat management in the region.

- **Climate-Adaptive Population Supplementation.** Climate-Adaptive Population Supplementation (CAPS) is a framework for enhancing species by matching climate-associated traits of cultivated strains with present and future environmental conditions. A cross-taxa approach simultaneously conducts trait/environment classification, stocking/planting experimentation, and conceptual framework development for fish and tree species. The project identifies strain-specific climate-associated traits in one trout and one oak species; characterizes several Northeast environments that fit the spectrum of traits; stocks/plants tagged individuals from each strain across different environments; and tracks the productivity and fitness of each strain over time. For example, several brook trout strains can be stocked across three lakes with different oxythermal profiles while several red oak strains can be planted across habitats with varying rainfall or drought frequency.
- **Future aquatic invaders of the Northeast U.S.: how climate change, human vectors, and natural history could bring southern and western species north.** Currently, hundreds of invasive aquatic species occur in the Southeast and the Western U.S. and can potentially move into the Northeast region. This project will help guide future monitoring efforts and bring attention to high-risk areas that could be invaded by Southern and Western invasive aquatic species.

Climate Change Response Framework. Development of a Wildlife Adaptation Menu for Resource Managers. The Climate Change Response Framework[191] is an example of a collaborative, cross-boundary approach to creating tools, partnerships, and actions that support climate-informed conservation and land management. This effort focused on the needs of forest managers and forestry professionals, but there has been increasing demand for science and tools to address climate change adaptation in wildlife management--and in conservation, more broadly. Wildlife and resource managers need the best available science in a usable format with feasible options within the purview of an individual manager. A comprehensive overview of peer-reviewed studies summarizing wildlife-related management actions as they currently exist for climate change adaptation was followed by a “menu” of actions that are suitable for wildlife management in terrestrial ecosystems. This Wildlife Adaptation Menu was modeled on existing adaptation menus for Forestry, including Urban Forestry, and is designed to be used in conjunction with the Adaptation Workbook. In addition to a menu of adaption strategies and approaches, the scientists identified site-level tactics and developed case studies demonstrating the use and implementation of the menu. To ensure that the information and tools meet the needs of managers, the team integrated input from wildlife managers at every step of the process.

4th National Climate Assessment- Northeast Climate Toolkit[192]. The seasonality of the Northeast is central to the region's sense of place. Milder winters and earlier springs in the region are altering ecosystems and environments in ways that adversely impact tourism, farming, and forestry. The region's rural industries and livelihoods are at risk as less distinct seasons lead to further changes in forests, wildlife, snowpack, and streamflow. Climate change impacts in the Northeast—including extreme precipitation events, sea level rise, coastal and riverine flooding, and heat waves—will challenge its environmental, social, and economic systems, increasing the vulnerability of its residents, especially its most disadvantaged populations. Communities in the Northeast are proactively planning and implementing actions to reduce risks posed by climate change. Using decision support tools to develop and apply adaptation strategies informs both the value of adopting solutions and the remaining challenges. Adapted from the Fourth National Climate Assessment[193].

Climate Change in the Northeast U.S. Shelf Ecosystem (NOAA). Over the past several decades, the Northeast continental shelf has warmed faster than any other U.S. Ocean region. Part of NOAA's mission is to understand and predict the impacts of this ocean change on the ecosystem and its living marine resources. Climate-related changes such as warming oceans, rising seas, droughts, and ocean acidification are affecting the distribution and abundance of marine species in the Northeast U.S. continental shelf ecosystem. Understanding the impacts of climate change is necessary to reduce climate-related effects on living marine resources and the people and communities that depend on them[194]. The NOAA Fisheries Climate Science Strategy is part of a proactive approach to increasing the production, delivery, and use of climate-related information needed to fulfill NOAA Fisheries mandates[195]. The Strategy is designed to be customized and implemented through Regional Action Plans[196] that focus on building regional capacity, partners, products, and services. The Northeast Fisheries Science Center[197] has a variety of research and monitoring efforts that help researchers track, understand, and forecast climate-related impacts on resources and resource-dependent communities.

- New England/Mid-Atlantic;
- Northeast US Shelf Ecosystem[198];
- **Northeast Shelf: A Changing Ecosystem storymap[199];**
- Northeast Regional Action Plan[200].

Projected Impacts of Climate Change on Shelf Habitat: The majority of research on historical and projected climate change impacts to the Northeast U.S. continental shelf ecosystem has focused on species distributions. Most of these studies use the Northeast Fisheries Science Center's fall and spring bottom trawl survey data to build species distribution models (SDMs) for fish, sharks, and invertebrates. The SDMs are compared to observations, and then future shifts are projected using global climate models. Most of these studies have focused exclusively on species' thermal habitat (the preferred temperature range of a species) and on ocean temperature change using only fall/spring fishery-independent data. New research explores other variables in addition to ocean temperature. Moreover, this new research (McHenry et al. 2019) also uses data collected by fishery observers to build SDMs throughout the entire year instead of just for the fall and spring. Results, which can be viewed as interactive graphics[201], suggest that SDMs based only on temperature can mask climate vulnerability for key commercial and recreational species such as Shortfin Squid, American Lobster, Atlantic Cod, Black Sea Bass, Striped Bass, Summer Flounder, and Winter Flounder.

Enhanced warming is accompanied by an increase in salinity due to a change in water mass distribution related to a retreat of the Labrador Current and a northerly shift of the Gulf Stream. A robust relationship between a weakening Atlantic Meridional Overturning Circulation and an increase in the proportion of Warm-Temperate Slope Water entering the Northwest Atlantic Shelf indicate that prior climate change projections for the Northwest Atlantic Shelf may be far too conservative and underestimate the amount of warming expected in the Northeast U.S. continental shelf ecosystem. Example projects include:

- New England's Groundfish in a Changing Climate[202]
- The Effect of Ocean Warming on Black Sea Bass (Slesinger et al. 2019)
- Atlantic Salmon Climate Scenario Plan (Borggaard et al. 2020)
- North Atlantic Right Whale Scenario Plan (Borggaard et al 2019)
- Impacts of Ocean Warming on Predator–Prey Interactions (Selden et al. 2017)
- Rebuilding Fisheries in the Face of Climate Change (Bell et al. 2018)

Designing Sustainable Landscapes and Nature's Network. Designing Sustainable Landscapes (DSL)[71] is a landscape conservation project applied to 13 states in the Northeastern United States. The purpose is to provide guidance for strategic habitat conservation by assessing ecological integrity and landscape capability for a suite of focal species across the landscape. Assessments are done for both the current landscape and potential future landscapes, as modified by models of urban growth, climate change, and sea level rise. The DSL project provides much of the basis of the conservation planning tools Nature's Network[72] and Connect the Connecticut[79].

Northeast USDA Climate Hub[203]. The effects of agricultural irrigation and runoff on coastal habitats are of concern to many states in the Northeast region. The Northeast USDA Climate Hub will help foster federal-state partnerships that address agricultural runoff into streams and river systems. See especially the Northeast CASC projects focusing on headwaters-to-coastal-scale conservation and management solutions aimed at reducing runoff from upstream land uses, including agriculture.

Massachusetts Fish and Wildlife Climate Action Tool.[84] The Massachusetts Wildlife Climate Action Tool is designed to inform and inspire local action to protect the

Commonwealth's natural resources in a changing climate. This Tool focuses on providing information for a range of local decision-makers, including conservation practitioners and landowners. For an example of new approaches to addressing non-native and invasive species in light of current and anticipated climate change, see the Tool website[204] and the Regional Invasive Species and Climate Change Management Network[205].

4.7 COORDINATE ACROSS STATE BOUNDARIES TO MAXIMIZE EFFICIENCY AND EFFECTIVENESS OF FISH AND WILDLIFE DIVERSITY CONSERVATION IN THE NORTHEAST

4.7.1 REGIONAL NEED AND PRIORITY ACTIONS

Regional Need: Conservation efforts for RSGCN must continue to include collaborative, cooperative landscape and watershed scale approaches, as species distributions and movements are not restricted by state boundaries. At the same time, constraints posed by limitations of funding and capacity make such collaborative efforts challenging. NEAFWA's technical committees are charged with developing and implementing regional projects that identify and address the top conservation targets and threats in the Northeast. Many of the needed actions are not under the authority or purview of state fish and wildlife agencies, so coordination and effective communication between the agencies impacting or regulating those impacts is essential. Clear, consistent, inclusive messaging and communication are needed to inform and engage broader participation across the region.

Priority Actions: Continue to collaborate and coordinate across state boundaries for effective landscape and watershed scale conservation of these regional priority species and habitats. Build state capacity and funding to more fully conserve, restore, and protect the SGCN, RSGCN, and their key habitats as identified in the 14 Northeast SWAPs. Develop improved, inclusive communication approaches for outreach, education, and technical assistance to target audiences including policy and land use decision makers, land managers, stakeholders, and the broader public to inform and engage them in addressing the top threat impacts to SGCN and key habitats. Coordinate with agencies and entities that regulate key impacts to fish and wildlife to develop and implement effective, consistent policies and approaches across Northeast lands and waters.

See Priority Species in Chapter 1, Priority Habitats in Chapter 2, Priority Threats in Chapter 3, each with partner and program opportunities and examples. See Table 4.1.1 and Appendix 4A for priority projects completed and Appendix 4B, the SWAP Synthesis, and individual SWAPs for additional priority Conservation Actions that all reflect decades of regional collaboration and coordination at the landscape and watershed scale.

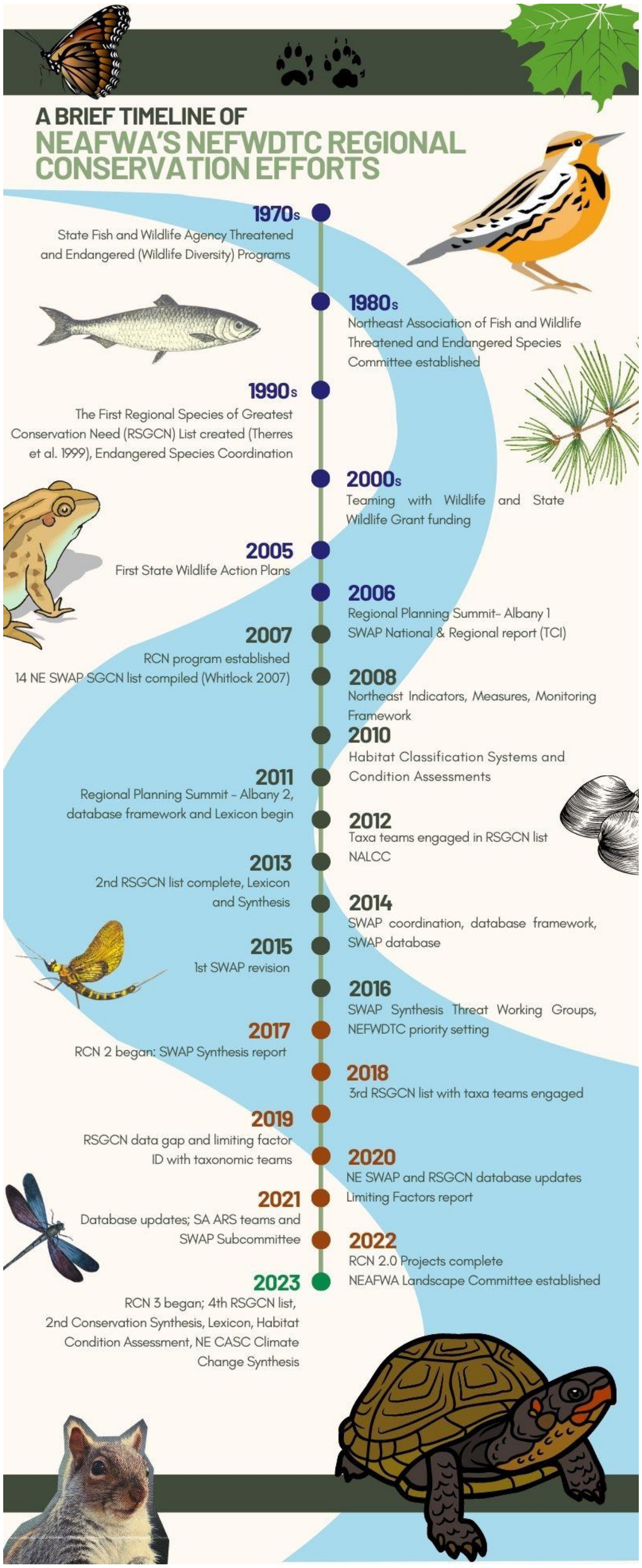

Figure 4.7.1 Timeline of the Northeast 14 state Fish and Wildlife Diversity Conservation Program Collaboration.

4.7.2 APPROACH

For more than four decades, the 14 states in NEAFWA's NEFWDTC have collaborated to identify priorities and conserve regional fish and wildlife diversity across state boundaries. Since the 1980s they have worked together to identify species conservation priorities and support coordinated actions[1] that address regional resource concerns (NEFWDTC 2017). In 2001, the State & Tribal Wildlife Grants program was created to support development of comprehensive wildlife conservation strategies, now called State Wildlife Action Plans. The first-generation plans were completed in 2005, marking an historic milestone for state-based fish and wildlife conservation (Meretsky et al. 2012). This work advanced the creation of the RCN program, which in turn led to more than 150 jointly funded research projects summarized in the 2013 Northeast Regional Synthesis for State Wildlife Action Plans (TCI and NEFWDTC 2013) and updated in this 2023 Synthesis.

The NEFWDTC undertook an unprecedented compilation of all 14 State Wildlife Action Plans (SWAPs) in the Northeast Region. This collaboration led to a coordinated revision of the 2015 SWAPs, with all

the Northeast states utilizing a common framework, guidance, and terminology from the Northeast Lexicon. This enabled compilation of information on RSGCN, their habitats, and the threats they face. The goal was to find common threats to SGCN and their habitats, determine common conservation priorities, and identify actions that could be implemented through regional collaboration and coordination. This allowed for the compilation, analysis, and development of a Regional SWAP Synthesis (TCI and NEFWDTC 2017) that summarized the threats to SGCN and their habitats as well as regional conservation priority actions with recommendations for collaborative steps. The resulting regional priorities summarized in the 2017 SWAP Synthesis were further prioritized and refined by NEFWDTC's taxonomic teams and Regional Threat Working Groups to identify top threats and actions to address them. This Synthesis presents those top regional priorities and actions developed collaboratively by the NEFWDTC in 2017.
In 2018, AFWA adopted a landscape conservation resolution.

In 2020, the **AFWA President's Task Force on Shared Science and Landscape Conservation Priorities** recommended convening a new working group to develop recommendations on how SWAPs could become even more effective at improving range-wide conservation of SGCN by leading or contributing to national and/or regional landscape conservation priorities. The AFWA SWAP and Landscape Conservation Working Group subsequently prepared the *Leading At-risk Fish and Wildlife Conservation: A Framework to Enhance Landscape-Scale and Cross-Boundary Conservation through Coordinated State Wildlife Action Plans* report in 2021 (AFWA 2021). This report summarizes five Guiding Principles:

1. Identify and apply regional and shared approaches for development, implementation and measuring progress of SWAPs, to improve effectiveness, efficiency, cost-savings, and consistency.
2. Increase consistency and alignment of SWAPs across jurisdictions so conservation can more readily be implemented at biologically relevant scales.
3. Provide support and incentives to leverage and build capacity for cross-jurisdictional and landscape conservation.
4. Ensure SWAPs are developed and implemented collaboratively and in partnership with a diverse set of partners.
5. Make SWAPs more accessible, understandable, and relevant to broad constituencies.

Each of these Guiding Principles has specific Recommended Actions, associated outcomes, and a recommended implementation framework. Kanter and Newsome (2022) provide a summary of regional and interregional approaches and efforts to implement these principles.

A NEAFWA Landscape Committee was established in 2022 to guide the implementation of this report in the Northeast. The NEFWDTC and its SWAP coordinators subcommittee contribute to this effort on a monthly basis as they work together to identify and prioritize projects that facilitate even more robust and strategic collaboration while the 2025 SWAP revisions are being developed. A draft of this synthesis was shared with this new committee as they began their work to document how these principles are being addressed in the Northeast.

Each of the Chapters of this Regional Conservation Synthesis addresses multiple Recommended Actions, implementing the first four of the five Guiding Principles. This Regional Conservation Synthesis implements at least 11 of the AFWA Recommended Actions:

- **1.1** Using clear and consistent criteria, identify priority species, habitats, landscapes, threats, and conservation actions for regional conservation.
- **1.2** Develop and use a common lexicon and classification system for species, habitats, threats, and conservation actions.
- **1.3** Develop and refine best practices for habitat and population restoration and management.
- **1.4** Promote the development of shared science, data, research, and monitoring protocols.
- **2.1** Incorporate regional priorities and approaches into SWAP development and implementation.
- **2.2** Work at landscape and regional scales to address key threats such as climate change, habitat loss/fragmentation, and invasive species.
- **2.3** Promote the use of adaptive management, best available science, and shared learning so the plans keep pace with changing conditions and innovations.
- **3.1** Provide funding and support for regional tool development, shared science, and landscape conservation projects.
- **3.3** Explore options for sharing resources, leveraging partnership contributions, and engaging non-traditional partners as well as options to lower grant match requirements and develop other incentives to encourage regional collaboration.
- **4.1** Increase collaboration and involvement of local, regional, and national partners in the development and implementation of SWAPs, including cross-jurisdictional efforts.
- **4.4** Incorporate scalable goals/strategies and priority landscapes from other planning efforts into SWAPs (i.e., State Forest Action Plans, State Comprehensive Outdoor Recreation Plans, National Fish Habitat Plan, North American Waterfowl Management Plan, TNC Ecoregional Plans, etc.).

Several recent grant projects were prioritized and funded to accomplish this in 2022-2023. The **Updating Three Foundational Tools for the 2025 State Wildlife**

Action Plan Revisions project added the development and production of the 2022 Northeast Lexicon (Crisfield and NEFWDTC 2022); the 2023 Northeast Conservation Synthesis (TCI and NEFWDTC 2023); and the 2023 Northeast Conservation Status Assessment (Anderson et al. 2023a). NEFWDTC's SWAP subcommittee also secured WSFR CSWG funding to upgrade and **Modernize the Northeast SWAP Database**. These projects facilitate coordination, providing the 14 Northeast SWAPs with a common terminology, data framework, and a portal to enter and analyze consistent SWAP data. Significant progress enhancing SWAP coordination for the 2025 revisions continues through the NEFWDTC and its SWAP Subcommittee.

This Northeast legacy of collaboration continues through monthly coordination between the 14 states and annually through the RSGCN and RCN prioritization and planning processes. This shapes the NEFWDTC's ability to respond to its regional charges through its technical services and RCN projects that focus action on the highest priority land, water, and seascapes in the Northeast. RCN and key partner projects (Table 4.1.1 and *Appendix 4A*) enable the states to collaboratively address these emerging and current priorities through mutual investment and consistent, more effective regional implementation. This high level of commitment and coordination has enabled the Northeast states to emerge as national leaders in regional landscape and watershed conservation. As a result, agencies and organizations incorporating this information at all scales have greatly advanced the effectiveness of Northeast fish and wildlife diversity conservation.

Consistent Regional Incentives, Laws, and Policies

Among the most important monitoring and evaluation actions identified in the SWAP Synthesis are efforts to review and evaluate the various approaches, incentives, laws, and policies that address the top regional threats, priority species, and habitats, thus ensuring currency and conservation effectiveness both state and regionwide. This includes environmental review and permitting processes that should more fully incorporate the monitoring needs of SGCN/RSGCN and key habitats, especially in the context of climate change. State Threatened and Endangered Species laws and policies differ significantly, yet there is a need for regional consistency. More coordination and consistency are needed between regulatory and other agencies and stakeholders to provide a more holistic approach to conserving priority state and regional species and habitats.

Encouraging consistent policies and approaches to RSGCN protection

The increased threat of take and collection of reptiles and amphibians has met with increased protection efforts. NEPARC and PARC developed important new outreach and education resources (www.northeastturtles.org). The USFWS CSWG project "Addressing Population Declines Due to Loss of Adult and Juvenile Turtles to Illegal

Wildlife Trade" along with SA ARS and state efforts provided additional capacity for strategic protection through targeted law enforcement and repatriation of confiscated animals. At the same time, states responded with stronger policies, regulations, and outreach for protection of reptiles and amphibians. An example of this is the coordination WV DNR provided during the effort to update its reptile and amphibian regulations (WV DNR 2021). They consulted and collaborated with NEPARC and other Northeast states and developed new regulations that better addressed the emerging threats to these taxa from collection, disease, and climate change. The regulations (Figure 4.7.1) were shared with all NEAFWA states and are used a model for the Northeast region.

Figure 4.7.1 West Virginia's reptile and amphibian regulations shared for consistency across the Northeast region.

Consistency in Threatened and Endangered Species Laws and Regulations

Since the 1980s, the 14 NEAFWA Fish and Wildlife Jurisdictions have collaborated to share information affecting their laws and regulations on fish and wildlife diversity. Most recently, in 2015 and again in 2020, the NEFWDTC collaborated to share information on Northeast state approaches and regulations on Threatened and Endangered species in the Northeast states. Results of these continuing efforts help inform all states and provide a foundation for consistency, coordination, and information sharing between states in the region. This promotes and helps facilitate use of best available scientific information. It also encourages support for the development of the most effective regulatory approaches for the region.

Consistency in approaches and management of invasive species
One of the primary tools states can use to reduce the number of invasive plants introduced as ornamentals is the development and use of incentives and “green light” alternatives. Encouraging the use of native species by local nurseries and seed banks provides industry incentives. Important incentives, outreach and messaging should include the use of native seed banks and “green lists” of native species alternatives. Dumroese (2009) provides a manual of native plants to the nurseries.

Another tool that states can use to reduce the introduction of invasive plants as ornamentals is the control or regulation of species as noxious weeds. There are opportunities for improved coordination and consistency of invasive plant regulation across state borders (Lakoba et al. 2020, Beaury et al. 2021b). For the lower 48 states, Beaury et al. (2021b) found only a 17% overlap in regulated plants between adjacent states. Focusing on six Northeastern states (CT, MA, ME, NH, NY, and VT), Bradley et al. (2022b) showed that these inconsistencies are largely due to the pool of species evaluated by each state rather than the different outcomes of state risk assessment protocols. Regulatory inconsistencies across state borders are often due to lack of state capacity to evaluate and recommend invasive plants for regulation. In order to increase consistency, Northeast states could evaluate risk from plants already regulated by adjacent states. A taxonomically standardized list of regulated plants as of April 2021 is available as supplementary material in Beaury et al. (2021b), and updated lists are posted online through the National Plant Board[206]. Increasing coordination and sharing of risk assessment resources across state borders could improve consistency and reduce the sale of known invasive plants (Bradley et al. 2022a, 2022b).

RSGCN Coordination within and between Regions
The Northeast continues to lead the RSGCN effort nationally with this 4th RSGCN list update to inform 2025 SWAP revisions. This effort allows the 14 states to prioritize and focus their efforts together at a landscape or watershed scale where many of these conservation issues are most effectively addressed. This approach also enables each state to see the important role it plays in the overall conservation effort. Similarly, when expanded to the species entire range, this concept provides the opportunity for interregional coordination. Table 4.7.1 shows the number of shared RSGCN/Proposed RSGCN between AFWA regions; and these overlaps represent opportunities for additional coordination. Just as the coordination of federally listed Threatened and Endangered species are afforded coordination through USFWS At-Risk and ESA recovery efforts, states and their partners can proactively work together to conserve these species across their ranges to preempt the need for federal listing. This is often most effectively accomplished at the multi-species landscape or watershed scale.

Table 4.7.1. Number of shared RSGCN/Proposed RSGCN between AFWA Regions.

AFWA Regions	Number of Shared RSGCN and Proposed RSGCN Species
NEAFWA and SEAFWA	120
NEAFWA and MLI / MAFWA	64
NEAFWA, SEAFWA, and MLI / MAFWA	30

The advancements in the RSGCN method now offer NEAFWA additional opportunities for coordination with other regions. The Watchlist Deferral category provides not only an effective way to address "peripheral species" at the state and regional level; it also provides opportunities to coordinate conservation of those species with neighboring regions for more holistic management across their range. Table 4.7.2 shows the number of Watchlist Deferral Species from the 2023 Northeast RSGCN update, indicating significant opportunities for collaboration and coordination for these species as each region continues to fulfill its role in the overall conservation of each species.

Figure 4.7.2. Number of Watchlist Species Deferral to other AFWA regions identified in the RSGCN list update.

Watchlist [Deferral] Region	Number of Species
SEAFWA	56
MAFWA / MLI	18
SEAFWA and MAFWA	15
Canada	2
Canada and WAFWA	3
MAFWA and WAFWA	1
Total	**95**

The Northeast deferred 56 species to the Southeast as a reflection of the fact that those species have more secure populations centered the Southeast while the mid-Atlantic states (VA and W VA watersheds, Appalachian Mountains, or Atlantic coast) represent the northern extent of their range. Almost 20 species were deferred to the Midwest region (MAFWA) reflecting species whose populations primarily occur in the Midwest but overlap with NEAFWA in the Ohio River drainage, Great Lakes, or eastern Midwest landscapes. In all, almost 100 species provide opportunities for coordinated interregional conservation that secures both the core and peripheral ranges of these species.

INCREASING FUNDING AND CAPACITY FOR RSGCN CONSERVATION

In the Northeast, both funding and staffing capacity are insufficient to effectively address the 418 RSGCN and proposed RSGCN, and 388 additional Watchlist and proposed Watchlist species currently under the jurisdiction of state fish and wildlife agencies in the Northeast. The NEAFWA NEFWDTC and their partners prioritized the need for additional support, funding, and capacity in state wildlife agencies to strengthen wildlife diversity conservation and education. They also prioritized efforts to create broader awareness of and support for state wildlife diversity conservation programs, including the SWAPs.

Adequate funding and staff capacity are both sorely lacking to effectively conserve the almost 4800 SGCN and their habitats listed in the 14 Northeast SWAPs and the thousands of additional species that were not able to be addressed in this RSGCN process due to lack of information and expertise across the region. Key conservation groups have joined the Alliance for America's Fish and Wildlife to fill the need for additional funding to strategically address priority SGCN and RSGCN conservation. In 2001, a partnership with the Teaming with Wildlife Coalition resulted in core fish and wildlife diversity funding through State Wildlife Grants. Two decades later, more adequate levels of funding and capacity are still needed. The Alliance for America's Fish & Wildlife's created a 21st century funding model to secure additional funding for much needed conservation[207].

The Wildlife Society[208] stated that the Recovering America's Wildlife Act (H.R. 2773; S. 2372) would bring much-needed resources to wildlife professionals tasked with conserving the diversity of America's native species. These resources were intended to fund multi-stakeholder efforts to conserve and monitor at-risk species, with the goal of reversing population declines. Since 2000, state and tribal wildlife agencies relied on a much smaller funding stream, the **State[209] and Tribal Wildlife Grant[210]** programs. This program depends on annual congressional appropriations which fluctuate and are not guaranteed. This limits state agencies from implementing the many SGCN projects identified in their SWAP conservation action blueprints by their many taxonomic experts and partners.

The National Wildlife Federation describes "America's Wildlife Crisis" with a stark statistic: one-third of America's wildlife species are at elevated risk of extinction (Stein et al. 2018). More than 1,600 U.S. species are already listed under the federal Endangered Species Act; more than 150 U.S. species are already extinct; and nearly 500 additional species have not been seen in decades[211]. This loss will have a negative impact on the quality of *human* life and harm local and regional economies. National Wildlife Federation[216] also notes that birds, bats, and butterflies create hundreds of billions of dollars in benefits to farmers by eating pests and pollinating plants, but all are currently experiencing stress and/or steep population declines. Outdoor recreation adds nearly $900 billion to the economy each year and much of this depends on healthy wildlife populations and habitats.

Responsive legislation and funding (e.g., proposed by the Recovering America's Wildlife Act) would allow the states, territories, and Tribes to invest $1.4 billion annually in proactive, on-the-ground, collaborative efforts to help species at risk by restoring habitat, controlling invasive species, reconnecting migration routes, addressing emerging diseases, and more. In the Northeast, the priority conservation targets, habitats and threats have already been identified, allowing this funding to be focused where it is most needed. The State Wildlife Grants Program is the main source of federal funding for implementing these plans. It currently provides around $65 million a year, split between all the states and territories. More than two decades of surveys and studies have shown that this is less than five percent of what would be needed to implement all recommendations contained in the SWAPS.

Additional coordination and capacity are needed to implement RCN and Competitive State Wildlife Grant-funded conservation projects seeking to develop conservation strategies for RSGCN across the Northeast. The list of projects in *Appendix 4A* underscores the impact of regional collaboration and funding across the region. There is a continuing need to develop and improve coordinated conservation incentives, laws, policies, and decisions regionwide. These in turn can assist the 14 jurisdictions, both in delivering consistent and effective actions that address the top regional threats listed in chapter 3, and in implementing the priority actions presented in this chapter. However, this cannot be accomplished without additional funding and capacity in the region and beyond.

IMPROVING INCLUSIVITY, RELEVANCE, COMMUNICATION AND OUTREACH

Effective regional conservation will depend on providing clear and consistent information about state and regional conservation targets, specifically: SGCN and Conservation Opportunity Areas in SWAPs and RSGCN and Regional Conservation Opportunity Areas/ habitats. When engaging partners, stakeholders, and the public, it is important to clearly state how top threats in the Northeast region impair RSGCN and then to show how conservation actions can address those impacts. It is also important to reach out to and engage broader audiences, helping them to better understand the needs and priorities of wildlife conservation, their urgency, and how to participate. This will require regionally consistent messaging of SWAP priorities and conservation needs as well as improved communication approaches targeting broader and more diverse audiences more effectively.

Consistent outreach information and messaging encourages the inclusion of RSGCN in Northeast agency and partner programs. NEAFWA's Northeast Conservation Information & Education Association could be engaged to assist; and the same is true of other social scientists and communication specialists. Creating new and more effective communication tools depends in part on capacity and funding. Targeted action items and messages could be developed for each internal and external partner on why and how to conserve RSGCN. As BMPs and protocols for the priority taxa presented in this synthesis are developed, they should continue to be promoted and distributed regionally. Improved social media and web presence are needed for achieving broader, more effective outreach.

Additional information and tools are available to help guide and support these outreach efforts. AFWA and its partners developed the **Relevancy Roadmap**[212] as a practical guide for use by state and provincial fish and wildlife conservation agencies, helping overcome barriers to public awareness, engagement, and support. The roadmap provides multiple pathways for navigating the diverse social, economic, demographic, political and environmental changes that states and provinces face (AFWA 2016, 2018, AFWA and MLI 2019, AFWA 2021). Several key resources are listed below, and please see Chapter 8 for additional, more detailed information:

Relevancy Roadmap Resources

- **Fish and Wildlife Relevancy Roadmap-Final Report** (December 2019)
- AFWA Fish and Wildlife Relevancy Resolution (Adopted September 2019)
- Fish and Wildlife Relevancy Roadmap Fact Sheet (January 2020)
- Presentation on Fish and Wildlife Relevancy Roadmap (January 2020)

Key Resources on Fish and Wildlife Relevancy

- State Fish and Wildlife Agency Transformation: An annotated bibliography (July 2018)
- Governance Principles for Wildlife Conservation in the 21st Century
- America's Wildlife Values: The Social Context of Wildlife Management in the U.S.
- Nature of Americans Study

Among the Northeast states, Virginia and Connecticut are working with the Wildlife Management Institute (WMI) and other partners, seeking to engage broader constituencies and increase understanding of the need for wildlife and habitat protection/restoration. The Association of Fish and Wildlife Agencies' Blue-Ribbon Panel[213] on the future of fish and wildlife conservation recommended that state agencies focus on public outreach and education as a way to broaden political and financial support. In response, WMI and AFWA coordinated development of strategies and tactics designed to overcome barriers to engaging broader constituencies. These strategies and tactics were incorporated into the Fish and Wildlife Relevancy Roadmap (AFWA and WMI 2019). WMI then began working with six "pilot" states under a 2020 Multi-State Conservation Grant (MSCG)[214] to implement the roadmap and launch a new Conservation Relevancy Community of Practice website[215].

Virginia's Department of Wildlife Resources' 2022-2025 Inclusive Excellence Strategic Plan, developed from staff throughout the agency via its Inclusive Excellence Council, outlines goals and initiatives to build a workforce that will deliver on its mission to "CONSERVE. CONNECT. PROTECT." Implementing the Inclusive Excellence Strategic Plan will increase DWR's capabilities; promote diversity, equity, and inclusion among the agency's staff; make the outdoors available, accessible, and safe for all Virginians; and help ensure that wildlife and outdoor recreation are enjoyed and supported by generations to come (VA DWR 2022).

4.7.3 REGIONAL EXAMPLES AND OPPORTUNITIES

See *Chapter 7* for additional information on partners and programs. Each Chapter of this synthesis provides information and examples for the specific SWAP Element it addresses (Species- *Chapter 1*, habitats- *Chapter 2*, threats- *Chapter 3*, actions- *Chapter 4*, monitoring- *Chapter 5*, and partner/public participation-*Chapters 7 and 8*). Conservation groups and individuals at the national, regional, state, and local levels joined the **Alliance for America's Fish and Wildlife** in seeking additional funding and capacity to strategically address priority SGCN/RSGCN conservation. This was successfully done for SWG funding in 2001 with the Teaming for Wildlife Coalition. Two decades later, additional funding and capacity are still needed. The Alliance for America's Fish & Wildlife's purpose is to create a 21st century funding model for much needed conservation of our most precious natural resources, our fish and wildlife[237].

Although the RAWA effort was not successful in 2022, there is a growing need that must be addressed if fish and wildlife diversity is to be conserved at any scale. To inform this effort, state fish and wildlife agencies are assessing and evaluating their effectiveness and relevancy in performing their public trust responsibility for wildlife conservation (AFWA 2016, 2018, AFWA and WMI 2019). Significant work has been conducted through a social science lens to better inform and equip agencies to be more effective in addressing their constituencies. Key projects and programs are described below, and Chapter 8 provides more detailed information on the effort to better align agency programs with America's Values and the needs of fish and wildlife.

The Association of Fish and Wildlife Agencies (AFWA) has provided guidance through Best Practices for SWAPS and on the participation of the public and their partners in the work of wildlife conservation (Elements 7 and 8) (AFWA 2012). AFWA (2016) also coordinated the "Future of America's Fish and Wildlife: A 21st Century Vision for Investing in and Connecting People to Nature," resulting in a Report and Recommendations from the Blue-Ribbon Panel on Sustaining America's Diverse Fish and Wildlife Resources. In 2018, AFWA produced an Annotated Bibliography (State Fish and Wildlife Agency Transformation) through the efforts of a Blue-Ribbon Panel Relevancy Working Group (AFWA 2018). In 2019, AFWA and the Wildlife Management Institute developed the Fish and Wildlife Relevancy Roadmap as guidance to "Enhance Conservation Through Broader Engagement" (AFWA and WMI 2019).

The Nature of Americans: Disconnection and Recommendations for Reconnection (Kellert et al. 2017) indicates that the relationship of Americans to nature and the natural world is changing. Adults and children alike spend evermore time indoors. Participation in activities like hunting and fishing is stagnant or declining and shifts in social expectations treat engagement with nature as an amenity. These trends pose a nationwide problem, since overwhelming evidence shows the physical, psychological, and social wellbeing of humans depends on contact with nature. To monitor these trends and to understand how to restore this relationship, social scientists conducted an unprecedented study of 11, 817 adults and children across the United States in 2015–16. This study was conducted as part of a national initiative called The Nature of Americans, which seeks to understand and connect (or reconnect) Americans and nature. Three different methods were used in this study. The first method involved 15 focus groups with 119 adults conducted in major cities of the five most populous US states. The second method featured personal interviews with 771 children, 8–12 years old, along with an online survey of one parent of each of the participating children. The third method was a nationwide online survey of 5, 550 adults, measuring their feelings toward nature, activities in nature, how they perceived benefits of nature, and the barriers and incentives to connect with nature. Oversamples of African Americans, Hispanics, and Asians provide a closer look at these important groups. The report offers 22 actionable recommendations.

Providing further guidance on collaborative conservation, AFWA (2021) also developed guidelines and recommendations for a "Framework to Enhance Landscape-Scale and Cross-Boundary Conservation through Coordinated State Wildlife Action Plans". This report from the AFWA State Wildlife Action Plan and Landscape Conservation Work Group to the AFWA Wildlife Diversity Conservation and Funding Committee set forth principles for conservation collaboration (see *Chapters 7* and *8* for more details).

Draft Summary Recommended Actions (April 2022) from the Future of Conservation Forum. In January 2022, the Future of Conservation Forum brought together more than 200 professionals to discuss and begin to prioritize the actions needed to ensure a durable future for conservation. Participants included representatives from federal, provincial, and state governments, Indigenous groups, NGOs, philanthropic organizations, businesses, landowners, and others, working together to identify cross-cutting themes with actions in a "living document". These themes and recommendations address the concepts of inclusivity and relevancy (AFWA and WMI 2019:

1. build trust to strengthen collaboration and achieve greater impact.
2. inventory approaches to landscape conservation and collaboration.
3. establish support for critical functions.
4. advance a framework that increases equity and inclusion.
5. secure new funding and develop a comprehensive funding approach.

Collaborative Conservation with Tribes in Virginia[216]. The Wildlife Management Institute (WMI), in partnership with the Metropolitan Group (MG) and the Virginia Department of Wildlife Resources (VA DWR) recently completed a 20-month effort to implement several recommendations presented in the Fish and Wildlife Relevancy Roadmap[242]. Information on WMI website describes the project, which was funded through a 2021 AFWA Multi-state Conservation Grant, and the journey undertaken by the VA DWR with Outdoor Afro, the Upper Mattaponi Indian Tribe, and the Rappahannock Tribe.

4.8 DEVELOP AND IMPLEMENT EFFECTIVE REGIONAL-SCALE MONITORING TO INFORM ADAPATIVE MANAGEMENT OF REGIONAL CONSERVATION PRIORITIES IN THE NORTHEAST

4.8.1 REGIONAL NEED AND PRIORITY ACTIONS

Regional Need: The 14 Northeast 2005 and 2015 SWAPS, the 2017 SWAP Synthesis, and the 2023 RSGCN process identified monitoring as a key need for effective fish and wildlife diversity conservation in the Northeast. Substantial efforts and investments have been made to conserve RSGCNs and key habitats across the Northeast region. A coordinated monitoring approach and consistent methodologies are also necessary to determine the effectiveness of these conservation efforts and inform adaptive management at the regional scale.

Priority Actions: Review and evaluate priorities, data and tools and their implementation. Review regional targets, indicators, incentives, laws, programs, and policies to ensure current relevance and conservation effectiveness. Develop and improve regional monitoring efforts to evaluate effectiveness and inform adaptive management at multiple scales. Work with agencies and entities that regulate impacts to fish and wildlife habitats to develop and implement effective, consistent monitoring policies and approaches across Northeast lands and waters.

See Priority Species in Chapter 1, Priority Habitats in Chapter 2, Priority Threats in Chapter 3, each with partner and program opportunities and examples. See Table 4.1.1 and Appendix 4A for priority projects completed and Appendix 4B, the SWAP Synthesis, and individual SWAPs for additional priority Conservation Actions that all reflect decades of regional collaboration and coordination to develop and improve monitoring at the landscape and watershed scale.

4.8.2 APPROACH

NEAFWA member states have long recognized the value of regional-scale monitoring. The importance of these regional efforts to improving the consistency and effectiveness of monitoring is reflected in the SWAPs and SWAP Synthesis. This section presents a chronology of Northeast Fish and Wildlife Diversity Technical Committee (NEFWDTC) efforts to support Northeast SWAPs by addressing regional monitoring needs in a coordinated, strategic way.

Ideally, the needs, actions, and projects presented in this and other chapters and appendices should all be monitored at the local, state, and regional levels to document their effectiveness. Unfortunately, monitoring has historically been one of the lowest funding priorities in conservation. On a practical level, priority key indicators and projects can be identified that address the needs of most RSGCN species and their habitats faced with the highest degree of threat. Using this approach, a Northeast Monitoring Framework was developed in 2008 through the RCN program. It identified eight key indicators (NEAFWA 2008). This RCN and Duke Foundation-funded project **"Monitoring the Conservation of Fish and Wildlife in the Northeast: A Report on the Monitoring and Performance Reporting Framework for the Northeast Association of Fish and Wildlife Agencies"** produced a regional monitoring framework report on the status of SGCN and their habitats while also evaluating the effectiveness of conservation projects implemented as part of SWAPs and the State Wildlife Grants program (NEAFWA 2008). The monitoring framework includes eight conservation targets (see Section 5.2.1 for more detailed information):

1. Forests
2. Freshwater streams and river systems
3. Freshwater wetlands
4. Highly migratory species
5. Lakes and ponds
6. Managed grasslands and shrublands
7. Regionally significant SGCN
8. Unique habitats in the Northeast

The report noted that additional work was needed to include coastal and marine systems. Specific indicators and stressors are identified for monitoring to assess each of the eight conservation targets, except for the managed grasslands and shrublands target where information was lacking (see Table 4.8.1 for an example of indicators).

Table 4.8.1 Northeast Regional Monitoring Performance Reporting target indicators for selected conservation target habitats.

Conservation Target	Example Indicators
Freshwater Wetlands	1. Extent of freshwater wetlands
	2. Percent impervious surface flow
	3. Buffer area and condition (buffer index)
	4a. Hydrology upstream surface water retention
	4b. Hydrology high and low stream
	5. Wetland bird population trends
	6. Road density
Highly Migratory Species	1. Migratory raptor population index
	2. Shorebird abundance
	3. Bat population trends
	4. Abundance of diadromous fish
	5. Presence of monarch butterfly

A few years later, the RCN program awarded funds to The Nature Conservancy (TNC) to assess these eight conservation targets as part of the **Conservation Status of Fish, Wildlife, and Natural Habitats in the Northeast Landscape: Implementation of the Northeast Monitoring Framework** (Anderson and Olivero Sheldon 2011). These metrics were identified as critical indicators for Northeast land and waterscapes in the NEAFWA region and were addressed in subsequent RCN projects. The **Condition of the Northeast Terrestrial and Aquatic Habitats: A Geospatial Analysis and Tool Kit** contains an analysis of 116 habitats in relation to 14 regionally assessed condition metrics (Anderson et al. 2013a). Additional RCN projects funded these important regional efforts to monitor the key indicators identified for Northeast habitats, resulting in reports, databases, and geospatial tools (Anderson et al. 2013b, Anderson et al. 2016a, 2016b, Olivero and Anderson 2008, Olivero Sheldon et al 2015, Olivero Sheldon and Anderson 2016).

Another recent RCN-supported project allowed The Nature Conservancy to update this condition assessment with new information and analysis tools. Trend information reflecting a decade of critical data on several key Northeast habitats and several RSGCN taxa are now available through the updated **Northeast Habitat Condition Assessment** (Anderson et al. 2023a). Chapter 2 of this Regional Conservation Synthesis supplements the 2023 condition assessment of Anderson et al. (2023a) by addressing the information need to assess the status and condition of the region's coastal and marine systems that are not currently included in the monitoring framework.

In 2012 the Association of Fish and Wildlife Agencies (AFWA) released national guidance for SWAPs under the title: **Best Practices for State Wildlife Action Plans – Voluntary Guidance to States for Revision and Implementation,** (AFWA 2012). The AFWA Best Practices defines monitoring under Element 5 "as the collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a management objective" (AFWA 2012). Figure 4.8.1 provides an example of the three levels of monitoring from the AFWA Best Practices (2012).

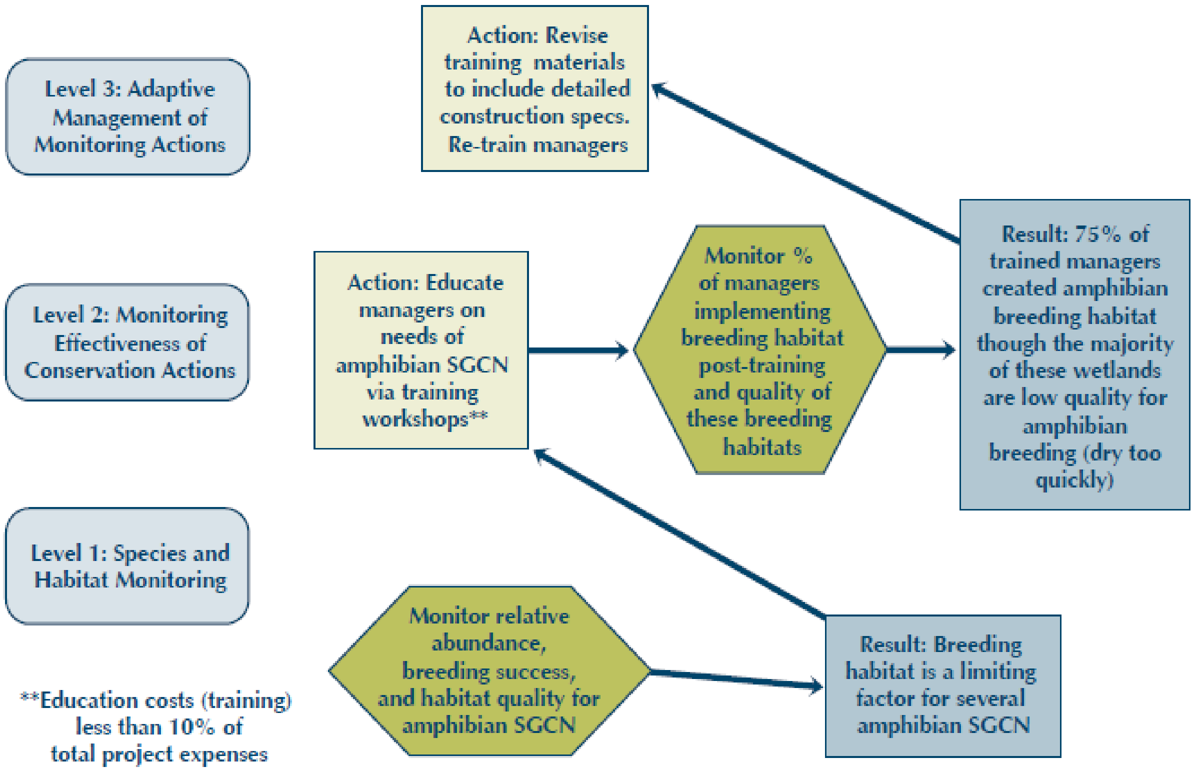

Figure 4.8.1. Example from AFWA Best Practices (2012) of the three levels of monitoring required by Congress in Element 5 of the Eight Required Elements for SWAPS.

The 2012 SWAP Best Practices Guidance also recommended the use of results chains to improve the evaluation of actions, which is the core of the Adaptive Management concept. Results Chains are important tools that help project managers be more adaptive. Open Standards for the Practice of Conservation v 4.0 was developed by Conservation Measures Partnership in 2020. CMP is a partnership of conservation-oriented NGOs, government agencies, and funders that works collectively to achieve greater impact and seek better ways to design, manage, and measure the effectiveness of conservation actions (CMP 2020).

The Northeast conservation community has worked for nearly a decade to reduce or eliminate threats outlined in the 2015 SWAPS and 2017 SWAP Synthesis. However, the challenge of how to fully demonstrate the effectiveness of each effort remains. The lack of funding and capacity constrains monitoring efforts, including finding available tools and methods. Results Chains graphically represent a project's life cycle and serve three important purposes (Margoluis et al. 2013). They help illustrate and clarify the steps needed to achieve specific conservation targets. They also help identify the specific type of output and outcome data needed to adequately evaluate the performance and effectiveness of a project. Finally, Results Chains are used to determine when output and outcome data should be available during the course of a project. Each step is critical to ensuring that data, collected by different organizations in varied locations, are consistent and therefore applicable to the management of regional conservation actions (CMP 2020, Foundations of Success 2007, 2008)[217].

The year 2015 marked the beginning of an annual, internationally focused effort to review the effectiveness of conservation interventions **Conservation Evidence: Providing Evidence to Improve Practice was established[218]**. Actions taken to benefit amphibians, bats, birds, and other conservation targets are reviewed to assess the effectiveness of various actions in achieving the intended goals. Projects with inconclusive evidence are also included. The international nature of the analysis can make larger-scale conclusions more difficult, but the database provided along with the **What Works in Conservation** summary publications offers a platform for measuring the effectiveness of a broad range of common conservation actions (Sutherland et al. 2021). Two separate databases inventory conservation actions and scientific studies of their effectiveness; and both are available online.

To effectively monitor or measure conservation targets or actions, consistency of language is important. The NEFWDTC and SWAP Coordinators recognized the need for a standard lexicon that provides conservationists with a uniform terminology that accurately describes the work of state fish and wildlife agencies. Therefore, the NEFWDTC developed a regional conservation lexicon in 2013 and updated it in 2022. This lexicon can be used by state fish and wildlife agencies and partners to better describe and monitor their conservation projects (Crisfield and NEFWDTC 2013 and 2022). Best practice recommendations are addressed in Chapter 5 of this Regional Conservation Synthesis and include incorporation of monitoring information into adaptive management approaches.

The 2017 SWAP Synthesis drew from the 14 individual Northeast SWAPs to identify the monitoring needs for priority threats, species, and habitats. State-specific actions and monitoring needs can be found in searchable format in the Northeast SWAP Database[1]. These are summarized and presented in the SWAP synthesis (TCI and NEFWDTC 2017), *Appendix 4A* and *Supplementary Information 5*. The SWAP Synthesis and the Limiting Factors report (TCI and NEFWDTC 2017, 2020a) both found common, recurring monitoring themes and needs reported across multiple taxa. Key overarching monitoring actions from the synthesis include:

- **Develop regionally coordinated and cost-effective monitoring protocols** that meet multiple objectives across states and monitor changes to the Northeast's land and waters and how those changes impact wildlife and people.

- **Measure and report the effectiveness of actions** to improve and enhance future conservation efforts; improve competitive grant applications; and recruit new partners by demonstrating the utility and efficacy of conservation programs.
- **Conduct adequate research, surveys, and then monitoring to determine baseline status and detect changes in SGCN, RSGCN, and key habitats** before they reach critical levels beyond which they cannot be recovered.

Multiple taxa recommendations included the need for consistent monitoring protocols range wide. This approach provides for improved status assessments as well as additional opportunities for conservation, thus avoiding the need to list target species at the federal level. Key RCN projects were developed that addressed some of these taxa needs; however, many other needs remain unaddressed. Priority RSGCN/watchlist species and their habitat needs identified in the 14 Northeast SWAPs and flagged for further investigation and monitoring, especially in the face of climate change, include:

- **Invertebrate biomass decline**. Because of the high number of vertebrate RSGCN relying on invertebrate food sources, there is a need to understand invertebrate biomass declines and the thresholds of food availability required to maintain or increase populations (Wagner 2020).
- **Insecticide toxicity for the high number of RSGCN invertivores**. Taxa experts cited concerns about the impact of insecticide spraying on forest-dwelling vertebrate RSGCN including bats, birds, reptiles, amphibians, fish, and aquatic invertebrates, especially the ingestion of harmful substances through food or water.
- **Disease**. There is an ongoing need to track the impacts of disease in RSGCN, particularly reptiles and amphibians, freshwater mussels, crayfish, and mammals.
- **Loss of genetic diversity in RSGCN**. Species in particular need monitoring include the Northern Right Whale, Sturgeon, the New England Cottontail and Allegheny Woodrat.
- **Wintering RSGCN vulnerabilities**. These are either poorly understood or increasing due to climate change.
- **Take and Collection**. The impact of collection is dynamic and responsive to changes in world markets.
- **Changes in hydrologic regimes**. Because of the large number of RSGCN associated with hydrologically defined habitats, changes in precipitation regimes, evapotranspiration, and water management structures will affect many RSGCN.

- **Coastal habitats**. These habitats have been degraded or reduced in size by intensive development and are now further threatened by sea level rise and storm surge.

The Northeast states recognized the importance of monitoring conservation efforts and using monitoring data to guide and improve future management. In the Northeast, monitoring to evaluate effectiveness has been a challenge exacerbated by lack of funding and capacity. Several examples are provided in this section that reflect approaches to capturing regional and state level species and monitoring. *Chapter 5* provides more detail on monitoring; and its appendices describe existing monitoring programs and projects across the region.

The RCN and other programs are most effective when they can demonstrate that project results have been implemented on the ground and across the region to improve and sustain RSGCN and the habitats on which they depend. Such an approach supports efforts to keep species from becoming imperiled, necessitating inclusion on the federal list of endangered and threatened species. Large scale collaborative conservation actions for New England Cottontails, Blanding's Turtles, Wood Turtles, and others presented in *Appendix 4A* illustrate the need for the continual evaluation of priority targets and the development of conservation plans and actions. They rely on an adaptive approach of periodic review and update to the RSGCN, SGCN and COAs, underpinned by an evolving database that is updated with information from the 14 jurisdictions as changes are made to individual SWAPs and supported by regional prioritization and evaluation.

Consideration should be given to how climate change may alter the effectiveness of monitoring programs in capturing true population trends and dynamics. (e.g., managers may erroneously conclude that a population has declined when it has shifted in space or seasonality because survey effort has remained static). Also monitoring efforts need to be expanded to: 1) observe and understand changes in climate variables; 2) detect species shifts in space and time that are out of the bounds of their historical ranges; 3) track novel species moving into a region to effect community structure and function; and 4) fill needed data gaps and reduce uncertainty in RSGCN responses to climate change and other stressors.

Monitoring occurs at multiple levels across the Northeast. *Chapters 1, 2, and 3* summarize monitoring efforts for SWAP Elements 1-3: RSGCN, their habitats, and threats respectively. Multiple RCN and other monitoring projects have been summarized in this and previous chapters. *Chapter 5* summarizes these important monitoring efforts in the Northeast and *Supplementary Information 5* provides a list of many regional and state standardized monitoring programs. Tracking SWAP Element 4-

Actions, remains a challenge at all scales, as it requires a robust monitoring effort that is seldom funded. Recent projects include states' efforts to track their SWAP implementation. **Maine's Conservation Action Tracker[219] is an example of this kind of monitoring project, designed to capture both state and partner efforts to conserve their SGCN and habitats**.

Conservation Evidence maintains a website and searchable database that allows users to search by species, habitat or an issue of interest[220]. The site provides both a list of possible actions conducted at a global scale (International Union for the Conservation of Nature (IUCN)'s Conservation Actions Classification Scheme)[221] and a summary of the projects and their effectiveness[222]. For more details see *What Works in Conservation*[223].

4.8.3 REGIONAL EXAMPLES AND OPPORTUNITIES

RCN, CSWG AND SA PROJECTS THAT ADDRESS MONITORING

The NEFWDTC and SWAP Synthesis identified monitoring as a top regional need in the 2005 and 2015 SWAPs. To address this, NEAFWA's RCN and key partner programs prioritized and funded multiple projects to provide information, guidance, BMPs, and protocols to improve assessment and monitoring of the impacts on RSGCN and their habitats in the region. Some of the key projects are listed below as resources. For a complete list of these projects please see Table 4.1.1 and *Appendix 4A*, for additional partner information see Chapter 7, and to see more about these threats see *Chapter 3*. For more detailed information on monitoring RSGCN and habitats, see *Chapters 1 and 2* respectively. *Chapter 2* provides information on Northeast habitat status and condition as well as RSGCN supported by each and provides examples of management and monitoring efforts that address monitoring across the region. *Chapter 3* provides information on threats, and *Chapter 5* provides more detail on monitoring across the Northeast.

Multiple RCN, CSWG, and SA efforts address survey and monitoring within species and habitat conservation strategies and plans, including the following RCN, CSWG and SA projects listed in Table 4.1.1 and *Appendix 4A*.

- Northeast Monitoring Framework
- Habitat Condition Assessment
- Rare Wetland Turtles (survey and monitoring protocols and forms)
- Xeric Woodlands and Barrens (pollinator and vegetation protocols)
- Freshwater mussels-Brook Floater (survey and monitoring)
- Chesapeake Logperch Conservation Strategy
- Hellbender (disease prevention, monitoring, eDNA, etc.)
- Diamondback Terrapin Conservation Strategy
- Wetland, Grassland, Mountain, Forest Bird survey/monitoring handbook
- Odonate Assessment
- Wetland butterfly Best Practices
- Coastal/Marsh Birds- Black Rail, Saltmarsh Sparrow
- Frog Monitoring
- New England Cottontail Conservation Strategy
- Others- please see Table 4.1.1 for links to these projects and *Appendix 4A*.

Northeast Monitoring Framework. One of the original RCN projects laid the foundation for collaborative, regional monitoring, and evaluation. The Northeast Monitoring Framework (NEAFWA 2008 and described in *Chapter 5*) was established to monitor key Northeast indicators and measures of fish and wildlife species and their habitats in the Northeast. NEAFWA RCN program supported The Nature Conservancy (TNC) in assessing the condition of species and habitats in the Northeast through the Conservation Status Project (Anderson et al. 2013a, 2023a). This project (incorporated into Chapter 2) used a GIS analysis to examine the relationship between species and habitat condition as well as land ownership and conservation management status. The original assessment project merged with another RCN-funded project, titled Regional

Indicators and Measures: Beyond Conservation Land (Anderson and Olivero Sheldon 2011), which focused on approximately 30 indicators of habitat condition and species and ecosystem health in the Northeast states. Together these projects implemented approximately 75% of the Northeast Regional Monitoring and Performance Measures Framework (NEAFWA 2008), previously funded by the NFWF and the RCN Grant Program[1].

Northeast State of the Frogs: Monitoring. This 2010 RCN project produced the first regional analysis of frog call survey data from the **North American Amphibian Monitoring Program** (NAAMP)[224]. Eleven years of survey data (2001-2011) from the NAAMP was used to provide a regional trend assessment and associated analytical methods for amphibians in the Northeast. NAAMP is a collaborative effort among USGS, State Agencies, and other partners to monitor calling amphibians using a standard, peer-reviewed protocol. NAAMP is active in more than 20 states, including 11 northeastern states (Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, Hudson region of New York, Pennsylvania, Vermont, Virginia, and West Virginia). This project developed the modeling and trend assessment framework for regional reporting, resulting in the first regional-level analysis using NAAMP data. This framework became the methodology for future reporting on NAAMP results.

This RCN project addressed RCN Topic 6: Design and implement monitoring protocols, measures, and indicators for NE Species of Greatest Conservation Need (SGCN) and targeted amphibians. Of the 30 species of frogs and toads in the Northeast, this study was able to report occupancy trends for 18, with the majority of omitted species being restricted to southeastern Virginia. Of the 18 species, 12 are SGCN in one or more Northeastern states. NEPARC has proposed 7 of these species as "high responsibility" for the Northeast.

Published results presented the first regional trends in anuran occupancy from North American Amphibian Monitoring Program (NAAMP) data from 11 Northeastern states. NAAMP's long-term monitoring program collected data at assigned random roadside routes, using a calling survey technique to assess occupancy trends for 17 species. Eight species had regional trends whose 95% posterior interval did not include zero; of these seven were negative (*Anaxyrus fowleri, Acris crepitans, Pseudacris brachyphona, Pseudacris feriarum-kalmi complex, Lithobates palustris, Lithobates pipiens, and Lithobates sphenocephalus*) and one was positive (*Hyla versicolor-chrysoscelis* complex). The project also assessed state-level trends for 103 species/state combinations; of these, 29 showed a decline and nine showed an increase in occupancy (Weir et. al. 2014).

Motus 1-3: Identifying Landscape-scale Habitat Use of Multiple SGCN in the Mid-Atlantic Region Using Nanotag Technology (2018, 2019, 2022) (CSWG). This project provides: 1) geographic and temporal data on migration; 2) full life cycle data to inform habitat management and conservation action decisions for SGCN; 3) corroboration of recent modeling based on NEXRAD radar data identifying high-use migratory stopover sites; and 4) expansion of telemetry monitoring network by adding 46 automated telemetry receiving stations. In 2019, CSWG supported Motus II: Using Nanotag Technology to Identify Landscape-scale Habitat Use of Multiple SGCN in New England. The project will provide these data outputs with an additional focus on American Kestrel (*Falco sparverius*) and Monarch butterfly (*Danaus plexippus*), with full life cycle data to inform habitat management and conservation action decisions for SGCN; provide new data on detection distances to optimize tower construction and placement for species tracking; and expand the telemetry monitoring network by adding 50 automated telemetry receiving stations. The Motus project contributes significantly to landscape- scale monitoring of migratory species in the region. Motus III: PA and VT Portion of Identifying SGCN Habitat Use Across Multiple Scales Throughout the Eastern U.S. Using the Motus Wildlife Tracking System expanded and employed Motus receiving stations to detect animal movements and determine the location of stopover habitats, where populations are breeding, and where they are migrating and wintering. Additionally, the Project expanded the telemetry monitoring network by adding 35 automated telemetry receiving stations across West Virginia, Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Connecticut, Delaware, Maine, Maryland, Massachusetts, Pennsylvania, New Hampshire, New Jersey, New York, Rhode Island.

Bird Assessment and Monitoring Standard Operating Procedures (2007-08) (RCN). The RCN program funded the Development of Avian Indicators and Measures for Monitoring Threats and Effectiveness of Conservation Actions in the Northeast. Northeast regional monitoring procedures are now available for birds of grasslands, tidal marshes, and mountain forests - habitats that span the Northeastern landscape, contain a high percentage of vulnerable species, and encompass the region's major management issues. These coordinated bird monitoring programs can measure region-level threats and management impacts on target birds and habitats identified by the SWAPs as being of greatest conservation need. Products of this work include peer-reviewed survey design, protocols, and standard operating procedures for each indicator group (grassland, tidal marsh, and mountain forest birds) along with a regional database for each of these groups. This project also resulted in the development and implementation of a regional coordinated bird monitoring framework (Northeast Coordinated Bird Monitoring Partnership 2007) and the Northeast Bird Monitoring Handbook (Lambert et al. 2009). The mountain bird survey data was gathered as part of the Vermont Center for Ecostudies' high-elevation bird monitoring program, Mountain Birdwatch.

CONSERVATION ACTION TRACKER – MAINE

The state of Maine developed a system to track actions identified in its State Wildlife Action Plan. Maine's Conservation Action Tracker (CAT) is an example of an effort to capture both state and partner actions and of successful on-the-ground efforts to conserve their SGCN and habitats. It allows users to document and showcase the conservation of Maine's most vulnerable species and habitats, learn about Wildlife Action Plan conservation projects statewide, search projects by the species or habitats they benefit, and make connections with other partners throughout the state[252].

Figure 4.8.1 Maine's State Wildlife Action Tracker.

CONSERVATION OPPORTUNITY AREA TOOL – PENNSYLVANIA

The Pennsylvania Conservation Opportunity Area (COA) Tool[225] is a component of the 2015-2025 Pennsylvania Wildlife Action Plan. The Tool can be used in several ways: 1) to discover SGCN in a user-defined area of interest; 2) to develop an output report with actions identified to support the species and habitats in an area of interest; 3) to produce a list of SGCN by county or watershed; and 4) to see range maps for most

SGCN. The COA Tool also expands access to core components of the SWAP and facilitates its use. The Pennsylvania COA Tool guides conservation actions and is filled with important information about species, habitats, environmental stressors, needed conservation actions and more.

EPA'S REPORT ON THE ENVIRONMENT

EPA's Report on the Environment[66] includes a broad set of indicators of ecological condition that provide insight into the degree to which the natural environment is being protected. These indicators and status are summarized below and in *Chapter 2*, as well as in the 2023 Northeast Habitat Condition Assessment (Anderson et al. 2023a)

Extent and Distribution. This indicator examines trends in the overall extent (area and location) of different kinds of ecological systems. It also examines spatial patterns in the distribution of ecological systems that affect interactions of nutrients, energy, and organisms.

- Ecological Connectivity
- Forest Extent and Type
- Forest Fragmentation
- Land Cover
- Land Use
- Urbanization and Population Change
- Wetlands

Diversity and Biological Balance. These indicators identify trends in the types and numbers of species that live within ecological systems and how they interact with each other.

- Benthic Macroinvertebrates in Wadeable Streams
- Bird Populations
- Coastal Benthic Communities
- Cyanobacteria in Lakes
- Fish Faunal Intactness
- Submerged Aquatic Vegetation in Chesapeake Bay

Ecological Processes. These indicators focus on trends in the critical processes that sustain ecological systems, such as primary and secondary productivity, nutrient cycling, decomposition, and reproduction.

Physical and Chemical Attributes. *Physical attributes* can include temperature, hydrology, and physical habitat, as well as major physical events that reshape ecological systems, such as fires, floods, and windstorms. *Chemical attributes* can include pH, dissolved oxygen concentrations, and nutrients (e.g., nitrogen and phosphorus).

Ecological Exposure to Contaminants. This indicator set provides information on biomarkers of exposure to contaminants that are particularly important with respect to the health of plants and animals, as well as to humans who might consume them.

US Forest Service PRISM[226] allows users to interactively explore key accomplishments of the Forest Service State and Private Forestry Programs and discover a current assessment of landscape impact. It can be queried by state, region, county, watershed, or congressional district. It presents information in a dashboard format to provide the number and acres of completed projects, as well as the number of acres of priority land impacted.

Wildfire Hazard Explorer[227]**.** This Portal contains the spatial footprints and associated metadata for known wildfire risk, threat, hazard and burn probability maps. The project was commissioned by the USFS and National Association of State foresters (NASF) to better catalog the existing wildfire data resources available to States, Federal Agencies, and Private and NGO partners. The site does not house the actual data for the risk / threat / hazard maps, but instead provides metadata and links to the sources (where available). The project team continues to look for new sources of data that might help interested parties. A link is provided (see "Useful Links"), allowing users to contribute information. The site was designed to be easy to use with simple filters and the ability to search by text or map.

Chapter 5 provides additional information and links to other key regional/national monitoring projects, including those conducted by the US Geological Survey, EPA, USFWS, USDA, NOAA and many more.

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CHAPTER 5: MONITORING

SWAP Element 5

Descriptions of the proposed plans for monitoring species identified in 1st Element and their habitats, for monitoring the effectiveness of the conservation actions proposed in the 4th Element, and for adapting these conservation actions to respond appropriately to new information or changing conditions.

Suggested components:

A. *The Plan describes plans for monitoring species identified in Element 1, and their habitats.*
B. *The Plan describes how the outcomes of the conservation actions will be monitored.*
C. *If monitoring is not identified for a species or species group, the Plan explains why it is not appropriate, necessary, or possible.*
D. *Monitoring is to be accomplished at one of several levels including individual species, guilds, or natural communities.*
E. *The monitoring utilizes or builds on existing monitoring and survey systems or explains how information will be obtained to determine the effectiveness of conservation actions.*

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TABLES

Table 5.2. 1 List of conservation targets and proposed indicators in the Monitoring and Performance Reporting Framework for the Northeast Association of Fish and Wildlife Agencies (NEAFWA 2008).

Table 5.4. 1 A total of 290 species were identified as priority species for additional survey, monitoring, and assessment on the 2023 RSGCN Watchlist.

Table 5.5. 1 Numerous non-governmental and citizen science databases are publicly available online that contain inventory, monitoring, and status information on fish and wildlife resources of the Northeast.

HOW TO USE THIS CHAPTER:

This Chapter provides national and regional information addressing State Wildlife Action Plan Element 5 (above) for monitoring. The resources included in this Chapter inform species abundance and status (Element 1), habitat availability and condition (Element 2), threats (Element 3), and evaluation of the effectiveness of conservation actions (Element 4). It also identifies monitoring partners for collaborative conservation and leveraging of limited resources (Element 7) and opportunities for public engagement through citizen science (Element 8).

- The Regional Overview (Section 5.0) describes the Northeast Association of Fish and Wildlife Agencies' Monitoring and Performance Reporting Framework (NEAFWA 2008), the Northeast Lexicon (Crisfield and NEFWDTC 2022), and Association of Fish and Wildlife Agencies' Best Practices (AFWA 2012) related to SWAP Element 5.
- Section 5.1 describes national research, inventory and monitoring programs that contribute to addressing SWAP Element 5.
- Section 5.2 highlights regional monitoring networks and programs in the Northeast.
- Section 5.3 provides examples of state monitoring programs and projects.
- Section 5.4 describes monitoring resources for species with a summary of available standardized monitoring protocols in Section 5.4.2 (and Appendix 5A) and the Watchlist Assessment Priority species in Section 5.4.3.
- Section 5.5 lists databases and related inventory resources.
- Appendix 5A provides a list of available standardized monitoring protocols.

Additional information on programs and projects that monitor the availability and condition of habitats are described in *Chapter 2*. Monitoring programs for threats are described in *Chapter 2* when addressing habitat condition, in *Chapter 3* when addressing singular threats (e.g., invasive species, disease), and this *Chapter 5* when addressing multiple species, taxa, and/or habitats.

5.0 REGIONAL OVERVIEW

The Northeast region has a rich history of landscape, watershed, and seascape scale monitoring programs and projects that can inform Element 5 of the 14 Northeast State Wildlife Action Plans (SWAPs) of 2025. NEAFWA member states have long recognized the value of regional-scale monitoring and the region's SWAPs reflect the value of these regional efforts to provide improved consistency and effectiveness in monitoring.

Monitoring the Conservation of Fish and Wildlife in the Northeast: A Report on the Monitoring and Performance Reporting Framework for the Northeast Association of Fish and Wildlife Agencies identifies a regional monitoring framework report on the status of Species of Greatest Conservation Need (SGCN) and their habitats and the effectiveness of conservation projects implemented as part of SWAPs and the State Wildlife Grants program (NEAFWA 2008). The monitoring framework includes eight conservation targets (see Section 5.2.1 for detailed information):

1. Forests
2. Freshwater streams and river systems
3. Freshwater wetlands
4. Highly migratory species
5. Lakes and ponds
6. Managed grasslands and shrublands
7. Regionally significant SGCN
8. Unique habitats in the Northeast

The monitoring framework report noted at the time that additional work was needed to include coastal and marine systems in the framework, which focused limited time and resources on terrestrial and freshwater systems. Specific indicators and stressors are identified for monitoring to assess each of the eight conservation targets, except for the managed grasslands and shrublands targets where information was lacking.

In 2011 The Nature Conservancy (TNC) assessed these eight conservation targets as part of the **Conservation Status of Fish, Wildlife, and Natural Habitats in the Northeast Landscape: Implementation of the Northeast Monitoring Framework** (Anderson and Olivero-Sheldon 2011). The Nature Conservancy updated this condition assessment in 2023 with new information and analysis tools (Anderson et al. 2023), except for RSGCN conservation target which is addressed in *Chapter 1* of this Regional Conservation Synthesis instead. *Chapter 2* of this Regional Conservation Synthesis supplements the 2023 condition assessment by addressing the information needed to assess the status and condition of the region's coastal and marine systems that are not currently included in the monitoring framework.

In 2012 the Association of Fish and Wildlife Agencies (AFWA) released national guidance for SWAPs, the **Best Practices for State Wildlife Action Plans – Voluntary Guidance to States for Revision and Implementation**, hereafter referred to as AFWA Best Practices (AFWA 2012). The AFWA Best Practices defines monitoring under Element 5 "as the collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a management objective" (AFWA 2012, p. 16). Best practice recommendations addressed in this Chapter of the Regional Conservation Synthesis include:

- the use of standardized techniques and protocols,
- participating in existing national monitoring programs,
- assessing the effectiveness of conservation actions,
- collaborating with partners in regional monitoring efforts,
- participating in research and conservation alliances, and
- augmenting with citizen science programs as appropriate to expand capacity.

The AFWA Best Practices incorporate monitoring information into adaptive management approaches. Adaptive management techniques and resources are discussed in *Chapter 2* of this Regional Conservation Synthesis for specific habitat types.

To most effectively monitor or measure conservation targets or actions, consistent terms are important. The NEFWDTC and SWAP Coordinators recognized the need for a standard lexicon that provides a uniform terminology that accurately and adequately describes the work of state fish and wildlife agencies. Therefore, the NEFWDTC developed a regional conservation lexicon in 2013 (Crisfield and NEFWDTC 2013) and updated it in 2022 (Crisfield and NEFWDTC 2022). The **Northeast Lexicon** enables state fish and wildlife agencies and partners to better describe and monitor their conservation projects. For example, the Northeast Lexicon describes the three distinct purposes for monitoring to address Element 5:

- Measuring population status and trends,
- Describing habitat quality, and
- Assessing conservation project results.

Different formats and approaches may be appropriate for each of these monitoring purposes. "Status assessments of species or habitats are referred to as 'surveys'; 'research' includes monitoring to understand links between species, their habitats, and threats impacting both; and assessing the results of 'actions' implies a more dynamic situation resulting from implementing a project to mitigate a threat, improve habitat, or otherwise support a Species of Greatest Conservation Need" (Crisfield and NEFWDTC 2022, p. 27).

In 2015, an annual international effort to review the effectiveness of conservation interventions began called **Conservation Evidence: Providing Evidence to Improve Practice**[1]. Actions taken to benefit amphibians, bats, birds, and other conservation targets are reviewed on a near annual basis to indicate the degree to which studies indicate the action is effective in achieving project goals. Projects with inconclusive evidence are also included. The international nature of the analysis can make translation of conclusions more uncertain, but the database provided along with the **What Works in Conservation** summary publications (Sutherland et al. 2020) can provide methods for measuring effectiveness for a broad range of common conservation actions. Two databases inventory conservation actions and scientific studies of their effectiveness and are available online[1]. The studies database included more than 8400 scientific studies evaluating conservation actions as of January 2023 and is searchable by keyword, category (e.g., control of freshwater invasive species, butterfly and moth conservation, marsh and swamp conservation), species, habitat, threat, action type, or geographic location. The similarly searchable actions database included nearly 3700 actions distilled from the literature, each with an effectiveness rating and the number of related studies available. Links to the Conservation Evidence databases are now integrated on the species profile pages of the **International Union for Conservation of Nature (IUCN) Red List**[2].

The 2017 **SWAP Synthesis** drew from the 14 individual Northeast SWAPs to identify the monitoring needs for priority threats, species, and habitats (TCI and NEFWDTC 2017). State specific actions and monitoring needs can all be found in searchable format in the **Northeast SWAP Database**[3]. These are summarized below and presented in the SWAP Synthesis:

- <u>Develop regionally coordinated and cost-effective monitoring protocols</u> that meet multiple objectives across states and monitor changes to the Northeast's land and water resources and how those changes impact wildlife and people.
- <u>Measure and report the effectiveness of actions</u> to improve and enhance future conservation efforts; improve competitive grant applications; and recruit new partners by demonstrating the utility and efficacy of conservation programs.

The SWAP Synthesis and the **Limiting Factors** report both found common, recurring threads reported across multiple taxa (TCI and NEFWDTC 2017, TCI and NEFWDTC 2020). One focused on the need for adequate research, surveys, and then monitoring to determine baseline status and detect changes in SGCN, RSGCN, and their key habitats before they reach critical levels beyond which they cannot be recovered. Multiple taxa recommendations included the need for consistent monitoring protocols range wide. This approach provides for improved status assessments as well as additional opportunities for conservation, thus avoiding the need to list target species at the federal level. Priority needs identified in the 14 Northeast SWAPs and flagged for further investigation and monitoring in relation to RSGCN and Watchlist species and their habitats include:

- Invertebrate biomass decline. There is a need to understand invertebrate biomass declines and the thresholds of food availability required to maintain or increase populations, particularly those of vertebrate RSGCN.
- Insecticide toxicity for the high number of RSGCN invertivores. Taxa experts cited concerns about the impact of insecticide spraying on forest-dwelling vertebrate RSGCN including bats, birds, reptiles, amphibians, fish, and aquatic invertebrates, especially ingestion through food or water.
- Disease. There is an ongoing need to track the impacts of disease in RSGCN, particularly reptiles and amphibians, freshwater mussels, crayfish, and mammals.
- Loss of genetic diversity in RSGCN. In addition to other data deficient species, these species in particular need monitoring: the New England Cottontail, Allegheny Woodrat, Northern Right Whale, and the sturgeon.
- Wintering RSGCN vulnerabilities. These are either poorly understood or increasing due to climate change.
- Take and collection. The impact of collection is dynamic and responsive to changes in world markets.
- Changes in hydrologic regimes. Because of the large number of RSGCN associated with hydrologically defined habitats, changes in precipitation regimes, evapotranspiration, and water management structures will affect many RSGCN.
- Coastal habitats. These habitats have been degraded or reduced in size by intensive development and are now further threatened by sea level rise and storm surge.

This Chapter 5 of the Regional Conservation Synthesis summarizes the inventory, monitoring, and research projects and resources currently available to inform these monitoring and investigation needs in the Northeast and the corresponding regional priority action discussed in *Chapter 4*.

The 2023 NEFWDTC website update (www.northeastwildlifediversity.org) allows for web-enabling this Regional Conservation Synthesis, the updated Northeast RSGCN Database, and associated communication tools and products. These tools and resources will be searchable with filters to provide detailed information for monitoring protocols and programs for RSGCN, Watchlist species and their habitats. Resources described in

Chapter 5 of this Regional Conservation Synthesis plus supplemental materials developed as part of the RCN 3.0 Technical Services project will be centralized on one user-friendly platform.

5.1 NATIONAL INVENTORY AND MONITORING PROGRAMS

AFWA Best Practices recommend that SWAPs participate in national monitoring programs and utilize national scale inventory, monitoring, and research programs to inform SWAPs (AFWA 2012). The Northeast Lexicon describes how survey and research programs can inform Element 5 in SWAPs by increasing understanding of the extent, distribution, and degree of impacts of factors affecting SGCN, RSGCN, and their key habitats (Crisfield and NEFWDTC 2022). The SWAP Synthesis supported collaboration to collect and compile effectiveness data for the diversity of conservation efforts being implemented within the Northeast region and that potential partners be identified to determine how existing data could be used to enhance the SWAPs, monitor threats, and/or inform the adaptive management of State Wildlife Grant funded efforts (TCI and NEFWDTC 2017).

The following federal inventory and monitoring programs, and their associated research projects, contribute to fulfilling these goals to inform Element 5 of the Northeast SWAPs.

5.1.1 EPA PROGRAMS

The Environmental Protection Agency (EPA) monitors a number of environmental conditions across the United States (US). The EPA maintains a **Report on the Environment** with indicators that track the state of the country's environment and human health over time[4]. Monitoring indicators include several that are relevant to State Wildlife Action Plans:

- Air
    - Outdoor air quality
    - Greenhouse gases
    - Indoor air quality
- Water
    - Fresh surface waters
    - Ground water
    - Wetlands
    - Coastal waters

    - Drinking water
    - Recreational water
    - Consumable fish and shellfish
- Land
    - Land cover
    - Land use
    - Chemicals used on land
    - Wastes
    - Contaminated lands
- Human exposure and health
    - Exposure to environmental contaminants
    - Health status
    - Disease and conditions
- Ecological condition
    - Extent and distribution
    - Diversity and biological balance
    - Ecological processes
    - Physical and chemical attributes
    - Ecological exposure to contaminants

Data on these monitoring indicators is available through the EPA website[4].

The EPA monitors water quality and ecological conditions in estuarine waters along the coasts and the freshwater of the Great Lakes in the **National Coastal Condition Assessment** (NCCA)[5]. The NCCA is conducted every five years and uses standardized sampling procedures and quality assurance protocols to assess coastal conditions at the regional and national scale. Ecological indicators monitored as part of the NCCA include: biological condition of benthic invertebrates including mollusks, worms and crustaceans; eutrophication; sediment contaminant levels; fish tissue contamination; Enterococci bacteria levels; and microcystin toxin levels. The 2020 NCCA expanded to include new indicators of total alkalinity and the level of microplastics and nitrogen isotopes in sediments (EPA 2021)[6]. Detailed results of the NCCA monitoring are available on the NCCA Dashboard at https://coastalcondition.epa.gov. The EPA released a mobile app in 2021 called the **Sanitary Survey App for Marine and Fresh Waters** to help communities track beach water quality with the assistance of citizen scientists[7].

The EPA monitors the condition of physical, chemical, and biological integrity of wetlands as part of the **National Wetlands Condition Assessment**[8]. The condition of water quality and ecological conditions of rivers and streams is monitored as part of the **National Rivers and Streams Assessment**[9]. The EPA **StreamCat** database provides data on the condition of more than 2.65 million stream segments across the country[10]. The StreamCat dataset currently contains over 600 metrics related to rivers and streams and their condition. Both natural and anthropogenic information is included. Anthropogenic condition variables include the percent urbanization within the watershed, dam reservoir volumes, the mean application rate of synthetic nitrogen fertilizer on agricultural lands, the erodibility of agricultural soils, the density of coal mines within the watershed, the mean pesticide use within the watershed, and many more that impact the condition of rivers and streams for fish and wildlife.

The EPA monitors the condition of water quality and ecological conditions of lakes as part of the **National Lakes Assessment**[11]. The EPA **LakeCat** database provides data on the condition of more than 378,000 Lakes and Ponds across the country[12]. The LakeCat dataset currently contains over 300 metrics related to lakes and ponds and their condition. Both natural and anthropogenic information is included. Anthropogenic condition variables include the percent urbanization and agriculture within the watershed, dam reservoir volumes, the mean application rate of synthetic nitrogen fertilizer on agricultural lands, the erodibility of agricultural soils, the density of coal mines within the watershed, the mean pesticide use within the watershed, and many more that impact the condition of lakes and ponds for fish and wildlife.

The **EPA monitors several indicators of climate change**. Ecological monitoring data from the Northeast tracks shifting ranges of marine species as climate change indicators[13]. The range shifts of RSGCN American Lobster (*Homarus americanus*) and Black Sea Bass (*Centropristis striata*) are two of the indicator species, with maps available that illustrate the northward shifts from 1973 to 2019. The EPA also uses monitoring data for lake water levels and surface temperatures in the Great Lakes as climate change indicators[14]. Data show how the water levels in each of the Great Lakes have fluctuated since 1860 and average lake surface temperature has increased slightly since 1995.

Ice cover monitoring data (both area and duration) for the Great Lakes serves as another indicator of climate change for the EPA[15]. Data are available since 1973 and indicate a long-term decrease in the maximum area of ice cover for all Great Lakes, although individual lakes significantly vary year to year. The duration of ice cover has also declined since 1973, by almost a full day per year in Lake Ontario, and the declines are concentrated on the land edges of the lakes. Overall the five Great Lakes are covered in ice by eight to 46 fewer days now than in the early 1970s.

Monitoring data for lake ice for another nine lakes in the US is an EPA climate change indicator[16]. Monitoring data are available from 1850 to 2019. The lake ice indicator shows that lakes generally are freezing later in the year than in the past (at a rate of approximately 0.5 – 1.5 days per decade) and thawing earlier in the spring (at a rate of 0.8 days per decade), shortening the period when the lakes are covered in ice annually by several weeks. The EPA also uses lake temperature monitoring data as a climate change indicator, with data available from 1985 to 2009[17]. Data from 34 lakes across the US and Canada for the average July to September surface temperatures document an increase in average temperature for 32 of the 34 lakes, with 24 lakes warming by more than 1 degree Fahrenheit and 15 by more than two degrees.

The EPA also uses **monitoring data of streamflow** as a climate change indicator across the US[18]. Indicator rivers and streams data from 1940 to 2018 include the seven-day minimum annual streamflow, three-day annual high streamflow, annual average streamflow, timing of winter-spring runoff, and number of days with very low streamflow. In the Northeast, the seven-day low streamflows have generally increased, indicating on the days with the lowest streamflows the Rivers and Streams are carrying more water than previously. High streamflows have generally increased or not changed much in the Northeast since 1940. The average annual streamflow has increased at most sites in the Northeast. The timing of the winter-spring runoff is five to ten days earlier across most of the Northeast. And the number of days when streamflow is very low has decreased overall in the Northeast but increased in some streams of the Mid-Atlantic.

The EPA uses **monitoring data of stream temperatures** as a climate change indicator in the Chesapeake Bay region[19]. Data from 1960 to 2014 from 129 stream gauges document warming temperatures at 79% of the sites and decreasing temperatures at 5% of the sites. The overall Chesapeake Bay region has increased stream water temperatures since 1960 by an average of 1.2 degrees Fahrenheit across all sites and by 2.2 degrees at sites where the long-term trends are statistically significant. The largest stream temperature increases are in the southern part of the region (e.g., Virginia).

The EPA regulates point and non-point source pollution under the federal Clean Water Act, designating waters that are impaired due to pollution under Section 303(d) and providing **National Water Quality Inventory Reports**[20]. States are required to assess water pollution and report to the EPA every two years on the waters that have been evaluated or assessed. Impaired waters have Total Maximum Daily Loads of pollutants allowed to address the water quality impairments. The EPA uses this state monitoring information in the **Assessment and Total Maximum Daily Load Tracking and Implementation System (ATTAINS)** to monitor water quality conditions of surface waters across the country. Monitoring data on the ATTAINS platform is publicly available[21]. The public can access water quality monitoring data from ATTAINS through the **How's My Waterway?** online platform that provides a user-friendly resource for determining water quality at the community, state, and national scales[22].

5.1.2 USFWS PROGRAMS

The United States Fish and Wildlife Service (USFWS) conducts monitoring of both species and habitats with the scale and scope variable with the species, habitat, and location. The USFWS monitors federally-listed species populations and status, but monitoring techniques and frequency vary by species. Reviews of federally-listed species status are conducted every five years and summarize available monitoring data across the species' range.

The USFWS **Fish and Aquatic Conservation Program**[23] leads the agency's aquatic conservation efforts. Major projects and initiatives of the program include the conservation of high priority aquatic species; the conservation, restoration, and enhancement of aquatic habitats; management of aquatic invasive species; enhancement of recreational uses of aquatic resources; fulfillment of Tribal trust and subsistence responsibilities; and education and outreach. This federal program conducts early detection surveillance and monitoring of aquatic invasive species. USFWS Fish Health Centers monitor the health of amphibians and fish in captivity and in the wild, with seven regional centers across the country; the **Northeast Fishery Center** is located in Lamar, Pennsylvania[24]. The **National Wild Fish Health Survey** and its associated **National Wild Fish Health Database** and **National Wild Fish Health Survey Mapper** offer real-time surveillance of pathogens in populations of wild aquatic animals[25]. This database and mapping tool includes information on the movement of fish in wild environments, the distribution of pathogens, which fish are susceptible to pathogens and where they are located, site selection to source broodfish, and an assessment on the risk of pathogen spread.

The USFWS **National Fish Passage Program**[26] monitors aquatic connectivity projects that restore or enhance fish passage across the country. An interactive dashboard displaying an inventory of proposed projects under the Bipartisan Infrastructure Law with detailed information on location, cost, project type, partners involved, stream miles to be reopened, and number of barriers to be removed is available[27].

The **Migratory Bird Program**[28] of the USFWS conducts surveys and other monitoring efforts to track the status of migratory bird populations. The annual **Waterfowl Breeding Population and Habitat Survey** (also known as the **Breeding Population Survey**) is conducted by the USFWS and the Canadian Wildlife Service every May and June through aerial breeding bird surveys[29]. Since 1955 this monitoring survey provides information on the spring population size and trend of 19 North American duck species or species groups. The number of waterfowl breeding ponds in Prairie-Parkland Canada is also monitored. **Waterfowl Population Status Reports** generated by this survey are available[30].

The **North American Bird Conservation Initiative (NABCI)** is a partnership supported by the USFWS between federal and state agencies, private organizations, and bird initiatives to collaborate on the conservation of more than 1150 bird species[31]. The NABCI Monitoring Subcommittee provides technical expertise and recommendations for effective and efficient integrated bird monitoring programs to support bird conservation at the regional and landscape scale. Monitoring best practices and protocols developed are available[32].

Since 2009 the USFWS, NABCI, and partners have prepared **State of the Birds** reports every two years that monitor long-term bird population trends[33]. The most recent State of the Birds report was issued in late 2022 and is discussed in *Chapters 1* and *2* of this Regional Conservation Synthesis. The bird status and trends information contained in the State of the Birds reports inform the current conservation status and long-term population trends of species of concern in SWAPs.

The USFWS and partners conduct annual monitoring surveys of American Woodcock (*Scolopax minor*) via the **American Woodcock Singing-ground Survey**[34]. Throughout the species' breeding range in the U.S. and Canada, partners survey the breeding population every spring to provide an index of species abundance and estimate population trends at the state, province, management region, and continent scales. American Woodcock is identified as a Species of Greatest Conservation Need (SGCN) in all 14 Northeast SWAPs of 2015, which this annual survey can inform.

The **National Migratory Bird Harvest Survey** began in 1955 and monitors the harvest of migratory birds, the number of active hunters, the number of days hunted, and the number of birds bagged per hunter by state[35]. Working in partnership with state wildlife agencies, the USFWS selects a statistical sample of registered migratory bird hunters to participate in the annual survey. Five separate types of surveys focus on particular groups of species: 1) doves and band-tailed pigeons, 2) waterfowl, 3) American Woodcock, 4) snipe, rails, gallinules, and coots, and 5) sandhill cranes. Results of the National Migratory Bird Harvest Survey informs decision-marking on hunting seasons at the state and federal levels. The **Parts Collection Survey** invites hunters to submit the wings of bird they shoot to provide species-specific estimates of bird sex and age ratios (when combined with the results of the National Migratory Bird Harvest Survey). Monitoring information in the National Migratory Bird Harvest Survey and Parts Collection Survey can inform the status and trends of biological resource use and bird population information in SWAPs.

The **National Survey of Fishing, Hunting, and Wildlife-Associated Recreation** from the USFWS is one of the oldest and most comprehensive wildlife-related recreation surveys in the US[36]. First given in 1955, this national survey collects information on anglers, hunters, and wildlife watchers, monitoring the number of people, how often they participate in these activities, and how much money they spend on outdoor wildlife-associated recreational activities. The survey is conducted every five years, allowing for long-term trend analysis. The monitoring information in the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation can inform the status and trends of biological resource use and human disturbance from recreational activities for SWAPs as well as public engagement in wildlife-associated activities. The most recent survey was conducted in 2022, with results expected to be released mid-2023.

The **National Wetlands Inventory (NWI)**, administered by the USFWS, monitors the status and trends of non-tidal wetlands, tidal wetlands and flats, and riparian wetlands throughout the country. The NWI maintains maps and geospatial datasets on the location and distribution of all wetland types, using the **Classification of Wetlands and Deepwater Habitats of the United States** for tidal and non-tidal wetlands plus permanently submerged aquatic substrates, originally developed in 1979 (Cowardin et al. 1979) and updated in 2013 (FGDC 2013). National and regional analyses on the status and trends of wetlands are periodically updated and inform SWAP Key Habitat assessments; the monitoring reports are available[37].

The USFWS **Natural Resource Program Center** conducts inventory and monitoring programs of National Wildlife Refuge lands, waters, air, wildlife, and plants as well as their responses to management actions[38]. The Center's **Wildlife Health Office** monitors the health of wildlife and conducts disease surveillance, response, and management for birds, ungulates, and other species. The program monitors wildlife morbidity and mortality events, harmful algal blooms, and animal diseases with the potential to spread to humans. The USFWS Wildlife Health Office partners with the United States Geological Survey's National Wildlife Heath Center (see next Section 5.1.3).

5.1.3 USGS PROGRAMS

The United States Geological Survey (USGS) operates several research, inventory, and monitoring programs that can inform SWAPs. The USGS **Amphibian Research and Monitoring Initiative** provides scientific information to wildlife managers to halt or reverse population declines in amphibians. This program issued a **State of the Amphibians** report based on 25 years of monitoring data documenting an average 3.7% annual rate of decline in the proportion of sites occupied by amphibians and predicting that the average amphibian species will be extirpated from half of the places it occurred in 2016 in less than 20 years[39]. The **North American Amphibian Monitoring Program**, led by the USGS with 26 state, university, and organizational partners, operated from 1997 to 2015. Standardized amphibian monitoring protocols developed by the program and publications of population status and trends in various regions, including the Northeast, are available[40].

The USGS **Eastern Ecological Science Center** (formerly the Patuxent Wildlife Research Center and Leetown Science Center)[41] conducts several research, inventory, and monitoring programs relevant to SWAPs in the Northeast, including a project underway to develop new survey techniques for small mammals in the region. The **North American Bird Breeding Survey** is supported by the Eastern Ecological Science Center and the Canadian Wildlife Service to monitor the status and trends of bird populations across North America[42]. Annual surveys for more than 420 species of birds are conducted, generally in June, using standardized monitoring protocols at over 4100 survey routes. Long-term population trends and relative abundances are available since 1955. The Eastern Ecological Science Center also operates the **Bird Banding Laboratory**, which is the central repository of bird banding data since 1920. The Laboratory collects, curates, archives, and disseminates bird banding data through the **North American Bird Banding Program's Bander Portal**[43]. The public can report band sighting information online[44]

The USGS, USFWS, US Army Corps of Engineers, and other partners have coordinated a **Midwinter Bald Eagle Survey** during the first two weeks of January since 1979. The long-term, national database associated with the survey recently transferred from the USGS to the US Army Corps of Engineers for analysis and maintenance[45]. Citizen scientists count Bald Eagles (*Haliaeetus leucocephalus*) using standardized survey techniques along standard, non-overlapping survey routes across the country.

The **North American Bat Monitoring Program** is coordinated by a partnership between the USGS, USFS, US Forest Service, National Park Service, Bat Conservation International Canadian Wildlife Service, and other partners[46]. Standardized monitoring protocols are used to survey multiple species of bats across North America. Results of long-term status and trends and a data inventory are available on the program's website[46] and through the USGS ScienceBase[47].

The USGS **Native Bee Inventory and Monitoring Lab** within the Eastern Ecological Science Center designs and develops small and large scale surveys for native bee species[48]. This program continues to develop identification tools and keys for native bee species, including accurate and detailed photographs of native bees and the plants and insects that they interact with, and protocols for processing bee specimens. The **Bee Database** created and maintained by the Laboratory focuses on the Mid-Atlantic region and is available as part of the **Discoverlife Global Mapper**[49]. The native bee photography collection is available on flickr[50].

The **Science Data Catalog** of publications and datasets produced by the USGS is available free online[51]. Detailed information on recent USGS scientific research, inventory and monitoring projects related to biological and ecosystem resources is available online as well[52]. Other monitoring programs conducted by the USGS include those dedicated to water resources, climate change, natural hazards, shoreline erosion, sea level rise, and energy development.

The USGS **Water Resources Program** monitors surface water and groundwater resources across the country, collecting water quality, water use, and water level data at approximately 1.5 million locations across all 50 states[53]. The **Water Availability and Use Science Program** conducts inventory and monitoring studies on the quantity and quality of the nation's water, long-term trends in the availability of water, and forecasts for future water availability for human and ecological uses[54]. These water resources programs provide several inventory and monitoring resources that can inform SWAPs:

- The **National Water Dashboard** provides real-time information from more than 13,000 stream, lake, reservoir, precipitation, water quality, and groundwater stations[55].
- The **Water Quality Portal**, operated by the National Water Quality Monitoring Council in partnership with the USGS, EPA and more than 400 other data sources, provides downloadable water quality data for any selected location in the country[56].
- The **National Groundwater Monitoring Network Data Portal** compiles data from groundwater monitoring wells across the United States, with more than 17,800 water level wells and 4000 water quality wells participating in the network as of early 2023[57].
- The USGS National Water Information System's **Water Data for the Nation** collates water resources monitoring data from all 50 states, the District of Columbia, and five territories into one tool[58].
- **StreamStats** provides statistics on streamflow and spatial analysis tools for water resources applications[59]. Users select an area of interest from an interactive online map, delineate a catchment area of interest, select parameters of interest (e.g., basin characteristics), and download a summary report.
- The **National Water Census** is a national water availability and use assessment that includes components for streamflow, groundwater, water use, environmental flows, and evapotranspiration[60].

Integrated Water Availability Assessments under development by the USGS provide a nationally consistent but regional assessment of water availability for human and ecological needs and identify factors that may limit availability or lead to conflict[61]. One of the pilot reginal assessments is the Delaware River basin in the Northeast. The **Delaware River Basin Integrated Water Availability Assessment**[62] includes trends in water quality for 16 priority parameters from 1978 to 2018, collated datasets from multiple organizations, maps of monitoring sites that visually display surface water quality trends, an Algal Assessment that characterizes and forecasts the probability of harmful algal blooms in four subwatersheds, characterizing the drought history of the basin and identify future drivers of drought, and an assessment of streamflow baseflow contributions from groundwater from 1950 to 2015. Ongoing research and analysis will simulate groundwater dynamics to create a basin-specific groundwater flow model to hindcast and forecast monthly variation in groundwater conditions within the Delaware River basin. Overall the pilot project in this major Northeast river basin will take ten years to complete, with an anticipated completion date in 2031.

The USGS **Dam Removal Information Portal (DRIP)** monitors dam removal projects in the US and offers a searchable database of scientific studies that evaluate the environmental response of dam removals[63]. As of January 2023, the DRIP inventory of dam removal projects numbered 1796, with 203 of the removals associated with evaluation studies. This monitoring dataset shows an increasing trend in dam removal projects, with data for projects removed since 1980.

The USGS conducts research and monitoring of natural hazards and disasters across the country, providing resources to reduce risk and build resilience[64]. Although this program's efforts related to earthquake and volcanic hazards are not relevant to the Northeast region, other natural hazards work related to floods, drought, extreme weather (e.g., hurricanes, nor'easters, blizzards), wildland fires, landslides, and biological threats are regionally applicable. The USGS monitors flooding from thunderstorms, storm surge, and tsunamis and maintains current flood and high-flow stream conditions through its **WaterWatch** platform[65]. Historical flood data and information on droughts are also available through WaterWatch. The **Flood Event Viewer** provides geospatial information on specific flood and storm events, such as individual hurricanes[66]. Flood data from rain and tidal gages are integrated with observational sensors and measurements for barometric pressure, water level, wave height, high water, and meteorological parameters.

The USGS maintains national resources related to coastal storms. The **Coastal Change Hazards Portal** combines geospatial information resources on tropical storms and hurricanes, extreme storms, shoreline change, and sea level rise into one online interactive map[67]. Users can search by location and topic, with the available datasets shown and selectable for exploration or downloading (e.g., historical locations of shorelines in New Jersey, the probability of sandy beach erosion or inundation during a nor'easter in Massachusetts). The experimental **Total Water Level and Coastal Change Forecast Viewer**, a partnership between the USGS and the National Oceanic and Atmospheric Administration (NOAA), offers geospatial data on the combined total water level from tides, storm surge, and wave runup forecast for a particular section of coastline during current and near-future conditions[68]. The USGS also tracks coastal hazards through a **National Assessment of Storm-Induced Coastal Change Hazards** through oblique aerial photography missions to inventory baseline and storm-response conditions. The **Oblique Aerial Photography Viewer** provides access to this photographic database[69].

The Fire Science program of the USGS works to improve scientific understanding of wildland fires to inform decision-making by fire and land managers. The **Inttera National Fire Situation** map tool monitors current wildfires and provides related information for each in an interactive online map[70]. The USGS is also a partner in **LANDFIRE** spatial datasets of land cover and wildfire related information[71], which are described in *Chapter 2*.

The USGS **Landslide Hazard Program** has developed an inventory of landslides across the US, recording the date, causes, number of fatalities, and a confidence rating for each landslide. The **US Landslide Inventory**, most recently updated in 2019, is available with an interactive online map viewer[72].

The USGS **Biological Threats and Invasive Species Research Program** monitors several biological threats at the national level. A database of nonindigenous aquatic species with spatially referenced biogeographic accounts of each, with distribution maps, spatial datasets, and scientific reports[73]. The Program has integrated the **Nonindigenous Aquatic Species Database** with storm surge and flood events information to assess the potential spread of nonindigenous freshwater species due to flooding associated with storms, creating **Flood and Storm Tracker (FaST)** maps[74]. The **Invasive Species Habitat Tool (INHABIT)** provides an online interactive national map of known and modeled distributions for selected species of interest with risk management information[75]. An inventory of USGS invasive species research to improve detection, awareness, decision support, and control of invasive species is available online[76].

The USGS **National Wildlife Health Center** partners with state, tribal, other federal agencies, and academic institutions to conduct disease surveillance, diagnostic services, and holistic research studies[77]. Wildlife diseases currently monitored and researched by the National Wildlife Heath Center include avian influenza, avian botulism, *Batrachochytrium salamandrivorans* (Bsal), chronic wasting disease, coronaviruses, rabbit hemorrhagic disease, salmonellosis, snake fungal disease, sylvatic plague, toxoplasmosis, trichinosis, West Nile virus, white-nose syndrome, and diseases in ducks, sea turtles, fish, cranes, and coral. The Center facilitates information sharing to quickly identify and mitigate wildlife health issues through the **Wildlife Health Information Sharing Partnership**, or **WHISPers**, event reporting system[78]. An index of wildlife disease information sources, including quarterly monitoring reports on wildlife mortality, is available online[79].

The USGS and EPA collaborated with other federal agencies to develop a web tool that provides a mapped inventory of the presence of microbes in soil, namely the bacterium that causes anthrax (*Bacillus anthracis*) and other *Bacillus* species. The national datasets available include soil physical, chemical, and mineralogical data, historical and current climate data, land cover, and biological surveys. The **Presence of Microbes and the Distribution of Climatic, Environmental, and Geochemical Variables** interactive map is available online[80]. Sampling protocols for bacterial pathogens in surface soil, including *Bacillus anthracis*, are available[81].

The USGS supports the **National Climate Adaptation Science Center** and nine regional centers across the nation[82], including the **Northeast Climate Adaptation Science Center (NE CASC)** within the NEAFWA region based at the University of Massachusetts, Amherst[83] (UMass). The Northeast collaboration with the NE CASC / USGS / UMass consortium includes a team of climatologists, biologists, ecologists, and hydrologists with cutting-edge approaches to address major challenges posed by climate change. The Center's robust scientific contributions have produced valuable tools and information on addressing climate change in the Northeast. One of the most significant contributions was the 2015 **Northeast Climate Change Synthesis** to support the 2015 Northeast SWAP revisions (Staudinger et al. 2015). NECASC has again initiated a project to assist the 2025 SWAP revision process and to update the 2015 Synthesis which will be available in late 2023 (Staudinger et al. 2023, *in prep*).

Collaboration with natural and cultural resource managers in the Northeast has provided the climate change science to help inform fish and wildlife management decision-making and produce actionable products and results including more than 160 research projects and tools to facilitate climate change adaptation strategies for the Northeast as of 2022. A searchable inventory of research projects and assessments prepared by NE CASC is available online[84]. Recent NECASC projects relating to inventorying and monitoring the region's natural resources and the effectiveness of conservation actions include:

- **Science to Inform the Reconnection of Floodplains and Restoration of Green Space to Minimize Risk in the Future**: This project identifies opportunities to manage flows, connections, and landscapes in ways that increase the resilience of human communities and ecosystems. This research identifies dynamic and adaptive solutions to managing river flows that support continuation of valuable infrastructure services (Palmer and Nislow 2019).
- **Small Dam Removal as a Tool for Climate Change Resilience**: Across the United States, millions of small dams fragment the landscape and alter stream ecosystems. This project is evaluating the effectiveness of removal of obsolete dams and related structures as a way to eliminate or reverse the negative impacts on humans and ecosystems[85].
- **Framework for Protecting Aquatic Biodiversity in the Northeast Under Changing Climates**: This project uses an analytical, iterative process to

evaluate aquatic biodiversity protection and management scenarios across four northeastern states (Connecticut, Massachusetts, New Hampshire, and Vermont). It directly integrates climate change and management to identify land protection and restoration actions that optimize aquatic biodiversity protection into the future. Ultimately, the results will help managers to promote aquatic ecosystem health and prioritize climate adaptations[86].

- **Rethinking Lake Management for Invasive Plants Under Future Climate: Sensitivity of Lake Ecosystems to Winter Water Level Drawdowns**: Small lakes are important to local economies as sources of water supply and places of recreation. Commonly, lakes are considered more desirable for recreation if they are free of the thick weedy vegetation, often comprised of invasive species, that grows around the lake edge. This project is evaluating the effectiveness of winter water level drawdowns to control vegetation along lake edges[87].
- **Mapping Salt Marsh Response to Sea Level Rise and Evaluating 'Runneling' as an Adaptation Technique to Inform Wildlife Habitat Management in New England**: Loss of saltmarsh habitat is one of the greatest threats to coastal sustainability in the Northeast. Salt marsh has been identified as an essential fish and wildlife habitat, and loss of saltmarsh corresponds with precipitous declines in marsh-dependent wildlife. This project is testing the effectiveness of runneling, or creating micro-channels, as a management technique to restore saltmarsh[88].
- **Future Aquatic Invaders of the Northeast**: Currently, hundreds of invasive aquatic species occur in the Southeast and the Western US and can potentially move into the Northeast region. This project will help guide future monitoring efforts and bring attention to high-risk areas that could be invaded by southern and western invasive aquatic species[89].
- **Putting the Sampling Design to Work: Enhancing Species Monitoring Programs in the Face of Climate Change**: Established sampling protocols for monitoring wildlife are designed to evaluate the effects of non-climate stressors and related management actions. This project will develop an optimal sampling design that enables monitoring programs to track climate change impacts and provide early indicators for fish and wildlife responses[90].
- **Designing Wabanaki Adaptive Capacity for Climate Change***:* The Wabanaki Tribal Nations and other Tribal Nations of the Northeast face a disproportionate impact from climate change. This project will use Indigenous research methods and programs to build a regional tribal network for climate change adaptation and create a Wabanaki Climate Adaptation and Adaptive Management Workbook[91].

The USGS **Coastal and Marine Hazards and Resources Program** researches and monitors the nation's coastlines, estuaries, and marine environments[92]. In the

Northeast, the regional program office is based at the Woods Hole Coastal and Marine Science Center in Massachusetts, which maintains a repository of geological, geochemical, and biological samples as scientific collections. **The US Coastal Wetland Synthesis** is a national map of unvegetated and vegetated coastal wetlands and adjacent lands for the conterminous United States using satellite imagery from 2014-2018 at 30-meter resolution[93]. Regional wetland syntheses are available for the estuarine coastline from Massachusetts to Virginia on the same platform. Other recent work relevant to SWAPs from the USGS Coastal and Marine Hazards and Resources Program include geospatial modeling to forecast the impacts of sea level rise impacts on barrier island characteristics and habitat availability for nesting shorebirds; monitoring long-term shoreline change in the estuaries of Barnegat and Great Bay, New Jersey; and predicted coastal change at Fire Island, New York, resulting from storms. Detailed information about these projects and others are available through the **Coastal and Marine Geoscience Data System**[94].

The USGS maintains several inventories of the marine environment of the Northeast. The **National Archive of Marine Seismic Surveys** collects and archives data collected by US Department of the Interior agencies, including the USGS and the Bureau of Ocean Energy Management, of the marine seafloor within the federal Exclusive Economic Zone (EEZ). This inventory can be explored (and downloaded) through an online map[95]. **Maps of America's Submerged Lands** are maintained by the USGS, with associated reports and geospatial datasets depicting bathymetry, surficial geology, and/or subsurface structure at various scales[96]. The **Cold-Water Coral Geographic Database** has an inventory of coral records in the Northwest Atlantic and Gulf of Mexico from 1880 to 2008[97].

National shoreline change is monitored by the USGS Coastal and Marine Hazards and Resources Program using historical maps, field measurements, and remote sensing survey techniques. The **Digital Shoreline Analysis System** provides a standardized methodology for monitoring shoreline change. The methodology and datasets created by state and regional applications, including to the coast of Massachusetts, are available online[98].

The rate of global mean sea level rise is measured and monitored by the National Aeronautics and Space Administration (NASA)[99]. The USGS monitors national and regional sea level rise along the US coast, with an **Interactive Guide to Global and Regional Sea Level Rise Scenarios for the US** jointly developed with NOAA in 2017. Detailed information about this project and an interactive map of its datasets are available[100].

The USGS maintains a spatial dataset of mineral resources in the US, including an inventory of known locations and types of mines, in their **Mineral Resources Online** interactive map viewer[101]. The USGS also has spatial data layers of prospect- and mine-related landform features identified on topographic maps, including prospect pits, mine shafts and adits (horizontal mine entry shafts), open-pit mines, quarries, tailings ponds and piles, gravel and borrow pits, and related features (Horton and San Juan 2022). Data layers are available for every state except West Virginia[102]. These datasets include an inventory of historical and active mine and quarry operations, to the extent that they have readily identifiable surface features. The Vermont dataset, for example, includes 1172 prospect- and mine-related features on the landscape, from granite and marble quarries to talc and asbestos mines. Altogether 35,732 mine-related features are identified on the Northeast landscape, excluding West Virginia (see *Chapter 2*, Table 2.8.2).

The USGS inventories and monitors several environmental resources through citizen science projects. **CrowdHydrology** is a USGS public project that began in the Northeast and has since spread across the country to monitor stream levels[103]. Citizen scientists submit water level data from stream gaging staffs or stations to the CrowdHydrology database via text messages. The database is publicly available for researchers, students, resource managers and others to use. The USGS developed the **iPlover** mobile app that collects information about beach and dune habitat and their surrounding environments[104]. The USGS **iCoast** online resource engages the public in annotating aerial photographs taken along the country's coastlines following extreme storms[105]. **Nature's Notebook** tracks seasonal changes in plants and animals across the US in a citizen science project sponsored by the USGS and the **National Phenology Network**[106].

5.1.4 UNITED STATES FOREST SERVICE PROGRAMS

The United States Forest Service (USFS) monitors forest and woodland habitats across the country. The federal agency conducts an annual census of forests and woodlands with its **Forest Inventory and Analysis (FIA) Program**[107]. The program assesses forests and woodlands by collecting data on tree species composition, size and health as well as tree growth, mortality and removals by harvest. There are 6,952 sample points in the FIA dataset within the Northeast region. The US Forest Service also monitors forests and woodlands via remote sensing and has developed a field sampling protocol to pair with remote sensing data to monitor carbon in forests and woodlands[108].

US Forest Service PRISM allows an interactive exploration of key accomplishments of the USFS State and Private Forestry Programs and discover a current assessment of landscape impact[109]. It can be queried by state, region, county, watershed, or congressional district. PRISM presents information in a dashboard format to provide the number and acres of accomplished projects, as well as the number of acres and percentage of priority land impacted. As of January 2023, almost 425 million acres of priority lands were identified nationally with 19.1 million acres impacted with projects, stewardship plans, landscape plans, and other plans.

The USFS **Wildfire Hazard Explorer** portal contains the spatial footprints and associated metadata for known wildfire risk, threat, hazard, and burn probability maps[110]. The project was commissioned by the USFS and National Association of State foresters (NASF) to better catalog the existing wildfire data resources available to states, federal agencies, and private and NGO partners. The site does not house the actual data for the risk / threat / hazard maps, but instead, provides metadata and links to the sources (where available). Users can submit project information to be added to the dataset. The site was designed to be easy to use with simple filters and the ability to search by text or map.

5.1.5 USDA PROGRAMS

The United States Department of Agriculture (USDA) offers several national monitoring programs and projects informative for Northeast SWAPs. The **Animal and Plant Health Inspection Service (APHIS)** of the USDA, for example, conducts animal disease surveillance of both wildlife and agricultural and aquacultural animals through the **National Animal Health Monitoring System** and the **Animal Health Surveillance System**[111]. The APHIS **Plant Protection and Quarantine Program** protects the nation's natural and agricultural resources from the entry, establishment, and spread of environmentally and economically significant pests through detection and monitoring programs for pests[112]. The National Veterinary Services Laboratories monitors animal diseases, offers diagnostic services, and hosts an international reference library for animal diseases of importance to the Americas[113]. The APHIS Wildlife Services program operates the **National Wildlife Research Center**, which conducts research and develops techniques for managing wildlife damage, nuisance and pest animals, invasive species, wildlife disease, overabundant wildlife, and other issues affecting ecosystem health[114]. The National Wildlife Research Center maintains a regional Field Station in Philadelphia, Pennsylvania.

The USDA maintains the **Plant List of Attributes, Names, Taxonomy, and Symbols (PLANTS) Database**[115]. This inventory provides a standardized information about the vascular plants, liverworts, mosses, lichens, and hornworts of the US and its territories. The **2020 National Wetland Plant List** identifies wetland indicator species (8000+) and is included in the PLANTS Database with species profile pages, searchable by region[116]. The PLANTS Database website now includes related resources and tools for pollinators, ecosystem dynamics, plant identification keys, culturally significant plants, invasive and noxious weeds, federally and state-listed plants, and technical publications from the Plant Materials Program. The Natural Resources Conservation Service maintains state plant lists available online[117].

The **National Invasive Species Information Center** is within the USDA, providing invasive species information from local, state, federal, and international sources[118]. The Center maintains an **Invasive Species Profiles List** for aquatic and terrestrial species declared as invasive, noxious, prohibited, or otherwise harmful or potentially harmful in the United States[119]. Species profiles include taxonomy, imagery, native range, the date of introduction to the US, how it was introduced, current known distribution, and the location of any quarantine areas.

The USDA National Agricultural Statistics Service monitors agricultural lands with **CropScape**, an interactive online mapping tool and associated data layer of cropland across the country[120]. Datasets are available for every year starting from 1997 and distinguish croplands by type (e.g., corn, cotton, rice, soybeans), pasture, wetlands, forest, developed, and other land cover types.

The National Statistics Service conducts a **Census of Agriculture**[121] every five years that is a complete count of all farms and ranches in the country, with the most recent census underway in 2022. A series of atlas maps illustrate the data from the Census of Agriculture and are publicly available. Census of Agriculture data are available by state, county, tribal reservation, watershed and zip code.

The USDA conducts regular monitoring assessments and evaluations of the agency's programs and initiatives, such as bird conservation benefits from the Conservation Reserve Program, the benefits of prairie strips and saturated buffers, Chesapeake Bay benefits from Conservation Reserve Enhancement Program, water quality and quantity studies, pollinator studies, and other wildlife studies (e.g., Northern Bobwhite, grassland birds, amphibians). Monitoring, assessment and evaluation reports related to wildlife benefits are available online[122].

5.1.6 NOAA PROGRAMS

The National Oceanic and Atmospheric Administration (NOAA) has been monitoring the marine ecosystem of the Northeast for more than 40 years[123]. Multiple programs and projects within this federal agency monitor aspects of the marine habitats and their species in the Northeast. The **Marine Mammal Health and Stranding Response Program** coordinates emergency responses to injured, distressed, sick, or dead marine mammals[124]. The program maintains a network of volunteer, local, tribal, state, and federal agencies responding to marine mammal strandings and entanglements, with reported data collected in the **National Stranding Database**[125]. The **Greater Atlantic Marine Mammal Stranding Network** provides a consistent framework for monitoring and responding to marine mammal strandings and entanglements in the NEAFWA region. The Marine Mammal Health and Stranding Response Program conducts biosurveillance and baseline health research on marine mammals, maintaining a **National Marine Mammal Tissue Bank** with standardized protocols and techniques for the long-term storage of samples for retrospective analyses[126].

The **Sea Turtle Stranding and Salvage Network** similarly monitors and responds to sea turtle strandings[127]. Sea turtle standardized and verified stranding data are available in an online database[128].

NOAA Fisheries monitors recreational and commercial fishing in the marine system, including for several species that are RSGCN or Watchlist species in the Northeast. The NOAA **Northeast Fisheries Science Center (NEFSC)** conducts several ecosystem surveys in the Marine Nearshore of the region, including a database of biannual fisheries-independent bottom trawl surveys, from the 1960s to present[129]. The NEFCS **Marine Resources Monitoring, Assessment and Prediction Program (MARMAP)** conducted periodic standardized surveys of the Northeast Marine Nearshore and Marine Offshore and Oceanic areas at 193 stations from Cape Sable, Nova Scotia, to Cape Hatteras, North Carolina from 1977 to 1988. Since 1992 portions of the MARMAP survey design were continued with the **Ecosystem Monitoring Program (EcoMon)** for long-term monitoring at 120 stations[130].

NOAA also maintains a **Digital Coast** resource that provides data, tools and training resources for addressing coastal issues, including data and maps for land cover, sea level rise, elevation, hurricanes, coastal flooding, imagery, socioeconomics, weather and climate, marine habitat and species, ocean uses and planning areas, water quality, infrastructure, oceanography and more[131]. NOAA monitoring data on environmental conditions, marine habitat, and biological resources are publicly available through the **National Centers for Environmental Information** at https://www.ncei.noaa.gov/. The NOAA **Tides and Currents** data portal includes local water levels, tide and current predictions, and other oceanographic and meteorological conditions, which is searchable by monitoring station, city, state or zip code[132]. These monitoring datasets include both real-time observational data and historical data.

Other seascape level monitoring programs supported by NOAA address particular threats or species. For example, NOAA maintains the **Invasive Lionfish Web Portal** to monitor the spread of invasive Lionfish (*Pterois volitans*) in the Atlantic Ocean and Gulf of Mexico[133]. The **National Centers for Coastal Ocean Science** at NOAA monitors eutrophication levels in the nation's estuaries as part of the periodic **National Estuarine Eutrophication Assessment**, but the frequency of the assessment is dependent on the availability of funding[134]. NOAA maintains the **National Deep-Sea Corals and Sponges Database**, with a digital map of deep-sea coral and sponge locations, site characterization reports, and habitat suitability models[135]. The **Deep-sea**

Coral National Observation Database for the Northeast Region is publicly available[136].

The NOAA **Ocean Acidification Program** operates a national monitoring program with vessel surveys, stationary buoys and moorings, and wave gliders that measure a number of physical and oceanographic indicators of coastal and marine system health and acidification levels[137]. The primary goal of this national monitoring program is to measure and understand the exposure and effects of ocean acidification on marine resources like shellfish and coral. The NOAA Ocean Acidification Program operates 19 monitoring buoys across the world's oceans, one of which is located in the Gulf of Maine within the NEAFWA region. Research ship surveys monitor temperature, salinity, conductivity, depth and other indicator metrics at multiple depths along designated survey routes every five years, contributing to the **Global Ocean Acidification Network**[138]. The monitoring program also collects data on Ships of Opportunity and Volunteer Observing Ships (e.g., commercial cargo ships, ferries), which are at sea for other research or monitoring purposes but provide an opportunity to collect ocean acidification data.

Several research and monitoring projects supported by the NOAA Ocean Acidification Program are currently underway in the Northeast to assess the threat and impacts of ocean acidification on coastal and marine systems[139]:

- The **Low pH in Coastal Waters of the Gulf of Maine: A Data Synthesis-driven Investigation of Probable Sources, Patterns and Processes Involved** project synthesized decades of monitoring data on unusually high acidic conditions in the subsurface waters of Maine's estuaries.
- The **Interactions Between Ocean Acidification and Metal Contaminant Uptake by Blue Mussels (*Mytilis edulis*)** project includes ten research locations in the NEAFWA region to understand how changing ocean acidification conditions affect the accumulation and toxicity of metals, with potential implications for seafood safety and aquaculture.
- The **Assessing Vulnerability of the Atlantic Sea Scallop Social-Ecological System in the Northeast Waters of the United States** project is refining previous assessments that the biomass of Atlantic Sea Scallop (*Placopecten magellanicus*), may decline by more than 50% by the end of the century, informing fishery management of this Northeast RSGCN species of High Concern.
- The **Optimizing Ocean Acidification Observation for Model Parameterization in the Coupled Slope Water System of the U.S. Northeast Large Marine Ecosystem** project seeks to improve understanding of the region's greater susceptibility to ocean acidification in the Gulf of Maine and Mid-Atlantic regions by adding seasonal deployments of underwater gliders

with new sensor technologies, optimizing the location of monitoring stations, and integrating existing ocean acidification datasets.

- The **Assessment of the Observing Network to Identify Processes Relevant to the Predictability of the Coastal Ocean of the Northeast on Centennial Time Scales** project is evaluating the factors influencing the difference between the global and regional acidification rates, evaluating the existing monitoring network's ability to detect changes in ocean acidification rates in the Northeast region and corresponding stressors on the RSGCN Atlantic Sea Scallop.
- The **Ocean and Coastal Acidification Thresholds from Long Island Sound to the Nova Scotian Shelf** project is assessing how the Northeast's nearshore and coastal ecosystems will respond to ocean and coastal acidification and how those changes will impact human communities by expanding the Northeast Coastal Ocean Forecast System to develop actionable guidance for coastal water quality and marine resource managers.
- The **Strategy for Ocean and Coastal Acidification Education and Citizen Science Monitoring in the Northeast** project is calibrating citizen science monitoring protocols and training for ocean acidification with those of independent organizations in accordance with the Environmental Protection Agency's recent **Guidelines for Measuring Changes in Seawater pH and Associated Carbonate Chemistry in Coastal Environments of the Eastern United States**.
- The **Tracking Ocean Alkalinity using New Carbon Measurement Technologies** is expanding the quantity and quality of ocean acidification monitoring by installing new monitoring sensors on the **Northeastern Regional Association of Coastal Ocean Observing Systems** monitoring network.
- The **Interactions Between Ocean Acidification and Eutrophication in Estuaries: Modeling Opportunities and Limitations for Shellfish Restoration** project is integrating existing monitoring and experimental work with biogeochemical model frameworks to delineate the drivers of acidification in Chesapeake Bay, develop a spatial framework to identify shellfish restoration areas the most and least prone to impacts of acidification, and improve understanding of future environmental conditions for shellfish restoration.
- The **Sensitivity of Larval and Juvenile Sand Lance (*Ammodytes dubius*) on Stellwagen Bank to Predicted Ocean Warming, Acidification, and Deoxygenation** project is quantifying the sensitivity of this Northeast Watchlist [Interdependent] species to the individual and interactive effects of ocean warming, acidification, and deoxygenation.

- The **Probing Molecular Determinants of Bivalve Resilience to Ocean Acidification** project is assessing the resilience of the Blue Mussel and two Northeast Watchlist [Assessment Priority] species - Eastern Oyster (*Crassostrea virginica*), Northeast Hard Clam (*Mercenaria mercenaria*) - to ocean acidification.
- The **Genetic and Phenotypic Response of Larval American Lobster to Ocean Warming and Acidification Across New England's Steep Thermal Gradient** project will fill knowledge gaps regarding the sensitivity and resilience of American Lobster (*Homarus americanus*), a Northeast RSGCN of High Concern, to ocean acidification.
- The **Synthesis and Understanding of Ocean Acidification Biological Effects Data by Use of Attribute-Specific, Individual-Based Models** project seeks to identify the potential or realized effects of ocean acidification on Winter Flounder (*Pseudopleuronectes americanus*), a Northeast RSGCN of High Concern.
- The **Monitoring of Water Column Dissolved Inorganic Carbon, Total Alkalinity and pH on the Northeast U.S. Shelf and the Development of Ocean Acidification Indicators to Inform Marine Resource Managers** project expands the four annual ecosystem monitoring cruises of the Northeast Fisheries Science Center to include sampling for ocean acidification indicators.

These research and monitoring projects inform the needs of multiple Northeast RSGCN and Watchlist species, inform understanding of their threats from climate change, and allow for long-term monitoring of these effects of climate change at the regional and national scale.

5.2 REGIONAL INVENTORY AND MONITORING PROGRAMS

The Northeast states of NEAFWA participate in several regional, national, and international inventory and monitoring programs. These collaborative partnerships advance the conservation of RSGCN and Watchlist species and their habitats within the region and beyond, oftentimes addressing life cycle needs more wholistically. Monitoring partnerships that are species-based are discussed in *Chapter 1* under specific taxonomic groups, that are habitat-based are discussed in *Chapter 2* under specific habitat types, and that are threat-based are discussed in *Chapter 3* under specific threat types. The following regional partnerships are multi-taxa and/or landscape or seascape scale programs.

5.2.1 NORTHEAST MONITORING AND PERFORMANCE REPORTING FRAMEWORK

Monitoring the Conservation of Fish and Wildlife in the Northeast: A Report on the Monitoring and Performance Reporting Framework for the Northeast Association of Fish and Wildlife Agencies identifies a regional monitoring framework for the status of SGCN and their habitats and the effectiveness of conservation projects implemented as part of SWAPs and the State Wildlife Grants program (NEAFWA 2008). The monitoring framework includes eight conservation targets:

1. Forests
2. Freshwater streams and river systems
3. Freshwater wetlands
4. Highly migratory species
5. Lakes and ponds
6. Managed grasslands and shrublands
7. Regionally significant SGCN
8. Unique habitats in the Northeast

The monitoring framework report noted at the time that additional work was needed to include coastal and marine systems in the framework, which focused limited time and resources on terrestrial and freshwater systems. Specific indicators and stressors are identified for monitoring to assess each of the eight conservation targets, with the exception of the managed grasslands and shrublands target where information was lacking (Table 5.2.1).

The Nature Conservancy assessed these eight conservation targets as part of the **Conservation Status of Fish, Wildlife, and Natural Habitats in the Northeast Landscape: Implementation of the Northeast Monitoring Framework** (Anderson and Sheldon 2011). The Nature Conservancy updated this condition assessment in 2023 with new information and analysis tools (Anderson et al. 2023), with the exception of the RSGCN conservation target which is addressed in *Chapter 1* of this Regional Conservation Synthesis instead. *Chapter 2* of this Regional Conservation Synthesis supplements the 2023 condition assessment by addressing the need to assess the status and condition of the region's coastal and marine systems not currently included in the monitoring framework.

The updated condition assessment identifies trends in the conservation targets and indicators over the past decade, but also incorporates new data resources to identify long-term trends across multiple decades (Anderson et al. 2023). By utilizing standardized techniques and datasets, the Northeast Monitoring and Performance

Reporting Framework provides a consistent and regional assessment of priority species and their habitats for landscape level collaboration and the regional context in SWAPs.

Table 5.2. 1 List of conservation targets and proposed indicators in the Monitoring and Performance Reporting Framework for the Northeast Association of Fish and Wildlife Agencies (NEAFWA 2008).

Targets	Recommended Indicators
1. Forests	1a. Forest area - by forest type
	1b. Forest area - by reserve status
	2. Forest composition and structure - by seral stage
	3. Forest fragmentation index
	4. Forest bird population trends
	5. Acid deposition index
2. Freshwater streams and river systems	1. % impervious surface
	2. Distribution and population status of native Eastern brook trout
	3. Stream connectivity (length of open river) and number of blockages
	4. Index of biotic integrity
	5. Distribution and population status of non-indigenous aquatic species
3. Freshwater wetlands	1. Size/area of freshwater wetlands
	2. % impervious surface flow
	3. Buffer area and condition (buffer index)
	4a. Hydrology - upstream surface water retention
	4b. Hydrology - high and low stream
	5. Wetland bird population trends
	6. Road density
4. Highly migratory species	1. Migratory raptor population index
	2. Shorebird abundance
	3. Bat population trends
	4. Abundance of diadromous fish (indicator still under development)
	5. Presence of monarch butterfly
5. Lakes and ponds	1. % impervious surface/landscape integrity
	2. % shoreline developed (shoreline integrity)

Targets	Recommended Indicators
	3. Overall Productivity of Common Loons
6. Managed grasslands and shrublands	To be developed
7. Regionally Significant Species of Greatest Conservation Need	1. Population trends and reproductive productivity of federally listed species
	2. State-listing status and heritage rank of highly imperiled wildlife
	3. Population trends of endemic species
8. Unique habitats in the Northeast	1. Proximity to human activity/roads
	2. Wildlife presence/absence
	3. Wildlife population trends
	4. Land use/land cover changes

5.2.2 THE MOTUS WILDLIFE TRACKING SYSTEM

The **Motus Wildlife Tracking System** network is an international program that uses nanotag technology to track and monitor migratory wildlife via telemetry receiver stations at the landscape scale, targeting species that are too small for satellite tracking equipment. As of 2022, there were more than 1550 Motus receiver stations located in 34 countries on five continents[140]. More than 300 species (with more than 36,500 individuals) have been tagged as part of 573 projects. Nearly 1700 partners collaborate as part of the international Motus network.

In the eastern United States, the network was initially developed to monitor shorebirds, seabirds, and coastally migrating songbirds, with most of the array located in coastal areas and along the Great Lakes shorelines. Since 2017, the **Northeast Motus Collaboration** has expanded the array throughout the interior Northeast, filling a geographic gap along a key migratory route in the western hemisphere[141]. More than 470 Motus stations exist in the NEAFWA region as of 2022, the densest concentration of receiver stations in the world. Wildlife that is tracked in the Northeast with the Motus network includes songbirds, seabirds, raptors, bats, bumble bees, Monarch butterfly (*Danaus plexippus plexippus*), and migratory dragonflies. A Motus project in Tennessee tracked the movements of the RSGCN Bog Turtle (*Glyptemys muhlenbergii*).

The Northeast Motus Collaboration has been supported by three competitive State Wildlife Grants (CSWG) projects[141]:

- (2018) **Motus I: Overcoming Geographic and Temporal Barriers to Identifying Landscape-scale Habitat Use of Multiple SGCN in the Mid-Atlantic Region Using Nanotag Technology** [Birds, Mammals (bats); lead state Pennsylvania]
- (2019) **Motus II: Using Nanotag Technology to Identify Landscape-scale Habitat Use of Multiple SGCN in New England** [Birds, Insects (Monarch); lead state New Hampshire]
- (2022) **Motus III: Identifying SGCN habitat use across multiple scales throughout the eastern U.S. using the Motus Wildlife Tracking System** [Birds, Mammals (bats), Reptiles (Bog Turtle); lead state Alabama, funded efforts in Pennsylvania and Vermont]

Recent Motus projects in the Northeast have tracked and monitored the movements of RSGCN Wood Thrush (*Hylocichla mustelina*), Bicknell's Thrush (*Catharus bicknelli*), Rusty Blackbird (*Euphagus carolinus*), American Woodcock (*Scolopax minor*), Northern Long-eared Bat (*Myotis septentrionalis*), and Watchlist [Assessment Priority] species Peregrine Falcon (*Falco peregrinus anatum*)[142].

The Motus network can identify migratory routes, stopover sites, and wintering areas of migratory species as well as inform habitat use, phenology, and hazards such as window collisions. Numerous Motus studies have monitored the movements of RSGCN and Watchlist species at the hemispheric scale[143].

5.2.3 GREAT LAKES OBSERVATION SYSTEMS

The Great Lakes have multiple monitoring and research programs and partnerships. The **Great Lakes Observing System (GLOS)**, part of the national **Integrated Ocean Observing System**, maintains a network of observational monitoring stations and projects across the Great Lakes and their watersheds[144]. Data collected include physical, biogeochemical, and biological data, including a number of metrics relevant to State Wildlife Action Plans regarding species, habitats, and threats. Much of the data is real-time from observation platforms and models are used to generate short-term and long-term projections on a number of indicators. Monitoring data are shared publicly and free on the Seagull and GLOS apps, including lake temperature, waves and currents, and water quality parameters. The Seagull information sharing platform was launched in 2022 in support of the **Smart Great Lakes Initiative**, which intends to improve understanding, conservation, use, and management of the Great Lakes in both the United States and Canada through the use of advanced technology applications[145]. Another priority of GLOS is to complete mapping of the entire lakebed with high-resolution bathymetric surveys, which is currently only 15% mapped, by 2030.

The **Great Lakes Acoustic Telemetry Observation System (GLATOS)** is a monitoring network of receiver stations on the lakebeds of the Great Lakes that tracks tagged fish using acoustic telemetry[146]. Established by the Great Lakes Fishery Commission with funding from the **Great Lakes Restoration Initiative**[147] in 2010, GLATOS is a collaborative monitoring and research program that includes Canadian and American partners. Participating researchers represent state, provincial and federal agencies, universities, and tribal nations. Data are shared within the GLATOS project membership in accordance with individual partners' data sharing policies.

As of 2022, GLATOS receiver stations were present throughout Lake Champlain, Lake Ontario, Lake Erie, and portions of the St. Lawrence Seaway, Niagara River, and several Great Lakes tributaries in New York within the Northeast region. Recent projects that monitored the movements and habitat use of Northeast RSGCN and Watchlist species include Lake Trout (*Salvelinus namaycush*), Lake Sturgeon (*Acipenser fulvescens*), American Eel (*Anguilla rostrata*), Lake Whitefish (*Coregonus clupeaformis*), and Burbot (*Lota lota*). A directory of GLATOS research and monitoring projects with detailed information about each is available online[148].

GLATOS is the Great Lakes node within the global **Ocean Tracking Network**[149]. The Ocean Tracking Network is an aquatic animal tracking, technology, data management, and partnership platform that as of 2022 has been implemented to track over 300 endangered, keystone, and commercially important species through nearly 2500 acoustic receivers across five oceans. Based out of Dalhousie University in Canada, this global network has allowed seascape level monitoring of marine fish, sharks, sea turtles, and marine mammals, including the RSGCN White Shark (*Carcharodon carcharias*), Porbeagle (*Lamna nasus*), Blue Shark (*Prionace glauca*), Atlantic Salmon (*Salmo salar* pop. 5), American Eel, Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*), and Leatherback Sea Turtle (*Dermochelys coriacea*). Research informed by the use of the Ocean Tracking Network includes species distribution, habitat use, seasonal movements, spawning behavior, species interactions, and assessing the impacts of climate change. Detailed information about these global ocean projects is available online[150].

5.2.4 GREAT LAKES RESTORATION INITIATIVE

The **Great Lakes Restoration Initiative (GLRI)** monitors several performance measures for conservation projects funded by the program[147]. The current 2020-2024 GLRI Action Plan has five focus areas (GLRI 2019):

- Toxic substances and areas of concern
- Invasive species
- Nonpoint source pollution impacts on nearshore health

- Habitats and species
- Foundations for future restoration actions

Each focus area has targets and objectives which are monitored as performance measures, many of which address the effectiveness of management actions. Monitoring indicators relevant to species, habitats, and threats assessed in Northeast SWAPs include:

- Acres of coastal wetland, nearshore and other habitats protected, restored, or enhanced
- Miles of connectivity established for aquatic species
- Miles of Great Lakes shorelines and riparian corridors restored or protected
- Acreage of aquatic and terrestrial habitats controlled for invasive species
- Estimated pounds of phosphorus reductions from implementation of conservation practices throughout Great Lakes watersheds
- Acres of land receiving financial or technical assistance for nutrient management in priority watersheds
- Estimated gallons of untreated stormwater runoff captured or treated
- Number of discrete chemical monitoring and assessment activities conducted to fill data gaps on "chemicals of mutual concern" identified in the Great Lakes Water Quality Agreement between the United States and Canada
- Number of species benefited where actions have been completed to significantly protect or promote population recovery of state, tribal, and Great Lakes native species of importance (including fish, birds, mussels, snails, Lepidoptera, mammals, bumble bees, and plants)
- Number of youth impacted through education and stewardship projects

The GLRI provides annual results on these monitored measures of conservation progress[151]. Through Fiscal Year 2021, cumulatively project partners have:

- protected, restored, or enhanced more than 479,000 acres of habitat, including 65,000+ acres of coastal wetlands,
- improved aquatic connectivity on more than 6700 river miles,
- protected or restored 43.6 miles of Great Lakes shoreline or riparian corridors,
- conducted invasive species control activities on more than 216,000 acres,
- provided technical and financial assistance for nutrient management on over 1.8 million acres of Great Lakes watersheds,
- reduced more than 2 million pounds of phosphorous loads in priority watersheds,
- captured more than 413 million gallons of untreated urban runoff annually,

- salvaged 53 Piping Plover eggs from historically high flooding in 2020, successfully incubating and hatching 85% of the eggs and releasing 39 captively reared chicks,
- conducted education and stewardship projects with more than 627,000 youth.

5.2.5 CHESAPEAKE BAY WATERSHED

Multiple partners in the **Chesapeake Bay Program**[152] monitor conservation efforts, species status, and habitat conditions in the estuary and its watershed. Monitoring information is collated and provided to oversight partners and the public through **Chesapeake Progress**[153]. More than two dozen indicators track progress on meeting the goals and outcomes of the **Chesapeake Bay Watershed Agreement** among six states and the District of Columbia[154]:

- *Vital habitats*
  - Black Duck (*Anas rubripes*) population [a Northeast RSGCN]
  - Area of headwater streams occupied by wild populations of Brook Trout (*Salvelinus fontinalis*) [the wild population is a Northeast Watchlist Assessment Priority species]
  - Length of rivers and streams habitat with restored fish passage
  - Length of riparian forest buffers restored and protected
  - Length of rivers and streams with improved stream health above 2008 baseline, as measured by the Chesapeake Basin-wide Index if Biotic Integrity
  - Area of submerged aquatic vegetation (SAV) habitat in the estuary
  - Increase in urban tree canopy area
  - Area of tidal and non-tidal wetlands restored or created
- *Sustainable fisheries*
  - Blue Crab (*Callinectes sapidus*) abundance [a Northeast Watchlist Assessment Priority species]
  - Fish habitat – identify and track key habitat areas
  - Forage fish – track abundance of key invertebrates and factors influencing the abundance of forage
  - Protect and restore Oyster (*Crassostrea virginica*) populations and habitats [a Northeast Watchlist Assessment Priority species]
- *Water quality*
  - Number of pollution best management practices (BMPs) and controls identified in the 2025 Watershed Implementation Plans of participating states implemented
  - Attainment of water quality standards for Chesapeake Bay Total Maximum Daily Loads

- *Toxic contaminants*
  - Identify and characterize the occurrence, concentrations, sources, and effects of mercury, polychlorinated biphenyls (PCBs), and other contaminants of emerging and widespread concern; identify stormwater BMPs that may reduce toxic contaminants as well as reducing nutrient and sediment pollution through pollutant removal efficiency studies
  - Number of impaired waters for toxic contaminants under Section 303(d) of the Clean Water Act
- *Healthy watersheds* – proportion of state-identified healthy waters and watersheds retaining healthy status
- *Land conservation*
  - Develop methodology and indicator metrics to measure the rate of farmland, forest, and wetland conversion; extent and rate of change in impervious surface cover per capita; and quantify potential impacts of land conversion on water quality
  - Local adoption of the Conservation Land-Use Policy Toolkit and associated resources to slow the conversion of forests, wetlands, and agricultural lands by incentivizing conservation and dis-incentivizing development
  - Acres of protected lands throughout the watershed
- *Public access* – number of new sites developed
- *Environmental literacy*
  - Degree of environmental literacy preparedness among school districts as measured by the Environmental Literacy Indicator Tool
  - Proportion of schools providing at least one Meaningful Watershed Educational Experience to school students in elementary, middle, and high schools
  - Number of schools identified as sustainable through reducing the impact of their buildings and grounds on their local watershed, environment, and human health through best practices, including student-led protection and restoration projects
- *Stewardship*
  - Improvement of the Stewardship Index of watershed residents, which measures personal actions, volunteering, and advocating of individuals
  - Improvement of the diversity of Chesapeake Bay Program participants and leaders
  - Number of local government elected officials and staff reached for engagement and education of restoration and protection issues related to the estuary and number of local governments participating in restoration activities

- *Climate resiliency*
    - Number of climate adaptation and resiliency projects identified and implemented
    - Climate change indicators developed, monitored, and assessed to prioritize conservation efforts and resources

Detailed information on recent progress and the future outlook (i.e., completed, on course, uncertain, off course) of each of these performance measures is available, including discussions of factors influencing progress[155]. The Chesapeake Bay Program performs an annual review of the watershed's environmental health and restoration, called the **Bay Barometer**, that summarizes the status of these indicators[156].

The Chesapeake Bay Foundation also monitors efforts to conserve the estuary and its watershed, releasing **State of the Bay** reports every two years. The most recent monitoring report was issued in late 2022, the **State of the Bay 2022** (Chesapeake Bay Foundation 2022). Thirteen indicators are monitored for pollution, habitat, and fisheries:

- *Pollution*
    - Nitrogen
    - Phosphorus
    - Dissolved oxygen
    - Water clarity
    - Toxics Release Inventory chemical pollution levels
- *Habitat*
    - Forest buffers
    - Wetlands
    - Underwater grasses
    - Resource land conversion
- *Fisheries*
    - Rockfish (Striped Bass [*Morone saxatilis*], a Northeast Watchlist Assessment Priority species)
    - Oysters (a Northeast Watchlist Assessment Priority species)
    - Blue Crabs (a Northeast Watchlist Assessment Priority species))
    - Shad (both Hickory Shad [*Alosa mediocris*] and American Shad [*Alosa sapidissima*] are Northeast RSGCN species)

Each indicator is given a score compared to pre-Colonial conditions, based on available monitoring data and field observations. A report card for the Chesapeake Bay averages the scores of the three indicator categories which are translated into letter grades for communication purposes. The organization's report card issued a health index score of 32 out of 100 for 2022, equivalent to a D+ letter grade and unchanged from the previous assessment. Failing grades, or the poorest indicators, were nitrogen, water clarity, oysters and shad. A health index score of 50 is considered stable and 70 is considered "saved."

The Chesapeake Bay Foundation also monitors progress of meeting the goals and objectives of the Chesapeake Bay Watershed Agreement, releasing a **2022 Chesapeake Bay State of the Blueprint**[157] monitoring report in late 2022. Although monitoring indicates a 42% reduction in nitrogen pollution levels and 64% in phosphorous since 2010, the organization found overall efforts are not on track to meet 2025 pollution reduction targets.

5.2.6 DELAWARE RIVER WATERSHED

The **Delaware River Basin Commission** is a partnership between the states of New York, New Jersey, Pennsylvania, and Delaware and federal agencies to protect the Delaware River watershed and estuary with both regulatory and non-regulatory programs and initiatives[158]. The Commission collates monitoring reports, surveys, and research findings, particularly on water quality[159]. Every two years the Delaware River Basin Commission compiles a **Delaware River and Bay Water Quality Assessment** for the EPA, which includes four surface water quality monitoring programs on the non-tidal and tidal portions of the river, plus chronic toxicity monitoring in the estuary and macroinvertebrate monitoring in the non-tidal portion of the river[160]. The biennial assessment supplements Commission monitoring data with monitoring program data from each of the four participating states, the United States Geological Survey, National Oceanic and Atmospheric Administration, and Environmental Protection Agency.

The **Delaware River Watershed Initiative** also conducts monitoring throughout the watershed of this Big River[161]. This Initiative of more than 50 organizations and academic institutions works to conserve the terrestrial and aquatic resources of the watershed across four states. The partnership's monitoring program intends to detect incremental changes in the health of the basin's waters through the collaboration of research teams, conservation partners, and citizen scientists. Monitoring data is then incorporated into modeling efforts to evaluate the effectiveness of on-the-ground conservation projects.

The **Stroud Water Research Center** is a lead partner in the Delaware River Watershed Initiative's monitoring and modeling efforts[162]. The Center and other Initiative partners have numerous continuous water quality monitoring stations throughout the Delaware River watershed and provide support to citizen scientists and local community partner organizations to install and maintain monitoring stations for both water quality and aquatic macroinvertebrates. Monitoring data is collected and available through the online **Monitor My Watershed** platform[163]. The monitoring data collated on Monitor My Watershed is incorporated into **Model My Watershed**, an interactive online mapping and analysis tool that provides collated data for the upstream catchment of any point or shape drawn on the map[164]. Data provided in this application include medium and high-resolution stream networks, land use / land cover from the most recent National Land Cover Dataset (NLCD), soils, terrain, climate, point sources of pollution, the number and types of farm animals present, and multiple water quality parameters. Models are available for stormwater runoff during storm events, water quality over time, and the potential effects of different conservation and development scenarios. The Model My Watershed datasets and analyses are the most comprehensive for the Delaware River basin, but some of the datasets are national in extent.

5.2.7 LONG ISLAND SOUND

The **Long Island Sound Study**[165], a National Estuary Program with multiple state and federal partners, monitors several indicators as part of its **Comprehensive Conservation and Management Plan for Long Island Sound**. Ecosystem Indicators that measure the health of the estuary and measure performance to achieve Ecosystem Targets include[166]:

- Extent of hypoxia
- Duration of hypoxia
- Severely hypoxic and anoxic areas
- Nitrogen loads
- Water clarity
- Extent of impervious cover
- Extent of riparian buffers
- Area of approved shellfish areas
- Sediment quality index
- Industrial chemical discharges
- Water quality index
- Extent of coastal habitat
- Eelgrass abundance
- Acres of tidal wetlands restored
- Miles of river restored for fish passage
- Shellfish harvested
- Habitat connectivity restored
- Area of open space protected
- Changes in forest cover in New York and Connecticut

- Index of anadromous fish runs
- Counts of river herring and shad in tributaries with completed fishway projects [Alewife (*Alosa pseudoharengus*), Blueback Herring (*A. aestivalis*), American Shad (*A. sapidissima*), and Hickory Shad (*A. mediocris*) are Northeast RSGCN]
- Horseshoe Crab (*Limulus polyphemus*) abundance [a Northeast RSGCN]
- American Lobster (*Homarus americanus*) abundance [a Northeast RSGCN]
- Forage fish abundance (14 species, including Northeast RSGCN Bluefish [*Pomatomus saltatrix*], Weakfish [*Cynoscion regalis*], and Blueback Herring) in open water and along the New York and Connecticut coastlines
- Invertebrate biomass index (15 species, including Northeast RSGCN Horseshoe Crab and American Lobster, plus Northeast Watchlist Assessment Priority species Blue Crab [*Callinectes sapidus*], Knobbed Whelk [*Busycon carica*], Channeled Whelk [*Busycotypus canaliculatus*], and Eastern Oyster)
- Game fish abundance (eight species, including Northeast RSGCN Black Sea Bass [*Centropristis striata*], Bluefish, Tautog [*Tautoga onitis*], Weakfish, and Winter Flounder [*Pseudopleuronectes americanus*], plus Northeast Watchlist Assessment Priority species Striped Bass [*Morone saxatilis*])
- River herring abundance (American Shad, Blueback Herring – both Northeast RGCN)
- Least Tern (*Sternula antillarum*) abundance [a Northeast RSGCN]
- Piping Plover (*Charadrius melodus*) abundance [a Northeast RSGCN]
- Number of beach day closures due to water quality impairments
- Pounds of marine debris collected annually
- Number of public access points to the Sound and its tributary rivers
- Number of federal navigation channels maintained in a sustainable manner in accordance with the Long Island Sound Dredged Material Management Plan
- Human population in the watershed and within 50 miles of the Sound
- Number of volunteers at coastal cleanups
- Number of coastal municipalities with plans for shoreline resiliency and infrastructure sustainability and resiliency

The **Long Island Sound Water Quality Monitoring Program** is conducted by the state of Connecticut and the Interstate Environmental Commission, collecting water quality data in both surface and bottom waters of the estuary[167]. Monitoring indicators include water temperature, salinity, dissolved oxygen, particulate nitrogen, and dissolved nitrogen, which is collected both by research vessels (monthly from October to May plus bi-weekly hypoxia surveys from June to September) and continuously on monitoring station buoys throughout the estuary. The **Unified Water Study** monitoring protocol enables citizen scientists and community organizations to collect and contribute water quality data to the Long Island Sound Study monitoring program[168].

The **Long Island Sound Study Climate Change and Sentinel Monitoring Program**[169] is a part of the **Integrated Sentinel Monitoring Network** (see next Section). This research and monitoring program includes several climate change indicators in the estuary and its watershed[170]:

- Frequency of heavy precipitation events that exceed normal frequency
- Length of growing season
- Timing and temperature of the spring freshet on the Connecticut River
- Sea level rise
- Water temperature
- Species richness index of Warm Water Fish (38 species) to Cold Water Fish (33 species) annually

Monitoring data collected as part of the Long Island Sound Study Climate Change and Sentinel Monitoring Program are available at the **Sentinel Monitoring Data Citation Clearinghouse**[171]. As of 2019 more than 2000 acres of habitat, including forest and tidal wetlands, have been restored in the Long Island Sound watershed in New York and Connecticut as part of the Long Island Sound Study program, as has more than 400 miles of river connectivity for anadromous fish passage.

5.2.8 MARINE SEASCAPE

The North Atlantic Ocean is home to numerous regional monitoring partnerships and programs that can inform Northeast State Wildlife Action Plans and offer opportunities for implementation of the plans. These research, inventory, and monitoring programs and projects inform not only coastal and marine species (*Chapter 1*) and coastal and marine habitat status and condition (*Chapter 2*) but also the regional priority threats of pollution, climate change, development, natural system modifications, invasive and problematic species and disease, and biological resource use described in *Chapter 3*, as well as the threats of transportation (both terrestrial and maritime), renewable energy development, and mining (of seafloor sediments).

The NEAFWA region includes three of the 11 regional authorities within the national **Integrated Ocean Observing System: Northeastern Regional Association of Coastal Ocean Observing System**, **Mid-Atlantic Regional Association Coastal Ocean Observing System**, and **Great Lakes Observing System**[172]. These regional monitoring and research networks support information sharing, collaboration, and partnerships across federal and state agencies, academia, industry, and non-governmental conservation and planning partners.

The **Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS)** collects ocean information with a regional network, consolidating information in one place and supporting long-term ecosystem monitoring projects[173]. NERACOOS operates a network of monitoring stations, buoys, high-frequency radars, models and other ocean observing assets from the Canadian Maritime Provinces to New York. Real-time observational data collected by NERACOOS exceeds more than 21,500 observations daily across New England, with historical datasets available since 2001. Integrated datasets are collated and available through the **Mariners' Dashboard** and an interactive map server and on the **Northeast Ocean Data Portal[174]**. Fact sheets on the activities and impacts of NERACOOS projects are available for each of the five New England states in its region[175].

The **Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS)** is a regional monitoring network across ten states and five estuaries (from Cape Cod, Massachusetts, to Cape Hatteras, North Carolina) with more than 70 government, academic, industry, and non-governmental partners[176]. The network has five focus areas: fisheries, water quality, coastal hazards, energy, and maritime commerce and safety. Monitoring data collected by MARACOOS include air and water temperature, oceanographic variables, carbon dioxide, chlorophyll, dissolved oxygen, pH, salinity, and the locations and abundance of numerous marine animals.

The MARACOOS **OceansMap** is a data visualization tool that integrates near real-time observational data with model forecasts to facilitate monitoring of the coastal and marine system of the Mid-Atlantic region[177]. The interactive map allows customized filtering and analysis of monitoring and modeling data collected by the network's partners. The MARACOOS partnership recently launched a **Storm Resource Center** to track storms and collect related data for storms and extreme events along the eastern coast of the United States, using data from gliders, drifters, buoys, satellites, radars, weather stations, and buoys to inform potential impacts in the Mid-Atlantic region. MARACOOS monitoring data also is available on the **Mid-Atlantic Ocean Data Portal[178]** and the **NOAA Center for Operational Oceanographic Products and Services (CO-OPS) portal**[179].

The Great Lakes Observing System is discussed in Section 5.2.3 above for the Great Lakes.

The **Integrated Sentinel Monitoring Network** is supported by numerous Northeast conservation partners, including the Northeast Regional Ocean Council, Marine Biodiversity Observation Network (MBON), NERACOOS, Bureau of Ocean Energy Management, Environmental Protection Agency, National Oceanic and Atmospheric Administration, the states of Connecticut and New Hampshire, and numerous academic and non-governmental organizations[171]. Established in 2019, this “network of networks” aims to convene the Northeast region’s ocean monitoring projects into one resource with three objectives:

- Find and fill gaps in present ecosystem observation activities,
- Facilitate data sharing, integration, and communication among existing monitoring efforts, and
- Synthesize results to make individual project results more impactful

An inventory of regional sentinel monitoring projects in the marine seascape of the Northeast is available online[180].

The **Marine Biodiversity Observer Network** is a national network of monitoring programs, with the NERACOOS program through the Integrated Sentinel Monitoring Network, administering the MBON project in the Gulf of Maine ecosystem[181]. The goal of this monitoring effort is to identify and understand long-term changes in the Gulf of Maine ecosystem, with a focus on plankton biodiversity. The copepod *Calanus finmarchicus* serves as the primary indicator species because of its important role in the marine food web, serving as a dominant food source for RSGCN herring and North Atlantic Right Whale (*Eubalaena glacialis*) plus the Watchlist [Interdependent] Sand Lances (*Ammodytes americanus* and A. *dubius*).

Partners in the Integrated Sentinel Monitoring Network periodically convene **Centers for Analysis, Prediction and Evaluation (CAPE)** to conduct expert analysis and interpretation of monitoring data. The scope, scale, and duration of a thematic CAPE varies, as does membership among the expert partners. One current CAPE is currently analyzing monitoring datasets on the abundance of zooplankton to develop spatial maps and predictions of change for key marine species, thus informing foraging habitat for marine fish and whales. Analysis results from CAPE assessments are publicly available[182].

The **Northeast Regional Ocean Council (NROC)** is a state and federal partnership in New England facilitating regional collaborations to address coastal and marine issues and resources[183]. The **Northeast Ocean Data Portal**[174] provides a collection of research and monitoring products and datasets focused on ocean and coastal ecosystem health, coastal hazards resilience, and ocean planning. The Ocean and Coastal Ecosystem Health standing committee of NROC is a key partner with the NERACOOS Ecosystem Health Committee to develop the Integrated Sentinel Monitoring Network. A collaborative **Integrated Sentinel Monitoring Plan for Ecosystem Change in the Northeast Ocean and Coastal Waters** is currently under development, covering the region’s seascape from the Canadian Maritime Provinces to Long Island Sound. The NROC Ocean and Coastal Ecosystem Health standing committee is also developing guidance on standardized data collection protocols, including use of the

Coastal and Marine Ecological Classification Standard and regionally consistent methodology to map and monitor salt marshes and manage monitoring data to support habitat conservation and restoration projects.

The **Ocean Health Index** framework (Halpern et al. 2012) was applied to the Northeast region in 2021 (Montgomery et al. 2021), implementing one of the assessment needs identified by NROC to inform decision-making and compatibility among ocean uses. More than 50 datasets were synthesized to monitor trends in ocean health in the North Atlantic from 2005 to 2017. Monitoring indicators identified by Northeast stakeholders and NROC partners with eight distinct goals for ocean health were evaluated across 11 subregions, providing annual scores and trends. The eight goals are: biodiversity, clean waters, food provision, habitat services, livelihoods and economies, resource access opportunities, sense of place, and tourism and recreation. Reference targets and monitoring indicators for these ocean and coastal health goals include several relevant to State Wildlife Action Plans and can be used to identify management priorities.

The biodiversity goal is divided into habitat and species subgoals. The habitats subgoal indicators are the extent of salt marsh habitat (as compared to pre-1920 historical estimates), the proportion of eelgrass beds with good water quality conditions (as defined by the EPA), and the level of disturbance of unvegetated seabed habitats from fishing activities. The species subgoal indicators are the number of species present in the region that are not at risk of extinction or classified as Least Concern by the IUCN. Indicators for the clean waters goal include the level of water pollution from pathogens and trash in coastal waters and sediment and water quality levels that exceed EPA thresholds. The habitat services goal uses monitoring indicators related the proportion of nearshore biogenic habitats in good condition that support carbon storage and coastal protection. The sense of place goal is evaluated partially by the number of iconic species present in the nearshore that have an IUCN conservation status of Least Concern, and partially by the percentage of coastal waters and lands within one kilometer of the shoreline that are protected (Montgomery et al. 2021).

Over the 13-year evaluation period, overall index scores for biodiversity remained stable or increasing but the clean water index showed a steady and significant downward trend. The level of habitat protection did not change for marine areas but increased by 3% for inland areas, with some parts of the region having already met the conservation targets for habitat protection. The status of iconic species was unchanged over the period and remains below the conservation target (Montgomery et al. 2021). Detailed information and results from this assessment, including all of the monitoring indicators, is available on the **Ocean Health Dashboard for the US Northeast**[184].

The **Northeast Coastal Acidification Network (NECAN)**[185] monitors coastal and ocean acidification in the region, established by NERACOOS in 2013. A map of regional conditions from Maine to New York with monthly data is available online[186]. NECAN provides a reference library for resources on coastal and ocean acidification, education and outreach resources, reports from monitoring workshops, monitoring guidelines for citizen scientists, and links to monitoring datasets for alkalinity, dissolved inorganic carbon, pH, and other metrics related to acidification. The **NECAN Implementation Plan** identifies regional priorities for monitoring, modeling, and research[187]. NROC is supporting the development of a regional ocean acidification action plan, in partnership with NECAN, based on the results of a forthcoming **Strategic Plan for Federal Research and Monitoring of Ocean Acidification** from the **NOAA Ocean Acidification Program**[188].

The **Mid-Atlantic Regional Council on the Ocean (MARCO)** is the southern counterpart to NROC within the NEAFWA region, extending from New York to Virginia[189]. Established in 2009, MARCO is a partnership led by the Governors of the Mid-Atlantic states with an interstate agreement on ocean conservation that has four shared regional priorities: climate change adaptation, renewable energy, marine habitats, and water quality. To assist achievement of these ocean planning goals, MARCO maintains the **Mid-Atlantic Ocean Data Portal** as an online toolkit and resource center to collate data in a shared information management system for multiple uses[178]. The data portal includes federal, state, academic and other datasets, including monitoring data from the Mid-Atlantic Regional Association Coastal Ocean Observing System that provides real-time oceanographic monitoring data. Hundreds of datasets include inventories and locations of marine life and their habitats, from cold water corals and marine mammals to sea grasses and salt marshes; datasets are available for several Northeast RSGCN and Watchlist species, including marine and diadromous fish, marine mammals, sea turtles, birds, and marine invertebrates. Some of the datasets cover the entire NEAFWA region (Maine to Virginia) while others are limited to the Mid-Atlantic area (New York to Virginia). Water quality monitoring datasets available include acidification, marine debris, wastewater, and EPA attainment areas for Total Maximum Daily Loads. A catalog of the datasets available on the Mid-Atlantic Ocean Data Portal[190].

The **New England and Mid-Atlantic Fishery Management Councils** monitor the status of the Northeast marine ecosystems, collaborating with NOAA to issue annual **State of the Ecosystem Reports** on the Mid-Atlantic and New England shelf systems (NOAA 2022a, 2022b). These monitoring reports assess the trends and status of several indicators related to seascape scale fishery management objectives. Monitoring indicators include:

- Seafood production (landings)

- Commercial fishery profits
- Recreational fishing opportunities
- Fishery and ecosystem diversity indices
- Social and cultural (community fishery engagement, reliance, and environmental justice vulnerability)
- Protected species (juvenile and adult population, bycatch, and mortality)
- Biomass or abundance by feeding guild
- Climate change (marine heatwaves, ocean warming, changes in the Gulf Stream, acidification, circulation)
- Phytoplankton chlorophyll concentrations
- Fish productivity (condition and recruitment of managed species, primary productivity)
- Trophic structure (relative biomass of feeding guilds, zooplankton)
- Estuarine and offshore habitat conditions (including extent of submerged aquatic vegetation in Chesapeake Bay)

The State of the Ecosystem reports also discuss the threats of proposed offshore wind energy development in the region, identifying overlaps between known fishery areas and proposed wind development sites and the implications for the marine ecosystem and fishery industry and ports (NOAA 2022a, 2022b). Links between climate change and managed species, including several Northeast RSGCN and Watchlist species, are also assessed in the State of the Ecosystem reports using monitoring indicators data.

5.3 STATE INVENTORY AND MONITORING PROGRAM EXAMPLES

The regional synthesis of the 2015 Northeast SWAPs identified shared monitoring approaches across the region (TCI and NEFWDTC 2017). One finding of this regional compilation was that Northeast SWAPs identified and used existing monitoring efforts and tools from state fish and wildlife agencies and their partners to assess the status of SGCN, the condition of key habitats, and relevant information on threats or existing program efforts. The following examples describe existing and new state inventory and monitoring programs that inform the SWAPs identification and use of existing monitoring efforts and tools from state fish and wildlife agencies and their partners to assess the status of species (Section 5.3.1), the condition of key habitats (Section 5.3.2), and relevant information on threats (Section 5.3.3) and existing program efforts (Section 5.3.4). A full list of survey and monitoring programs listed in the 2015 Northeast SWAPs is available as Appendix 5 in the SWAP Synthesis (TCI and NEFWDTC 2017).

5.3.1 EXAMPLES OF MONITORING SPECIES

Northeast states have incorporated several types of survey, inventory, monitoring, and assessment programs and projects into their SWAPs and conservation efforts. Several NEAFWA states have created and maintain fish and wildlife Atlases as inventories of species within the state for mammals (Pennsylvania, Vermont), fish (West Virginia), birds (Delaware, Rhode Island, Vermont), reptiles and amphibians (Maine, Maryland, New Jersey, Vermont), bees (Maine, Maryland, Vermont, Virginia), Lepidoptera (Connecticut, Maryland, Massachusetts, Virginia, West Virginia), freshwater mussels (Maine, New Jersey), Odonates (New Jersey, Rhode Island, Vermont), and tiger beetles (Maine). Most if not all states participate in national and international bird monitoring surveys every year. Some state conservation partners host or participate in BioBlitz events that target rapid species inventories at a specific location. An increasing number of states are harnessing the power of citizen scientists to survey, inventory, and monitor their fish and wildlife resources and habitat condition. The following list highlights state programs and projects addressing species, habitats, environmental conditions, and conservation actions.

VERMONT ATLAS OF LIFE

The **Vermont Atlas of Life** combined the results of multiple individual taxonomic Atlases into one comprehensive resource of the state's biodiversity[191]. This publicly available online Atlas of Life includes 14,328 species with more than 7.9 million records that is integrated with iNaturalist, eBird, eButterfly, and the Global Biodiversity Information Facility (GBIF) to capture observations from citizen scientists and the public.

REPORT WILDLIFE OBSERVATIONS - RHODE ISLAND

The Rhode Island Department of Environmental Management Division of Fish and Wildlife recruits citizen scientists in monitoring the distribution, abundance, and health of Rhode Island's wildlife[192]. A free mobile Survey123 app allows the public to submit observations to select multiple surveys. **Herp Observer** collects information on frogs, toads, salamanders, snakes, and turtles. The **Wild Turkey Brood Survey** and **Summer Deer Survey** report summer sightings of Wild Turkey (*Meleagris gallopavo*) and White-tailed Deer (*Odocoileus virginianus*) respectively. The **Songbird Mortality Report** collects observations of dead or dying wild birds. **Bee Observer** monitors bee distribution and status. General wildlife observations may also be submitted for Bobcat (*Lynx rufus*), Black Bear (*Ursus americanus*) and Coyote (*Canis latrans*). The Department collects the observation data for use in monitoring species and produces story maps of the results to share with the public.

OSPREY NATION - CONNECTICUT

The Connecticut Department of Energy and Environmental Protection (DEEP) has monitored populations of Osprey (*Pandion haliaetus*) in partnership with The Connecticut Audubon Society since 2014. **Osprey Nation** is a citizen science partnership collecting long-term data on arrival dates each spring, nest locations, nesting success, and departure dates[193]. Stewards monitor the condition of nesting sites and partner with Connecticut Audubon and the Connecticut DEEP to ensure the security and safety of the sites. Guidelines are provided to the stewards to standardize data collection. An interactive online map allows stewards, partners, and the public to view monitoring data and nest locations. The program also installs a remote camera to live stream an osprey nest. The Connecticut DEEP incorporates Osprey Nation monitoring data into the state's coastal permitting process to anticipate and plan for potential Osprey conflicts during the planning phase of proposed projects.

BIG NIGHT AMPHIBIAN MIGRATION MONITORING PROJECT - MAINE

The **Big Night Amphibian Migration Monitoring Project** in Maine invites citizen scientists and the public to participate in an annual spring survey of migrating amphibians and road crossing mortality levels across the state[194]. More than 2000 amphibians have been recorded since the project began in 2018. A volunteer scientist manual is provided to train observers. Through a partnership with the Center for Wildlife Studies the project expanded in 2021 with expanded coverage (300+ sites across all counties), additional equipment, and outreach to new audiences. The monitoring project is integrated with iNaturalist as a designated project to collect observations from the public.

NEW HAMPSHIRE WILDLIFE SIGHTINGS

The **New Hampshire Wildlife Sightings** resource is an online database collecting observations from citizen scientists and the public on wildlife occurrences in the state[195]. Sightings are reported via the online portal or a mobile devices app. Species of Interest are highlighted with species profiles, distribution maps, and links to additional information. Links are provided to the New Hampshire Fish and Game Nongame and Endangered Wildlife Program, New Hampshire Management Conservation Areas, and tips for wildlife watching in New Hampshire, facilitating education and outreach to the public.

CITIZEN SCIENCE - DISTRICT OF COLUMBIA

The District of Columbia offers several citizen science programs to engage the public in monitoring urban wildlife and their habitats[196]. The District supplements monitoring of bats through mist netting and acoustical surveys with a **Bat Spotters** volunteer program and by soliciting reports of bat colonies living in buildings from the public[197]. The Bat Spotters program engages volunteers to adopt and monitor bat houses, which are available for purchase or can be built with building plans and instructions. Residents are encouraged to report to the Department of Energy and the Environment bat colonies of ten or more bats and offered the opportunity to monitor summer colonies by counting bats as they emerge from their roosts at sunset. Informational resources are provided online to educate the public on bat identification, threats to bats like White Nose Syndrome, and how to live with bats in urban areas.

The **Cottontails and Chipmunks! Oh My!** project recruits the District in monitoring populations of Eastern Cottontail Rabbits (*Sylvilagus floridanus*) and Eastern Chipmunks (*Tamias striatus*). An online form allows the public to submit sightings of these species. The District also provides a list of national citizen science projects and programs to encourage participation and representation of the District in those efforts, for bees, frogs, birds, and plants. Citizen scientists can also be trained in water quality monitoring, which monitors 22 locations across the District since 2018. Monitoring is conducted weekly from May to September and annual reports are prepared by the Department of Energy and the Environment.

LIGHT UP WEST VIRGINIA

In 2019-2020 the West Virginia Department of Natural Resources conducted a citizen science project to survey fireflies across the state[198]. More than 2000 observations were submitted with at least 24 confirmed species, including the rare and unique Synchronous Firefly (*Photinus carolinus*), which had not been documented in the state since the 1930s and is a Proposed RSGCN as of 2023. The resulting **Light Up West Virginia** storymap and online resource includes a heat map showing the density of firefly observations collected by the project, video of the synchronous flashing of *P. carolinus*, and a list of places where the public can see these evening displays[199]. Information on threats to fireflies and recommendations on how the public can help conserve and protect fireflies is included as well.

5.3.2 EXAMPLES OF MONITORING HABITATS

DELAWARE CENTER FOR THE INLAND BAYS

The **Delaware Center for the Inland Bays** is a partnership of the Department of Natural Resources and Environmental Control, Department of Agriculture, EPA, Delaware Senate, Delaware House of Representatives, Sussex County, and others with a mission to research, educate, and restore the habitats of Delaware's inland estuaries, excluding Delaware Bay[200]. The partnership monitors the inland bays' watershed, its non-tidal wetlands, tidal wetlands, streams, and estuaries. **State of the Delaware Inland Bay** reports are prepared every five years, with 35 monitoring indicators that include habitat losses and shifting shorelines. Inventory projects to map the extent and distribution of seagrasses are conducted every year. Species surveys annually monitor Horseshoe Crab (*Limulus polyphemus*) spawning, Osprey (*Pandion haliaetus*) nests, diadromous fish passage, Blue Crab (*Callinectes sapidus*), Northern Diamondback Terrapin, and marine fish along the shoreline.

VERNAL POOLS – NEW HAMPSHIRE

The New Hampshire Department of Environmental Services conducts monitoring of vernal pools in the state[201]. Guidelines are available for standardized identification and documentation of vernal pool habitats, with designated **Northeast Vernal Pool Indicator Species**. A standardized documentation form is provided along with guidelines from the University of New Hampshire Cooperative Extension for the importance, vulnerabilities, wildlife, and stewardship of vernal pools. The public can report sightings of reptiles and amphibians in and near these wetland habitats through the New Hampshire Fish and Game **Reptile and Amphibian Reporting Program**[202]**,** the **New Hampshire Wildlife Sightings portal**[195], via email, or with a mail-in reporting form. A link to the US Army Corps of Engineers guidelines on avoiding and minimizing impacts to vernal pools and complying with wetland protection requirements also is provided.

NEW JERSEY LANDSCAPE PROJECT

The **New Jersey Landscape Project**, with version 3.3 released in 2017, offers a wildlife habitat mapping resource to assist community land-use planning and conservation[203]. Both terrestrial and aquatic habitats are included, as are potential sites for vernal pools. An online storymap illustrates and explains the methodology behind the habitat mapping project and each of its updates. The New Jersey Department of Environmental Protection maintains an online mapping application of the Landscape Project that allows an interactive selection of a particular location. Detailed habitat type and associated imperiled species are provided for the site selection. Technical appendices are available describing the protocol for accepting or rejecting species sighting reports, species occurrence area justifications, the land use / land cover categories, and the methods for identifying the patch and species labels on the maps. Habitat fragmentation by roads is included and riparian corridors identified. The Landscape Project is periodically updated with new land cover / land use datasets, allowing for long-term monitoring of landscape changes since 1986.

VIRGINIA CAVE BOARD

The **Virginia Cave Board**, established by the Virginia Cave Protection Act, maintains an inventory of the cave and karst systems in the state[204]. As of 2015, the inventory had documented 3805 caves of at least five feet in length in the state[205]. The Virginia Cave Board and Virginia Speleological Survey assess known caves and may designate Significant Caves, which are afforded natural heritage resource status and are subject to environmental project reviews. The Board participates in environmental reviews of projects in or near cave habitats and has developed guidelines and recommendations for private landowners on several topics.

5.3.3 EXAMPLES OF MONITORING ENVIRONMENTAL CONDITIONS

States monitor environmental conditions through multiple agencies and programs. Water quality monitoring of rivers, streams, and other water bodies, for example, is well established in state programs and can involve citizen scientists and non-governmental organizations. Point source pollution is monitored by regulatory agencies. Coastal erosion is monitored in coastal states by regulatory and non-regulatory agencies. This section highlights a few other environmental conditions or threats are monitored through state associated programs and projects.

ENVIRONMENTAL CONTAMINATION – NEW YORK

The Bureau of Ecosystem Health of the New York Department of Environmental Conservation, Division of Fish and Wildlife annually monitors environmental contaminants, resulting biotic disturbances to aquatic ecosystems, and the cleanup of contaminated sites[206]. Analyses of fish tissue samples collected during monitoring are used to issue health advisories for human consumption of sportfish and game. The Ecotoxicology and Standards Unit develops water quality and other standards to protect fish and wildlife and performs risk assessments for pesticides proposed for registration in New York state. Monitoring is conducted statewide and recent assessments include xenobiotic chemicals in fish across multiple watersheds, polychlorinated biphenyl (PCB) and organochlorine pesticide residues in Great Lakes fish, heavy metals and PCB residues in Blue Crab, chemical residues in fish and American Lobster (*Homarus americanus*) in Long Island Sound, and dioxins and furans in fish following remediation of a hazardous waste site.

SALT MARSH AND SEA LEVEL RISE – MARYLAND

The Maryland Department of Natural Resources monitors the elevation of salt marsh habitat within the Chesapeake Bay National Estuarine Research Reserve to track the impacts of climate change and sea level rise[207]. Changes in salt marsh elevation have been monitored since 2007 using two standardized techniques. The goal of this long-term monitoring project is to determine if the marshes will be resilient to sea level rise, to share the data to inform management and protection efforts, and to promote the monitoring results for education and stewardship actions.

MARINE INVASIVE SPECIES PROGRAM – MASSACHUSETTS

The **Massachusetts Marine Invasive Species Program** monitors invasive species in the state[208]. Rapid Assessment Surveys are conducted at marinas every few years to collect and accurately identify new marine invasive species and to document the distribution of established species. The **Marine Invader Monitoring and Information Collaborative (MIMIC)** recruits volunteers to assist scientific experts to monitor marine invasive species. An online storymap provides photographs and descriptions of monitored species as well as maps of the distribution of each. Identification cards are available for 18 common marine invasive species monitored by the program. The MIMIC program is integrated with iNaturalist as a designated project.

WILDLIFE HEALTH – PENNSYLVANIA

The **Wildlife Futures Program** of PennVet at the University of Pennsylvania, in partnership with the Pennsylvania Game Commission, monitors wildlife health and provides several education, outreach, and guidance resources for the public, veterinarians, and wildlife rehabilitators[209]. The guidance resources include biosecurity recommendations, when to suspect diseases like Highly Pathogenic Avian Influenza, and summaries of state agency response programs to disease detection. Toll free hotlines are available to report abnormal, sick, injured, or dead birds and mammals to the Pennsylvania Game Commission. The Game Commission's **Wildlife Health Survey** also allows the public to easily report observations of wildlife health issues online[210]. The Wildlife Futures Program and the Pennsylvania Game Commission monitor new and recurring wildlife diseases, such as the avian morbidity and mortality event in the region in 2021, Highly Pathogenic Avian Influenza, Chronic Wasting Disease, White-Nose Syndrome, and West Nile Virus. A **Chronic Wasting Disease Data Visualization Dashboard** provides an interactive tool of monitoring data on the disease in Pennsylvania[211].

5.3.4 EXAMPLES OF MONITORING ACTIONS

Tracking SWAP Element 4 (Actions), remains a challenge at all scales, as it requires a robust monitoring effort that is seldom funded. Recent monitoring includes states' efforts to track their SWAP implementation.

CONSERVATION ACTION TRACKER – MAINE

The state of Maine developed a system to track actions identified in their State Wildlife Action Plan. **Maine's Conservation Action Tracker (CAT)** is an example of an effort to capture both state and partner actions and of successful on-the-ground efforts to conserve their SGCN and habitats[212]. It allows users to document and showcase efforts to conserve Maine's most vulnerable species and habitats, learn about Wildlife Action Plan conservation projects statewide, search projects by the species or habitats they benefit, and make connections with other partners throughout the state.

5.4 SPECIES MONITORING

In addition to NEAFWA's Monitoring and Performance Reporting Framework (NEAFWA 2008) and the national framework for evaluating effectiveness of State Wildlife Grants funded projects (AFWA 2012), a number of taxa-specific surveys, inventory, or monitoring programs have been developed and implemented with NEAFWA's support and through other regional collaborations.

5.4.1 RCN PROJECTS

The NEAFWA Regional Conservation Needs (RCN) Grants program[213] strategically fills critical monitoring gaps and needs highlighted in SWAPs including surveys, assessments, and monitoring protocols on priority species. Directed RCN projects have been developed to address these needs for priority RSGCN species and their habitats. See *Chapter 4* and *Appendix 4A* for the full list of RCN projects with links to their final products. The following representative survey, monitoring, and assessment projects were completed within the last decade since the 2013 Regional Conservation Synthesis (TCI and NEFWDTC 2013).

FIVE-FACTOR ANALYSIS

An important RCN project was developed in 2015 to inform and expedite the federal workplan and listing process. Since 2010, the USFWS has received numerous listing petitions for potentially imperiled species. More than 25% of the species on the complete list occur in at least one state in the NEAFWA service region. Many of these species have been included as SGCN in one or more Wildlife Action Plan developed by NEAFWA state members.

A preliminary evaluation by state fish and wildlife agencies identified a number of these species for which the case for federal protection under the federal Endangered Species Act was thought to be unwarranted. The state NEAFWA partnership has found that needed actions may be taken sooner if relevant data are assembled for species of potentially lower conservation concern. The objective of this project was to facilitate state input and engagement in the USFWS listing process by synthesizing existing state and regional information. It uses the "five-factor analysis" approach of the USFWS, applied to selected species on which substantial information is already available. The goals are to support on-going conservation action and reduce the likelihood of federal listing.

Five-factor status reviews were created for Little Brown Bat (*Myotis lucifugus*), Northern Red-bellied Cooter (*Pseudemys rubriventris*), Popeye Shiner (*Notropis ariommus*), and Chesapeake Logperch (*Percina bimaculata*). By providing this information in a form that can be readily used by the federal Endangered Species review team, the NEAFWA states can facilitate and/or potentially accelerate listing decisions for these four species of relatively low conservation concern and decrease the time needed for agency staff to respond to Service requests for information. Multiple benefits include the reduction of state and federal agency staff time needed for Section 7 compliance reviews for all WSFR funded grants.

EASTERN BLACK RAIL

Multiple RCN projects were developed to strategically address the need for more consistent and effective survey and monitoring protocols and procedures to be implemented regionally (for a full list see *Appendix 4A*). The Eastern Black Rail (*Laterallus jamaicensis jamaicensis*) is considered one of the most endangered birds in the Northeast region of the US and along the Atlantic Coast. Populations have declined by 85% in the Northeast since 1992, and this species now breeds in only a dozen (sometimes fewer) locations per state within its breeding range. Funds from an RCN grant were used to partially support the creation of a **Status and Distribution of the Eastern Black Rail along the Atlantic and Gulf Coasts of North America** (Watts 2016). Specifically, the funds supported collection of information from an established consortium of agencies, biologists, academic institutions, and land managers represented on the Eastern Black Rail Conservation and Management Working Group; a value-added synthesis of this information; and development of action items needed for a successful conservation campaign.

BIRD ASSESSMENT AND MONITORING STANDARD OPERATING PROCEDURES

The RCN program funded the **Development of Avian Indicators and Measures for Monitoring Threats and Effectiveness of Conservation Actions in the Northeast**[214]. Northeast regional monitoring procedures are now available for birds of grasslands, tidal marshes, and mountain forests - habitats that span the northeastern landscape, contain a high percentage of vulnerable species, and encompass the region's major management issues. These coordinated bird monitoring programs can measure region-level threats and management impacts on target birds and habitats identified by State Wildlife Action Plans as being of greatest conservation need. Products of this work include peer-reviewed survey design, protocols, and standard operating procedures for each indicator group (grassland, tidal marsh, and mountain forest birds) along with a regional database for each of these groups. Support for the project accelerated implementation of **A Framework for Coordinated Bird Monitoring in the Northeast** (2007), **The Northeast Bird Monitoring Handbook** (2009), and essential components of The Northeast Monitoring and Performance Reporting Framework (NEAFWA 2008). The mountain bird survey data was gathered as part of the Vermont Center for Ecostudies' high-elevation bird monitoring program, **Mountain Birdwatch**[215]**.**

THE CONSERVATION OF TIDAL MARSH BIRDS: GUIDING ACTION AT THE INTERSECTION OF OUR CHANGING LAND AND SEASCAPES

The goal of this initiative was to provide the information necessary for all states along the New England and Mid-Atlantic Coast (Bird Conservation Region, BCR, 30) to protect regionally important habitats for tidal marsh birds (including direct actions for 26 SGCN). In the long-term, the project's goal is to provide a regionally consistent platform for tidal marsh monitoring in the face of anticipated sea-level rise and upland/watershed development.

This Competitive State Wildlife Grant supports work done in Maryland and Virginia that contributes to the Regional Conservation Needs grant awarded in 2010 **Identification of Tidal Marsh Bird Focal Areas in BCR 30.** This project conducted bird surveys using both passive and broadcast point count methods along tidal marshes in Maryland and Virginia, recording all bird species detected by sight and sound. In 2011, 398 points were surveyed spanning the Delmarva coastline of Maryland and Virginia and a few sites on Virginia's western Chesapeake Bay coastline. A total of 143 bird species in Maryland and 151 species in Virginia were observed from 273 points surveyed in April to June 2011-2012, spanning the Delmarva coastline of Maryland and Virginia. Spatial patterns of abundance were similar between years among 14 marsh bird species. Vegetation data were collected at 261 sample points according to the standardized protocol for the associated RCN project in 2011 and at 256 sample points in 2012. Vegetation data collected at each point included cover classes for plant communities present, presence of invasive species, percent cover of one to four dominant species, and percent cover of pannes/pools/creeks, open water, upland, and wrack. Dead snags were counted in each plot and the tide cycle during data collection was noted. All bird survey and vegetation plot data were submitted to the RCN grant cooperators for incorporation into the final regional analyses. Final regional maps, estimates of changes in distribution and abundance, and critical areas for long-term protection were determined.

BATS AND WHITE-NOSE SYNDROME

The RCN Grant Program supported two projects to address the ongoing White Nose Syndrome (WNS) crisis in Northeast bat populations (Reeder et al. 2011). The first studied the effects of the fungus that causes WNS on hibernating bats and demonstrated that bats infected by the fungus were aroused to normal body temperatures more frequently than uninfected bats. These arousals depleted the bats' fat stores and likely contributed to their subsequent mortality. The number of arousal events significantly predicted the bats' date of death; and the severity of fungal infection correlated with the number of arousal events.

The second project developed methodologies to combat WNS. Specific goals included: 1) testing potential treatments for efficacy against cultures of the fungal pathogen associated with WNS under laboratory conditions; 2) testing potential treatments for safety in healthy bats; and 3) testing potential treatments for efficacy against fungal infection in hibernating bats. The project tested formulations of terbinafine and other anti-fungal compounds.

A CSWG project supported this regional effort to address WNS through a multi-state coordination, investigation, and rapid response grant project. At the start of the 2008 grant, WNS was only known to be present in New York, Connecticut, Massachusetts, and Vermont. The hope was for the spread of the fungus to be limited to adjacent states the following year. Unfortunately, by the spring of 2009, it had swept south all the way to western Virginia. Although the sudden magnitude of the problem was unexpected, this grant was critical to preventing state agencies from being completely overwhelmed by the crisis. Eleven states participated in this grant: Pennsylvania, New Hampshire, Vermont, Connecticut, New Jersey, Delaware, Maryland, West Virginia, Virginia, Wisconsin, and New York. All of these states except for Wisconsin felt the impact of WNS on their bat populations during the grant period. Common goals of developing a public reporting system, improving public outreach, coordinating sample requests, and improving ability to monitor and track bat populations were developed and shared. The group cooperated in identifying and selecting research priorities that were most important to states already experiencing heavy mortalities associated with WNS.

ALLEGHENY WOODRAT RECOVERY

The objectives of this RCN project were to determine interactions between Allegheny Woodrat (*Neotoma magister*) populations and forest dynamics; to determine incidence of Raccoon Roundworm (*Baylisascaris procyonis*) parasite load in raccoon feces; to conduct population analysis based on previous mark/recapture data; and to compare the relative efficacy of live-trapping versus remote cameras for detecting presence of Allegheny Woodrats. The study estimated populations at the six long-term monitoring sites. Results suggest that woodrat populations exist at low densities, are continuing to decline in western Maryland, and that certain sites represent critical habitat. These long-term monitoring sites are also considered to be some of the best strongholds for Allegheny Woodrat populations in western Maryland. But low population densities, continued declines in population, and the possible genetic consequences of interbreeding due to low populations put into question the species' long-term viability in the state.

BEST MANAGEMENT PRACTICES FOR RSGCN IN NORTHEAST FORESTS

This important RCN project provides BMPs to address the concerns about and impacts of biological resource use of forested habitats. Northeastern forests are considered key habitat for a large suite of wildlife, including several habitat specialists listed as SGCN in multiple states. Their vulnerability to various stressors has prompted the formation of several species--level conservation and research initiatives. This RCN project collaborated with several focused partnerships and with key forest stewards to integrate current ecological and biogeographic information into on the ground habitat enhancement. This collaboration produced spatially explicit management and conservation support for five regional SGCN: Bicknell's Thrush (*Catharus bicknelli*), Wood Thrush (*Hylocichla mustelina*), Canada Warbler (*Cardellina canadensis*), Rusty Blackbird (*Euphagus carolinus*), and American Marten (*Martes americana*). For each of these species, the report contains a species profile, conservation status, habitat landscape characteristics, desired habitat conditions, recommended practices and benefits with associated species, and ecosystem services and comprehensive planning. The project engaged both experts and end users to produce scientifically sound and practical guidelines for conserving these species and other SGCN in their guilds. Available occurrence data, distribution models, and stakeholder input delineated and prioritized areas with high management and conservation potential. Working directly with habitat stewards ensured that the recommended practices are implemented in management and conservation opportunity areas. Results include field guides and guidelines to managing habitat for RSGCN in the Northeast and Mid-Atlantic Forests (Lambert et al. 2017), a final report, and spatial prioritization for implementing these guidelines for RSGCN.

HELLBENDER POPULATION ASSESSMENT AND PROTOCOLS

The Hellbender (*Cryptobranchus alleganiensis*) is a Northeast RSGCN of High Concern Level. The Common Mudpuppy (*Necturus maculosus*) shares a significant portion of its habitat with the Hellbender. Both species have been identified as a Species of High Conservation Concern by the Northeast Partners in Amphibian and Reptile Conservation (NEPARC). Given the habitat overlap of these two species, efforts to detect Hellbenders concurrently generated data useful in monitoring Mudpuppy populations from 2014-2016. The objectives of this RCN project were: 1) to better document

Hellbender distribution in the northeast region; and 2) to develop standardized methodologies for monitoring Hellbender populations while collecting opportunistic information about Mudpuppy distribution. This was accomplished through stream surveys (including environmental DNA detection), improved communication among individuals working with Hellbenders or Mudpuppies, and the establishment of a regional stakeholder working group. Standardized protocols that ensure the consistency and efficiency of Hellbender/Mudpuppy surveys while minimizing disturbance of stream boulder habitat were developed. During the study, environmental DNA (eDNA) samples were collected from sites in New York, Pennsylvania, Maryland, West Virginia, and Virginia. Results of the project include: 1) a more comprehensive map of hellbender distribution in the northeast; 2) an eDNA archive (for detection of other stream-dwelling species); and 3) a protocol and communication framework to enable coordinated and efficient conservation of Hellbenders and Mudpuppies.

RANAVIRUS IN AMPHIBIAN POPULATIONS

In order to better understand the extent to which Ranavirus is impacting amphibian and reptile populations in the Northeast and to develop a sampling protocol for the region, this RCN project led by Maryland Department of Natural Resources staff with NEFWDTC and NEPARC participation, conducted a survey of amphibian larvae at randomly selected Wood Frog (*Lithobates sylvaticus*) breeding ponds in a study area encompassing parts of Delaware, Maryland, New Jersey, Pennsylvania, and Virginia. In 2013 and 2014, a total of 4,306 individual Wood Frog larvae were collected for quantitative PCR analysis by Montclair State University in New Jersey. Individuals representing seven amphibian species that are subject to active die-offs were collected for analysis by the USGS National Wildlife Health Center, representing both the largest geographic area and the greatest sample size ever screened for Ranavirus. A regional survey, diagnostic lab reports, and published scientific literature indicated that Ranavirus has been lab-confirmed in 33 herpetofauna species in at least 64 counties in the Northeast region. It was most found in Wood Frog larvae, Eastern Box Turtles (*Terrapene carolina*), and the larvae of Spotted Salamanders (*Ambystoma maculatum*), Green Frogs (*Lithobates clamitans*), and American Bullfrogs (*Lithobates catesbeianus*).

Scientists and conservation groups in the Northeast continue to address the challenge of how to best respond to the threat posed by Ranavirus, as the study indicated that state response capacity varied across the region. Most states (11 of 14) make use of the diagnostic services of the NWHC. The study developed and applied field protocols and recommended that disinfection protocols become standard operating procedure for all land management agencies as they work with groups like PARC to develop strategies to address the threat of emerging diseases.

PREVENTING BSAL IN AMPHIBIAN POPULATIONS

The 2015 SWAP Synthesis (TCI and NEFWDTC 2017) prioritized prevention and spread of the amphibian disease *Batrachochytrium salamandrivorans* (Bsal). In September 2016, the NEFWDTC and NEPARC reached out through the Northeast and Southeast Wildlife Disease Cooperatives to help protect wild populations of amphibians by preventing the introduction of *B. salamandrivorans* from imported amphibians. Collaborators, working with the Disease Cooperatives, developed methods for early detection that require swabbing individual animals and then testing the samples. Practical approaches to implementing these diagnostic tests are yet to be developed. Ideally, animals should be tested before leaving the country of origin. If imported, individuals would need to be held for a few days until results were returned or tracked and retrieved if testing positive. NEPARC provides information and resources and multiple protocols on preventing the introduction and spread of this disease in the Northeast[216]. A **North American Bsal Task Force** has been established and a **North American Strategic Plan to Prevent and Control Invasions of the Lethal Salamander Pathogen *Batrachochytrium salamandrivorans*** was developed in 2022.

TIMBER RATTLESNAKE POPULATION ASSESSMENT

The Timber Rattlesnake (*Crotalus horridus*) was once widespread throughout eastern North America but in the four New England states that were the focus of this RCN study, it now persists only in small, isolated populations. The goals of the study were to: 1) assess the viability of New England Timber Rattlesnake populations; 2), describe the population genetics structure of Timber Rattlesnakes in New England; 3) provide recommendations for genetic management and monitoring; and 4) develop a standardized protocol for monitoring Timber Rattlesnake populations informed by model-based estimates of occupancy and abundance.

Model-based estimates of population growth and Population Viability Assessment (PVA) results both suggest that populations in Vermont, New Hampshire, and Connecticut may be declining while the Berkshire Mountains metapopulation does not appear to be declining under current conditions. In all cases, population persistence was highly sensitive to survival suggesting that reducing anthropogenically-induced mortality is critically important. Available data strongly suggest that some Timber Rattlesnake populations in New England could benefit from genetic rescue. Recommendations suggest that managers consider the ecology and conservation status of each population, available resources, and potential impacts, and then assess the information provided by each method of monitoring in the development of any new project design.

CONSERVATION STRATEGY FOR THE NORTHERN DIAMONDBACK TERRAPIN

The Northern Diamondback Terrapin (*Malaclemys terrapin terrapin*) is found in eight states of the Northeast /Mid-Atlantic regions and is considered Threatened in Massachusetts, Endangered in Rhode Island, and of Special Concern in Connecticut. The species has been identified by the Northeast Partners in Amphibian and Reptile Conservation as a species of regional conservation concern in the Northeast. It is identified in more than three-quarters of the region's SWAPs; and more than 50% of the species' distribution is within the Northeast Region of North America (NEPARC 2010). Previous work in 1999 also suggested that the terrapin merits a federal listing assessment (Therres 1999).

This RCN project represented the first regional, comprehensive view of the status of the terrapin in the Northeast and Mid-Atlantic regions. The resulting regional Conservation Strategy can guide and coordinate multiple-state laws and policies to protect the terrapin and its habitat and may reduce the need for a federal listing assessment. The strategy includes a status and distribution assessment throughout the Northeast; gathering life history information; and identifying threats and conservation actions along with additional resources and needs. This project also conducted a Threat Assessment outlined by the Northeast Lexicon**Error! Bookmark not defined.**. Populations have d eclined due to multiple factors since the early 1900's. Bycatch in commercial fishing, loss of habitat, drowning in commercial and recreational crab pots, increased nest failure due to predation from raccoons and other subsidized predators, and road mortality have been the primary causes of population decline.

The project compiled state efforts and protocols to advance a **Regional Coordinated Survey including the Maryland Coastal Bays Terrapin Project**[217] for land and boat survey protocol and data sheets. The **Maryland Coastal Bays Program** created a database on local terrapin habitats to aid in conservation of the terrapin, using citizen scientists. The Program has also produced terrapin brochures, fact sheets, field guides, and other outreach information.

CONSERVATION PLAN FOR BLANDING'S TURTLE AND ASSOCIATED WETLAND-DEPENDENT SGCNS

Over the past decade, significant advancements have been made in addressing the information and conservation needs of RSGCN turtles. Multiple partners and grants (RCN and Competitive State Wildlife Grants) have resulted in robust conservation plans, protocols, and best management practices to be implemented regionally for these important RSGCN. They are summarized below with additional information available on https://www.northeastturtles.org.

Blanding's Turtle (*Emydoidea blandingii*) is a wide-ranging, semiaquatic species found in discontinuous areas from Nebraska to Nova Scotia. In the eastern United States, Blanding's Turtles occur in discrete areas of Maine, New Hampshire, Massachusetts, New York, and Pennsylvania, with the largest areas of occurrence in New England and northern New York and the largest known population in Massachusetts. Eastern populations are of conservation concern because of habitat alterations, adult roadkill, elevated nest and hatchling depredation, and other factors. In 2004, the **Northeast Blanding's Turtle Working Group** was formed as a partnership including representatives from four state wildlife agencies (ME, NH, MA, NY), universities, land managers, and researchers. Between 2004 and 2010, the group expanded to involve other key partners and the state of Pennsylvania. It published a status assessment (Compton 2007) summarizing the causes of regional population decline and calling for strategic, proactive conservation measures. In June 2014, the Northeast Blanding's Turtle Working Group completed the **Conservation Plan for Blanding's Turtle and Associated Wetland-Dependent Species of Greatest Conservation Need in the Northeastern United States**. This plan was updated in July 2021 after a second round of sampling and habitat management actions. Both efforts were multi-year collaborative projects funded by the USFWS through its Competitive State Wildlife Grant program (CSWG). The resulting website (https://www.northeastturtles.org) contains conservation and management plans for each of the four RSGCN species: Spotted (*Clemmys guttata*), Wood (*Glyptemys insculpta*), Blanding's, and Box (*Terrapene carolina*) Turtles. It also provides survey forms and protocols including the pit tag protocol.

IMPLEMENTATION OF THE BOG TURTLE CONSERVATION PLAN FOR THE NORTHERN POPULATION, WITH BENEFITS TO ASSOCIATED HEADWATER WETLAND SPECIES OF GREATEST CONSERVATION NEED

This RCN project supplemented efforts to perform habitat management, engage in landowner outreach, continue application of a multi-state database, continue implementation of standardized population and habitat monitoring protocols, survey potential and historic wetlands, perform health assessments, draft best management practices, expand upon and refine the recently developed conservation plan, and perform a genetic assessment to determine conservation units for the northern population of Bog Turtle (*Glyptemys muhlenbergii*).

Most recently, CSWG supported the continuation of the RCN project work with funding for the **Creating a Comprehensive Conservation and Management Plan for the Southern Lineage of the Bog Turtle and its Associated Habitats** project. The objective of this project is to fill critical information gaps by beginning to address the two most pressing threats for the southern lineage of the Bog Turtle. The project will

1) improve understanding of the current distribution of the southern lineage of Bog Turtles, 2) determine the status and viability of populations within the southern lineage of Bog Turtles, 3) conduct a large genetic study to identify metapopulations, management units, corridors, and current population genetic parameters, habitat management and nesting habitat creation for a subset of populations, and 4) perform outreach to landowners and law enforcement officials.

SPOTTED TURTLE CONSERVATION

The Spotted Turtle Working Group, a team of state and federal biologists and university and NGO partners, collaborated to quantify the Spotted Turtle (*Clemmys gutatta*) status and distribution from Maine to Virginia as well as the effects of climate change and habitat fragmentation on the species to prioritize both habitat conservation and management. As part of this RCN project, the sponsors conducted standardized population assessments at multiple spatial scales, with centralized data analysis, to: (1) establish population baselines; (2) inform a comprehensive adaptive management strategy; and (3) identify priority habitat and population management actions at the regional, state, and local levels. The resulting Status Assessment and 2022 Conservation Plan, the 2019 Monitoring Protocol, and field and data entry forms with instructions are available online[218].

A CSWG project supported expansion of this work on the Spotted Turtle through the **Conserving Vermont's Spotted Turtles: Using Novel Techniques to Detect a Cryptic Species and Identify Unknown Populations** project. This project will identify suitable Spotted Turtle habitats and will determine if those habitats are occupied. It will support the development of eDNA sampling protocols in lentic systems, which will be transferrable to other states with Spotted Turtle information gaps and to other SGCN freshwater turtle species. It will use standardized methods and protocols developed for the ongoing CSWG/RCN Spotted Turtle project to evaluate the species' presence at 25 sites and improve priority nesting habitat.

WOOD TURTLE CONSERVATION PLAN

The Conservation Plan for the Wood Turtle in the Northeastern United States is the product of a multi-year, proactive effort among Northeastern State Wildlife Agencies and their partners to articulate a strategic action plan for the protection of regionally significant populations of Wood Turtles (*Glyptemys insculpta*) in the northeastern United States. The fundamental objective of this Plan is to protect the evolutionary potential of the Wood Turtle by ensuring the persistence of functional, ecologically viable, and regionally significant populations throughout the Northeast Region. To accomplish this objective, and to effectively triage conservation efforts, the sponsors developed a spatially explicit, stratified **Wood Turtle Conservation Area Network** based on the best available population, landscape, and genetic data. Ultimately—in order to achieve meaningful conservation of this unusual and iconic species--it will be necessary to stabilize, and reverse population declines both within this Conservation Area Network and elsewhere throughout the species' range. The plan includes a standardized survey protocol, field survey and turtle field forms, and a data entry template. Management guidelines, habitat management and poaching brochures, regulatory status, environmental review recommendations, and other helpful resources for Wood Turtles are available[219].

STATUS ASSESSMENT AND CONSERVATION PLAN FOR THE EASTERN BOX TURTLE

Although widespread and still relatively common throughout much of its range, the Eastern Box Turtle (*Terrapene carolina carolina*) has experienced dramatic declines in recent decades. This recent RCN project developed a status assessment and conservation plan for the Eastern Box Turtle in the Northeastern United States (West Virginia to Maine). Products include: (1) a standardized monitoring protocol; (2) a status assessment for the northeastern US; (3) a conservation area network representing conservation priorities for the species; and (4) a set of BMPs. Survey forms and multiple protocols, guides, partners, and other useful information for box turtle conservation are available[220]. NEPARC has developed habitat management guidelines, land use planning resources, and references for conservation of this species in the Northeast. Both the regional group (NEPARC) and its national affiliate (PARC) are dedicated to the conservation of herpetofauna and their habitats.

STATUS ASSESSMENT OF NORTHEAST LAND SNAILS

The Land Snails and Slugs of the Mid-Atlantic and Northeastern United States online database provides a wealth of information on invertebrate taxa status and distribution in the Northeast. NEAFWA's RCN program sponsored a 2016 Land Snail Assessment of the status and distribution of land snails in the Northeast as a first step to their conservation. Since then, almost 30 species of land snails have been identified as RSGCN or Watchlist species.

Land snails are an integral part of native habitats throughout the Northeast, playing important roles in cycling organic material and creating soil, moving energy and nutrients in food chains, and hosting major wildlife parasites. This project informed the important conservation needs and opportunities associated with 245 land snail species of the northeastern United States, many of which are listed as SGCN or Data Deficient by many of the 14 State Fish and Wildlife Agencies. This project assisted states in proactive participation in the USFWS Federal Prelisting Process and may potentially lead to preventing or minimizing additional listings under the Federal Endangered Species Act.

The project also expanded and upgraded the existing land snail and slug website of the Carnegie Museum of Natural History, using data compiled from other museum collections to produce a more comprehensive resource with regional maps[221]. There are at least 317 species profiles for the region, 311 with specimen records, and another six that may be reported in the future. Fifty of the species are non-native. The USFWS Science Applications program is providing additional funding to support expansion of this project and its online database.

CONSERVATION ASSESSMENT OF ODONATA IN THE NORTHEASTERN REGION

A similar assessment supported by the RCN program for the dragonflies and damselflies of the Northeast serves as the foundation for RSGCN data for these species. Odonata are well represented on imperiled species lists for the Northeast due to narrow distributions, low population abundance, documented threats, and declines of many species. At present, nearly 200 different species are listed as SGCN by at least one Northeastern SWAP.

The first Region-wide conservation assessment for the order Odonata (dragonflies and damselflies) was completed for more than 230 species that occupy a wide range of forested lentic and lotic habitats in the Northeast region. This assessment followed a procedure similar to those already conducted for certain vertebrate taxa in the Northeast (e.g., birds, reptiles and amphibians). It included measures of regional responsibility, conservation concern, and vulnerability in a matrix format that can be used to prioritize species and conservation actions. Odonata were well suited to an assessment because their distributions and habitat affinities are relatively well known and the number of species is manageable, especially as compared to other insect groups. The project compiled available status and distribution information for all Odonate species in the thirteen states that make up Region 5 of the USFWS. Regional responsibility was evaluated for all states within the Northeast and updated at the regional scale, supporting conservation decisions that benefit Odonates and their habitats. The resulting prioritization scheme directs limited state and regional resources toward effective conservation actions that benefit Odonata and their habitats and thereby guide implementation of SWAPs.

DISTRIBUTION AND CONSERVATION STATUS OF NEWLY DESCRIBED LEOPARD FROG SPECIES

Objectives of this study were to: 1) determine which leopard frog species occur presently and occurred historically in ten eastern US states; 2) refine the range of *Rana kauffeldi* relative to the two other leopard frog species; 3) map new, potentially reduced, ranges for the two congeners; 4) assess the species' conservation status, particularly in areas where *R. kauffeldi* is already known to be of concern; 5) contrast multi-level habitat associations among the three species; and 6) improve upon the separation of species using acoustic and morphological field characters to facilitate future inventory, monitoring, and status assessments of the new species.

Significant changes in distribution of these species were documented but *R. kauffeldi* was confirmed in eight eastern US states: Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, and North Carolina. Eighty-nine percent of *R. kauffeldi* locations were within 20 kilometers of coastal waters. Differing habitat associations were also documented throughout its range. This multi-year, 10-state project demonstrated conclusively that *R. kauffeldi* is a habitat specialist with a small range centered in the most densely populated region of the United States. Making it more susceptible to stochastic events may exacerbate the impact of fungal pathogens and render it vulnerable to habitat fragmentation that in turn results in inhospitable dispersal. Another point of concern for *R. kauffeldi* is the coastal proximity of many populations. Coastal populations of wetland organisms may be threatened by rising sea levels and the increasing frequency and intensity of coastal storms, two threats associated climate change.

The study also found that *R. kauffeldi* has disappeared from a large part of its historical range in southern New York and Connecticut, including much of the Hudson Valley and all of Long Island. The study also reported disappearance of *R. pipiens* from much of the southern portion of its range from Pennsylvania east through northwestern New Jersey, southeastern New York, southern Connecticut, southern Rhode Island, and coastal Massachusetts. A new northern range limit was identified for *R. sphenocephala* in central New Jersey.

BEST MANAGEMENT PRACTICES FOR WETLAND BUTTERFLIES

This RCN project addressed the uncertain status and distribution of many wetland butterfly species in several Mid-Atlantic States, including SGCN and RSGCN species in the Northeast. Some species declines may be due in part to threats impacting groundwater wetlands, including outright destruction, habitat degradation, and the succession of open wetland habitats to forest or dense shrubland. Climate change and habitat fragmentation may further impact these species and leave them vulnerable to local extirpations. The primary objective of this effort was to enhance and expand populations of wetland butterfly SGCN through developing a greater understanding of the distribution and habitat requirements for these species, and by implementing habitat enhancement projects where needed. Project goals were to: (1) update distribution data for 14 butterfly SGCN in the region; (2) model species distribution and climate conditions for each species; (3) identify and prioritize wetlands that support one or more of these 14 species; (4) implement wetland enhancement and improvement projects; and (5) develop best management practices (BMPs) for species distribution and climate modeling and for wetland enhancement projects.

Results should guide targeted survey work for these species as well as prioritize wetlands for enhancement projects. In the long-term, results may serve to improve habitats for these species, offering the potential to increase populations of butterfly SGCN and promote connectivity between populations through increased habitat availability. Fourteen species of wetland-inhabiting butterflies with SGCN status were surveyed in 2016 and 2017 at multiple sites across four states – Maryland, New Jersey, Pennsylvania, and West Virginia. Survey data was used to evaluate the status of each species in all states where they occurred as well as refine the distribution data for each species across the region. All data points were mapped in ArcGIS and used to model species distribution in terms of both habitat and climate. BMPs were developed, and habitat enhancement projects were initiated in Maryland and Pennsylvania. The report includes **Life History Guides** to the 14 species, the **Pennsylvania Habitat Management Guide for Pollinators**, **Wetland Butterfly Habitat Enhancement BMPs**, and additional resources including a model Wetland Restoration Report.

XERICS PROJECT BEE, MOTH, AND VEGETATION MONITORING

The Xeric Habitat for Pollinators RCN project developed monitoring protocols for bees, moths, and vegetation management of xeric habitats in the Northeast[222]. A protocol was developed to track native bee communities at survey sites. Bee identification by regional experts was critical to the effort, and the collection is now with the National Bee Inventory and Monitoring lab. The bee monitoring protocol outlines 5 sampling windows, monthly, from May to September. Transects are laid out in the target habitat with 24 small bowls of soapy water placed 5 meters apart and left through the daylight hours or overnight if possible. Observers also net bees for 30 minutes while visiting the site. Samples are submitted with a standardized label to the USGS Bee Inventory and Monitoring Laboratory.

The moth monitoring protocol developed by the project outlines five sampling monthly windows from April to October, adjusted as necessary for latitude. The primary goals were to develop more complete species lists and document relative abundances for nocturnal moths in xeric habitats in the Northeastern US and to link these results with habitat condition data and management strategies which are also being tracked and analyzed. Three 15W UV bucket traps are set at each site. In 2021, 715 macro moths and 354 micro moths were identified across 16 sites. This list includes nine Northeast RSGCN.

This Xerics Project focused on fire adapted habitats (Xeric Grassland, Barren, and Woodland) in the Northeast to improve the ability of Northeast states to implement cost-effective habitat management for the benefit of native pollinators and other RSGCN that depend upon these priority habitat types. Templates for data collection and reporting were developed along with the vegetation monitoring project protocol, which seeks to provide data consistent with the long-standing monitoring programs at some of the more established sites. A key variable, the percent of vegetative cover, is expected to respond to treatments and to indicate habitat suitability for ground-nesting bees.

5.4.2 STANDARDIZED MONITORING PROTOCOLS

The Northeast Lexicon and AFWA Best Practices recommend the use of standardized monitoring protocols to facilitate data sharing and allow for regional assessments of species population status and trends (Crisfield and NEFWDTC 2022, AFWA 2012). The RCN Grant program has funded taxa surveys and assessments which have developed monitoring protocols for priority RSGCN reptiles and amphibians, birds, mammals, and several invertebrate taxa (see Section 5.4.1 above and *Appendix 4B*).

More than 120 species or groups of species that occur in the NEAFWA region have standardized monitoring protocols available, which are listed in *Supplemental Information 5*. The updated Northeast RSGCN Database includes information on the availability of standardized monitoring protocols for RSGCN and Watchlist species.

5.4.3 WATCHLIST [ASSESSMENT PRIORITY] SPECIES

The addition of a Watchlist [Assessment Priority] species list in 2023 alongside the identification of RSGCN allowed the taxonomic teams to prioritize species in need of survey, monitoring, or assessment in the Northeast. Two hundred twenty-nine (229) species were identified as RSGCN Watchlist [Assessment Priority] and 61 as Proposed RSGCN Watchlist [Assessment Priority] species that are not currently SGCN in any Northeast state (see *Chapter 1*). The majority of RSGCN Watchlist [Assessment Priority] species (53%) and Proposed RSGCN Watchlist [Assessment Priority] species (87%) are invertebrates (Table 5.4.1).

This category, new to the Northeast region in 2023, incorporates RSGCN previously identified as Data Deficient in 2018 that remain priorities for regional surveying efforts. In some cases, regional differences in species status and trends were identified by the taxa teams. Other species were data deficient, but enough concern or known declines were noted to warrant inclusion as a Watchlist species. Current taxonomic uncertainties or reclassification were ongoing for other species which precluded taxa experts' ability to assess the status or distribution of these taxa. These species should be a priority for assessment efforts to collect additional data to document status, trends, and threats across the region.

The RSGCN Watchlist [Assessment Priority] and Proposed RSGCN Watchlist [Assessment Priority] species are associated with all 24 coarse habitat types associated with RSGCN (see *Chapter 2*). The highest numbers of Watchlist species are associated with interface, riverine, and palustrine habitat types:

1. Shorelines (131 species)
2. Riparian and Floodplains (131 species)
3. Beaches and Dunes (131 species)
4. Rivers and Streams (120 species)
5. Big Rivers (120 species)
6. Tidal Rivers and Streams (120 species)
7. Non-Tidal Wetlands (119 species)
8. Tidal Wetlands and Flats (119 species)

Table 5.4. 1 A total of 290 species were identified as priority species for additional survey, monitoring, and assessment on the 2023 RSGCN Watchlist.

Taxonomic Group	Number of Watchlist [Assessment Priority] Species	Number of Proposed Watchlist [Assessment Priority] Species
Amphibians	6	-
Bees	10	14
Birds	29	1
Caddisflies	7	2
Crayfish	3	14
Diadromous Fish	2	-
Fairy Shrimp	2	-
Fireflies	1	5
Freshwater Fish	31	3
Freshwater Mussels	2	-
Lepidoptera	39	5
Mammals	12	3
Marine Fish	11	1
Marine Invertebrates	9	-
Mayflies	9	11
Odonata	20	-

Reptiles	8	-
Stoneflies	2	-
Terrestrial Snails	22	2
Tiger Beetles	4	-
Total	**229**	**61**

Forested upland habitats (Forests and Woodlands, High Elevation Forests, and Agriculture: Plantations and Orchards; =108 species each) or open upland habitats (Alpine, Cliff and Talus, Grasslands, Shrublands, Agriculture: Croplands and Pasture, and Glades, Barrens and Savanna; n=100 each) also are associated with high numbers of these Watchlist species. Monitoring efforts could target these habitat types to survey or assess multiple Watchlist species concurrently.

5.5 OTHER DATABASES AND RESOURCES

Monitoring programs and databases for fish, wildlife, and plant species are available from numerous non-governmental, academic, and citizen science sources. These species data sources supplement governmental monitoring programs and offer an opportunity to address AFWA Best Practices recommendations to expand the capacity of state fish and wildlife agencies (AFWA 2012).

The **Xerces Society**, for example, offers numerous identification and monitoring guides for citizen scientists to monitor bees, Lepidoptera, dragonflies, freshwater mussels, aquatic macroinvertebrates, and pollinator plants[223]. Conservation biologists with the Xerces Society developed survey protocols and guidance for public agencies to facilitate monitoring of at-risk invertebrate species and their habitats on public lands; monitor the effectiveness of pollinator habitat restoration projects; and provide training to agency staff and citizen scientists on pollinator identification and monitoring[224].

The **Wildlife Monitoring Network of Long Island** collects observations of wildlife from citizen scientists and the public for Horseshoe Crabs, birds, crustaceans, fish, mammals, reptiles, and insects[225]. This network supports organized monitoring projects and educational workshops and offers field guides and wildlife rescue resources.

Table 5.5.1 lists species databases currently available from non-governmental, academic, and citizen science inventorying and monitoring programs and projects.

Table 5.5. 1 Numerous non-governmental and citizen science databases are publicly available online that contain inventory, monitoring, and status information on fish and wildlife resources of the Northeast.

Informational Database	Location and Description
Discover Life	https://www.discoverlife.org/ International database and encyclopedia of plant and animal species observations and profiles for more than 1.4 million species with 822,000+ known distribution maps.
FishBase	https://www.fishbase.se/search.php International database of 35,000+ fish species profiles with taxonomy, location, conservation status, habitat, biological use, protection status, trophic ecology, life history, identification keys, citations, and imagery.
Global Biodiversity Information Facility (GBIF)	https://www.gbif.us/ National species database for animals, plants, and fossils in the US and its Territories. More than 825 million observation records with taxonomy, occurrence status, location, date, issues and flags, source dataset, and publisher (e.g., USGS, NatureServe, NOAA). Previously known as the Biodiversity Information Serving Our Nation (BISON) database.
Global Invasive Species Database	http://www.iucngisd.org/gisd/ International database of invasive species with species profiles that include taxonomy, species description, native distribution, alien distribution, impacts, life cycle stages, reproduction, spread pathways, management techniques, references, and photographs.
iNaturalist	https://www.inaturalist.org/ Public observations of animal and plant species across the world, which are searchable by name or location with information on the seasonality, number, life stage, and sex of observations. Includes more than 411,000 species and 125 million observations contributed by 5.9 million people.

Informational Database	Location and Description
Invasive and Exotic Species of North America	https://invasive.org Database of invasive and exotic species profiles that include taxonomy, origin, life cycle, distribution, imagery, and invasive listing sources. Includes plants, insects, pathogens, and other species.
ITIS	https://www.itis.gov/ Integrated Taxonomic Information System (ITIS) is the authoritative taxonomic information source on animals, plants, fungi, and microbes of North America and the world and is the taxonomic reference standard for RSGCN and the national SGCN database maintained by the USGS.
IUCN Red List of Threatened Species	https://www.iucnredlist.org/ International Union for Conservation of Nature (IUCN) maintains a Red List of Threatened Species with comprehensive information on the global extinction risk status of animal, fungus, and plant species. Information on more than 153,000 species includes taxonomy, conservation status, status assessments, geographic range, population trends, habitat and ecology, threats, use and trade, and needed conservation actions.
NatureServe Explorer	https://www.natureserve.org/ NatureServe Explorer includes detailed information on the taxonomy, distribution, conservation status, ecology, life history, population, management and monitoring needs, threats, habitat, and biological research needs of more than 100,000 species of plants, animals, and ecosystems.

Informational Database	Location and Description
World Register of Marine Species (WoRMS)	https://www.marinespecies.org/ International authoritative classification and catalog of marine species names with more than 241,500 species recognized. Species profiles include taxonomy, distribution, attributes, images, conservation status, and associated datasets. Taxonomic reference standard for marine RSGCN.
Ocean Biodiversity Information System (OBIS)	https://obis.org/ International database of marine species observational records with more than 108 million records for nearly 180,000 species searchable by taxa, species, location, dataset, or data source. Species profiles include taxonomy, distribution, observation dates, number of observation records, environmental conditions of the observations, data quality, and associated datasets. Taxonomic reference standard for marine RSGCN.
SeaLifeBase	https://www.sealifebase.ca/ International database of 85,000 marine species searchable by species, location, taxonomic group, or ecosystem with information on life history, trophic ecology, data source, photographs, and more.
AmphibiaWeb	https://amphibiaweb.org/ AmphibiaWeb includes nearly 8600 amphibian species profiles from around the world that are searchable by species, location, taxa, or photograph. Species profiles in the database include taxonomy, distribution, reasons for decline, and conservation status.
Amphibian Disease Portal	https://amphibiandisease.org/ International database monitoring the distribution of amphibian pathogens *Batrachochytrium dendrobatidis* (Bd) and *B. salamandrivorans* (Bsal).

Informational Database	Location and Description
Birds of the World	https://birdsoftheworld.org/bow/home International database of birds across the world with comprehensive life history profiles searchable by species or family. Includes identification, taxonomy, systematics, distribution, habitat, movements and migration, diet and foraging, sounds and vocal behavior, behavior, breeding, demography and populations, conservation and management, priorities for future research, and photographs. Integrated with eBird database.
eBird	https://ebird.org Public observations of bird species across the world, which are searchable by species name or location in a database that includes species maps, photographs, and sounds.
Audubon Christmas Bird Count	https://www.audubon.org/conservation/science/christmas-bird-count Database of December bird observations across the US and Canada since 1900 with location, species counts, weather conditions, sponsoring organization, and participants.
Audubon Great Backyard Bird Count	https://birdcount.org Public global observation counts of birds conducted annually in February across four days since 1998, with data integrated into eBird since 2013.
Project FeederWatch	https://feederwatch.org/ Database and maps of public bird observations at bird feeders between November 1 and April 30 across the US and Canada since the mid-1970s.

Informational Database	Location and Description
Botanical Information and Ecology Network (BIEN)	https://bien.nceas.ucsb.edu/bien/ International database of georeferenced plant locations, plot inventories and surveys, species geographic distribution maps, plant traits, species-level phylogeny, and cross-continent, continent, and country-level species lists with more than 464,000 species.
BugGuide	https://bugguide.net/node/view/15740 Database of insects, spiders, and related species with identification keys, imagery, taxonomy, and species profiles with information on range, habitat, season, food, and citations.
Bumble Bee Watch	https://www.bumblebeewatch.org/ Database of 122,000+ observations of bumble bees and their nests across North America with verified identification of species, location, conservation status, observation date, and related information.
Butterflies and Moths of North America (BAMONA)	https://www.butterfliesandmoths.org/ International database of Lepidoptera observations across North America with regional species checklists, taxonomy, and species profiles for more than 7000 species with distribution maps, identification, life history, flight, caterpillar hosts, adult food, habitat, conservation status, management needs, verified sightings, and imagery.
eButterfly	https://www.e-butterfly.org/#/ Database of butterfly 491,000+ observations across North and Central America for 1,250+ species with species profiles including weekly frequency of observations, taxonomy, distribution, imagery, and citations.

Informational Database	Location and Description
North American Butterfly Association Butterfly Count	https://www.naba.org/butter_counts.html International database of butterfly observations since 1993 across 400+ 15-mile count circles in North America.
Land Snails and Slugs of the Mid-Atlantic and Northeastern US	https://www.carnegiemnh.org/science/mollusks/index.html Database of known terrestrial snails and slugs of the Northeast and Mid-Atlantic regions with imagery, taxonomy, and species profiles.
Atlas of Common Freshwater Macroinvertebrates of Eastern North America	https://www.macroinvertebrates.org/#/ Database of freshwater macroinvertebrate species for eastern North America with identification keys, diagnostic characteristics, high resolution imagery, genus overview, habitat, pollution tolerance, feeding habits, movements, and distribution. Integrated with the PocketMacros app.
Mayfly Central	https://www.entm.purdue.edu/mayfly/ Database of Ephemeroptera (mayfly) species across North America, including records for 573 species in the US organized by taxonomy.
Freshwater Mussel Host Database	https://mollusk.inhs.illinois.edu/57-2/ Database of more than 2700 known host interdependent relationships for freshwater mussels searchable by mussel or host species or family with location, data source, and natural or lab evidence for the relationship.
Nature's Notebook	https://www.usanpn.org/natures_notebook National database of 500,000+ phenology records for plants and animals tracking seasonal changes, with featured campaigns to track nectar sources for pollinators, the emergence of mayflies, flowers for bats, insect pests, and non-native invasive plants.

Informational Database	Location and Description
Odonata Central	https://www.odonatacentral.org/#/ Database of Odonata (dragonflies and damselflies) observations in the Western Hemisphere including species, location, date, level of confidence in identification, and imagery with more than 300,000 records.

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5.7 ENDNOTES

Many online resources are available for learning about topics in this chapter. However, URLs are not permanent resources; pathways may be changed or removed over time. These endnotes were all accessed in January and February of 2023, and were active at that point in time.

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CHAPTER 6: REVIEW

SWAP Element 6

Descriptions of procedures to review the Plan at intervals not to exceed ten years.

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HOW TO USE THIS CHAPTER:

This Chapter provides national and regional information addressing SWAP Element 6 (above) for plan review and revision. This Regional Conservation Synthesis is updated every ten years (Section 6.0). A summary of key revisions and new guidance resources since the 2013 Synthesis are described in Section 6.1.

- Section 6.1 describes guidance documents for State Wildlife Action Plans (SWAPs) prepared by the Association of Fish and Wildlife Agencies (AFWA) and United States Fish and Wildlife Service (USFWS) over the last decade.
- Section 6.1.1 details revisions in this Regional Conservation Synthesis relating to Element 1, Species of Greatest Conservation Need (SGCN) and Regional Species of Greatest Conservation Need (RSGCN).
- Section 6.1.2 details revisions in this Regional Conservation Synthesis relating to Element 2, habitats for RSGCN.
- Section 6.1.3 details revisions in this Regional Conservation Synthesis relating to Element 3 for threats to species and their key habitats.
- Section 6.1.4 details revisions in this Regional Conservation Synthesis relating to Element 4 for conservation actions.
- Section 6.1.5 details revisions in this Regional Conservation Synthesis relating to Element 5, inventory and monitoring of species, habitats, and threats.
- Section 6.1.6 details revisions in this Regional Conservation Synthesis relating to Element 7, conservation partners.
- Section 6.1.7 details revisions in this Regional Conservation Synthesis relating to Element 8 for public engagement.

6.0 REVIEW PERIOD

The Northeast Regional Conservation Synthesis is updated and revised every ten years in sequence with the ten-year State Wildlife Action Plan (SWAP) revision cycle. The first Northeast Regional Synthesis was published in 2013, entitled **Taking Action Together: Northeast Regional Synthesis for State Wildlife Action Plans** (Terwilliger Consulting Inc. [TCI] and Northeast Fish and Wildlife Diversity Technical Committee [NEFWDTC] 2013). This document and associated resources are the second edition.

6.1 SUMMARY OF KEY REVISIONS FOR 2023

New national and regional guidance is available for 2025 SWAPs. In late 2012, the Association of Fish and Wildlife Agencies (AFWA) Teaming with Wildlife Committee issued **Best Practices for State Wildlife Action Plans: Voluntary Guidance for States for Revision and Implementation** (AFWA 2012). These best practices include guidance on all eight SWAP elements, from classification standards and systems to assessing conservation status. AFWA is currently updating this guidance for the 2025 SWAPs (AFWA *in prep*). More recently, in August 2022 AFWA provided guidance on adding plants as Species of Greatest Conservation Need to SWAPs through the minor revision process (AFWA 2022a).

In 2018, AFWA adopted a landscape conservation resolution. In 2020, the AFWA President's Task Force on Shared Science and Landscape Conservation Priorities recommended the convening of a new work group to develop recommendations on how SWAPs could become even more effective at improving range-wide conservation of Species of Greatest Conservation Need (SGCN) by leading or contributing to national and/or regional landscape conservation priorities. The AFWA SWAP and Landscape Conservation Working Group subsequently prepared the **Leading At-risk Fish and Wildlife Conservation: A Framework to Enhance Landscape-Scale and Cross-Boundary Conservation through Coordinated State Wildlife Action Plans** report in 2021 (AFWA 2021). This report summarizes five Guiding Principles:

1. Identify and apply regional and shared approaches for development, implementation and measuring progress of SWAPs, to improve effectiveness, efficiency, cost-savings, and consistency.
2. Increase consistency and alignment of SWAPs across jurisdictions so conservation can more readily be implemented at biologically relevant scales.

3. Provide support and incentives to leverage and build capacity for cross-jurisdictional and landscape conservation.
4. Ensure SWAPs are developed and implemented collaboratively and in partnership with a diverse set of partners.
5. Make SWAPs more accessible, understandable, and relevant to broad constituencies.

Each of these Guiding Principles has specific Recommended Actions, associated outcomes, and a recommended implementation framework. This Regional Conservation Synthesis implements at least 11 of the AFWA Recommended Actions:

1.1 Using clear and consistent criteria, identify priority species, habitats, landscapes, threats, and conservation actions for regional conservation.

1.2 Develop and use a common lexicon and classification system for species, habitats, threats, and conservation actions.

1.3 Develop and refine best practices for habitat and population restoration and management.

1.4 Promote the development of shared science, data, research, and monitoring protocols.

2.1 Incorporate regional priorities and approaches into SWAP development and implementation.

2.2 Work at landscape and regional scales to address key threats such as climate change, habitat loss/fragmentation, and invasive species.

2.3 Promote the use of adaptive management, best available science, and shared learning so the plans keep pace with changing conditions and innovations.

3.1 Provide funding and support for regional tool development, shared science, and landscape conservation projects.

3.3 Explore options for sharing resources, leveraging partnership contributions, and engaging non-traditional partners as well as options to lower grant match requirements and develop other incentives to encourage regional collaboration.

4.1 Increase collaboration and involvement of local, regional, and national partners in the development and implementation of SWAPs, including cross-jurisdictional efforts.

4.4 Incorporate scalable goals/strategies and priority landscapes from other planning efforts into SWAPs (i.e., State Forest Action Plans, State Comprehensive Outdoor Recreation Plans, National Fish Habitat Plan, North American Waterfowl Management Plan, TNC Ecoregional Plans, etc.).

Each of the Chapters of this Regional Conservation Synthesis addresses multiple Recommended Actions, implementing the first four of the five Guiding Principles and contributes to aspects of the fifth recommendation (see Section 6.1.6).

In December 2017 the United States Fish and Wildlife Service (USFWS) and AFWA issued a joint memorandum with updated guidance for reviewing and revising State Wildlife Action Plans (USFWS and AFWA 2017). The guidance provides detailed information regarding procedures for comprehensive, major, and minor SWAP revisions. The roles of Regional Review Teams are outlined, and examples of comprehensive, major, and minor revisions are provided.

In 2022 the **Northeast Lexicon: Terminology Conventions and Data Framework for State Wildlife Action Plans in the Northeast Region** (Crisfield and NEFWDTC 2022) was updated with recommended methods and systems to standardize SWAPs across the NEAFWA region, contributing to Recommended Action 1.2 of the AFWA landscape conservation guidance (AFWA 2021). The standardized classification systems of the 2022 Northeast Lexicon have been applied throughout this Regional Conservation Synthesis, also implementing Recommended Action 1.2.

The 2023 NEFWDTC website update (www.northeastwildlifediversity.org) allows for web-enabling this Regional Conservation Synthesis, the updated Northeast RSGCN Database (version 1.0), and associated communication tools and products. These tools and resources will be searchable with filters to provide detailed information for SGCN, RSGCN, and Watchlist species. Resources described in this Regional Conservation Synthesis, supplemental materials developed as part of the RCN 3.0 Technical Services project, the 2022 Northeast Lexicon, and RCN project resources will be centralized on one user-friendly platform with integrated links to the Northeast Climate Adaptation Science Center climate change syntheses and the habitat condition assessments prepared by The Nature Conservancy.

The following sections describe the advancements contained within this Regional Conservation Synthesis since the 2013 Synthesis for SWAP Elements 1 through 5 (TCI and NEFWDTC 2013).

6.1.1 ELEMENT 1: SPECIES

Since 2013, the Northeast Regional Species of Greatest Conservation Need (RSGCN) list has been updated twice and expanded to now include 20 taxonomic groups (see *Chapter 1*). The RSGCN list is updated every five years to include updated information on the status of species in the region and taking into account new information that has become available for additional taxonomic groups, particularly invertebrates.

In 2017 the **Northeast State Wildlife Action Plan (SWAP) Synthesis: Regional Conservation Priorities** report synthesized the 14 Northeast SWAPs of 2015, identifying regional themes and priorities for each SWAP Element (TCI and NEFWDTC 2017). These regional 2015 SWAP priorities and themes are incorporated throughout this 2023 Regional Conservation Synthesis.

In 2017 the list and status of Northeast RSGCN were added to the Northeast SWAP Database. Limiting factors for each RSGCN identified by the taxa teams and from available information sources were added to the Northeast SWAP Database, version 3.0, in 2020.

In 2019 the Southeast Association of Fish and Wildlife Agencies developed a list of RSGCN vertebrates, crayfish, freshwater mussels, and bumble bees using a slightly revised version of the Northeast RSGCN selection methodology[1]. In 2021, the Midwest Landscape Initiative and Midwest Association of Fish and Wildlife Agencies developed a list of RSGCN and Watchlist species for 13 taxonomic groups[2], again advancing the RSGCN selection methodologies of the Northeast and Southeast. In 2022-2023 the Southeast region developed the first list of RSGCN plant species in the country[3]. The Midwest region created a Midwest RSGCN Database modeled after the Northeast RSGCN Database, and the Southeast region has recently completed a SWAP Database for the region's 2025 SWAPs.

In 2022-2023, the Northeast RSGCN list was updated with several methodological advancements, informed by the RSGCN projects in the Southeast and Midwest (see *Supplementary Information 1* for detailed information). Three Watchlist categories were added, consistent with the Midwest RSGCN list: Watchlist [Assessment Priority], Watchlist [Interdependent Species], and Watchlist [Defer to an adjacent region]. All fish and wildlife species known to occur in the Northeast were pre-screened for potential identification as RSGCN or Watchlist species. Species that are not currently identified in a Northeast SWAP as a SGCN but that the taxa teams identified as meeting selection criteria are now identified as Proposed RSGCN or Proposed Watchlist species, until such time that a SWAP identifies them as SGCN.

With the updated and expanded Northeast RSGCN list, an updated **Northeast RSGCN Database** (version 1.0) was developed separately in anticipation of a new or substantially revised **2025 SWAP Database**, a Competitive State Wildlife Grant project. The Northeast RSGCN Database includes extensive data fields on the species status, distribution, habitats, threats, limiting factors, management needs, monitoring protocols, and research needs.

This Regional Conservation Synthesis incorporates these advancements for addressing Element 1 at the regional level, as described in *Chapter 1*. Additional new information will continuously become available from the completion of Regional Conservation Needs (RCN), Competitive State Wildlife Grant (CSWG) projects, and other projects as described in *Appendix 4A*.

6.1.2 ELEMENT 2: KEY HABITATS

In the past decade, the **Northeast Aquatic Habitat Classification System** describing and mapping Northeast stream systems was finalized and then expanded to the entire eastern United States (Olivero and Anderson 2008, Olivero-Sheldon et al. 2015, McManamay et al. 2018). The **Northeast Lake and Pond Classification** for lake and pond habitats was developed and applied to the region in 2016 (Olivero-Sheldon and Anderson 2016).

The 2022 Northeast Lexicon (Crisfield and NEFWDTC 2022) reflects the 24 coarse habitat types identified for use in the Northeast RSGCN and SWAP Databases, updating the previous list of coarse habitat types with new classification systems for aquatic habitats (i.e., rivers, streams, lakes, ponds, and marine areas – see *Chapter 2* for details). These 24 coarse habitat types allow a synthesis of the finer scale Key Habitats from the 14 Northeast SWAPs for SGCN for regional analysis and application to RSGCN and Watchlist species. *Chapter 2* provides a synthesis of the available information on each of these 24 habitat types for the Northeast region, including the list of RSGCN and Watchlist species associated with each, current information on the habitat's availability and condition, threats, relevant national and regional management plans, available best management practices, and habitat information and research needs. Information on partner programs and initiatives and citizen science projects that engage the public in conservation of each habitat are summarized.

The Northeast RSGCN Database (version 1.0) includes data fields to capture habitat use and characteristics for RSGCN and Watchlist species, providing an organizational structure for collecting and sharing species and habitat information at the regional level for SWAP revisions and implementation as well as facilitating landscape level conservation across the Northeast. In many cases these habitat characteristics may serve as required habitat conditions for RSGCN and Watchlist species conservation.

In 2011, The Nature Conservancy prepared a **Conservation Status of Fish, Wildlife, and Natural Habitats in the Northeast Landscape: Implementation of the Northeast Monitoring Framework** that assessed the condition of multiple habitats in the Northeast region (Anderson and Olivero Sheldon 2011). For the 2025 SWAPs, The Nature Conservancy updated this habitat condition assessment and provided assessment data on most of the 24 coarse habitat types (Anderson et al. 2023), which has been incorporated throughout *Chapter 2* of this Regional Conservation Synthesis.

The **Map of Terrestrial Habitats of the Northeastern United States** was completed in 2013, along with detailed habitat guides and condition assessments for 140 ecological systems or macrogroups across the region (Anderson et al. 2013a, Anderson et al. 2013b, Ferree and Anderson 2013). The Nature Conservancy and partners identified **Resilient and Connected Landscapes for Terrestrial Conservation** in 2016, providing detailed analyses of the connectedness and resiliency of ecological systems or macrogroups in the Northeast and beyond to climate change (Anderson et al. 2016a, 2016b).

The **Designing Sustainable Landscapes (DSL)** project at the University of Massachusetts built upon the Map of Terrestrial Habitats of the Northeastern United States by augmenting it with additional spatial datasets and developing an Index of Ecological Integrity for more than 150 land cover types that assesses each habitat's ecological setting, intactness, connectedness, and resiliency (McGarigal et al. 2018a). **Nature's Network** launched in 2017, provides a regional habitat prioritization tool and multiple associated datasets based on the DSL datasets. The DSL project periodically releases updates of their datasets for the Northeast, including in 2020 and 2022.

This Regional Conservation Synthesis incorporates all these advancements for addressing Element 2 at the regional level, as described in *Chapter 2,* providing significantly improved information on the availability and condition of aquatic habitats across the Northeast in particular, including freshwater, estuarine and marine systems, as compared to the previous regional synthesis (TCI and NEFWDTC 2013).

6.1.3 ELEMENT 3: THREATS

The previous regional synthesis summarized regional threats identified in the 2005 Northeast SWAPs and RCN projects (TCI and NEFWDTC 2013). The 2005 SWAP threats information was classified using the **Direct Threats Classification System, version 1.1,** of the International Union for the Conservation of Nature (IUCN) and Conservation Measures Partnership (CMP), which was crosswalked to the Wildlife Tracking and Reporting Actions for the Conservation of Species (TRACS) system used by the State Wildlife Grants Program. The Wildlife TRACS system has since been revised to serve more as a grant reporting system than a threats classification system.

Following the development of the 2015 SWAPs, the Northeast State Wildlife Action Plan Synthesis: Regional Conservation Priorities report synthesized the threats to both species and habitats identified in the 14 revised regional SWAPs (TCI and NEFWDTC 2017). Regional working groups reviewed and prioritized this threats compilation. The top five most frequently identified threats to SGCN and their Key Habitats, prioritized by the regional working groups, were pollution, development, climate change, invasive species and disease, and modification of natural systems. These threats were classified with the CMP **Direct Threats Classification System, version 2.0,** which was released in 2016 with minor revisions to the IUCN-CMP version 1.1 classification.

In December 2019 the IUCN released an updated **Direct Threats Classification System, version 3.2,** with some Level 3 categories to allow for more detailed threats descriptions. In 2021 Lamarre et al. (2021) advanced a regional threats classification system consistent with both the CMP Direct Threats Classification System version 2.0 and IUCN version 3.2, releasing the **Standardized Classification of Threats to Biodiversity: Definitions for Quebec's Conservation Data Centre, version 1.0**. This regional classification system includes a third level, providing more detailed threat categories applicable to the NEAFWA region. The new Level 3 threat categories allow for an actionable level of detail, such as identifying a specific source of pollution or a specific invasive species or disease of concern. The 2022 Northeast Lexicon recommends the use of this regional threat classification scheme for the 2025 SWAPs in the Northeast (Crisfield and NEFWDTC 2022).

In December 2022, IUCN and CMP released a draft **Unified Classification of Direct Threats, version 3.3,** with Level 3 threat categories applicable at the global scale (IUCN and CMP 2022). The Level 2 categories for climate change were revised and a 12th category to capture unknown threats was added.

Climate change remains one of the top regional threats to biodiversity in the Northeast. The Northeast Climate Adaptation Science Center prepared **Integrating Climate Change into Northeast and Midwest State Wildlife Action Plans**, a synthesis of the available information on climate change projects and assessments to assist the 2015

Northeast SWAPs (Staudinger et al. 2015). This climate change synthesis is being updated in 2023 with the newest and best available information on the effects of climate change in the Northeast, available climate change vulnerability assessments and resources, and recommendations on how to make conservation actions climate-smart (Staudinger et al. 2023).

In late 2022 AFWA issued a 2nd edition of **Voluntary Guidance for States to Incorporate Climate Adaptation in State Wildlife Action Plans and Other Management Plans**, updating guidance from 2009 (AFWA 2022b). The updated guidance includes "principles and tools that can be used to plan for and implement climate change adaptation, voluntary guidance for incorporating climate change into the existing required elements of SWAPs, and case studies to demonstrate adaptation strategies deployed by states in their management efforts" (AFWA 2022b, p. 4).

This Regional Conservation Synthesis incorporates all these advancements for addressing Element 3 at the regional level, as described in *Chapter 3*. The regional threats classification system developed by Quebec (Lamarre et al. 2021) was customized to add a select number of additional Level 3 threats to fully capture the range of threats identified in the region's SWAPs and to add the 12th category for unknown threats, consistent with the 2022 Northeast Lexicon (see *Supplementary Information 3*). The Northeast RSGCN Database (version 1.0) captures species-level threats using this customized threat classification system for the updated list of RSGCN and Proposed RSGCN, with a regional analysis provided in *Chapter 3* of this Regional Conservation Synthesis.

6.1.4 ELEMENT 4: CONSERVATION ACTIONS

The previous regional synthesis summarized conservation actions implemented through the Regional Conservation Needs Grants program (TCI and NEFWDTC 2013). Since that time, the regional SWAP synthesis provided a collective summary of the conservation actions identified in the 14 Northeast SWAPs of 2015, highlighting regional themes and priorities (TCI and NEFWDTC 2017, see *Appendix 4A*).

This Regional Conservation Synthesis updates the inventory of RCN projects supported by the NEFWDTC and Competitive State Wildlife Grant projects undertaken in the Northeast region over the past decade (see *Chapter 4* and *Appendix 4A*). The synthesis of existing regional conservation actions is now updated to include information on regional projects conducted by the Science Applications program of the USFWS, all of which address RSGCN and/or Watchlist species that were also identified as At-Risk Species by the USFWS in 2021 (USFWS 2021).

In 2016, CMP released the **Conservation Actions Classification, version 2.0**, replacing the CMP and IUCN joint version 1.0 that was released in 2007 and its version 1.1 update of 2008. The classification system allows conservation actions to be classified and categorized in a hierarchical system with four levels, organized into three categories for **Target Restoration / Stress Reduction Actions, Behavioral Change / Threat Reduction Actions**, and **Enabling Condition Actions**[4]. The Northeast RSGCN Database (version 1.0) is structured to incorporate species-based conservation actions for RSGCN and Watchlist species as information becomes available, consistent with the CMP Conservation Actions Classification system and as recommended by the 2022 Northeast Lexicon for the 2025 SWAPs.

6.1.5 ELEMENT 5: INVENTORY AND MONITORING

New information and resources for inventorying and monitoring species (Element 1), habitats (Element 2), and threats (Element 3) has become available in the last decade. The Northeast RSGCN Database (version 1.0) includes information on the availability of standardized monitoring protocols for RSGCN and Watchlist species. New regional monitoring networks developed over the last decade are described in *Chapter 5* of this Regional Conservation Synthesis. Programs and projects that monitor the availability and condition of habitats are described in *Chapter 2*. Monitoring programs for threats are described in *Chapter 2* when addressing habitat condition, in *Chapter 3* when addressing singular threats (e.g., invasive species, disease), and *Chapter 5* when addressing multiple species, taxa, and/or habitats.

Monitoring the Conservation of Fish and Wildlife in the Northeast: A Report on the Monitoring and Performance Reporting Framework for the Northeast Association of Fish and Wildlife Agencies identifies a regional monitoring framework report on the status of SGCN and their habitats and the effectiveness of conservation projects implemented as part of SWAPs and the State Wildlife Grants program (NEAFWA 2008). The monitoring framework includes eight conservation targets:

1. Forests
2. Freshwater streams and river systems
3. Freshwater wetlands
4. Highly migratory species
5. Lakes and ponds
6. Managed grasslands and shrublands
7. Regionally significant SGCN
8. Unique habitats in the Northeast

The monitoring framework report noted at the time that additional work was needed to include coastal and marine systems in the framework, which focused limited time and resources on terrestrial and freshwater systems. Specific indicators and stressors are identified for monitoring to assess each of the eight conservation targets, with the exception of the managed grasslands and shrublands target where information was lacking.

In 2011 The Nature Conservancy assessed these eight conservation targets as part of the **Conservation Status of Fish, Wildlife, and Natural Habitats in the Northeast Landscape: Implementation of the Northeast Monitoring Framework** (Anderson and Olivero Sheldon 2011). The Nature Conservancy updated this condition assessment in 2023 with new information and analysis tools, with the exception of the RSGCN conservation target which is addressed in *Chapter 1* of this Regional Conservation Synthesis instead (Anderson et al. 2023). *Chapter 2* of this Regional Conservation Synthesis supplements the 2023 condition assessment of Anderson et al. (2023) by addressing the information need to assess the status and condition of the region's coastal and marine systems that are not currently included in the monitoring framework.

6.1.6 ELEMENT 7: PARTNERS

Guiding Principle 4 of the AFWA landscape conservation guidance states "Ensure SWAPs are developed and implemented collaboratively and in partnership with a diverse set of partners" (AFWA 2021, page 5). This Regional Conservation Synthesis contributes to three corresponding Recommended Actions, addressing SWAP Element 7:

- **3.3** Explore options for sharing resources, leveraging partnership contributions, and engaging non-traditional partners as well as options to lower grant match requirements and develop other incentives to encourage regional collaboration.

- **4.1** Increase collaboration and involvement of local, regional, and national partners in the development and implementation of SWAPs, including cross-jurisdictional efforts.

- **4.4** Incorporate scalable goals/strategies and priority landscapes from other planning efforts into SWAPs (i.e., State Forest Action Plans, State Comprehensive Outdoor Recreation Plans, National Fish Habitat Plan, North American Waterfowl Management Plan, TNC Ecoregional Plans, etc.).

This Regional Conservation Synthesis provides detailed information on conservation partners and their programs, projects, and initiatives that address the needs of RSGCN and Watchlist species in *Chapter 1* and each of the 24 habitats for RSGCN and Watchlist species in *Chapter 2*. Goals, priorities, and/or focal species, habitats, and actions from other planning efforts and management plans are linked to RSGCN and Watchlist species and their habitats throughout *Chapters 1, 2, 7* and *8*. *Chapter 7* of this Regional Conservation Synthesis summarizes landscape and seascape level conservation partnerships in the Northeast that address multiple taxonomic groups and/or habitats. This synthesis of conservation partners and their ongoing efforts in the Northeast present opportunities to enhance collaboration, leverage resources, and synergize conservation efforts.

6.1.7 ELEMENT 8: PUBLIC ENGAGEMENT

Guiding Principle 5 of the AFWA landscape conservation guidance states “Make SWAPs more accessible, understandable, and relevant to broad constituencies” (AFWA 2021, page 5). This Regional Conservation Synthesis contributes to two corresponding Recommended Actions:

- **5.1** Make SWAPs more accessible and user-friendly to both technical and general audiences by making them web-based, easily searchable, and by creating targeted products for specific users.
- **5.2** Improve communication and marketing to ensure SWAPs and related landscape conservation efforts are valued as an important tool for conserving biodiversity.

The NEFWDTC website[5] update in 2023 allows for web-enabling this Regional Conservation Synthesis, the Northeast RSGCN Database, and associated communication tools and products. These tools and resources will be searchable with filters to provide detailed information for specific targets, purposes, or users. By linking with other NEFWDTC programs such as the RCN Grants Program, regional information will be integrated in a centralized online platform available to the states, conservation partners, and the public.

Chapter 8 of this Regional Conservation Synthesis provides a summary of available information on best practices for education and outreach activities and diversity, equity, justice, and inclusion initiatives. Citizen science projects and programs that are currently contributing to conservation of RSGCN and Watchlist species and their habitats in the Northeast are included in *Chapter 1* (species or taxa-based), *Chapter 2* (habitat-based), and *Chapter 8* (multi-taxa and/or habitat). All these resources can enhance public engagement and contributions to SWAP development and implementation, addressing required Element 8.

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6.3 ENDNOTES

Many online resources are available for learning about topics in this chapter. However, URLs are not permanent resources; pathways may be changed or removed over time. These endnotes were all accessed in January and February of 2023, and were active at that point in time.

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[1] Southeast RSGCN List, https://georgiabiodiversity.org/natels/sersgcn.
[2] Midwest RSGCN List, https://www.mlimidwest.org/midwest-regional-species-of-greatest-conservation-need/.
[3] Southeast Plant Conservation Alliance, http://www.se-pca.org/.
[4] Conservation Standards, https://conservationstandards.org/library-item/threats-and-actions-taxonomies/.
[5] NEFWDTC, https://www.northeastwildlifediversity.org/.

CHAPTER 7: PARTNERS IN NORTHEAST CONSERVATION

SWAP Element 7

Descriptions of the plans for coordinating, to the extent feasible, the development, implementation, review, and revision of the Plan-Strategy with Federal, State, and local agencies and Indian tribes that manage significant land and water areas within the State or administer programs that significantly affect the conservation of identified species and habitats.

Suggested Components:

A. *The State describes the extent of its coordination with and efforts to involve Federal, State, local agencies, and Indian Tribes in the development of its Strategy.*
B. *The State describes its continued coordination with these agencies and tribes in the implementation, review, and revision of its Strategy.*

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Figure 7.1.3. The area of protected lands in the Chesapeake Bay watershed from 2011 to 2018, as tracked by Chesapeake Progress by type of land ownership.

Figure 7.3.1. The Native Lands Digital identifies the best available information on the Indigenous peoples of the Northeast region and their historical territories, which often overlap.

HOW TO USE THIS CHAPTER:

Chapter 7 of this Regional Conservation Synthesis provides a summary of available information on collaborating with partners in the development, revision, and implementation of State Wildlife Action Plans (SWAPs).

- The Regional Overview (Section 7.0) describes the purpose and need for collaborative partnerships in fish and wildlife conservation.
- Section 7.1 discusses established regional partnerships and programs in the Northeast, organized by major watershed.
- Section 7.2 describes federal agency partners engaged in fish, wildlife, and habitat conservation, organized by how they can contribute to SWAP development and implementation.
- Section 7.3 provides information and resources for engaging Tribal partners.
- Section 7.4 discusses botanical partners and resources.
- Section 7.5 addresses inter-regional collaboration opportunities among the AFWA regions and summarizes shared RSGCN, Proposed RSGCN, and Watchlist [Deferral to an adjacent region] species.
- Section 7.6 highlights academic partners and programs in the region that can enhance state agency capacity to fill research, inventory, and monitoring needs identified in SWAPs.
- Section 7.7 describes opportunities to collaborate with sister state agencies, non-governmental organizations, and land trusts in fish and wildlife and habitat conservation.

7.0 INTRODUCTION

The Association of Fish and Wildlife Agencies (AFWA) recognizes the value of partnership contributions and opportunities in state wildlife action planning. The AFWA Best Practices recommend that state fish and wildlife agencies collaborate with other agencies and non-governmental organizations (NGOs) in long-term, multi-state efforts to assess species populations, habitats, and the effectiveness of conservation actions (AFWA 2012). The Northeast region has a rich and well-established history of partner collaboration to advance fish and wildlife conservation, as described in *Chapter 1* for species or taxonomic group focused efforts, *Chapter 2* for those that are habitat-based, and *Chapter 5* for research, inventory, and monitoring partnerships. This Chapter focuses on landscape-scale partnerships that include multiple taxonomic groups and/or habitat types.

The AFWA Blue Ribbon Panel Relevancy Working Group reaffirmed the importance of partners in conservation in 2018 (AFWA 2018). The Blue Ribbon Panel found that state fish and wildlife agencies "need to acknowledge [that] NGOs [non-governmental organizations] and partners are [a] legitimate part of [the] conservation institution and have important and significant contributions to conservation" and that agencies "need to find common ground with NGOs and partners and leverage their resources but recognize their constraints" (2018, p. 2).

In 2021, AFWA Resolution 2021-05-07 recommended that states ensure State Wildlife Action Plans (SWAPs) are developed and implemented collaboratively and in partnership with a diverse set of partners. AFWA adopted the recommendations of the SWAP and Landscape Conservation Work Group, as described in **Leading At-Risk Fish and Wildlife Conservation: A framework to enhance landscape-scale and cross-boundary conservation through coordinated State Wildlife Action Plans**, which call for engaging partners (AFWA 2021).

Conservationists in the Northeast can be proud of a long history of cooperative, collaborative conservation efforts. Even as threats to wildlife and habitat seem to grow, state fish and wildlife agencies have banded together to address pressing regional conservation problems. With increasing demands on scarce federal and state funds, these types of coordinated activities appear to have an especially bright future. Collaboration provides states with opportunities to share funds, staff and staff time, equipment and technical expertise, and other limited resources. Through collaborative efforts with adjoining states, each of the individual Northeast states can help address shared conservation concerns and tackle larger-scale regional priorities that would be difficult for each state to address alone. The Northeast Association of Fish and Wildlife

Agencies (NEAFWA) and its partners provide a firm foundation for regional collaboration, and these continued efforts will help to ensure that the Northeast states continue to teem with fish and wildlife for generations to come.

Some organizations and agencies in the Northeast states have identified “keystone” or “focal” species that can serve as “umbrella taxa” for cross-jurisdictional partnerships. Moving forward, these organizations will be focusing their conservation investments on projects and partnerships that benefit these species. Funding organizations that have adopted this approach include the National Fish and Wildlife Foundation (NFWF) and the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). The **United States Fish and Wildlife Service (USFWS), Wildlife and Sport Fish Restoration (WSFR) Program** administers the State Wildlife Grants (SWG) and Competitive State Wildlife Grants (CSWG) Programs, among others[1]. These grant programs support the development and implementation of State and Tribal Wildlife Action Plans and foster cross-jurisdictional partnerships.

By including information about the cooperative conservation ventures described in this Regional Conservation Synthesis in their SWAPs, individual states can provide a more robust picture of the full range of conservation planning activities focused on Northeast wildlife species and their habitats. Collaborative conservation planning efforts demonstrate partnerships that are broader than just the coalition of partners assembled in each state. Collaboration can also mean additional leverage and funding from competitive grants programs, such as the Regional Conservation Needs (RCN) Grants Program, and private funders such as the Doris Duke Charitable Foundation, and the National Fish and Wildlife Foundation.

The programs and funding sources described in the following sections can serve as mechanisms or sources of support for regional collaboration among state fish and wildlife agencies. Additional information on partners will be available through the online suite of resources and tools for this Regional Conservation Synthesis on the Northeast Fish and Wildlife Diversity Technical Committee (NEFWDTC) website (https://northeastwildlifediversity.org).

7.1 REGIONAL LANDSCAPE AND SEASCAPE PARTNERSHIPS

Numerous landscape- and seascape-level partnerships exist in the Northeast region, each of which can enhance the capacity of state fish and wildlife agencies to address all eight required elements of SWAPs. These partnerships are organized by major watershed.

7.1.1 GREAT LAKES

Chapter 2 (*Section 2.14*) describes the Great Lakes habitats in the Northeast region, which includes three lakes: Lake Champlain, Lake Ontario, and Lake Erie. The Great Lakes support at least 36 Northeast RSGCN and Watchlist species, not including those in connected habitats along the lakeshore, its beaches, wetlands, and tributaries. More than a dozen landscape scale plans, agreements, and collaborative partnerships are addressing the conservation needs of the Great Lakes in the NEAFWA region.

GREAT LAKES WATER QUALITY AGREEMENT

The **Great Lakes Water Quality Agreement** is a joint agreement between the U.S. and Canada to protect and restore the waters of the Great Lakes initially signed in 1972 and updated in 2012 (US and Canada 2012). In the US, the Environmental Protection Agency (EPA) coordinates activities under the agreement.

THE GREAT LAKES RESTORATION INITIATIVE

The **Great Lakes Restoration Initiative** (GLRI) is an interagency partnership established by Executive Order in 2004 administrated by the Environmental Protection Agency (EPA) with a mission to protect and restore the freshwater system of the Great Lakes[2]. Nine federal agencies serve on the GLRI Regional Working Group. The partnership collaborates with states, tribes, local communities, regional bodies, and other partners in the Great Lakes region to implement shared management goals and objectives. Since 2004, the Initiative has leveraged more than $3.3 billion for over 6850 projects. Competitive grants are available for conservation projects throughout the Great Lakes watersheds and are not limited to the Great Lakes waterbodies themselves.

The Great Lakes Restoration Initiative updates an Action Plans every five years that includes terrestrial shoreline habitat as well as aquatic habitats (GLRI 2019). The **Great Lakes Restoration Initiative Action Plan III** for fiscal years 2020-2024 includes a long-term goal of protecting and restoring habitat to sustain healthy ecosystem functions and native species (GLRI 2019). Conservation measures the Action Plan uses for tracking progress include the acres of habitat restored, protected or enhanced and the number of species benefiting from implemented projects. The return of breeding Piping Plovers to beaches in Pennsylvania and New York is considered a success story towards this goal. Northeast RSGCN and Watchlist species identified as potential target species for conservation activities include Piping Plover (*Charadrius melodus*), Mitchell's Satyr (*Neonympha mitchellii mitchellii*), Moose (*Alces alces*) and Rusty-patched Bumble Bee (*Bombus affinis*).

The Great Lakes Restoration Initiative has five focus areas in its 2020-2024 GLRI Action Plan (GLRI 2019):

- Toxic substances and areas of concern
- Invasive species
- Nonpoint source pollution impacts on nearshore health
- Habitats and species
- Foundations for future restoration actions

Each focus area has targets and objectives which are monitored as performance measures, many of which address the effectiveness of management actions. Monitored targets and objectives as part of this program are described in *Chapter 5* (Section 5.2). Conservation targets for 2024 include the protection, restoration, or enhancement of 442,000 acres of coastal wetland, nearshore, and other habitats; restoration of 6540 miles of aquatic connectivity in the watershed; and conservation benefits for eight federally-listed species.

The GLRI provides annual results on these monitored measures of conservation progress[3]. Through Fiscal Year 2021, cumulatively project partners have:

- protected, restored, or enhanced more than 479,000 acres of habitat, including 65,000+ acres of coastal wetlands,
- improved aquatic connectivity on more than 6700 river miles,
- protected or restored 43.6 miles of Great Lakes shoreline or riparian corridors,
- conducted invasive species control activities on more than 216,000 acres,
- provided technical and financial assistance for nutrient management on over 1.8 million acres of Great Lakes watersheds,
- reduced more than 2 million pounds of phosphorous loads in priority watersheds,
- captured more than 413 million gallons of untreated urban runoff annually,
- salvaged 53 Piping Plover eggs from historically high flooding in 2020, successfully incubating and hatching 85% of the eggs and releasing 39 captively reared chicks,
- conducted education and stewardship projects with more than 627,000 youth

GREAT LAKES COMMISSION

The **Great Lakes Commission**, established in 1955 by the **Great Lakes Basin Compact**, is a partnership among the eight states of the Great Lakes and St. Lawrence Seaway watershed, with the Canadian Provinces of Quebec and Ontario serving as associate members[4]. The mission of the Great Lakes Commission is to balance the use, development, and conservation of the Great Lakes' water resources by addressing issues of common concern, developing shared solutions, and collectively advancing the environmental health and economic prosperity of the region.

The Commission partners with the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) in its **Great Lakes Sediment and Nutrient Reduction Program**, established more than 30 years ago[5]. The program offers grants to reduce runoff and improve water quality in the Great Lakes watershed. In 2019 an annual **Great Lakes Aquatic Invasive Species Blitz** was established to educate boaters on how to prevent the spread of aquatic invasive species[6]. The Commission has a Memorandum of Understanding with the United States Geological Survey (USGS) to collaborate on scientific priorities for research and to facilitate incorporation of scientific information into decision-making by Commission partners. The **Great Lakes Harmful Algal Blooms Collaborative** is coordinated by the Commission, with support from the USGS, to address the threats and information needs of harmful algal blooms in the Great Lakes[7]. The **Great Lakes Phragmites Collaborative** develops and shares resources to identify, map, monitor, and adaptively manage for the non-native forms of *Phragmites* in the basin[8]. The **Invasive Mussel Collaborative** monitors, conducts research, manages, and controls invasive freshwater mussels throughout the Great Lakes system[9].

The **Great Lakes Stormwater Collective** is a network of and for water management professionals in the basin, both in Canada and the US, to develop and adopt innovative best management practices (BMPs) for stormwater management. Other activities of the Great Lakes Commission and its partners include habitat restoration projects, protection of drinking water supplies, advocacy of federal lawmakers for investment in the Great Lakes system (including in the Great Lakes Restoration Initiative), and strategic planning to support the economic development, infrastructure, and resiliency of the Great Lakes basin. A library of resources and spatial datasets are available on the Commission's website[4].

The Commission's **Blue Accounting** framework and interactive map tracks regional progress on meeting the shared goals of the Great Lakes Water Quality Agreement[10]. The **Great Lakes Regional Water Use Database** maintains an inventory of water withdrawals, diversions, and consumptive uses in the basin[11], implementing portions of the **Great Lakes – St. Lawrence River Basin Water Resources Compact** and **Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement**.

GREAT LAKES - ST. LAWRENCE RIVER BASIN WATER RESOURCES COUNCIL

The **Great Lakes – St. Lawrence River Basin Water Resources Council**, also known as the **Great Lakes Compact Council**, promotes the efficient use and conservation of the waters of the Great Lakes and St. Lawrence River basin[12]. The Council consists of the Governors (or their representatives) of the eight Great Lakes states. Established in 2008, the Council is governed by the **Great Lakes – St. Lawrence River Basin Water Resources Compact**, which is enacted as both state and federal law. The Compact outlines how the states will collaborate to manage and protect the basin and provides a framework for each state to enact laws and programs for its protection.

The Council monitors water withdrawals from the Great Lakes, which in general have a ban on new water diversions with limited exceptions. Regional goals and objectives are developed and/or reviewed by the Council for water conservation and efficiency every five years. State water conservation and efficiency programs may be voluntary or mandatory. The Council identifies science and research strategies every each of the subsequent three years. In 2020 the science focus was estimating consumptive use, which contributes to the Great Lakes Regional Water Use Database mentioned in the previous section[13]. In 2021 water quantity and improving measurement and estimation of water budget components was the science focus. In 2022 water conservation and water use efficiency were the focus topic. Every five years the Council conducts a comprehensive cumulative impact assessment of water withdrawals, diversions, and consumptive uses.

GREAT LAKES INDIAN FISH AND WILDLIFE COMMISSION

The **Great Lakes Indian Fish and Wildlife Commission** was formed in 1984 and provides natural resource management expertise, legal and policy analysis, conservation enforcement, and public information services throughout treaty ceded territories[14]. Although focused on the western Great Lakes outside of the Northeast region, the Traditional Ecological Knowledge and expertise of the Commission is relevant to the Northeast because the Great Lakes are connected and face shared threats. The Great Lakes Indian Fish and Wildlife Commission has multiple focus areas relevant to SWAPs:

- Climate change
- Forest pests
- Great Lakes fisheries
- Inland fisheries
- Mercury levels in inland lakes
- Environmental contaminants in the Great Lakes
- Invasive species
- Mining
- Wildlife
- Wild plants, particularly wild rice
- Conservation law enforcement

The Commission issues off-reservation harvest permits for its eleven member Ojibwe Tribes. Environmental education materials and technical reports are available, including materials on monitored threats to fish and wildlife resources, invasive species control, cumulative impacts assessments of proposed pipeline construction projects, and application of climate change adaptation frameworks to Tribal lands. The Great Lakes Indian Fish and Wildlife Commission participates in the Great Lakes Restoration Initiative, which established a Distinct Tribal Programming initiative to fund Tribal projects that are consistent with the goals and objectives of the Great Lakes Restoration Initiative.

GREAT LAKES FISHERY COMMISSION

The **Great Lakes Fishery Commission** monitors fish populations and habitat within the Great Lakes, including State of the Lake Reports every five years[15]. Fish species managed by the Great Lakes Fishery Commission include Walleye (*Sander vitreus*), Yellow Perch (*Perca flavescens*), White Bass (*Morone chrysops*), Lake Whitefish (*Coregonus clupeaformis*), Black Bass (*Micropterus dolomieu* and *M. salmoides*), Muskellunge (*Esox masquinongy*), and steelhead Rainbow Trout (O*ncorhynchus mykiss*). Lake Trout (*Salvelinus namaycush*), Lake Sturgeon (*Acipenser fulvescens*), Cisco (*Coregonus artedi*) and Sauger (*Sander canadensis*) are species undergoing restoration or preservation programs with the Commission. Lake Sturgeon is a Northeast RSGCN and Lake Whitefish, the native population of Lake Trout, and Sauger are Northeast Watchlist [Assessment Priority] species, as is the diadromous population of Sea Lamprey. Several prey fish are also monitored to understand predator-prey relationships. Control of invasive Sea Lamprey (*Petromyzon marinus*) is another strategic focus of the Commission. Abiotic factors monitored by the Commission include trends in productivity and status of critical fish habitat, plus several water quality parameters.

The Great Lakes Fishery Commission produces State of the Lake reports every five years that summarizes recent trends in fish populations and progress toward reaching fish community objectives within each of the lakes. The Commission has individual lake committees to develop recommended actions and coordinate management among partners geographically. Databases are maintained and publicly available for Great Lakes fish stocking, Lake Sturgeon tag identification, lampricide research, and historical commercial fish catch or production.

EPA GREAT LAKES NATIONAL PROGRAM OFFICE

The Environmental Protection Agency (EPA) **Great Lakes National Program Office** coordinates the binational Great Lakes Water Quality Agreement and the Great Lakes Restoration Initiative[16]. As part of these efforts, the EPA coordinates **Lakewide Action and Management Plans** for each of the Great Lakes and their watersheds[17].

The EPA monitors water quality and ecological conditions in the freshwater of the Great Lakes as part of the **National Coastal Condition Assessment (NCCA)**[18]. The NCCA is conducted every five years and uses standardized sampling procedures and quality assurance protocols to assess coastal conditions at the regional and national scale. Other conservation activities of the EPA in the Great Lakes include remediation of contaminated sediments, pollution prevention and reduction, and community assistance for localized Remedial Action Plans.

GREAT LAKES SEA GRANT NETWORK

The National Oceanic and Atmospheric Administration (NOAA) operates a national system of Sea Grant Programs in coastal and Great Lake states. The **Great Lakes Sea Grant Network** conducts research, education, and outreach on behalf of the Great Lakes system with eight programs based across a dozen universities in the basin, including in Lake Champlain[19]. The Network has more than 130 Sea Grant Extension Agents across the region that provide technical and financial assistance to partners. The Great Lakes Sea Grant Network currently has five regional initiatives:

- Center for Great Lakes Literacy: collaborative effort to support environmental education and promote Great Lakes literacy among educators, scientists, and the public[20].
- Great Lakes Aquaculture Collaborative: federally-funded project (2019-2023) to support environmentally responsible, competitive, and sustainable aquaculture in the Great Lakes with science-based recommendations[21].
- Hazardous Material Transport Outreach Network: collaborative effort to improve public safety, the region's economy, and environmental stewardship of water resources related to the transport of crude oil and other hazardous materials[22].
- Cooperative Science and Monitoring Initiative: coordinated effort between the EPA and Environment and Climate Change Canada federal agencies to fill data gap priorities identified in Lakewide Action and Management Plans under the Great Lakes Water Quality Agreement, rotating field years among the five Great Lakes[23].
- Great Lakes Water Levels Resources: collated resources across partners and programs about water levels and their fluctuations in the Great Lakes to inform outreach activities[24].

NOAA GREAT LAKES ENVIRONMENTAL RESEARCH LABORATORY

The **NOAA Great Lakes Environmental Research Laboratory** and its partners conduct innovative research on the Great Lakes' dynamic environments and ecosystems to inform resource use and management decisions[25]. The Laboratory operates three research programs. The Ecosystem Dynamics program focuses on ecological data collection and experimental research on ecosystem processes. The Integrated Physical and Ecological Modeling and Forecasting program conducts research to predict the effects of changes in the Great Lakes system. The Observing Systems and Advanced Technology program develops and operates technologies for scientific observations in the basin. Ecosystem focused projects include a benthic organism surveys and monitoring, aquatic invasive species, harmful algal blooms, and spatial and temporal variability in the food web. Data and products generated by the research programs of the Great Lakes Environmental Research Laboratory are available on the program's website[26].

The Great Lakes Environmental Research Laboratory and NOAA maintain the **Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS)**, a one-stop shop for information about aquatic nonindigenous species in the region[27]. GLANSIS provides tools to generate custom lists of species for a geographic area of interest, explore species distributions and data through a map tool, and access risk assessment literature, methods and project results from partners. The system integrates spatial datasets from collaborators, allowing exploration of habitat relationships and creation of custom maps. Partners supporting GLANSIS include the Great Lakes Sea Grant Network, GLRI, USGS, and others.

GREAT LAKES ACOUSTIC TELEMETRY OBSERVATION SYSTEM (GLATOS)

The **Great Lakes Acoustic Telemetry Observation System (GLATOS)** is a network of Canadian and American researchers collaboratively using acoustic telemetry to research and monitor fish behavior in the Great Lakes. Monitoring stations have been installed throughout Lake Champlain, Lake Ontario and Lake Erie within the NEAFWA region. Fishery project leaders have shared and maintained a basin-wide database of tag detections since 2010. GLATOS is administered by the Great Lakes Fishery Commission, USGS, Michigan State University and the Great Lakes Observing System as a node within the global Ocean Tracking Network. A searchable list of research projects, maps, data and publications is available on the GLATOS website[28].

INVASIVE CARP REGIONAL COORDINATING COMMITTEE

The **Invasive Carp Regional Coordinating Committee** is a binational partnership to prevent invasive Asian carp from becoming established in the Great Lakes and beyond[29]. Committee partners represent more than 40 federal, state, tribal, provincial, and local organizations. A national **Management and Control Plan for Bighead, Black, Grass, and Silver Carp** was published in 2007 and provides a strategic framework for the Committee (Conover et al. 2007). The Committee coordinates early detection, monitoring, and assessment efforts among partners in both the US and Canada. Binational ecological risk assessments were conducted for Bighead and Silver Carp (*Hypophthalmichthys nobilis* and *H. molitrix*, respectively) in 2012 and Grass

Carp (*Ctenopharyngodon idella*) in 2017 (Cudmore et al. 2012, 2017). An ecological risk assessment for Black Carp (*Mylopharyngodon piceus*) is under development.

The Invasive Carp Regional Coordinating Committee partners identify and close potential pathways that could allow invasive carp to be introduced or spread, through primary and secondary routes as well as through law enforcement of illegal activities related to commercial fishing, aquaculture, bait, pet, aquarium, live fish market, and transportation industries. Partners are investigating acoustic deterrents, elevated levels of carbon dioxide, and other new technologies to strengthen existing barrier systems and develop new ones. Contracted commercial fishing of invasive carp reduces carp abundance and thus migration pressure towards barriers. Other research efforts involve improving harvest techniques and gear to increase targeted harvest of the invasive fish.

LAKE CHAMPLAIN BASIN PROGRAM

The **Lake Champlain Basin Program** is a collaboration of government agencies in Vermont, New York, and Quebec, plus non-governmental organizations, local communities, and individuals[30]. The mission of this partnership is to coordinate and fund actions that benefit the Lake Champlain basin's water quality, fisheries, wildlife, wetlands, recreation, and cultural resources. The Program's comprehensive management plan updated in 2022 guides these efforts with four goals: (1) clean water, (2) healthy ecosystems, (3) thriving communities, and (4) an informed and involved public (Lake Champlain Basin Program 2022).

Since 1992, the Program has funded more than 1600 research, demonstration, and conservation projects throughout the basin, awarding more than $20 million to implement the management plan. Funding for the Lake Champlain Basin Program historically has been appropriated through the EPA but in recent years has also received funding through the Great Lakes Fishery Commission and National Park Service (the Champlain Valley National Heritage Partnership). Recent projects undertaken as part of the Lake Champlain Basin Program include:

- Removal of aquatic invasive species
- Spiny Softshell Turtle (*Apalone spinifera*) conservation (a Northeast Watchlist [Assessment Priority] species)
- Culvert replacements
- Mapping fish distribution
- Monitoring fish communities
- Dam removals
- Stormwater management with BMPs
- Reducing road salt
- Reducing phosphorous nutrient loads

- Environmental education

The Bipartisan Infrastructure Law of 2021 includes $40 million spread over five years (2022-2027) to support the Lake Champlain Basin Program, allowing the partnership to prioritize projects that address ecosystem and wetland restoration, nature-based infrastructure, stormwater treatment and control, community resilience, resilient shorelines, and environmental education.

WATERKEEPERS

The Waterkeeper Alliance is a global effort to preserve and protect water quality, with local Riverkeepers and Lakekeepers in communities worldwide[31]. Four Waterkeeper organizations are active in the Great Lakes system in the Northeast region. In the Great Lakes basin, the **Buffalo Niagara Waterkeeper** focuses on conservation of the Niagara River watershed, which connects Lakes Erie and Ontario, with five initiatives: protecting headwaters, revitalizing waterways, living shorelines, education and engagement, and restoration of Scajaquada Creek[32]. The **Upper St. Lawrence Riverkeeper**, through Save The River organization, has a mission to protect and preserve the ecological integrity of the Upper St. Lawrence River[33].

The **Lake Erie Waterkeeper** works to protect the water quality of Lake Erie to support drinkable water, fishing, and recreation[34]. The **Lake Champlain Lakekeeper**, hosted by the Conservation Law Foundation, is dedicated to protecting and restoring the natural resources of the Lake Champlain system[35]. Each of these organizations are community-based with extensive environmental education and public engagement programs. They also actively monitor their waterbodies for illegal pollution, and to monitor ecological health, serving as stewards for their geographic areas.

7.1.2 CONNECTICUT RIVER WATERSHED

Partners throughout the Northeast work to protect and conserve the region's big rivers, with one landscape level effort focused on the Connecticut River watershed in New England. The Connecticut River watershed is 11,250 square miles in size across four states – New Hampshire, Vermont, Massachusetts, and Connecticut, draining into Long Island Sound. A small portion of the Canadian Province of Quebec is also within the headwaters of the river basin. The **Ramsar Convention** identifies wetland and estuarine sites of global significance, and the Connecticut River Estuary and Tidal Wetlands Complex is one of four such sites designated in the Northeast region[36]. Multiple partnerships are collaborating on the landscape scale conservation of this large watershed in the Northeast.

CONNECT THE CONNECTICUT

Connect the Connecticut is a collaborative effort to develop and implement a landscape conservation design for the Connecticut River watershed, identifying priority places to establish and maintain a network of lands and waters for species migration, habitat restoration and conservation, and development[37]. A gallery of science products developed by more than 30 partners is available to inform conservation planning, prioritize a network of core areas, anticipate future changes related to land use and climate, and restoring and enhancing terrestrial and aquatic connectivity. High quality habitat was identified for 15 species of fish and wildlife, including Northeast RSGCN and Watchlist species Moose (*Alces alces*), American Woodcock (*Scolopax minor*), Blackpoll Warbler (*Setophaga striata*), Eastern Meadowlark (*Sturnella magna*), Prairie Warbler (*Setophaga discolor*), Ruffed Grouse (*Bonasa umbellus*), Wood Thrush (*Hylocichla mustelina*), Brook Trout (*Salvelinus fontinalis*), and Wood Turtle (*Glyptemys insculpta*). Partners contributing to the Connect the Connecticut conservation design and associated tools include the four primary watershed states (CT, MA, NH, VT), USFWS, Designing Sustainable Landscapes project at the University of Massachusetts Amherst, EPA, USGS, and several non-governmental organizations.

CONNECTICUT RIVER CONSERVANCY

Formerly known as the Connecticut River Watershed Council (pre-2017), the **Connecticut River Conservancy[38]** has addressed water pollution threats in the watershed through watershed planning efforts since 1952. The mission of the conservation organization is to advocate for and protect the Connecticut River watershed from its headwaters to the sea. The organization currently has six focus areas:

- Reconnecting habitat for fish
- Preventing sewage discharges into streams and rivers
- Preparing for floods through environmental education
- Planting trees for healthy riverbanks
- Cleaner and greener hydropower
- Review of pollution and development proposals and permits that could degrade the watershed

The Connecticut River Conservancy offers volunteer activities and programs to engage the public in monitoring fish populations, invasive species control, water quality monitoring, river clean-ups, and riparian restoration projects. The organization also provides a library of environmental education and outreach materials[39].

SILVIO O. CONTE NATIONAL FISH AND WILDLIFE REFUGE

The **Silvio O. Conte National Fish and Wildlife Refuge** was established in 1997 to protect, conserve, and enhance the biodiversity and ecosystems of the Connecticut River watershed[40]. The refuge currently includes nearly 40,000 acres across 22 disjunct locations (managed through ten divisions and 12 units) in New Hampshire, Vermont, Massachusetts, and Connecticut. This watershed scale refuge system conserves multiple Northeast RSGCN and Watchlist species and their key habitats, from headwater creeks to floodplains to tidal wetlands. Each division of the system offers varying degrees of public access for hunting, fishing, hiking, wildlife observation, photography, environmental education, and interpretation.

The Nulhegan Basin Division is in remote Vermont near the Canadian border, protecting more than 26,600 acres of forest, wetlands, streams, rivers, and riparian habitats. The Pondicherry Division in New Hampshire includes 6405 acres of ponds, wetlands, forests, and riparian communities, which has been recognized as a National Natural Landmark. The Fannie Stebbins Unit (362 acres) that protects a portion of the Connecticut River floodplain in Massachusetts has also been designated a National Natural Landmark. The 293-acre Fort River Division protects the longest free-flowing tributary to the Connecticut River in Massachusetts. The Whalebone Cove Division consists of 160 acres at the confluence of the Connecticut River and Whalebone Cove in Connecticut, preserving tidal wetlands, a kettle pond wetland, upland meadows, mature forests, and the largest stand of wild rice in the state of Connecticut.

DECISION-SUPPORT TOOLS

The **Interactive, GIS-Based Application to Estimate Continuous, Unimpacted Daily Streamflow at Ungauged Locations in the Connecticut River Basin Project** RCN project developed an interactive map-based decision-support tool to estimate continuous unimpacted daily streamflow at ungagged locations in the Connecticut River basin (Archfield et al. 2013; see *Chapter 4* for further details). Work from this project allows users to identify a stream reach of interest in the Connecticut River basin and obtain estimated continuous daily, unregulated or "natural" streamflow at the selected location. The **Connecticut River UnImpacted Streamflow Estimator (CRUISE)** tool spans the entire Connecticut River basin, including the states of Connecticut, Massachusetts, New Hampshire, and Vermont. This work expands on a method developed for Massachusetts to estimate daily streamflow at ungagged locations. The CRUISE software tool and user manual are available through the USGS[41].

The **Connecticut River Flow Restoration Study**, led by The Nature Conservancy, U.S. Army Corps of Engineers, and University of Massachusetts Amherst, developed a watershed-scale assessment of the potential to restore river and stream flow in the

Connecticut River basin through re-operation of dams (Kennedy et al. 2018). This project assessed the current alteration of river and stream flows in the basin, assessed the ecological flow needs, developed hydrological models, assessed the impacts of high and low streamflows, and evaluated multiple management alternatives[42]. Optimized flow management actions for operations at U.S. Army Corps of Engineers dams were identified. The study concluded that additional flow management in the Connecticut River watershed beyond flow operations at U.S. Army Corps of Engineers operated facilities may be needed to fully restore river health and function in some locations.

7.1.3 LONG ISLAND SOUND

Long Island Sound is the second largest estuary in the Northeast, spanning approximately 1268 square miles. This large estuary is connected to the watersheds of the Connecticut River (see Section 7.1.2 above), Housatonic River, and Thames River on its northern Connecticut side and several smaller watersheds on the North Shore of Long Island, New York, on its southern side. With over 600 miles of shoreline, Long Island Sound is long (110 miles), narrow (21 miles at its widest), and shallow (averaging 65 feet; Van Patten et al. 2009). The Long Island Sound basin includes New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, and New York (plus a small bit of Quebec). In addition to the partners involved in the largest of its river basins, the Connecticut River, described in the previous section, other partners are collaborating on conservation of the second largest estuary in the region.

LONG ISLAND SOUND STUDY

The **Long Island Sound Study** is a National Estuary Program with multiple state and federal partners[43]. The partnership is guided by the **Comprehensive Conservation and Management Plan (CCMP) for Long Island Sound**, which is updated periodically much like a SWAP[44]. National Estuary Program CCMPs are implemented through Implementation Actions, which are prioritized by each program and share some similarities to SWAP conservation actions. The Long Island Sound CCMP was revised in 2015 and the Long Island Sound Study issued a list of **Implementation Actions for 2020-2024**[45]. Example Implementation Actions include the projects that restore or maintain habitat connectivity, development of a habitat connectivity model, identification of which sites are likely to be impacted by sea level rise and which are ideal for habitat migration, and the development and application of standardized habitat quality metrics and assessment methodologies for targeted habitat types. Ecosystem Indicators that measure the health of the estuary and measure performance to achieve Ecosystem Targets identified in the plan are described in *Chapter 5*.

The **Long Island Sound Study Climate Change and Sentinel Monitoring Program** is a part of the **Integrated Sentinel Monitoring Network**[46]. The Long Island research and monitoring program[47] includes several climate change indicators in the estuary and its watershed that are described in *Chapter 5*.

The Long Island Sound Study conducts conservation activities throughout its basin to improve ecological conditions in the estuary. As of 2019 more than 2000 acres of habitat, including forest and tidal wetlands, have been restored in the Long Island Sound watershed in New York and Connecticut as part of the Long Island Sound Study program, as has more than 400 miles of river connectivity for anadromous fish passage.

LONG ISLAND SOUND WATER QUALITY MONITORING PROGRAM

The **Long Island Sound Water Quality Monitoring Program** is conducted by the state of Connecticut and the Interstate Environmental Commission, collecting water quality data in both surface and bottom waters of the estuary[48]. Monitoring indicators include water temperature, salinity, dissolved oxygen, particulate nitrogen, and dissolved nitrogen, which is collected both by research vessels (monthly from October to May plus bi-weekly hypoxia surveys from June to September) and continuously on monitoring station buoys throughout the estuary. The **Unified Water Study** monitoring protocol enables citizen scientists and community organizations to collect and contribute water quality data to the Long Island Sound Study monitoring program.

WILDLIFE MONITORING NETWORK OF LONG ISLAND

The **Wildlife Monitoring Network of Long Island** collects observations of wildlife from citizen scientists and the public for Horseshoe Crabs, birds, crustaceans, fish, mammals, reptiles, and insects[49]. This network supports organized monitoring projects and educational workshops and offers field guides and wildlife rescue resources.

WATERKEEPERS

Three members of the Waterkeeper Alliance are devoted to the Long Island Sound watershed. The **Long Island Soundkeeper**[50] is hosted by **Save the Sound**, a conservation organization focused on ecological restoration, healthy waters, protected lands, and climate resiliency across the Long Island Sound region[51]. Save the Sound issues a Long Island Sound Report Card on the health of the estuary every two years, with an interactive **Sound Health Explorer** platform to review environmental indicators and trends[52]. The Long Island Soundkeeper and Hudson Riverkeeper were two of the founding members of the international Waterkeeper Alliance.

The **Housatonic Riverkeeper** is sponsored by the Housatonic River Initiative[53]. This ad hoc coalition of environmental groups and concerned citizens are dedicated to the restoration and maintenance of a fishable, swimmable river through public engagement in the clean-up of toxic pollution in the Housatonic River. The **Peconic Baykeeper** monitors, protects, and restores the Peconic Estuary of eastern Long Island, part of Long Island Sound[54]. Programs conducted by the Peconic Baykeeper include a community oyster restoration program, Horseshoe Crab monitoring, water quality monitoring, commercial oyster aquaculture, patrolling for pollution, diadromous fish restoration, green marinas, and environmental education.

7.1.4 HUDSON RIVER WATERSHED

The Hudson River watershed encompasses 13,390 square miles of New York and New Jersey, including the New York City metropolitan area, and small portions of Vermont and Massachusetts. Tidally influenced for nearly half of its 315-mile length, the Hudson River and its tributaries provide drinking water to nine million people in New York City and the Hudson Valley through an extensive system of reservoirs, aqueducts, and pipelines. Several conservation partners are involved in the protection and conservation of the Hudson River watershed and the drinking water it supplies at the landscape scale.

HUDSON RIVER FOUNDATION

For more than four decades the **Hudson River Foundation** has promoted science-based stewardship of the Hudson River watershed[55]. Programs and initiatives conducted by the Hudson River Foundation include restoring signature fisheries, restoring and improving habitats, improving water and sediment quality, supporting public access and stewardship, addressing climate change, and promoting public understanding. The Foundation has developed numerous environmental education materials[56] and other outreach materials in support of its public access mission, such as a paddling guide for the river's estuary.

The organization provides grants through its **Hudson River Fund** to support scientific research on all aspects of the Hudson River ecosystem (including its estuary) with a particular emphasis on studies that inform its human uses. The Fund administers grants through the New York – New Jersey Harbor and Estuary Program to assist citizen science projects, habitat restoration, public access, and stewardship activities. Graduate and undergraduate fellowships also are offered by the Hudson River Foundation.

The Hudson River Foundation recently assumed administration of the **Champlain Hudson Environmental Trust**, also known as the Hudson River and Lake Champlain Habitat Enhancement, Restoration and Research / Habitat Improvement Project Trust. This Trust is funded to address impacts from the Champlain Hudson Power Express project, which will connect hydroelectric dams in Quebec to Astoria, Queens via a high voltage direct current line installed underwater. The Trust will appropriate $117.5 million over 35 years to protect, restore, and improve aquatic habitats and fisheries resources in the Hudson River estuary, Harlem and East Rivers, Lake Champlain, and their tributaries. Governing committee members include the Hudson River Foundation, state of New York, New York City, the Hudson Riverkeeper, and Scenic Hudson.

NEW YORK / NEW JERSEY HARBOR AND ESTUARY PROGRAM

The **New York – New Hersey Harbor and Estuary Program**, a part of the National Estuary Program, is supported by the Hudson River Foundation, described above. The Hudson River Foundation and the New York - New Jersey Harbor and Estuary Program developed an **Environmental Monitoring Plan**[57] for the watershed's estuary in 2018. The Plan includes 40 key indicators to monitor the health of the estuary with five goals:

- Water quality
- Habitat and ecological health of five key habitats (marine, riparian, shorelines and shallows, terrestrial, and wetlands)
- Public access and stewardship
- Toxic contamination related to legacy port and maritime industries
- Community engagement

The Estuary Program partners with the New York State Department of Environmental Conservation to produce periodic **State of the Hudson** reports[58], the most recent in 2020. These reports are based on the set of indicators outlined in the Environmental Monitoring Plan.

Habitat restoration supported by the Program is guided in part by the **Hudson-Raritan Estuary Comprehensive Restoration Plan**, developed in collaboration with the US Army Corps of Engineers and The Port Authority of New York and New Jersey (USACE et al. 2016). The associated Waters We Share collaboration includes more than 100 partners representing federal, state, and local government agencies, academia, research foundations, non-profit organizations, business interests, and others. The Restoration Plan describes the existing conditions of the estuary and defines target ecosystem characteristics. Funding partners and sources are identified to assist in implementing the recommended management actions. The Hudson River Foundation and the New York – New Jersey Harbor and Estuary Program track restoration activity progress to implement the plan with an interactive map that can be used to find opportunities for restoration, including as mitigation for natural resources damages funding[59].

Other activities of the Estuary Program include oyster restoration, water quality monitoring, aquatic habitat restoration along riverfront parks, environmental education programs, identification of opportunities to advance wetland migration pathways, and investigating the impacts of climate change on the health and biological integrity of the estuary.

SCENIC HUDSON

Scenic Hudson[60] actively preserved, protected, and revitalized land and communities in the Hudson River Valley since 1963. The largest environmental organization in the region in membership, Scenic Hudson's mission is to preserve and strengthen the open spaces, working forms, and historic cities and town centers of the Hudson River Valley and the natural resources that all of them depend upon. The organization's roots are in a grassroots-led effort to halt a proposed industrial project from developing Storm King Mountain in the Hudson Highlands. Since then, Scenic Hudson has successfully transformed contaminated industrial sites along the river into public parks. To date more than 48,000 acres across ten counties have been conserved by the organization, including the creation of more than 40 public parks. They also create and maintain land and paddle trails. Much of their land protection activities is through the use of conservation easements to protect scenic vistas, working farms, wetlands, woodlands, and river shorelines.

A climate change adaptation framework guides the organization's work to protect tidal wetlands along the Hudson River estuary. The **Hudson Valley Conservation Strategy** provides a framework for landscape level conservation in the basin. A **Foodshed Conservation Plan** secures a supply of fresh, local food for the region and New York City by supporting working agricultural lands[61]. Other activities of Scenic Hudson include efforts to improve climate resilience, regenerative agriculture, and extensive environmental education programs and resources.

HUDSON RIVER WATERSHED ALLIANCE

The **Hudson River Watershed Alliance** seeks to protect the water resources of the river basin[62]. The Alliance supports 32 local watershed groups, participates in municipal watershed planning, and has produced several watershed and subwatershed maps to inform decision-making. The organization hosts an Annual Watershed Conference for its partners to share information and promote collaboration. Technical and strategic assistance, training workshops, monitoring water quality, environmental education, stream cleanups, tree plantings, and partnering with academic institutions to conduct research are some of the Alliance's other activities that contribute to conservation of the Hudson River watershed.

WATERKEEPERS

Two members of the international Waterkeeper Alliance operate in the Hudson River watershed and its estuary. The **Hudson Riverkeeper** is one of the founding members of the Alliance, active since 1966 in protecting the resources of the Hudson River[63]. Originally established to combat pollution of the river, the Hudson Riverkeeper continues to monitor the waterways of the river for sources of pollution and water quality, continue recovery and restoration of the basin's ecosystem, protect drinking water supplies, improve wildlife habitat, foster sustainable energy development, restore local river fronts, and increase investment in water supply and sewer systems.

The **New York / New Jersey Baykeeper** considers itself the citizen guardian of the New York – New Jersey Harbor Estuary[64]. Since 1989 the Baykeeper has worked to protect, preserve, and restore the ecological integrity and productivity of the estuary's waterways and habitats. The Baykeeper preserves and restores habitat, champions public access, educates the public, influences land use decisions, and monitors water quality and sources of pollution. Active in both New York and New Jersey, the **Baykeeper Auxiliary** volunteers patrol the bay for pollution violations. The Baykeeper has assisted in natural resources damage assessments and recovery from oil spills, participated in dredged materials management planning, and advocated for federal, state, and local investments in habitat restoration.

7.1.5 DELAWARE RIVER WATERSHED

From the Catskill Mountains of New York to an estuary of global and hemispheric significance, the Delaware River watershed includes portions of five states, although only 8 square miles of Maryland are in the watershed. The 326-mile Delaware River is the longest undammed river east of the Mississippi River and forms the borders between Pennsylvania and New Jersey, New Jersey and Delaware, and a portion of Pennsylvania and New York. More than 15 million people live in the watershed, which covers 13,500+ square miles of landscape in the Northeast region (USFWS 2017). The Delaware River is tidal as far north as Trenton, New Jersey (DRBC 2001).

The Upper Delaware Scenic and Recreational River, Middle Delaware Scenic and Recreational River, and Delaware Water Gap National Recreation Area are managed by the National Park Service. Other protected lands along this 326-mile-long big river and its estuary include several National Wildlife Refuges and state parks and forests. Delaware Bay (at 782 square miles) is designated as a Western Hemisphere Shorebird Reserve of hemispheric importance and an Important Bird Area of global significance, supporting a critical migratory bird stopover site for millions of shorebirds every year.

As of 2010, the Delaware River watershed was 47% forest, 24% agricultural lands, 16% developed, 9% wetland, and 2% open water (PDE 2019).

More than 50 conservation partners actively are collaborating on the conservation of the fish and wildlife resources and their habitats in the Delaware River watershed, with significant investments for landscape level conservation over the past decade (Figure 7.1.1). Multi-state collaboration began in 1961 with the Delaware River Basin Compact, expanded with a newly established Delaware Estuary Program in 1989, and then benefited from a watershed ecological condition assessment from the Delaware River Basin Initiative in 2011 that identified priority conservation areas and actions (TNC et al. 2011). More recently, federal investments in landscape level conservation in the basin exceeded $16.7 million in Fiscal Year 2022, with $15.8 million of that available in competitive grants for conservation projects. With a five-year funding supplement from the Bipartisan Infrastructure Bill, that annual funding level is expected to continue through Fiscal Year 2026.

DELAWARE RIVER BASIN COMMISSION

The **Delaware River Basin Commission (DRBC)** is a partnership between the states of New York, New Jersey, Pennsylvania, and Delaware and federal agencies to protect the Delaware River watershed and estuary with both regulatory and non-regulatory programs and initiatives[65]. Created by the **Delaware River Basin Compact** in 1961, the powers and duties of the Commission address water supply, pollution control, flood protection, watershed management, hydroelectric power, recreation, and water withdrawals and diversions (DRBC 1961).

In accordance with the Delaware River Basin Compact, the DRBC developed a **Delaware River Basin Comprehensive Plan** that was updated in 2001 (DRBC 2001). This Comprehensive Plan describes general characteristics of the basin and more than 1700 projects spanning 39 years undertaken by the Commission, which include existing reservoir projects, proposed reservoir projects, municipal water supply and waste disposal projects, non-urban recreation areas, and stream gaging stations. The Commission annually adopts a water resources program for the next six years which must be based on the Comprehensive Plan. Proposed projects that may have a substantial effect on the water resources of the Delaware River basin are subject to regulatory approval by the Commission for conflict with the Comprehensive Plan.

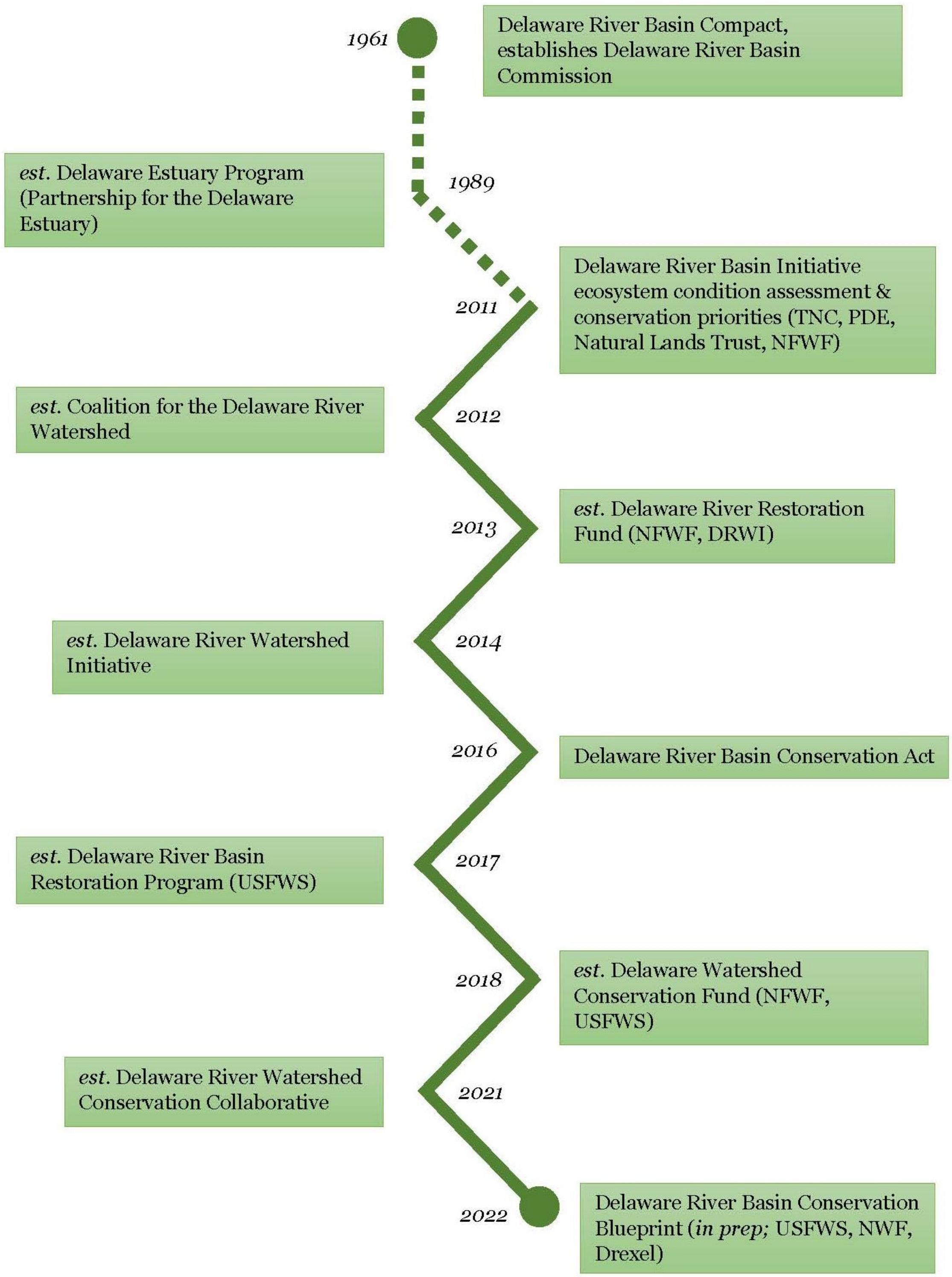

Figure 7.1.1 Timeline of landscape level collaborative partnerships and conservation programs in the Delaware River watershed in New York, Pennsylvania, New Jersey, and Delaware discussed in this section.

The **Delaware River Basin Water Code**, as amended, regulates water resources and sets water quality standards throughout the basin (DRBC 2013). The Code's regulations identify pollutant minimization plans for toxic pollutants, interstate water quality zones, interstate operation formulas for reservoirs, and flow objectives during drought periods. Priority water conservation uses during times of drought are specified at reservoirs and dams to balance recreation, water supply, and salinity. Major water supply reservoirs in the Delaware River basin managed by the Commission include those that supply New York City, Trenton, Philadelphia, and other large urban areas in Pennsylvania, New Jersey and Delaware. The Commission also regulates flood plain use, hydraulic fracturing, and groundwater protected areas in the basin.

The Commission collates monitoring reports, surveys, and research findings, particularly on water quality[66]. Every two years the Delaware River Basin Commission compiles a **Delaware River and Bay Water Quality Assessment** for the EPA, which includes four surface water quality monitoring programs on the non-tidal and tidal portions of the river, plus chronic toxicity monitoring in the estuary and macroinvertebrate monitoring in the non-tidal portion of the river. The biennial assessment supplements Commission monitoring data with monitoring program data from each of the four participating states, the United States Geological Survey, National Oceanic and Atmospheric Administration, and Environmental Protection Agency.

DELAWARE RIVER BASIN RESTORATION PROGRAM

The Delaware River Basin Conservation Act of 2016 established the **Delaware River Basin Restoration Program**[67]. The USFWS and over 35 partners developed a strategic framework for the new program in 2017 (USFWS 2017). The goals of the Delaware River Basin Restoration Program are (USFWS 2017):

- Sustain and enhance fish and wildlife habitat restoration and conservation activities
- Improve and maintain water quality to support fish and wildlife, as well as habitats for fish and wildlife, and drinking water for people
- Sustain and enhance water resource management for volume and flood damage mitigation improvements to benefit fish and wildlife habitat
- Improve opportunities for public access and recreation in the basin consistent with the ecological needs of fish and wildlife habitat
- Engage the public through outreach, education, and citizen involvement to increase capacity and support for coordinated restoration and protection activities in the basin

- Facilitate strategic planning to maximize resiliency of natural systems in changing watershed conditions
- Increase scientific capacity to support planning, monitoring, and research activities necessary to carry out coordinated restoration and conservation activities in the basin
- Provide technical assistance for restoration and conservation activities
- Conserve areas of regional significance

The National Fish and Wildlife Foundation (NFWF) provides Delaware River Basin Restoration Program grant funding through its Delaware River Program. The NFWF Delaware River Program administers the **Delaware Watershed Conservation Fund** and **Delaware River Restoration Fund**[68]. These annual competitive grant programs are dedicated to restoring the water quality of the Delaware River and its tributaries and restoring fish and wildlife habitats. Funding partners for the grants are the USFWS, William Penn Foundation, and AstraZeneca. The Bipartisan Infrastructure Law of 2021 appropriated $26.2 million in supplemental funding to the Delaware Watershed Conservation Fund to be distributed over five years. Funding goals and objectives are described in the **Delaware River Watershed Business Plan for 2017-2027,** as updated in January 2023 (NFWF 2023).

Since its inception in 2018, the Delaware Watershed Conservation Fund has awarded $40.4 million to 159 projects that leveraged an additional $59.7 million in matching funds from 59 grantees. More than 22 miles of riparian habitat and 76 miles of stream habitat were restored in the first five years of the program. More than 1300 acres of wetlands have been conserved and enhanced, over 27,105 acres of forest habitat has been improved, and 4179 acres opened for public access[68].

The Delaware River Basin Restoration Program partners are developing a **Conservation Blueprint** for the basin to prioritize non-regulatory restoration and conservation efforts. The National Wildlife Federation, with technical assistance from Drexel University, is coordinating this effort. The Conservation Blueprint will conduct outreach with multiple user groups, identify data gaps and strategies to fill them, build upon the existing strategic and conservation plans of partners, and incorporate environmental justice metrics (Schaeffer et al. 2022).

Programs modeled after the Delaware River Basin Restoration Program have been proposed for the New York – New Jersey Harbors and Estuary and the Connecticut River basin.

DELAWARE RIVER WATERSHED INITIATIVE

The **Delaware River Watershed Initiative**, established in 2014, is a collaboration among more than 50 organizations and academic institutions to conserve the terrestrial and aquatic resources of the watershed across New York, Pennsylvania, New Jersey, and Delaware[69]. The mission of the Initiative is to safeguard clean water for the basin's 15 million residents, foster green and livable communities that filter polluted runoff, and support river friendly farms. Eight priority target areas identified by the Initiative concentrate conservation efforts in locations with the highest potential for lasting impacts.

The Initiative uses a science-based approach to landscape conservation through a combination of modeling, monitoring, and community science. Delaware River Watershed Initiative partners conduct monitoring throughout the watershed. The partnership's monitoring program intends to detect incremental changes in the health of the basin's waters through the collaboration of research teams, conservation partners, and citizen scientists. Monitoring data is then incorporated into modeling efforts to evaluate the effectiveness of on-the-ground conservation projects.

The **Delaware River Restoration Fund** administered by NFWF pre-dates the Delaware River Basin Restoration Program, launched in late 2013 to assist government agencies and community-based organizations to collaborate on cleaning up and restoring polluted waters in the river basin. Habitat improvements for targeted species like Brook Trout and river herring is another goal of the fund. The Fund awards approximately $2 million annually with three priorities: (1) working lands stewardship, (2) restoration of wetlands, floodplains, and stream corridors, and (3) promoting the adoption of green infrastructure in urban and suburban landscapes. Since 2014 the Delaware River Restoration Fund has awarded 108 grants worth $18.6 million, which leveraged $28.2 million in matching funds. Best management practices to improve water quality have been installed on over 30,000 acres. Sixty-two miles of riparian and instream habitat and more than 143 acres of wetlands have been restored. The Delaware River Restoration Fund is administered by NFWF in cooperation with the Delaware River Watershed Initiative.

DELAWARE RIVER WATERSHED CONSERVATION COLLABORATIVE

The **Delaware River Watershed Conservation Collaborative** is a partnership among 40 partners that have shared priorities and goals in the conservation of the river basin. The Delaware River Basin Restoration Program enabling legislation mandated that the USFWS create a technical assistance program to identify, prioritize, and implement meaningful and coordinated conservation in the watershed, which was affirmed in 2019 when the governors of the watershed states committed to interstate collaboration. The collaborative relationship of the partners was formalized in an organizational governance system in 2021 (USFWS 2021a). The four strategic areas of the Collaborative are:

- Conserving and restoring fish and wildlife habitat

- Improving and sustaining water quality
- Upgrading water management, and reducing flood damage
- Enhancing recreational opportunities and public access

A Delaware River Watershed Conservation Collaborative Steering Committee will establish priorities for and provide guidance on the operation of the Delaware Watershed Conservation Fund that is administered by NFWF to achieve landscape scale conservation.

DELAWARE RIVER BASIN FISH AND WILDLIFE MANAGEMENT COOPERATIVE

The **Delaware River Basin Fish and Wildlife Management Cooperative** is a partnership between the states of New York, Pennsylvania, New Jersey, Delaware, the USFWS, and the National Marine Fisheries Service to manage fish species in the basin, including diadromous fish RSGCN like American Shad (*Alosa sapidissima*). The Delaware River Basin Commission is a liaison member of the Cooperative and other supporting organizations include the National Park Service, Philadelphia Water Department, and The Nature Conservancy. The Cooperative organizes annual surveys to monitor American Shad and other managed fish species. Management of these species is under the direction of the Atlantic States Marine Fisheries Commission.

PARTNERSHIP FOR THE DELAWARE ESTUARY

The Delaware Bay is part of the National Estuary Program and as such is managed by the **Partnership for the Delaware Estuary** as the Delaware Estuary Program[70]. The mission of the Partnership for the Delaware Estuary is to lead collaborative, science-based conservation efforts to improve the Delaware River and Bay in Delaware, New Jersey, and Pennsylvania. With a vision for clean water, thriving fish and wildlife communities, and accessible recreational activities that supports people, communities, and a robust economy, the organization is dedicated to collaboration, science, innovation, engagement, and social justice.

As part of the National Estuary Program, the Partnership for the Delaware Estuary maintains a **Comprehensive Conservation and Management Plan for the Delaware Estuary** that identifies strategic conservation priorities and performance measures (Partnership for the Delaware Estuary 2019). The Bipartisan Infrastructure Law of 2021 provided supplemental funding to the National Estuary Program, allowing the Partnership for the Delaware Estuary to implement the conservation strategies and projects identified in their updated CCMP more quickly.

A **Technical Report for the Estuary and Basin** is prepared every five years, assessing more than 70 environmental indicators[71]. The most recent assessment report was published in 2022, which graded the state of the Delaware Estuary as "fair," unchanged from 2017. The program continually conducts scientific studies and analyses to inform decision-making and conservation priorities, from exploring the use of freshwater mussels to improve water quality in stormwater management ponds to the effects of coastal flooding on tree growth in forested wetlands. Studies and reports are available to the public online[72] and a **Standard Methods Bank** provides guidance on the methods and metrics most appropriate for a project, along with the availability of funding[73].

The Partnership for the Delaware Estuary has three goals related to fish and wildlife habitat: prevent wetland loss, stem the loss of forest, and increase and improve fish and shellfish habitat. To achieve these goals, the program conducts habitat restoration projects, develops natural and nature-based techniques for habitat restoration, and conducts habitat inventory and assessment projects to identify priority sites for protection, enhancement, and restoration. Horseshoe Crabs, Oysters, and freshwater mussels are of particular interest. The **Mussels for Clean Water Initiative** is a partnership between the estuary program and the Pennsylvania Infrastructure Investment Authority to construct and operate a multi-million-dollar, large scale freshwater mussel hatchery and research center that broke ground in 2020, building on the organization's existing freshwater mussel propagation research at the Fairmount Water Works[74]. The geographic focus area of this initiative is both the Delaware and Susquehanna River basins, depending on funding.

COALITION FOR THE DELAWARE RIVER WATERSHED

The **Coalition for the Delaware River Watershed** coordinates the protection and restoration work of 170+ member organizations and stakeholders in the Delaware River basin to enhance their capacity[75]. Formed in 2012, the Coalition coordinates communications and advocate policy at the state and federal levels, considering itself the voice of nonprofit organizations to the Delaware River Basin Restoration Program. In 2020, the Coalition adopted a 5-year strategic plan that describes shared goals, objectives, and activities (Coalition for the Delaware River Watershed 2020). The five goals of the Coalition identified in their 2021 – 2026 Strategic Direction are:

1. To address systemic racism, the Coalition will advance its diversity, equity, inclusion, and justice efforts to serve as a clearinghouse for resources and peer-to-peer learning.
2. As a convener of organizations throughout the region, the Coalition will strive to empower and engage a larger, more inclusive constituency to support watershed-wide planning and advocacy initiatives.

3. Advocate for robust federal restoration funding to support the watershed's restoration and protection needs (particularly through the Delaware River Basin Restoration Program).
4. Ensure federal and state policies, spending, and implementation support a resilient and healthy Delaware River watershed.
5. Respond in a swift and unified manner to defend the watershed against emergent and systemic threats on the state and federal level as they relate to our mission of protecting and restoring the land and waters in the Delaware River Basin.

The Coalition for the Delaware River Watershed maintains a **Diversity, Equity, Inclusion and Justice (DEIJ) Resource Hub** that provides access to a DEIJ Workgroup, a DEIJ Lens and Screening Tool, and resources for individual learning and training, external engagement practices, internal organizational practices, and communications and digital media[76]. The Coalition's website also collates funding, grant, and support opportunities for both DEIJ efforts and infrastructure.

WATERKEEPERS

Since 1988 the **Delaware Riverkeeper Network** works throughout the entire Delaware River watershed in support of healthy waterways and their resources[77]. As with other Waterkeepers, the Delaware Riverkeeper Network conducts volunteer monitoring programs, effective environmental advocacy, habitat and stream restoration projects, public education, and when necessary, litigation to ensure enforcement of environmental laws. The organization's citizen science volunteers conduct water quality monitoring through the **Water Watch** program[78], established in 1992. Data collected since 2007 as part of this program has trained 85 watershed groups and 3000+ residents and alerted regulatory officials of more than 170 incidents of pollution through a Water Watch Pollution Hotline. Monitoring protocols and tools are available, customized to different types of environmental conditions (e.g., streams underlain by shale, vernal pools). The **For the Generations Initiative** is a nationwide project to advance constitutional rights to pure water, clean air, and a healthy environment.

The Habitat Restoration Program provides ecological design services and assists municipalities, agencies, local conservation and community groups, and private landowners to develop restoration plans and implement projects. Example projects include ecological master plans, riparian corridor restoration, tree plantings, bioswale installation, rain gardens, trails, woodland restoration, and invasive species removal.

7.1.6 CHESAPEAKE BAY WATERSHED

The Chesapeake Bay watershed spans more than 64,000 square miles in six states – New York, Pennsylvania, Maryland, Delaware, West Virginia, Virginia - and the District of Columbia. Chesapeake Bay is the largest estuary in the United States and third largest in the world, with approximately 4480 square miles of open water and tidal wetlands and flats and around 3600 fish, wildlife and plant species. Nearly one million waterfowl winter on or near the bay, roughly one-third of the Atlantic Coast's migratory waterfowl population (USFWS 2021b). The Chesapeake Bay Estuarine Complex has been identified as an internationally important wetland under the Ramsar Convention[36]. The Susquehanna River is the dominant river in the bay's watershed, with other major tributaries being the Potomac River, Rappahannock River, York River, and James River. Altogether there are 180,000 miles of rivers and streams in the watershed and more than 11,680 miles of estuarine shoreline along Chesapeake Bay. More than 18 million people live in the bay's watershed.

Like the Delaware River basin, existing landscape scale conservation partnerships in the Chesapeake Bay watershed have received supplemental federal investments from the Bipartisan Infrastructure Law. An expected boost of $248 million over five years, Fiscal Years 2022 – 2026, is shared among existing competitive grant programs (i.e., the Chesapeake Bay Stewardship Fund, Chesapeake Bay Program) and as part of the EPA's Most Effective Basins Program that provides funding for state-based implementation of projects in the most effective river basins. Several conservation partnerships in the Chesapeake Bay watershed provide opportunities to advance SWAP implementation and leverage enhanced funding programs.

CHESAPEAKE BAY PROGRAM

The **Chesapeake Bay Program**, established in 1983, is a regional partnership implementing the goals of the Chesapeake Bay Watershed Agreement[79]. The **Chesapeake Bay Watershed Agreement** is a multi-state and federal agreement that includes all the states within the Bay's watershed. The 2014 Agreement, as amended in August 2022, has ten goals and 31 outcomes (conservation targets) guiding the restoration of Chesapeake Bay and its watershed[80]. State specific plans with pollution reduction goals for 2025 address Environmental Protection Agency pollution limits for the estuary that were set in 2010. The EPA issues two-year milestones on implementation of the state **Watershed Implementation Plans**[81]. The October 2022 evaluation found that there were new significant successes in 2022, but most of the watershed's states are not on track to meet the 2025 water quality restoration goals. Only West Virginia and the District of Columbia are on track to meet their cleanup goals of the nation's largest estuary.

The Chesapeake Bay Program partnership coordinates citizen science and non-traditional monitoring of water quality and benthic macroinvertebrates in the Chesapeake watershed through the **Chesapeake Monitoring Cooperative**[82]. The program's **Chesapeake Data Explorer** allows citizen scientists to store and manage data they collect and the public an opportunity to access data collections. The Program provides technical assistance to interested organizations or members of the public who desire to start a monitoring program.

Similar to the programs in the Delaware River basin, the NFWF, EPA, Chesapeake Bay Program, USFWS and other partners administer the **Chesapeake Bay Stewardship Fund** in a public-private partnership[83]. The Chesapeake Bay Stewardship Fund offers four grant programs, which awarded $22.4 million in grants in Fiscal Year 2021 (NFWF 2022). While the **Pennsylvania Most Effective Basins Grants Program** is state-based to assist the state of Pennsylvania in implementing its Watershed Implementation Plan for the Chesapeake Bay, the other three grant programs are regional in scope.

The **Small Watershed Grants Program** is supported by the EPA, Chesapeake Bay Program, US Forest Service, US Department of Agriculture, and Altria to provide planning and technical assistance grants to enhance local capacity or to implement projects that restore water quality, species, or habitat. The **Innovative Nutrient and Sediment Reduction Grants Program** supported by the EPA and Chesapeake Bay Program funds water quality improvement projects using practices approved by the Chesapeake Bay Program for crediting under the Chesapeake Bay Total Maximum Daily Load (TMDL) pollution limits and associated state Watershed Implementation Plans. Supplemental funding for the Small Watershed and Innovative Nutrient and Sediment Reduction Grants Programs through the Bipartisan Infrastructure Law prioritizes projects that restore riparian forest buffers; create, rehabilitate, or enhance tidal and non-tidal wetlands; restore floodplains; manage shorelines; and plant and/or maintain urban tree canopies. The **Chesapeake Watershed Investments for Landscape Defense (WILD) Grants Program** is described in the next section.

The NFWF **Chesapeake Bay Business Plan** describes the funding priorities of the Chesapeake Bay Stewardship Fund (NFWF 2018). Between 1999 and 2022, the Chesapeake Bay Stewardship Fund awarded over 1350 grants worth more than $248 million, leveraging over $351 million in matching funds[83]. According to NFWF, these projects have:

- Reduced annual nitrogen pollution loading by an estimated 28 million pounds
- Reduced annual phosphorus loading by an estimated 5.4 million pounds
- Reduced annual sediment loading by an estimated 1.3 billion pounds
- Restored more than 3,700 miles of streams
- Treated stormwater runoff from 14,764 acres of impervious surfaces

- Reached an estimated 7.5 million residents through outreach efforts
- Restored more than 15,987 acres of wetlands and 2,443 miles of forested riparian buffers
- Installed more than 2,175 miles of livestock exclusion stream fencing
- Reconnected more than 581 miles of rivers and streams for fish passage
- Established 396 acres of oyster reefs
- Protected 171,291 acres of forests

The Program also maintains a list of grant opportunities and requests for proposals related to Bay conservation[84]. More than 125 maps, figures, and infographics on Chesapeake Bay and its ecological conditions are available from the Chesapeake Bay Program, which can inform SWAPs and education and outreach by the Bay's conservation partners[85].

The policy direction of the Chesapeake Bay Program is established by the **Chesapeake Executive Council**. Council members are the governors of the six watershed states, the mayor of the District of Columbia, the chair of the Chesapeake Bay Commission, and the administrator of the EPA[86].

CHESAPEAKE BAY COMMISSION

The **Chesapeake Bay Commission** is a legislative body serving Pennsylvania, Maryland, and Virginia[87]. Recently celebrating its 40th anniversary, the Commission was established to be a catalyst for the coordinated leadership of state legislative and policy actions to restore Chesapeake Bay. The Commission represents the state legislative interests in the Chesapeake Bay Program partnership and as a liaison to the US Congress on budgetary and policy matters for the watershed. Three citizen representatives serve on the Chesapeake Bay Commission, along with five legislators and the cabinet secretary of natural resources from each state.

The Commission's enabling legislation adopted by the three states has five goals[88]:

1. To assist the legislatures in evaluating and responding to mutual Bay concerns;
2. To promote intergovernmental cooperation and coordination for resource planning;
3. To promote uniformity of legislation where appropriate;
4. To enhance the functions and powers of existing offices and agencies; and
5. To recommend improvements in the management of Bay resources.

The Chesapeake Bay Commission is a member of the Chesapeake Executive Council, a signatory on the Chesapeake Bay Watershed Agreement, and the Chesapeake Bay Program partnership.

CHESAPEAKE WILD

The **Chesapeake Watershed Investments for Landscape Defense (WILD) Program**, established in 2020 by the **America's Conservation Enhancement Act**, requires the USFWS establish a non-regulatory program with three purposes (USFWS 2021b):

1. Coordination among federal, state, local, and regional entities to establish a shared vision for sustaining natural resources and human communities throughout the Chesapeake Bay and its watershed.
2. Engagement of diverse agencies and organizations to build capacity and generate funding that address shared restoration and conservation priorities.
3. Collaboration to administer a grant program and implement projects to conserve, steward, and enhance fish and wildlife habitats and related conservation values.

The **Chesapeake WILD Framework** completed in 2021 has five Program pillars to fulfill the purposes of the enabling legislation (USFWS 2021b):

- Fish and Wildlife Habitats: Conserve, restore, enhance, and sustain a resilient network of fish and wildlife habitats and connecting corridors, with an emphasis on at-risk and federally listed species.
- Climate Change: Advance climate change adaptation and land-use planning by increasing science capacity to support improved strategic planning, conservation design, monitoring, and applied science activities necessary to ensure resilience of natural ecosystems and habitats.
- Community Partnership: Increase capacity and support for coordinated restoration and conservation activities in the Chesapeake Bay watershed, particularly in historically and systemically under-resourced communities, through outreach, education, and civic engagement.
- Public Access: Enhance recreational opportunities and public access with a strong emphasis on equitable access to nature and all associated benefits, consistent with the ecological needs of fish and wildlife habitat.
- Water Quality: Improve and sustain water quality, upgrade water management capability, and reduce flood damage to support fish and wildlife, habitats of fish and wildlife, and drinking water for people.

The **Chesapeake Watershed Investments for Landscape Defense (WILD) Grants Program**[89] supported by the USFWS, with private contributions from Altria, focuses on efforts to improve the condition and connectivity of habitats for fish and wildlife species in the Chesapeake Bay watershed in accordance with these five pillars. NFWF administers the Chesapeake WILD Grant Program through the Chesapeake Bay Stewardship Fund.

CHESAPEAKE CONSERVATION PARTNERSHIP

The **Chesapeake Conservation Partnership** was established in 2009 as a network of conservation partners representing a diverse cross-section of stakeholders and partners[90]. The mission of the Partnership is to foster collaboration to conserve the ecologically and culturally important landscapes of the Chesapeake Bay watershed to benefit people, economies, and nature. Formerly known as the Chesapeake Large Landscape Conservation Partnership, the Chesapeake Conservation Partnership brings together partners with shared principles of conservation, preservation, information sharing, and long-term sustainability.

The Chesapeake Conservation Partnership collaborated with experts across the region to create the **Chesapeake Conservation Atlas**, incorporating science and decision-support tools from Nature's Network (see *Chapter 2*), the earlier **LandScope Chesapeake**, and other resources[91]. The Chesapeake Conservation Atlas, version 1.1 completed in March 2018, maps existing natural resources that relate to the long-term conservation goals for habitats, forests, farms, heritage, and human health. The priorities identified in the Atlas provide a foundation for the Chesapeake WILD Program. The Chesapeake Conservation Partnership has also created a **Green Space Equity Tool** that highlights in an interactive map low-income communities and communities of color that have limited access to open space in the Chesapeake Bay watershed[92].

Federal **Executive Order 13508, Chesapeake Bay Protection and Restoration** of 2009 identified a need for greater federal leadership in conservation of Chesapeake Bay. In 2010 the resulting **Strategy for Protecting and Restoring the Chesapeake Bay Watershed** aligned with the goals and objectives of the existing Chesapeake Bay Program, which recommended protection of an additional two million acres of land and creation of 300 public access sites by 2025 (Federal Leadership Committee for the Chesapeake Bay 2010). The Chesapeake Conservation Partnership broadened its focus to include these priorities as well as priorities to address diversity, equity, inclusion, and justice considerations. The Partnership now includes a broad coalition of the Chesapeake Bay Program, USFWS, other federal agencies, natural resource agencies from the six watershed states, and the District of Columbia, and more than 50 organizations and agencies engaged in land conservation, habitat restoration, outdoor recreation access, and related work (USFWS 2021b).

CHESAPEAKE PROGRESS

The Chesapeake Bay Program and its federal, public and internal oversight groups track the Program's progress toward reaching the goals and outcomes of the Chesapeake Bay Watershed Agreement through **Chesapeake Progress**[93]. Chesapeake Progress is an online platform repository of status and trends data on clean water, abundant life, conserved lands, engaged communities, and climate change goals of the Chesapeake Bay Program. More than two dozen indicators of environmental health, restoration, and stewardship are tracked with accurate, up-to-date and accessible data available to the public and partners (see *Chapter 5* for the list of indicators). Indicator data is compiled from multiple sources, from government agencies, nongovernmental organizations, and academic institutions to direct demographic and behavior surveys. The data and analysis provided by Chesapeake Progress informs the adaptive management based decision-making process of the Chesapeake Bay Program.

One of the shared goals of the Chesapeake Bay Program, Chesapeake WILD, and the Chesapeake Conservation Partnership, as adopted in the Chesapeake Bay Watershed Agreement, is to protect an additional two million acres of the watershed between 2010 and 2025 (Federal Leadership Committee for the Chesapeake Bay 2010). Chesapeake Progress is tracking progress towards this goal (Figures 7.1.2, 7.1.3). As of early 2019, nearly 1.36 million acres had been protected, bringing the total to 9.2 million acres, or 22% of the watershed. The performance monitoring target is on target and has been

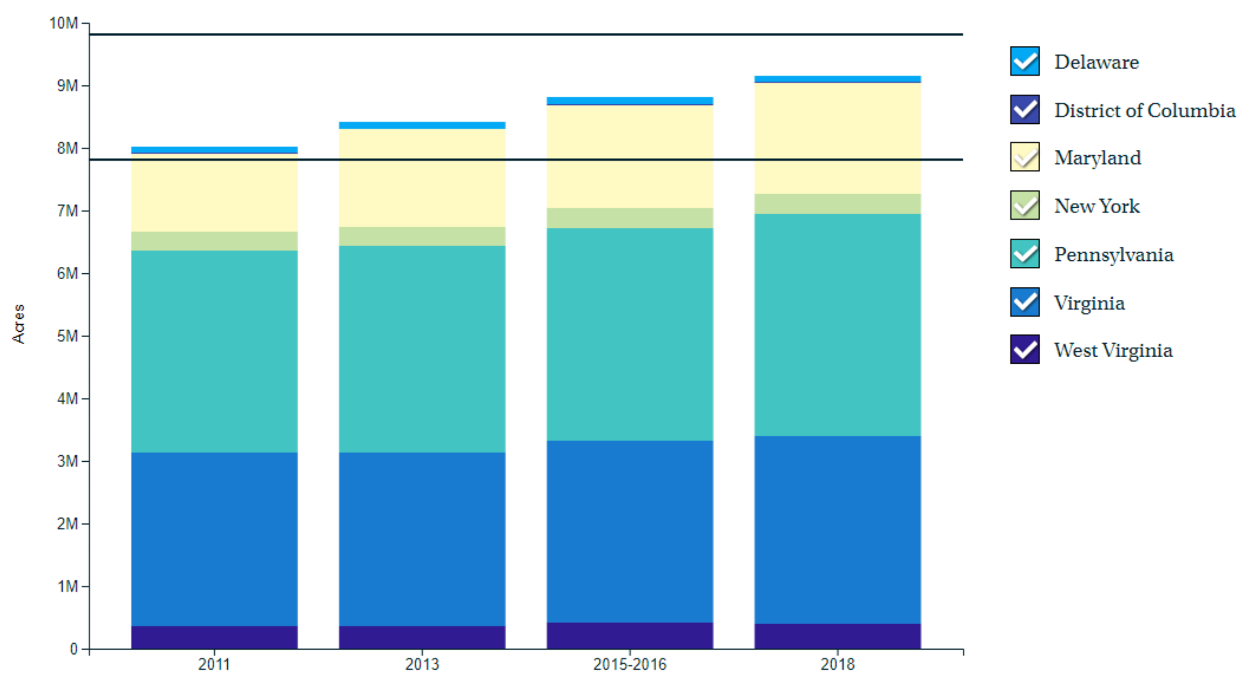

Figure 7.1.2. The area of protected lands in the Chesapeake Bay watershed from 2011 to 2018, as tracked by Chesapeake Progress for each of the watershed states and the District of Columbia[94].

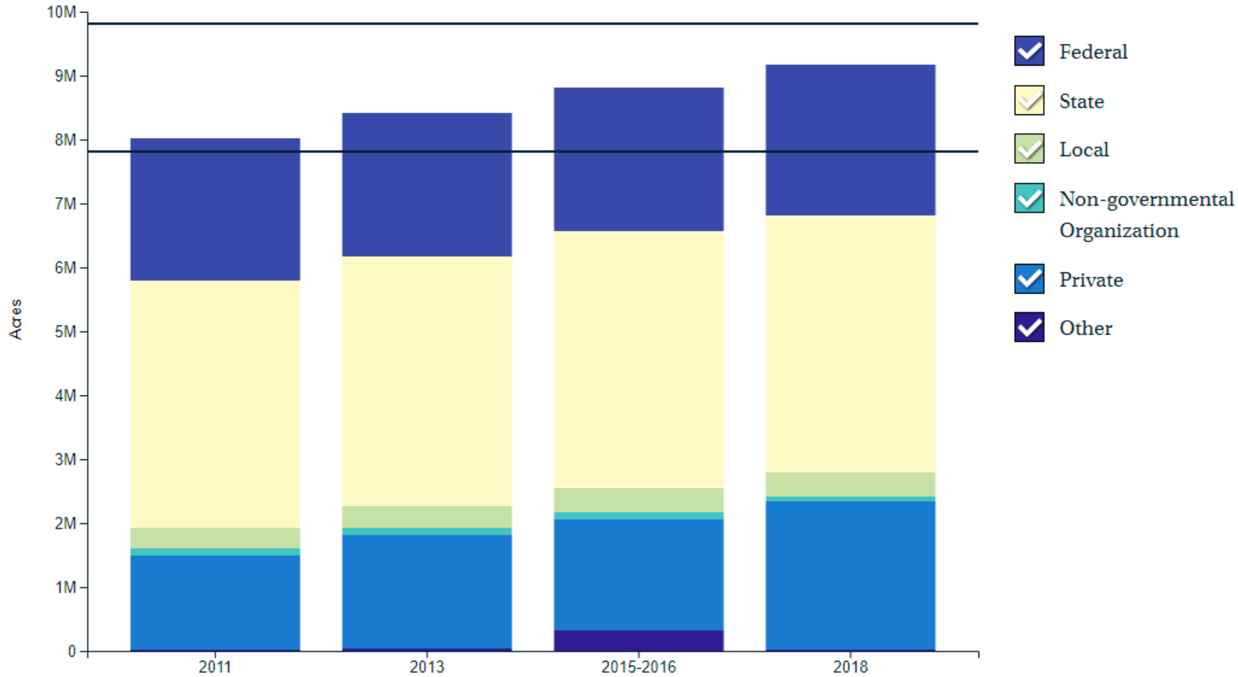

Figure 7.1.3. The area of protected lands in the Chesapeake Bay watershed from 2011 to 2018, as tracked by Chesapeake Progress by type of land ownership[94].

revised to target 30% protected lands by 2030 in accordance with the **America the Beautiful Initiative**[95] and the Chesapeake Executive Council's **Directive No. 21-2: Collective Action for Climate Change**. State lands are the largest contributors to the watershed's land protection, owning approximately 44% of the protected lands (Figure 7.1.3).

SUSQUEHANNA RIVER BASIN COMMISSION

The **Susquehanna River Basin Commission (SRBC)** is a regulatory and non-regulatory partnership between the states of New York, Pennsylvania, and Maryland as per the 1961 Susquehanna River Basin Compact[96]. The Commission is structured and functions similar to the Delaware River Basin Commission. The updated **Comprehensive Plan and Water Resources of the Susquehanna River Basin** describes the Commission's vision, needs, and strategy to effectively manage the 27,500 square mile river basin's water resources for 20 years – from 2021 to 2041 (SRBC 2021). The Plan identifies four Priority Management Areas for water supply, water quality, flooding and drought, and watershed management.

The Monitoring and Protection Program of the Susquehanna River Basin Commission conducts biological, chemical, and physical monitoring of the streams in the river basin, including water quality monitoring for fish, macroinvertebrates, stormwater, sediment and nutrient loadings, and abandoned mine drainage. The **Susquehanna Atlas** provides an interactive online platform to explore the river basin, Commission projects and program locations, and many spatial datasets for environmental characteristics and settings[97]. The Commission also provides online public access to regulated water use projects, monitoring data on quarterly water usage and passby volumes, post-hydrofracture reports, historical water usage and passby monitoring data, continuous instream monitoring data, sediment and nutrient assessments, water quality indices, invasive species eDNA monitoring, and chemical data associated with mine drainage impacts to rivers and streams. Resources for the Commission's environmental education programs, such as **Eels in the Classroom**, are also available through a series of story maps and dashboards[98].

The Commission provides grants for projects that improve the sustainability of streamflows and groundwater during times of drought, with up to $6 million available in 2023. Other grants are available for monitoring groundwater levels.

UPPER SUSQUEHANNA CONSERVATION ALLIANCE

The **Upper Susquehanna Conservation Alliance** was created in 2010 by the New York Ecological Services Field Office of the USFWS to promote landscape level conservation in the upper portion of the Susquehanna River and Chesapeake Bay watershed[99]. The Alliance has brought together 50 organizations with shared conservation interests in the watershed. The USFWS hosts annual meetings of the Upper Susquehanna Conservation Alliance to share information, strengthen partnerships, share funding opportunities, and collaborate on conservation projects. The Alliance has eight work groups:

- Landscape Conservation and Planning Work Group
- Flood Work Group
- Invasive Species Work Group
- Roadside Ditch Work Group
- Eastern Brook Trout Work Group
- Eastern Hellbender Work Group
- Pearly Mussel / American Eel Work Group
- Outreach Work Group

Example projects and accomplishments of the Upper Susquehanna Conservation Alliance include technical assistance with mapping analyses to identify important habitat connectivity areas, landscape areas for restoration and protection, and priority floodplains for protection; grants for land purchases; aquatic barrier removals; stream and wetland restoration; outreach to municipalities; professional training; a roadside ditch improvement program; development of standardized species survey protocols; species reintroductions; and species management plans for the watershed.

UPPER SUSQUEHANNA COALITION

The **Upper Susquehanna Coalition** is a partnership of 22 soil and water conservation districts in New York and Pennsylvania, representing 99% of the upper Susquehanna River watershed upstream of Towanda, Pennsylvania[100]. Together these districts include 16,800 miles of rivers and streams, 17,000 miles of roads, and 7500 square miles of watershed. Since 1992 the Coalition has collaborated to address water quality in the headwaters of Chesapeake Bay. In 2006 the Coalition formalized their partnership with a legally-binding Memorandum of Understanding. The partnership plans and implements restoration projects to improve water quality, including programmatic approaches that address barriers to effective conservation. Priority issues for the group are flooding, streambank erosion, gravel deposition, and nutrient loading. The Coalition has developed BMPs for timber harvesting operations and a climate change resiliency toolkit that prioritizes BMP locations and types to maximize their efficiency to assist farms with climate adaptation.

CHESAPEAKE CONSERVANCY

The **Chesapeake Conservancy** nonprofit organization contributes to the conservation of Chesapeake Bay through land protection, public access sites, and the use of innovative technology to accelerate progress in conserving the Bay's landscapes and cultural heritage while providing equitable access to people[101]. The Conservancy's Conservation Innovation Center, for example, is using cutting-edge technology approaches for the **Precision Conservation Partnership** to streamline farmer outreach and grant administration, identify the most important and impactful sites for stream restoration, and implement a rapid de-listing strategy for rivers and streams in the Susquehanna River watershed impaired on the Clean Water Act Section 303(d) list[102].

The organization has assisted in creating 206 new public access sites throughout the Bay and is a partner with the National Park Service on the **Chesapeake Bay Gateways Network**[103]. The National Park Service's Chesapeake Bay Gateways and Watertrails Program was established in 1998 to enhance conservation stewardship through connecting people with the Bay with outdoor recreation opportunities, interpretive trail signage and exhibits, and youth programs. The National Park Service program provides financial and technical assistance for community projects that improve public access and support the outdoor recreation economy of the Bay, supporting 360 projects to date.

Defining **Indigenous Cultural Landscapes** is a focus area for the Chesapeake Conservancy. Cultural landscapes are defined by the National Park Service as areas that reveal people's relationship with place and strengthen understanding of historic events, significant people, and patterns in American history[104]. Indigenous Cultural Landscapes associated with the Captain John Smith Chesapeake National Historic Trail, which spans the Chesapeake Bay watershed, are places where uniquely Indigenous perspectives can inform land management decisions. These landscapes include both cultural and natural resources that would have supported the lifestyles and settlement patterns of an Indian group as a whole. The Chesapeake Conservancy has contributed to studies defining Indigenous Cultural Landscapes for the Greater York River, Rappahannock, Nanticoke, Nanjemoy and Mattawoman Creek, and Lower Susquehanna Area[105].

The Chesapeake Conservancy also is a partner with the USFWS, Chesapeake Conservation Partnership, Chesapeake Bay Program, Bureau of Land Management, and other regional and community collaborations to protect the resources of Chesapeake Bay.

CHESAPEAKE BAY FOUNDATION

The **Chesapeake Bay Foundation**, founded in 1966, is the largest independent nongovernmental organization dedicated solely to the conservation of Chesapeake Bay[106]. With the motto "Save the Bay," the Chesapeake Bay Foundation advocates for effective and science-based solutions to pollution that is degrading the Bay and its rivers and streams. The organization operates offices across the watershed, engaging public leaders in making commitments to restoration of Chesapeake Bay. The Chesapeake Bay Foundation's mission to restore water quality in the Bay is defined as reaching a score of 70 (out of 100) on the organization's Health Index, with a perfect score of 100 equivalent to the theoretical condition of the Bay at the time of Colonial exploration in the early 1600s. To that end, the group monitors the Bay's water quality and issues **State of the Bay Reports** every two years using 13 indicators (described in *Chapter 5*).

In addition to monitoring the condition of Chesapeake Bay and its watershed, the Chesapeake Bay Foundation performs restoration work with partners to restore forests, wetlands, and oyster reefs in particular. The Foundation works with farmers to implement regenerative agriculture practices and increase resilience to climate change. Trees for restoration projects are grown on a sustainable farm operated by the organization, which are planted at restoration and urban forestry sites by hundreds of volunteers annually all across the watershed. Another initiative supported by the Foundation is the **Mountains-to-Bay Grazing Alliance**, a collaboration of private and public partners to promote rotational grazing and related conservation practices and increase the number of pasture-based livestock operations in Pennsylvania, Maryland, and Virginia[107].

The Chesapeake Bay Foundation conducts extensive environmental education programs, both in the classroom and in the field. Their **Chesapeake Classrooms** program trained 260 teachers in outdoor education curriculum as ambassadors for environmental education in 2022. A **Student Leadership** program teaches students how to build advocacy skills, work together to study their local environments, and take action on conservation projects in their communities.

WATERKEEPERS

There are 16 Waterkeeper groups in the Chesapeake Bay watershed, monitoring thousands of miles of waterways across four states and the District of Columbia under the regional umbrella of **Waterkeepers Chesapeake**[108]. Together these 16 Waterkeeper groups enlist the support of nearly 18,000 volunteers and members to protect the water resources of the watershed. Individual Waterkeepers serve the following subwatersheds:

- Anacostia Riverkeeper
- Baltimore Harbor Waterkeeper
- Chester Riverkeeper
- Choptank Riverkeeper
- Gunpowder Riverkeeper
- James Riverkeeper
- Lower Susquehanna Riverkeeper
- Middle Susquehanna Riverkeeper
- Miles-Wye Riverkeeper
- Patuxent Riverkeeper
- Potomac Riverkeeper
- Sassafras Riverkeeper
- Severn Riverkeeper
- Shenandoah Riverkeeper
- South, West and Rhode Riverkeeper
- Upper Potomac Riverkeeper

More information can be found about each of these Waterkeepers on the Waterkeeper Alliance website[109].

7.1.7 MARINE COUNCILS AND COMMISSIONS

The **Northeast Regional Ocean Council (NROC)** is a state and federal partnership to assist New England partners at the regional level address ocean and coastal issues including the conservation of the region's ocean and coastal resources[110]. NROC was formed by the five Governors of the states of New England, from Maine to Connecticut, in 2005. The three primary focus areas of NROC, which each have a standing committee, are:

- Ocean and Coastal Ecosystem Health: promoting sustainability through science-based management
- Ocean planning: coordinating regional planning for ocean industry, conservation, and recreation
- Coastal Hazard Resilience: providing data and tools to prepare for storms, erosion, and inundation

Climate change is recognized by NROC as a major driver that affects all three focal areas and as such is addressed by all three committees. Each committee develops two-year work plans with strategic priorities. The **Ocean and Coastal Ecosystem Health Committee** has two subcommittees addressing New England estuaries and marine nearshore habitats – the **Marsh Migration Group** and the **Living Shorelines Group**, both aiming to improve understanding and enhancement of habitat resiliency. Resources developed by both subcommittees can be found on the NROC website[110].

The **Mid-Atlantic Regional Council on the Ocean (MARCO)[111]** a collaboration of five states (NY, NJ, DE, MD and VA) formed by their Governors in 2009. MARCO established a **Mid-Atlantic Committee on the Ocean** to facilitate collaboration among state, federal and tribal partners plus the MAFMC and other stakeholders. Shared regional priorities include adaptation to climate change, marine habitats, water quality and renewable energy. MARCO maintains the **Mid-Atlantic Ocean Data Portal** for the southern portion of the NEAFWA region, with some data layers extending farther north or south[112]. To increase awareness and appreciation of the biodiversity of the region's deep-sea canyons, MARCO and partners have developed a multiple webinar series and educational materials that showcase research about and imagery of these remote habitats[113].

Numerous RSGCN and Watchlist species are managed by the National Marine Fisheries Service (NOAA Fisheries), **New England Fishery Management Council (NEFMC)**, **Mid-Atlantic Fishery Management Council (MAFMC)** and **Atlantic States Marine Fisheries Commission (ASMFC)**, with management plans that address habitat as well as species populations. A group of highly migratory species (HMS) of marine fish, for example, are managed jointly by the National Marine Fisheries Service under the **Atlantic HMS Fishery Management Plan[114]**. RSGCN and Watchlist marine fish managed as HMS in this management plan include Bluefin Tuna (*Thunnus thynnus*), Common Thresher Shark (*Alopias vulpinus*), Scalloped Hammerhead (*Sphyrna lewini*), Shortfin Mako (*Isurus oxyrinchus*), and White Shark (*Carcharodon carcharias*). Internationally HMS are managed by the **International Commission for the Conservation of Atlantic Tunas (ICCAT)** and include RSGCN Bluefin Tuna and White Marlin (*Kajikia albida*), although several pelagic oceanic sharks are also of interest like Watchlist Blue Shark (*Prionace glauca*) and RSGCN Shortfin Mako[115].

The **Atlantic Coast Fish Habitat Partnership** is the regional Fish Habitat Partnership to conserve, protect, restore and enhance habitat for native Atlantic coastal, diadromous and estuarine-dependent fishes, from river headwaters to the edge of the continental shelf, with a focus on estuarine habitats. The ACFHP has identified several conservation objectives for the North Atlantic and Mid-Atlantic regions for coastal fish habitat in their **Conservation Strategic Plan 2017-2021** and accompanying **Conservation Strategic Plan 2020-21** (ACFHP 2017, 2020).

The ACFHP conducts conservation actions throughout the Northeast, from restoring aquatic connectivity on Rivers and Streams habitat to restoring oyster reefs, salt marsh and SAV beds. In Estuaries, ACFHP priority habitats include shellfish beds, live hardbottoms, unvegetated substrates, SAV, macroalgae and associated Tidal Wetlands. In the North Atlantic region the three priority habitats for ACFHP conservation efforts are riverine bottoms (for diadromous fish), SAV and marine and estuarine shellfish beds. In the Mid-Atlantic priority conservation habitats include the same three plus Tidal Wetlands (ACFHP 2017). The Partnership provides funding through the National Fish Habitat Partnership for habitat conservation projects. All five projects funded by the ACFHP in 2022 are within the NEAFWA region and include a fish passage project for Atlantic Salmon in Maine, oyster restoration in Chesapeake Bay, and dam removals in Massachusetts, Connecticut and New Jersey.

The ACFHP has developed a number of decision-making tools addressing the conservation needs of fish and their habitats along the Atlantic coast, including a species-habitat matrix tool[116] to evaluate the relative importance of specific habitat types for a given life history stage of an individual species (Kritzer et al. 2016) and the estuarine and diadromous sections of the **Fish Habitat Decision Support Tool** that visualizes and ranks fish habitat[117].

7.2 FEDERAL PARTNERS

Federal agency partners provide an integral role in conserving the Northeast's fish and wildlife resources and their habitats. These national conservation partners contribute to protecting, conserving, and restoring the fish and wildlife resources of the NEAFWA region in a myriad of ways that can leverage state resources to develop, revise, and implement State Wildlife Action Plans. The following federal agencies, programs, and projects, a representative set of examples that is by no means exhaustive, provide opportunities to inform and contribute to SWAP implementation in six key ways. Additional information about these agencies, programs, and projects are available online through each agency.

7.2.1 LAND PROTECTION AND MANAGEMENT

Several federal agency partners own land and/or conservation easements in the Northeast that create opportunities for habitat protection, restoration and/or enhancement. The USFWS operates the **National Wildlife Refuges System**, with at least 87 National Wildlife Refuges in the NEAFWA region. Each refuge has a **Comprehensive Conservation Plan** describing its natural resources, conservation needs and priorities. The US Forest Services owns and manages six **National Forests** in the Northeast covering more than 4.4 million acres of land.

The National Park Service has at least 38 **National Parks, Recreation Areas, Historic Sites, and Trails** with significant landholdings, plus countless smaller historical parks and National Monuments. The NOAA has three **National Marine Sanctuaries and Monuments** in the Northeast: Gerry E. Studds / Stellwagen Bank National Marine Sanctuary, Northeast Canyons and Seamounts Marine National Monument, and Mallows Bay – Potomac River. Additional National Marine Sanctuaries have been proposed for the Hudson Canyon offshore New York and New Jersey and on Lake Ontario, with the formal designation process starting in June 2022 for the former and April 2019 for the latter.

The US Department of Defense operates approximately 90 military installations in the NEAFWA region, each with an **Integrated Natural Resources Management Plan** in coordination with the USFWS and state in which the installation is located. These installations own and manage 1.2 million acres of land (Ineson and Tur 2022), one of which (Fort Indiantown Gap in Pennsylvania) hosts the only extant population of the RSGCN eastern subspecies Regal Fritillary (*Argynnis idalia idalia*). The **Department of Defense Partners in Amphibian and Reptile Conservation** Network[118] and the **National Military Fish and Wildlife Association**[119] offer partnership opportunities for natural resource managers, such as the use of BMPs for turtles on military lands. The **Sentinel Landscapes Partnership** is a coalition of federal agencies (Department of Defense, Department of the Interior and USDA), state and local governments, and nongovernmental organizations that partners with private landowners surrounding military installations and ranges to advance sustainable land management practices and protect the installations from incompatible land uses[120]. In the NEAFWA region, the **Middle Chesapeake Sentinel Landscape** was established in 2015 and as of 2022 has protected 51,107 acres of land and enrolled 203,259 acres in management programs, enhancing habitat for more than 120 rare, threatened, or endangered species[121].

The **United States Army Corps of Engineers** (USACE) is perhaps a less well recognized landowner in the Northeast region[122]. The USACE operates and manages 2700 miles of navigation channels, 54 dams, 63 miles of levees, and 22 storm and hurricane barriers in the NEAFWA region. In collaboration with partners, oftentimes state agencies, the USACE owns and/or manages 179 recreational sites in the Northeast with seven lakes, 763 miles of trails, and nearly 2500 campsites that received 10 million visits in 2019.

7.2.2 ENVIRONMENTAL REVIEW AND PERMITS

Several federal agencies have regulatory authorities that can inform and advance SWAP conservation. Federal partners who manage permitting programs or regulatory oversight can, and sometimes already do, incorporate SGCN, RSGCN, and key habitats as priorities, creating opportunities to avoid and minimize adverse impacts. Some of these regulatory programs delegate, coordinate, or have oversight of state authorities and programs, such as individual state coastal zone management programs approved and overseen by NOAA under the **Coastal Zone Management Act of 1972**. The federal consistency provision of the Coastal Zone Management Act requires that federal actions that have a reasonably foreseeable effect on any coastal land or water use, or natural resources of the coastal zone, be consistent with the state's federally approved coastal management program[123]. Federal actions include agency activities (e.g., construction, dredging, shoreline stabilization), license or permit activities, and funding. In this way there is a dual federal-state partnership to manage coastal resources, offering opportunities to incorporate SWAP priorities in environmental and consistency reviews plus permitting activities.

The USFWS and National Marine Fisheries Service (NMFS) have regulatory authority under the **Endangered Species Act of 1972**, as amended, to protect species listed under the Act. The status of federally-listed species is often included as a selection criteria for RSGCN or SGCN, and conservation of SGCN and RSGCN that are not federally-listed offer opportunities to conserve a species and preclude listing. The **Magnuson-Stevens Fishery Conservation and Management Act of 1976**, as amended, is administered by NMFS and governs marine fisheries management in federal waters of the US. In the Northeast, the New England and Mid-Atlantic Fishery Management Councils operate under this Act. Subsequent revisions to the Act in 1996 and 2002 established provisions to designate Essential Fish Habitat and Habitat Areas of Particular Concern that have important ecological functions and/or are particularly vulnerable to degradation. Many marine species managed under the Magnuson-Stevens Fishery Conservation and Management Act have been identified as SGCN or RSGCN in the Northeast and Essential Fish Habitat has been designated in virtually the entirety of the marine waters of the NEAFWA region (see *Chapter 2* for more information).

The USACE and the EPA administer provisions of the **Clean Water Act of 1972**, with permits issued by the USACE under Section 404 for projects that would impact waters and wetlands. Permit requirements include provisions to avoid, minimize, and mitigate for adverse impacts. Environmental reviews undertaken as part of the permitting process are an opportunity to incorporate threats and impacts to SGCN, RSGCN, and their key habitats. The USACE has a similar authority under the **Rivers and Harbors Act of 1899**, issuing permits under Section 10 for construction projects in or above navigable waterways.

The EPA regulates point and non-point source pollution under the federal Clean Water Act, designating waters that are impaired due to pollution under Section 303(d) and providing National Water Quality Reports. States are required to assess water pollution and report to the EPA every two years on the waters that have been evaluated or assessed. Impaired waters have regulatory Total Maximum Daily Loads of pollutants allowed to address the water quality impairments. The EPA uses this state monitoring information in the Assessment and Total Maximum Daily Load Tracking and Implementation System (ATTAINS) to monitor water quality conditions of surface waters across the country[124].

The **Sikes Act Improvement Act of 1997** requires that the Department of Defense prepare and manage their lands with an Integrated Natural Resource Management Plan in coordination with and approved by the USFWS and the relevant state fish and wildlife agency. Where applicable and appropriate, these plans must also provide for public access for outdoor recreation on military lands. A Memorandum of Agreement between the USFWS, Department of Defense, and AFWA defines the respective roles and responsibilities of the partners and agrees to an ecosystem-based management approach. Integrated Natural Resource Management Plans, which are updated every five years, provide opportunities to advance SWAP conservation actions on the 1.2 million acres of military lands in the Northeast.

The **Fish and Wildlife Coordination Act of 1934** grants authority to the USFWS, and sometimes NMFS, to conduct environmental reviews and evaluations of proposed water resources development projects. Federal agencies proposing to construct, license, or permit a project that may impact fish and wildlife resources must consult with the federal fish and wildlife agencies, and the relevant state fish and wildlife agencies, to characterize the fish and wildlife resources in a project area, evaluate potential adverse impacts, and identify measures to avoid, minimize, and mitigate those impacts. Inclusion of SGCN and RSGCN and their key habitats within Fish and Wildlife Coordination Act planning aid letters, evaluations, and reports could address threats to and conservation needs of those species as identified in SWAPs.

The USFWS and NMFS also maintain regulatory authority for species conservation under the **Migratory Bird Treaty Act of 1918**, **Bald Eagle Protection Act of 1940**, and **Marine Mammal Protection Act of 1972**.

7.2.3 CONSERVATION PLANNING

One of the key ways that federal partners can inform and contribute to SWAPs is through conservation planning resources and assistance. Federal partners with landholdings have existing management plans (e.g., Comprehensive Conservation Plans for National Wildlife Refuges, State Forest Action Plans, Integrated Natural Resource Management Plans for military installations, Comprehensive Conservation and Management Plans for the National Estuary Program) that do or could incorporate SWAP elements and priorities. Federal agencies with regulatory authorities are involved with the siting of new projects (e.g., infrastructure, pipelines, wind turbines, dredging channels, mines, transportation corridors) that could incorporate SWAP elements and avoid SGCN and RSGCN and their key habitats, minimizing habitat fragmentation and modification. The regional partnerships described above in Section 7.1 involve multiple federal partners in conservation that involves collaborative conservation planning at the landscape scale.

State Wildlife Action Plans can be informed by monitoring programs and projects of federal partners, particularly for Elements 1, 2 and 3, as described in *Chapter 5*. Many federal partners have habitat management projects and programs that can inform SWAP Elements 2 and 3 (see *Chapter 2*). Some agencies maintain their own lists of priority species for conservation, such as the Sensitive Species list of the US Forest Service[125]. The Northeast At-Risk Species Program of the USFWS included the RSGCN status of species when evaluating and identifying At-Risk Species for the region (USFWS 2021c).

7.2.4 RESEARCH, INVENTORY, AND MONITORING

Conservation partners have scientific research and/or survey programs or resources that do or could contribute to improved understanding of SGCN, RSGCN, their key habitats, threats and conservation needs, thus informing SWAPs. *Chapter 5* describes research, inventory, and monitoring programs in the Northeast, including numerous programs and projects conducted by federal partners. The USFWS, NOAA, USGS, and EPA in particular offer status, trends, and assessment information for fish and wildlife conservation. The NOAA, USGS, and USDA maintain science research centers across the country. By collaborating with the existing research, inventory, and monitoring programs of federal partners, state fish and wildlife agencies can expand capacity and inform research and monitoring priorities of those partners.

The recently established At-Risk Species Program teams in the Northeast, described throughout this Regional Conservation Synthesis, are a valuable resource to collaborate on the research, inventory, and monitoring needs of SWAPs, as are the other projects of the Science Applications program of the USFWS.

The Northeast Climate Adaptation Science Center (NECASC), supported by the USGS, is based at the University of Massachusetts, Amherst (UMass), but involves a consortium of scientists across the Northeast[126]. The Northeast collaboration with the NECASC / USGS / UMass consortium includes a team of climatologists, biologists, ecologists, and hydrologists with cutting-edge approaches to address major challenges posed by climate change. The Center's robust scientific contributions have produced valuable tools and information on addressing climate change in the Northeast. One of the most significant contributions was the 2015 Northeast Climate Change Synthesis to support the 2015 Northeast SWAP revisions (Staudinger et al. 2015). NECASC has again initiated a project to assist the 2025 SWAP revision process and to update the 2015 Synthesis which will be available in late 2023 (Staudinger et al. 2023 *in press*).

NE CASC established a Northeast Climate Change Working Group to solicit information leading to a better understanding of the climate change-related needs of state fish and wildlife agencies and their key partners, and then to develop and deliver science to meet those needs. Collaboration with natural and cultural resource managers has provided the climate change science to help inform fish and wildlife management decision-making and produce actionable products and results including more than 160 research projects and tools to facilitate climate change adaptation strategies for the Northeast as of 2022. A searchable inventory of research projects and assessments prepared by NE CASC is available on the Center's website[127]. Recent NE CASC projects particularly relevant to SWAPs are summarized in *Chapters 4* and *5*.

The National Estuarine Research Reserve (NERR) program within NOAA, not to be confused with the National Estuary Program of the EPA, offers long-term research and monitoring programs focused on coastal ecosystems[128]. Ten of the 30 NERR in the United States are located in the NEAFWA region, one in every Atlantic coastal state. The Connecticut NERR was newly established in 2022, protecting 52,160 acres of Long Island Sound estuary, tidal wetlands and flats, and adjacent beaches, dunes, bluffs, grasslands, shrublands, and forest. The nation's NERR also serve as environmental education and coastal stewardship resources.

7.2.5 TECHNICAL ASSISTANCE

Multiple federal conservation partners offer technical assistance programs that do or could incorporate SGCN, RSGCN and/or their key habitats as priorities for conservation. Oftentimes these programs can facilitate implementation of conservation practices and BMPs on private lands, such as the **Partners for Fish and Wildlife Program** of the USFWS[129] and the **Natural Resources Conservation Service** of the USDA[130] in particular. The USDA **Animal and Plant Health Inspection Service (APHIS)** provides technical assistance to partner government agencies and private landowners on wildlife management, predator control, wildlife health, and invasive species[131]. The **US Forest Service**, also within the USDA, provides technical assistance to state and private forestry programs, including guiding the development of State Forest Action Plans that are required to incorporate SWAP priorities (see *Chapter 2*). The **Engineer Research and Development Center** of the USACE offers technical guidance and resources for both civil and military activities, including nature-based solutions for coastal management (see *Chapter 2*). The Federal Highways Administration has several offices that provide technical assistance resources on transportation decision-making, such a **Wildlife Crossing Structure Handbook**[132] and resources for designating National Scenic Byways or Bikeways[133].

7.2.6 FINANCIAL ASSISTANCE

Just as several federal conservation partners offer technical assistance resources, multiple agencies offer financial assistance as well. These financial assistance programs can support implementation of conservation actions on private lands or can provide matching funds for SWAP implementation. Grant programs such as the Delaware River Restoration Fund, Delaware Watershed Conservation Fund, and the Chesapeake Bay Stewardship Fund described in Section 7.1 are investing millions of dollars every year in Northeast conservation projects. The Natural Resources Conservation Service provides millions of dollars in annual financial assistance programs for private farm owners throughout the region, as described in *Chapter 2* (see Sections 2.22 and 2.23).

The Federal Highways Administration **Recreational Trails Program** provides funds to states to develop and maintain recreational trails and trail-related facilities, both motorized and non-motorized[134]. The Recreational Trails Program received supplemental funding through 2026 as part of the Bipartisan Infrastructure Law of 2021. Transportation projects that include measures to reduce vehicle-caused wildlife mortality or that restore and/or maintain connectivity among aquatic or terrestrial habitats are eligible for funding through the **Surface Transportation Block Grant**

Program[135], **Highway Safety Improvement Act Program**[136], **Tribal**[137] **and Federal Lands Transportation Programs**[138], and **Federal Lands Access Program**[139].

The US Forest Service **Landscape Scale Restoration Grant Program** is a competitive grant program to address landscape level issues on state, tribal, and private forests and woodlands such as watershed protection and restoration, the spread of invasive species, disease, insect infestation, and wildfire risk reduction. Conservation strategies of State Forest Action Plans are prioritized and projects are evaluated and awarded regionally. A **Landscape Scale Restoration Manual** and **Landscape Scale Restoration Project Planning Tool** are available to guide conservation projects. An inventory of Landscape Scale Restoration Projects is available online[140].

In addition to financial assistance available through the Chesapeake Bay Program and Great Lakes Restoration Initiative described in the previous section, the EPA also offers financial assistance programs that can contribute to SWAP implementation[141]. **Multipurpose Grants Program** awards financial assistance to states and Tribes for high priority activities that complement programs under established environmental statutes – i.e., pollution, climate change, and environmental justice[142]. Competitive and non-competitive grants and rebate programs are available for projects and programs relating to air quality, transportation, climate change, and other related topics[143]. Grants are available to assess, clean up, and redevelop brownfields or contaminated sites, including non-competitive financial assistance for states and tribes to establish or enhance brownfields response programs[144]. **Environmental Education Grants** are available for projects that promote environmental awareness and stewardship[145]. Matching funds are available through the **Pollution Prevention Grant Program** and **Source Reduction Assistance Grant Program** for states and tribes to support pollution prevention, develop state-based programs, and conduct research, experiments, surveys, education, training, and demonstration projects[146].

7.3 TRIBAL PARTNERS

Twenty-five federally recognized Tribal Nations reside in the Northeast Region. All are generally supportive of efforts to conserve the region's native fish, wildlife, and plant species. While each Tribal Nation is unique, they all contend with similar challenges, which include the need to protect their sovereignty and self-determination and to keep their people safe. Tribal Leaders must address a wide variety of concerns, and conservation competes with other priorities. Some Tribes have well-developed conservation programs, with staff who are experienced in preparing grant proposals and have the capacity to conduct projects. Other Tribes may have only one Natural Resource Coordinator (their titles vary), and some either do not have such a position or have no one in place to fill it (T. Binzen, USFWS Tribal Liaison, pers. communication, January 20, 2023).

From the Indigenous perspective, the ancestors were given a world that was in balance ecologically. It is the duty of those now living to conduct themselves in ways that maintain and restore that balance and give consideration to the generations yet to come. People are not separate from nature and no one has ownership of the land. Distinctions between natural resources and cultural resources are artificial. In some traditions, fish and wildlife are considered as kin to human beings. What happens to the animals happens to the people (T. Binzen, USFWS Tribal Liaison, pers. communication, January 20, 2023).

Common concerns and objectives for Tribal conservationists in the Region involve climate change; aquatic connectivity and fish passage; habitat restoration; biodiversity; invasive species; environmental contaminants; water and air quality; technical capacity; food security; preservation of traditional cultural practices; and environmental education. Possibly the greatest challenge for Tribal conservation at this time is ensuring that Tribal Nations have access to available funding and resources, to ensure they have the capacity and expertise to implement projects on the ground in ways that will benefit their communities (T. Binzen, USFWS Tribal Liaison, pers. communication, January 20, 2023).

7.3.1 INDIGENOUS KNOWLEDGE

In November 2022 the White House Office of Science and Technology Policy (OSTP) and Council on Environmental Quality (CEQ) released guidance to assist government agencies in understanding Indigenous Knowledge, fostering mutually beneficial relationships with Tribal Nations and Indigenous peoples, and incorporating Indigenous Knowledge into policies, research, and decision-making (OSTP and CEQ 2022). The **Guidance for Federal Departments and Agencies on Indigenous Knowledge** includes practices that consider and apply Indigenous Knowledge in a way that respects Tribal sovereignty and provides benefits for Indigenous and Tribal communities.

Recognizing that Indigenous Knowledge is unique and specific to a Tribe or Indigenous people, the guidance assists agencies that often lack expertise in appropriately considering and applying Indigenous Knowledge in planning and decision-making. Traditional Ecological Knowledge is a valuable resource for natural resource management and can also be informative for SWAPs. At the federal level, the importance of Indigenous Knowledge is recognized in formal policies of the Departments of Agriculture and Interior, Environmental Protection Agency, National Oceanic and Atmospheric Administration, Advisory Council on Historic Preservation, and the U.S. Global Change Research Program (which produces the National Climate Assessments).

The federal guidance describes Indigenous Knowledge and how it relates to other systems of knowledge. It also provides a list of federal statutes where Indigenous Knowledge may be relevant, including the Endangered Species Act, Marine Mammal Protection Act, Magnuson-Stevens Fishery Conservation and Management Act, and National Environmental Policy Act, statutes that are also relevant wildlife conservation and SWAPs. Recommended Tribal engagement activities include public meetings, listening sessions, and other outreach activities. Out of respect for Tribal sovereignty, agencies should only engage with Tribal leaders directly or with individuals who are designated or appointed Tribal leadership. The federal guidance recommends that state engagement policies align with federal policies where possible and that any differences be clearly communicated to Tribal Nations and Indigenous peoples. Four Appendices in the guidance provide examples of how Indigenous Knowledge has been applied through collaboration between the federal government and Tribes and Indigenous peoples (OSTP and CEQ 2022, Appendix A); references and links to federal agency guidance documents (Appendix B); a framework for treating Indigenous Knowledge as highly influential scientific assessments under the Information Quality Act (OSTP and CEQ 2022, Appendix C); and additional references and resources for planning, engagement, decision-making, shared management structures, recognizing Indigenous methodologies, honoring Indigenous languages, applying Indigenous voice and style in writing, citing Indigenous Knowledge, and more.

Indigenous Knowledge is informing climate change adaptation nationally, and this includes the Northeast. The Northeast Climate Adaptation Science Center has a Tribal Liaison to engage Indigenous people and incorporate their Traditional Ecological Knowledge into adaptation strategy guidance and tools. Indigenous cultural practices regarding burning, for example, can inform larger climate adaptation strategies where regionally appropriate (Ryan et al. 2013, Oswald et al. 2020, Adlam et al. 2022). In the Northeast, one project currently in development is the creation of a **Wabanaki Climate Adaptation and Adaptive Management Framework**[147]. The Climate Change Response Framework of the Northern Institute of Applied Climate Science developed an extensive collection of climate change adaptation strategies for forest management using Indigenous Knowledge, the **Dibaginjigaadeg Anishinaabe Ezhitwaad: Tribal Climate Adaptation Menu** (Tribal Adaptation Menu Team 2019).

7.3.2 TRIBAL ENGAGEMENT - USFWS

Like other federal agencies, the U.S. Fish & Wildlife Service (USFWS) has a trust responsibility to the federally recognized Tribal Nations. The trust responsibility stems from the fact that all places in the United States were Indigenous homelands at one time. Historically, the government wanted the Tribes' lands and the resources they contained and wanted hostilities to cease. The government obtained these things, and in return, the Tribal Nations received the government's promise that the Tribes' sovereignty and self-determination would be respected, the Tribes' interests would be protected, and the Tribes would be provided with a land base for their occupation and benefit. Honoring these promises is a perpetual obligation for the federal government. This is the basis of the trust responsibility (T. Binzen, USFWS Tribal Liaison, pers. communication, January 20, 2023).

The Northeast Region of the US Fish and Wildlife Service works to uphold the trust responsibility in a variety of ways. There are many things that the USFWS is called upon to do with Tribes, or for Tribes, as required by policy or regulation. For anything that the USFWS funds, permits, or does, the agency considers whether that proposed action has the potential to affect the interests of any federally recognized Tribal Nation. If it does, the USFWS informs the Tribe, listens to any concerns, and does what is feasible within the agency's authority to address those concerns. The USFWS's actions may warrant Tribal consultation under the Endangered Species Act, National Environmental Policy Act, National Historic Preservation Act (Sec. 106), and Bald and Golden Eagle Protection Act, among other laws (T. Binzen, USFWS Tribal Liaison, pers. communication, January 20, 2023). In 2018 the USFWS released an updated **Tribal Consultation Handbook** that describes the rights and responsibilities of Tribal Nations, provides information on cultural diversity and awareness, and outlines recommended consultation protocols (Monette et al. 2018).

In addition to the USFWS's obligatory relations with Tribal Nations, there are ways that the various programs within the agency can seek alignment of conservation priorities with Tribes, as well as seek partnerships, which may in turn involve technical assistance or funding. USFWS programs that work with Tribes in the Northeast include Ecological Services, Fisheries and Aquatic Conservation, and the National Wildlife Refuge System. For more than two decades, the agency's Tribal Wildlife Grants Program (TWG) has provided funding for Tribes' conservation projects and capacity-building. TWG is administered by the USFWS's Wildlife and Sport Fish Restoration program (T. Binzen, USFWS Tribal Liaison, pers. communication, January 20, 2023).

7.3.3 TRIBAL SPATIAL RESOURCES

The **Native Lands Advocacy Project** and **Native Land Information System**, established in 2019 and sponsored by the Indian Land Tenure Foundation, Native American Agriculture Fund, and Village Earth, includes five thematic hubs of information[148]. The **Agriculture Resource Management Plans – Integrated Resource Management Plans Planning Portal** is a toolkit for Tribal Resource Management Plans, enabled by the American Indian Agricultural Resource Management Act of 1993. The **Food-System Transition Index for US Native Land** is a tool of 20 key indicators that measure the transition to healthy food-systems in support of sustainable Tribal land use planning. The **Lost Agriculture Revenue Database** helps to quantify the impacts of land cessions and discriminatory agriculture policies of the US government by allowing more than 175 years of county-level agriculture census data to be disaggregated into smaller blocks, facilitating data re-aggregation for areas that overlap county boundaries. The **Native Agriculture** hub collates datasets and other resources to inform the current extent, demographics, and potential for expanding agriculture on Indigenous lands. Lastly, the **Status of Native Lands** collects data resources to inform assessment of the US Bureau of Indian Affairs' management of lands and subsurface mineral estates held in trust for Indigenous peoples and Tribes. All of the project's datasets are available in the **Native Land Data Portal**[149].

The **Native Land Digital** platform is a global map of the best available information on the extent of Indigenous territories but does not represent the current legal boundaries of those territories[150]. For each territory on the map, there is an associated resource with Tribal links, related maps, information sources, a list of updates or changes to the known extent of the territory, and a place to submit corrections. Established in 2018 in Canada, this native lands resource is led by Indigenous peoples from across the world. Information on languages and applicable treaties is also included.

7.3.4 TERRITORY ACKNOWLEDGEMENTS

Federal guidance calls for agencies to acknowledge the historical context and past injustice and marginalization of Indigenous peoples (OSTP and CEQ 2022). This acknowledgement is needed to foster Tribal engagement and develop collaborative partnerships that are more equitable and inclusive, whether the Indigenous peoples are Federally-Recognized Tribes or not. Although the Native Lands Digital map can indicate the Indigenous peoples of a specific area like the Northeastern United States (Figure 7.3.1), it is recommended that the information be verified by contacting the Tribal Nations directly and inquiring if and how they wish to be acknowledged. Resources to inform territory acknowledgement is available online at Native Land Digital[151].

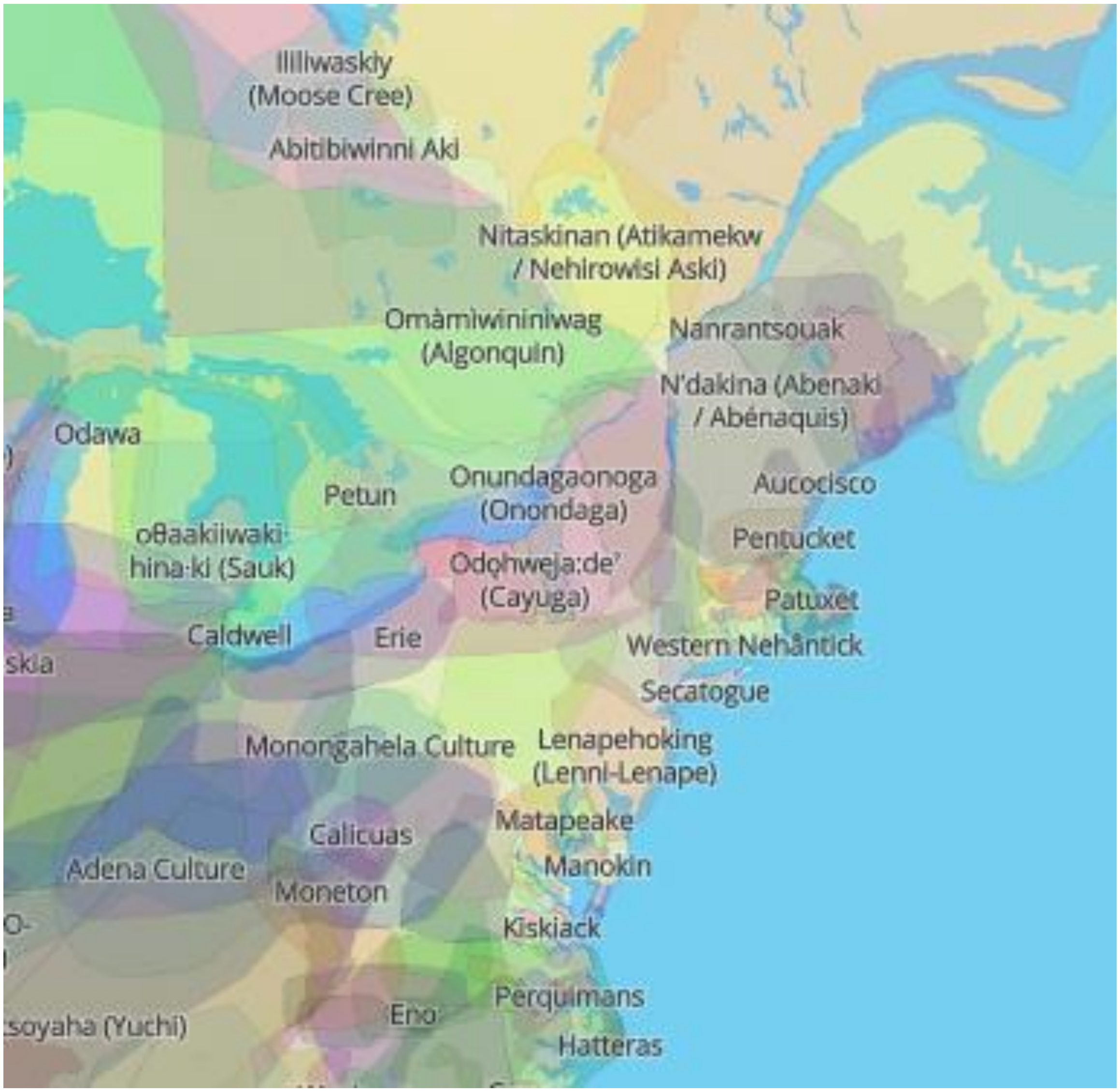

Figure 7.3.1. The Native Lands Digital identifies the best available information on the Indigenous peoples of the Northeast region and their historical territories, which often overlap[152].

7.3.5 TRIBAL NATURAL RESOURCE ORGANIZATIONS

INSTITUTE FOR TRIBAL ENVIRONMENTAL PROFESSIONALS (ITEP)

The **Institute for Tribal Environmental Professionals (ITEP)** has extensive resources for Indigenous natural resource management on climate change, air and water quality standards, clean transportation, status assessments, and more[153]. The organization hosts conferences and workshops, as well as classroom and online training on current topics of interest. Internships and scholarships are available to support

Indigenous education in the environmental fields. ITEP was founded at Northern Arizona University, in collaboration with EPA to act as a catalyst among Tribal governments, academia, government agencies at all levels, and the private sector, in support of environmental protection of Tribal and Indigenous natural resources. The mission of ITEP is to strengthen the capacity and sovereignty of Tribes in natural resource and environmental management through culturally relevant education, research, partnerships, and policy-based services to foster a healthy environment for strong, self-sustaining Tribal communities.

The **ITEP Tribes and Climate Change Program** distributes a monthly newsletter with information, news, and opportunities relevant to Tribal and Indigenous climate change planning efforts. The program hosts a biennial **National Tribal and Indigenous Climate Conference** and prepared **The Status of Tribes and Climate Change Report** in 2021 (STACC Working Group 2021). Tribal profiles with active climate change programs and projects are provided on the program's website, sorted by region. ITEP, the Affiliated Tribes of Northwest Indians, Bureau of Indian Affairs, various host institutions, and the Northwest, Southwest, and Southcentral Climate Adaptation Science Centers have hosted an annual Tribal Climate Camp since 2016. This professional Camp supports delegations of Tribal leaders, climate change coordinators, planners, and program managers to gather information, build skills, and develop Tribal plans and policies needed to address climate change impacts.

NATIVE AMERICAN FISH AND WILDLIFE SOCIETY

The mission of the **Native American Fish and Wildlife Society** (NAFWS) is to protect, conserve, and enhance Tribal fish and wildlife resources[154]. The organization facilitates and coordinates inter-tribal communications on matters relating to fish and wildlife; protects and conserves the wise use and management of Tribal fish, wildlife and recreation resources; provides environmental education on best management practices; serves as administrative support and expertise to Tribal governments; improves the general welfare of Tribal people through education and enhancement of fish and wildlife resources; and provides professional publications to share information among members and their conservation partners.

Current NAFWS initiatives of the Native American Fish and Wildlife Society focus on climate change, invasive species, Tribal wildlife corridors, wildlife health, and Tribal conservation law enforcement program enhancement. One ongoing project supports Tribal involvement in SWAPs[155]. The Society also actively supported the proposed Recovering America's Wildlife Act.

GREAT LAKES INDIAN FISH AND WILDLIFE COMMISSION

The **Great Lakes Indian Fish and Wildlife Commission** (GLIFWC) was formed in 1984 and provides natural resource management expertise, legal and policy analysis, conservation enforcement, and public information services throughout treaty ceded territories[156]. Although focused on the western Great Lakes outside of the Northeast region, the Traditional Ecological Knowledge and expertise of the Commission is relevant to the Northeast because the Great Lakes are connected and face shared threats. The GLIFWC has multiple focus areas relevant to SWAPs:

- Climate change
- Forest pests
- Great Lakes fisheries
- Inland fisheries
- Mercury levels in inland lakes
- Environmental contaminants in the Great Lakes
- Invasive species
- Mining
- Wildlife
- Wild plants, particularly wild rice
- Conservation law enforcement

The Commission issues off-reservation harvest permits for its eleven member Ojibwe Tribes. Environmental education materials and technical reports are available, including materials on monitored threats to fish and wildlife resources, invasive species control, cumulative impacts assessments of proposed pipeline construction projects, and application of climate change adaptation frameworks to Tribal lands. The Great Lakes Indian Fish and Wildlife Commission participates in the Great Lakes Restoration Initiative, which funds Tribal projects consistent with its goals and objectives.

I-COLLECTIVE

The **I-Collective** is a community of Indigenous chefs, herbalists, seed and knowledge-keepers, and activists working together within the framework of four guiding principles: Indigenous, Inspired, Innovative, and Independent[157]. The collective seeks to highlight Indigenous contributions to resiliency and innovation in agriculture, gastronomy, the arts, and society. By recognizing and supporting Indigenous food sovereignty, the effort addresses many health issues and the historical exploitation of resources and people. Member projects are reindigenizing the landscape, cultivating Indigenous sense of place, and promoting traditional knowledge.

7.4 BOTANICAL PARTNERS

Opportunities exist for enhanced partnerships with botanical organizations and agencies to advance fish and wildlife conservation and implement SWAPs. In addition to state Natural Heritage Programs that offer resources and expertise for plants within a state and regionally, national and regional botanical resources are available. In January 2023, the National Academies of Science, Engineering, and Medicine completed a multi-year **Assessment of Native Seed Needs and the Capacity for their Supply** (National Academies of Sciences, Engineering, and Medicine 2023). This Assessment includes the native seed needs of federal agencies, state agencies, and tribal organizations. Information is provided about seed suppliers and summarizing knowledge gaps and research needs to support the supply of native seeds. Numerous cooperative partnerships for native seed development, supply, and usage are described, from state and municipal-level programs (e.g., the Greenbelt Native Plant Center and Mid-Atlantic Regional Seed Bank in New York) to regional and national programs (e.g., USDA, USFS, Plant Conservation Alliance).

The **Plant Conservation Alliance** is a public-private partnership of organizations sharing the same goal to protect native plants by ensuring that native plant populations and their communities are maintained, enhanced, and restored[158]. As of 2022 the Alliance included 40 federal agencies and over 400 non-federal partners nationwide. The **Southeastern Plant Conservation Alliance** includes Virginia and West Virginia in its geographic focus area and is in the process of identifying regional priority plant species in partnership with the Southeast Association of Fish and Wildlife Agencies, NatureServe, the Atlanta Botanical Garden, and the USFWS[159]. The Mt. Cuba Center and other partners are establishing a **Mid-Atlantic Plant Conservation Alliance,** which would include New York, New Jersey, Pennsylvania, Delaware, Maryland, the District of Columbia, Virginia, and West Virginia. These regional partnerships offer opportunities to inform SWAPs and contribute to SWAP implementation.

Nationally, the USDA has several botanical programs. The USDA maintains the **Plant List of Attributes, Names, Taxonomy, and Symbols (PLANTS) Database[160]**. This inventory provides a standardized information about the vascular plants, liverworts, mosses, lichens, and hornworts of the US and its territories. The 2020 **National Wetland Plant List** identifies wetland indicator species (8000+) and is included in the PLANTS Database with species profile pages, searchable by region[161]. The PLANTS Database website now includes related resources and tools for pollinators, ecosystem dynamics, plant identification keys, culturally significant plants, invasive and noxious weeds, federally and state-listed plants, and technical publications from the

Plant Materials Program. The Natural Resources Conservation Service maintains state plant lists available online[162].

The US Forest Service manages the tribally guided **Intertribal Nursery Council** to advance the interests of Indigenous peoples involved with plant production in nurseries[163]. The goals of the Intertribal Nursery Council are to share information and technology transfer, preserve ecological knowledge, provide nursery training, conduct conservation education, and contribute to reforestation and habitat restoration projects by propagating native plants. The **Nursery Manual for Native Plants: A Guide for Tribal Nurseries** handbook contains detailed information on native plant propagation from seed collection to holistic pest management (Dumroese et al. 2009).

The US Forest Service maintains a **National Seed Laboratory** that propagates seeds of native plants for conservation and restoration projects and conducts research on restoring and sustaining native plant communities[164]. The Laboratory has developed a Native Plant Protocol for handling, germinating and storing seeds, provides training materials to transfer technology, and conserves seeds for genetic diversity. The **Reforestation, Nurseries and Genetic Resources Program** is a collaborative partnership sponsored by the US Forest Service to share technical information with land managers and nurseries related to the production and planting of trees and other native plant species for reforestation, restoration and conservation of forests and woodlands[165]. Numerous guidelines and resources have been developed by the Program and its partners, including a **Propagation Protocol Database** and the **Native Plant Network**.

In the Northeast, botanical gardens and herbarium collections contribute knowledge and conservation of native plant species, propagation, and environmental education programs. Notable examples are the US Botanic Garden, US National Arboretum, New England Botanical Society, Native Plant Trust (formerly the New England Wild Flower Society), Cornell Botanical Garden, Brooklyn Botanic Garden, Longwood Gardens, Mt. Cuba Center, and Winterthur Museum, Garden and Library. The New England Botanical Society, for example, has been active since 1896 and publishes a peer-reviewed scientifical journal (*Rhodora*)[166]. The environmental education and stewardship programs of some of these partners are extensive, from grades K-12 to professional horticulturalists and teachers worldwide.

The Partnership for the Delaware Estuary (see Section 7.1.5) collaborates with several botanical partners to research, propagate, and install native plants (aquatic and terrestrial) as part of habitat restoration and living shorelines projects, including Bartram's Garden, Longwood Gardens, and Winterhur. Their partnership with Bartram's Garden in Philadelphia contributes to restoration in the Delaware River watershed through an **Ecosystems Education Center** and a freshwater mussel hatchery[167].

7.5 AFWA AND OTHER AFWA REGIONS

The Association of Fish and Wildlife Agencies is divided into four regions. Each of the AFWA regional associations shares at least two states with a neighboring region. In the Northeast, Virginia and West Virginia are members of both the Northeast and Southeast Associations of Fish and Wildlife Agencies. In the Midwest, Missouri and Kentucky are members of both the Midwest and Southeast Associations of Fish and Wildlife Agencies. Canadian Provinces are members of NEAFWA and MAFWA as well. In 2022, AFWA, USGS, and the National Wildlife Federation completed a project to identify recommendations to facilitate implementation of the AFWA (2021) **Framework to Enhance Landscape-scale and Cross-boundary Conservation through Coordinated SWAPs** and for improving the USGS **SGCN National Database** (Kanter and Newsome 2022). This effort identified several recommendations to implement the AFWA (2021) guidance on landscape-scale and cross-boundary conservation within and between the regions:

- Establish consistency in habitat classification and mapping, geographic prioritization, species distribution modeling and state/regional SGCN determination, and data / database structure and management, both between regions and the USGS SGCN National Database.
- A committee of regional Wildlife Diversity Committee Chairs and representative State Wildlife Action Plan Coordinators should meet quarterly to share progress and practices among their multi-state efforts.
- The inter-regional committee should establish Work Groups to share information and best practices for:
    - Species conservation planning (SGCN and RSGCN),
    - Habitats and landscape analysis, and
    - Data and database management.
- A Data and Information Coordination Committee should be established to clarify the roles of AFWA, USFWS, USGS, NatureServe, and Terwilliger Consulting, Inc., to clarify their respective roles for providing data, information, and expertise to support SWAP revisions and cross-boundary planning and implementation.

Since the Northeast Association of Fish and Wildlife Agencies first identified a list of Regional Species of Greatest Conservation Need, the adjacent Southeast Association of Fish and Wildlife Agencies (SEAFWA) and Midwest Landscape Initiative (MLI) /

Midwest Association of Fish and Wildlife Agencies (MAFWA) also have identified RSGCN. The Southeast identified RSGCN animals (vertebrates, crayfish, freshwater mussels, and bumble bees) in 2019 as shared priorities for its 15 member states[168]. In 2021, the 13 states of the Midwest identified RSGCN animals for 13 taxonomic groups[169]. The three regions have used consistent RSGCN selection methodology, with slight advancements each time (see *Chapter 1*).

Comparison of the three AFWA RSGCN lists illustrates opportunities for shared cross-regional collaboration (Table 7.6.1). The Northeast and Southeast share the highest number of RSGCN and Proposed RSGCN species with 120. The Northeast and Midwest share 64 RSGCN and Proposed RSGCN. All three regions have 30 RSGCN and Proposed RSGCN representing eight taxonomic groups in common. Of these 30 shared species, nine are listed as Very High Concern by all three regions: three bats, one bumble bee, and five freshwater mussels. Seven of these shared Very High Concern RSGCN are federally-endangered, one is federally-threatened (Northern Long-eared Bat [*Myotis septentrionalis*]), and one is under review for federal listing (Little Brown Bat [*Myotis lucifugus*). The federally-endangered, Very High Concern RSGCN are Indiana Bat (*Myotis sodalis*), Rusty-patched Bumble Bee (*Bombus affinis*), Rough Pigtoe (*Pleurobema plenum*), Orangefoot Pimpleback (*Plethobasus cooperianus*), Sheepnose (*Plethobasus cyphyus*), Snuffbox (*Epioblasma triquetra*), and Cracking Pearlymussel (*Hemistena lata*). Conservation of these highest concern species benefits from cross-regional collaboration and partnership with the USFWS.

Table 7.6.1. The number of species identified as RSGCN or Proposed RSGCN in more than one region, with the 2023 Northeast RSGCN list, 2021 Midwest RSGCN list[170], and 2019 Southeast RSGCN list[171].

AFWA Regions	Number of Shared RSGCN and Proposed RSGCN Species
NEAFWA and SEAFWA	120
NEAFWA and MLI / MAFWA	64
NEAFWA, SEAFWA, and MLI / MAFWA	30

In the most recent RSGCN projects in the Midwest (2021) and Northeast (2023) a new Watchlist [Deferral to adjacent region] category was incorporated to capture species for which a region had conservation concern but limited regional responsibility, typically for species on the edge of their ranges. Watchlist [Deferral] species recognize the shared conservation stewardship of species that span multiple AFWA regions, informing the region with primary regional responsibility of the conservation status and trends in adjacent regions on the periphery of species ranges.

In the 2023 update to the Northeast RSGCN list, Watchlist [Deferral] species were identified for the Southeast, Midwest, Canada, and on rare occasion to the Western Association of Fish and Wildlife Agencies (WAFWA; Table 7.6.2).

Table 7.6.2. The 2023 Northeast RSGCN update identified 95 species as Watchlist [Deferral to an adjacent region] species, species for which the Northeast has conservation concern but low regional responsibility.

Watchlist [Deferral] Region	Number of Species
SEAFWA	56
MAFWA / MLI	18
SEAFWA and MAFWA	15
Canada	2
Canada and WAFWA	3
MAFWA and WAFWA	1
Total	**95**

The high number of species deferred to the Southeast (56) reflect the high level of endemism in the Appalachian and coastal ecological regions between the two AFWA regions, plus the shared status of Virginia and West Virginia. Twenty-one of these Southeast Deferral species are Southeast RSGCN. All but six of the 18 species deferred to the Midwest are listed as RSGCN or Watchlist species by MLI and MAFWA. Nine of the 15 Deferral species to both SEAFWA and MAFWA are already listed as RSGCN in those regions, eight by both regions and one by just SEAFWA.

The Evening Grosbeak (*Coccothraustes vespertinus*) is experiencing continent-wide declines but is deferred to both the Midwest and West as having primary regional responsibility. The two Watchlist [Defer to Canada] species are dragonflies – Boreal Snaketail (*Ophiogomphus colubrinus*) and Canada Whiteface (*Leucorrhinia patricia*) - with range shifts occurring or expected due to climate change. Within the US portion of NEAFWA, both species are only known to occur in Maine at present.

The three species deferred to both Canada and WAFWA are the Olive-sided Flycatcher (*Contopus cooperi*), Indiscriminate Cuckoo Bumble Bee (*Bombus insularis*), and Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*). The Olive-sided Flycatcher is listed as Special Concern by Canada and Near Threatened by the International Union for the Conservation of Nature (IUCN), as well as SGCN in ten NEAFWA states. The bird's breeding range is retracting north and the population is in steep decline, resulting in less regional responsibility for the Northeast and more for Canada and the West. Records of the Indiscriminate Cuckoo Bumble Bee are rare in the region, with larger populations in the Canadian Maritime Provinces and western US. The Suckley's Cuckoo Bumble Bee is listed Threatened by Canada and Critically Endangered by IUCN, experiencing severe decline across its range in the last two decades. Modern records of the species in the Northeast US are uncertain, with a disjunct population in the Canadian Maritimes. The new Northeast and Midwest Watchlist [Deferral] species lists inform cross-regional conservation collaboration efforts between not only those adjacent regions, but all four AFWA regions and the Canadian Provinces which are also members of AFWA.

7.6 ACADEMIC PARTNERS AND PROGRAMS

Academic institutions and programs actively contribute to fish and wildlife conservation in the Northeast, informing SWAPs, and addressing research, inventory, and monitoring needs. The University of Massachusetts at Amherst, for example, hosts the Northeast Climate Adaptation Science Center in partnership with the USGS and the Designing Sustainable Landscapes program, which created and maintains a number of spatial analysis tools and datasets of the region's landscape. The Cornell Lab of Ornithology maintains some of the best bird information resources in the world, hosting Birds of the World, the K. Lisa Yang Center for Conservation Bioacoustics, the Center for Avian Population Studies, and the Macaulay Library archive of natural history audio, video, and photograph specimens. The Cornell University Center for Conservation Social Science has developed resources to inform understanding of public wildlife values, agency relevancy, and outreach techniques (see *Chapter 8*). The Virginia Tech Shorebird Program is a consortium of university conservation biologists that studies, tracks, and develops management tools for shorebird conservation on the Atlantic and Gulf of Mexico coasts.

Some colleges and universities host long term coastal research programs and sites. The University of Connecticut is a key partner in the newly established Connecticut National Estuarine Research Reserve. Rutgers University is a partner in the Jacques Cousteau National Estuarine Research Reserve in New Jersey and also has research programs for shorebirds and grassland birds. The Virginia Coast Reserve Long Term Ecological Research program is hosted by the University of Virginia and involves numerous academic partners across the region. Academic partners in the Saltmarsh Habitat and Avian Research Program (SHARP) include the University of Maine, University of New Hampshire, State University of New York College of Environmental Science and Forestry, University of Connecticut, and the University of Delaware.

Several formal academic partnerships with federal fish and wildlife agencies also can inform state wildlife action planning.

7.6.1 USGS COOPERATIVE RESEARCH UNITS

The USGS has a collaborative partnership with academic institutions, the Wildlife Management Institute, and state agencies through the **Cooperative Fish and Wildlife Research Unit Program**[172]. Established in 1935, the national program now supports 41 Units in 39 states. Cooperative Fish and Wildlife Research Units conduct a wide range of scientific studies, with more than 1000 research projects underway as of early 2023. The mission of the Program is to enhance graduate education in fish and wildlife sciences and to facilitate research and technical assistance between natural resource agencies and academic universities on topics of mutual concern. In the Northeast, Cooperative Fish and Wildlife Research Units are located at the University of Maine[173], University of Massachusetts – Amherst[174], Cornell University[175], Penn State[176], University of Vermont[177], Virginia Tech[178], and West Virginia University[179]. The national program maintains a searchable database of projects, research publications, presentations, technical publications, theses, and dissertations[180].

7.6.2 COOPERATIVE ECOSYSTEMS STUDIES UNITS

Cooperative Ecosystem Study Units (CESU) are a collaborative partnership of federal, university, NGO, museum, and other entities, with 17 Units nationwide. In the Northeast region, the **North Atlantic Coast Cooperative Ecosystems Studies Unit** is hosted by the University of Rhode Island and has nine federal partners, one tribal partner (the Narragansett Indian Tribe), and 35 colleges, universities, research institutions, conservation organizations and marine aquarium partners[181]. The Unit supports research, education and technical assistance to inform decision-making within a number of natural and cultural resources areas, including estuaries, tidal wetlands and flats, beaches and dunes, other shorelines, and the marine nearshore. Detailed information about North Atlantic Coast CESU projects can be found online[182].

7.6.3 STATE COOPERATIVE EXTENSION SERVICE & AGRICULTURAL EXPERIMENT STATIONS

The United States Department of Agriculture operates two partnership programs with academic institutions. The **USDA Cooperative Extension Service** partners with land-grant colleges, historically black colleges and universities, and tribal colleges to provide education and outreach to the public of research-based information[183]. In the Northeast every state and the District of Columbia have at least one Cooperative Extension Service, with major Cooperative Extension programs that have informed fish and wildlife conservation at the landscape scale (beyond state borders) including those located at Cornell, Penn State, and Virginia Tech. These programs develop best management practices, guidelines, and tools for the public and private landowners, which are not limited to agricultural landowners. Cooperative Extension offices oftentimes offer Master Watershed Stewards and Master Gardener programs to train and educate citizen scientists in a number of conservation topics. These programs typically operate offices in each county of a state, providing education and outreach activities at the local level.

The USDA also partners with academia to host **Agricultural Experiment Stations**. Similar to the Cooperative Extension Service, there is at least one Agricultural Experiment Station in each NEAFWA state, located at a land-grant college or university[184]. These scientific research centers investigate potential improvements in agribusiness and food production. This research is then incorporated into educational and outreach programs of the Cooperative Extension Service.

7.6.4 NOAA COOPERATIVE INSTITUTES

The National Oceanic and Atmospheric Administration operates three national, formal partnerships with academic institutions. The **Cooperative Institutes** program funds consortiums of academic institutions and research institutes on a five-year cycle to focus research on a particular suite of topics[185]. There are currently four NOAA Cooperative Institutes in the NEAFWA region which can inform SWAPs, particularly Element 3 on understanding, assessing, and monitoring threats to fish and wildlife and their habitats.

The **Cooperative Institute for the North Atlantic Region (CINAR)** is hosted by the Woods Hole Oceanographic Institution, with a consortium of seven other universities and institutes across the Northeast (Rutgers, University of Maine, University of Maryland – Eastern Shore, University of Maryland Center for Environmental Science, University of Massachusetts - Dartmouth, University of Rhode Island, and the Gulf of Maine Research Institute)[186]. The **Cooperative Institute for the North Atlantic Region** has five research themes for its current funding period (2019-2024):

- Sustained ocean observations and climate research
- Ecosystem research, observation, and modeling
- Stock assessment research
- Protected species protection and recovery
- Ecosystem based fisheries management

The **Ocean Exploration Cooperative Institute (OECI)**, located at University of Rhode Island, has a consortium with the University of New Hampshire, University of Southern Mississippi, Woods Hole Oceanographic Institute and the Ocean Exploration Trust[187]. The Ocean Exploration Cooperative Institute currently has three research themes:

- Exploration planning and execution
- Ocean exploration technology
- Increase utility of ocean exploration information

The **Cooperative Institute for Modeling the Earth System (CIMES)** is hosted by Princeton University in partnership with the NOAA Geophysical Fluid Dynamics Laboratory[188]. The Cooperative Institute for Modeling the Earth System has three research themes for its current funding period (2018-2023):

- Earth system modeling – numerical models that simulate the climate and earth system to allow prediction of future changes
- Seamless prediction across time and space scales – application of the earth system models on time scales that range from days to centuries on spatial scales that range from an extreme event to global
- Earth system science: Analysis and applications – using earth system models to better understand the impacts of environmental variations and changes on marine ecosystems, weather extremes, drought, air quality, and other priority issues

The **Cooperative Institute for Satellite Earth System Studies (CISESS)**, located at the University of Maryland, College Park[189], is a consortium of 21 members across the country (including TNC), with three research themes for its current funding period (2019-2024):

- Satellite services
- Earth system observations and services
- Earth system research – to enhance monitoring and predicting ecosystems at regional to basin scales

These agency-academic partnerships provide opportunities for the NEAFWA states and the District of Columbia to increase scientific capacity and leverage resources to fill research, inventory, and monitoring needs of SWAPs.

7.6.5 NOAA SEA GRANT PROGRAM

The second formal agency-academic partnership program of NOAA that can inform SWAPs and contribute to their implementation is the **National Sea Grant College Program**[190]. Similar to the USDA Cooperative Extension Service in that Sea Grant Programs are located in every coastal and Great Lakes state and provide extensive environmental education and outreach programming, Sea Grant Programs also offer technical and financial assistance. The mission of the program is to enhance the use and conservation of Great Lakes, coastal, and marine resources to create a sustainable economy and environment. The four focus areas of the Sea Grant Program are healthy coastal ecosystems, sustainable fisheries and aquaculture, resilient communities and economies, and environmental literacy and workforce development.

National resources available target seafood industry professionals, learning at home, and storm preparedness. At the state level, more specific resources and tools are available from the 13 Sea Grant Programs in the NEAFWA region. The **Woods Hole Sea Grant Program**, for instance, conducts annual surveys of kelp forests in New England at 15 sites from Rhode Island to Maine as part of the global **Kelp Ecosystem Ecology Network (KEEN)**, which indicate that kelp forests have been declining in the Gulf of Maine since the late 1970s[191]. The **Lake Champlain Sea Grant Program**, established in 2018, is a cooperative program with the University of Vermont and State University of New York Plattsburgh that focuses on understanding and management of Lake Champlain, Lake George, and their watersheds[192]. In 2020 the program developed 25 new environmental literacy tools and engaged more than 6100 people in educational activities and programs. The **Maryland Sea Grant Program** recently completed a manual to train and certify landscape professionals in reducing runoff and provided training and technical support to the state's oyster aquaculture industry[193]. The **Pennsylvania Sea Grant Program** has developed resources and projects for green infrastructure and invasive species management[194]. The research, extension, and education resources of these state-based programs can contribute to implementing SWAPs throughout the Northeast region.

7.6.6 NOAA REGIONAL COLLABORATION NETWORK

The third academic partnership program of NOAA is the **Regional Collaboration Network**[195]. The mission of the Regional Collaboration Network is to identify, communicate, and respond to regional needs, catalyze collaboration among partners, and connect people and capabilities to advance NOAA's agency mission and priorities.

Eight interdisciplinary regional programs address issues specific to that particular region.

The North Atlantic Regional Collaboration Network and Great Lakes Regional Collaboration Network are both located in the NEAFWA region. The **North Atlantic Regional Collaboration Network** currently has two focus topics – climate and watersheds, and coastal and ocean uses[196]. Partners in the North Atlantic Regional Collaboration Network include the four Cooperative Institutes and Sea Grant Programs described above, the Consortium on Climate Change in the Urban Northeast, the Northeastern and Mid-Atlantic Regional Association of Coastal Ocean Observing Systems (see *Chapter 5*), the Northeast Regional Climate Center, the National Estuarine Research Reserves of the region, and each of the state coastal zone management programs. The **Great Lakes Regional Collaboration Network** includes all of the NOAA-affiliated programs and partners, as well as the Great Lakes Restoration Initiative and other regional partners. Recent projects of the Network collaborated on understanding and monitoring water levels in the Great Lakes and understanding how climate change is impacting Indigenous communities in the Great Lakes region.

7.7 OTHER PARTNERS AND PROGRAMS

7.7.1 SISTER STATE AGENCIES

One important consideration for the management of terrestrial animals and aquatic resources is that responsibility may be shared with other state agencies. Jurisdictional authority for fish, wildlife, and plant conservation varies among the states. For example, state marine programs usually have jurisdiction over marine plants and animals, though diadromous fish are often shared responsibilities. Some state fish and wildlife agencies may not have authority for all invertebrates or plants. They work closely with those regulatory authorities (e.g., state Department of Agriculture) and often have cooperative agreements with these agencies. Implementation of conservation actions may call for partnerships with other state agencies, such as Departments of Transportation to minimize threats to SGCN or RSGCN (e.g., aquatic connectivity, wildlife crossings). Departments of Agriculture may manage invasive species and wildlife disease, or they may offer opportunities to implement best practices on agricultural lands to address species threats. State fish and wildlife agencies need to clearly communicate and share information with sister state agencies on the highest priority species, activities that threaten imperiled species and their habitats, and opportunities to collaborate on species and habitat conservation.

7.7.2 NON-GOVERNMENTAL ORGANIZATIONS (NGOS)

Northeast NGO partners are described throughout this Regional Conservation Synthesis, with active contributions to all of the SWAP Elements. Non-governmental partners involved in research, inventory, and monitoring programs described in *Chapter 5* and regional conservation projects through Regional Conservation Needs (RCN) Grant and Competitive State Wildlife Grant projects are described in *Chapter 4*. Numerous NGOs partners involved in regional collaborations are described in Section 7.1 of this chapter.

Countless NGO partners focus on species or taxonomic groups. **Partners in Amphibian and Reptile Conservation**, and their Northeast chapter, focus on herptofauna conservation[197]. The **American Fisheries Society** is dedicated to freshwater and marine fish conservation[198]. **Partners in Flight** is an international NGO addressing the scientific and conservation needs of birds[199]. **Bat Conservation International** works to prevent bat extinctions across the globe[200]. The **North American Butterfly Association** conserves, monitors, and educates the public about butterflies[201]. The **Xerces Society for Invertebrate Conservation** advances the conservation of invertebrate species, especially pollinators and at-risk species[202].

Within the Northeast region, the **Atlantic Coast Joint Venture** coordinates landscape scale conservation of birds on the Atlantic Flyway[203]. This Joint Venture, like other Joint Ventures with different geographic focus areas, assesses the status and trends of bird populations, related population and habitat objectives to specific actions and locations, and evaluates the impact of conservation and management. The **Coastal Marsh Inventory and Saltmarsh Sparrow Project Inventory**, for example, tracks conservation projects throughout the region and the adjacent Southeast. Spatial datasets are available for impoundments, tidal marsh vegetation, and priority areas for salt marsh restoration and marsh migration projects. Landscape prioritization tools are available for Eastern Black Rail (*Laterallus jamaicensis jamaicensis*) and Saltmarsh Sparrow (*Ammospiza caudacuta*), two Northeast RSGCN, as are spatial analyses of predicted occupancy and density for several coastal species.

The **Appalachian Mountains Joint Venture** similarly serves as a partner for bird conservation but in the Appalachian Mountains[204]. The **Focal Landscape Initiative** of the Joint Venture strategically targets capacity and resources on the highest priority regions established with partners[205]. Four of the six Focal Landscapes are located entirely or partially within the NEAFWA region: Allegheny Highlands (PA, NY), Greebriar (WV), Virginia Highlands (VA, WV), and Southern Appalachian High Country (VA, TN, NC). In 2022, the Appalachian Mountains Joint Venture launched an **Outreach Toolkit** that offers guidance and resources to effectively communicate and engage with the public on managing Appalachian forests for birds and other wildlife[206].

Resources in the Toolkit include forest management, forest carbon, prescribed fire, urban forestry, and other topics to engage communities and private landowners in conservation. The Appalachian Mountains Joint Venture also provides technical and financial assistance to private landowners to manage and enhance wildlife habitat.

The **National Audubon Society** and numerous state and local Audubon organizations undertake countless activities related to the conservation, management and monitoring of bird species. These organizations own several nature preserves in the Northeast. The National Audubon Society is a key partner in Atlantic Flyway Shorebird Initiative and the Joint Ventures. Partnering with the Cornell Lab or Ornithology and others, Audubon launched a **Bird Migration Explorer** resource in 2022 that aggregates millions of bird observation data into an interactive map to illustrate the migratory paths and stopover sites for hundreds of bird species, including shorebirds and waterbirds in the Northeast[207]. The migratory pathways illustrated on the Bird Migration Explorer clearly highlights the importance of the NEAFWA region as a migration corridor.

Additional NGO with species or taxonomic group conservation missions are discussed in *Chapter 1*.

Many NGO partners focus on habitats and improving habitat condition, oftentimes protecting and restoring habitat nationally or in the Northeast. Some organizations also operate scientific programs that can inform SWAPs. Scientists with **The Nature Conservancy (TNC)**, for example, have developed habitat classification systems and conducted many ecological condition assessments for the Northeast and the nation (Anderson and Frohling 2015, Anderson and Olivero Sheldon 2011, Anderson et al. 2013a and 2013b, Anderson et al 2016a and 2016b, Anderson et al. 2023, Greene et al. 2010, Olivero Sheldon and Anderson 2008 and 2016, Olivero Sheldon et al. 2015). Products and tools developed by TNC are available through their **Conservation Gateway** portal[208].

The **National Wildlife Federation** partners with AFWA and its regional associations to advance landscape scale conservation, promote the use of SWAPs, and advocate for federal funding investments like the Farm Bill and the proposed Restoring America's Wildlife Act (see Section 7.5). With a long history of environmental education and public outreach programs, the National Wildlife Federation has improved habitat across the country at the local, grassroots level. Their **Critical Paths Project** is collaborating with state and federal partners in the Northeast to identify priority zones for wildlife crossings to reconnect habitat and protect wildlife[209]. The National Wildlife Federation recently launched a **Nature-based Solutions Funding Database** that helps community planners and other stakeholders connect with federal funding sources for projects that include nature-based elements[210]. At the local level, the National Wildlife

Federation offers several programs to encourage private landowners to improve wildlife habitat, including the **Million Pollinator Garden Challenge**[211] (see also *Chapter 2*, Section 2.24).

Additional NGOs with habitat and habitat condition conservation missions are discussed in on in *Chapter 2*.

Several institutes with conservation missions contribute to fish and wildlife conservation in the Northeast. The **Wildlife Management Institute** has a long-standing partnership with NEAFWA and the USFWS in the Northeast, administering and managing grant programs like the RCN Program. The Wildlife Management Institute is a national organization, however, that is involved in a wide range of conservation issues, policy, research, and education[212]. The organization leads national conservation partner initiatives, is a cooperator in the Cooperative Fish and Wildlife Research Unit Program (see Section 7.6.1), publishes journals and books on ecology and natural resource management, and hosts an annual North American Wildlife and Natural Resources Conference. The **Eagle Hill Institute and Foundation** also sponsors multiple journals that that contribute to scientific knowledge in the region (inc. *Northeastern Naturalist*), conducts natural history training, and sponsors the annual Northeast Natural History Conference[213]. The **Electric Power Research Institute (EPRI)** offers as a gateway to the energy industry, conducting scientific studies on interactions between the industry and fish and wildlife and developing best practices to avoid and minimize impacts[214]. Their **Ecosystem Risk and Resilience Program** has developed tools and resources relating to environmental justice, nature-based solutions, water resources, wildfires, and climate change. Recent projects and initiatives of the EPRI **Endangered and Protected Species Program** include energy infrastructure impacts to bats (e.g., survey techniques, wind turbine mortality), pollinators (e.g., co-locating solar installations with pollinator habitat), eagles, freshwater mussels, and grassland birds.

7.7.3 LAND TRUSTS

Land trusts play an important role in habitat conservation, benefiting fish and wildlife resources through local preservation and habitat management. The Northeast region supports more than 125 land trusts organizations, many of whom are partners in the Northeast Motus Collaboration[215] (see *Chapter 5*). "With access to enormous expanses of privately held property, land trusts are in a unique position to translate the data provided by Motus into on-the-ground conservation action, ensuring that conservation efforts are as strategically directed and permanent as possible."[215] Land trusts and other landowning conservation organizations were pivotal partners in the RCN Xeric Habitat for Pollinators project as well[216].

Although land trust organizations are often local, several state, regional, and national land trust associations offer opportunities to engage land trusts at the landscape level. **WeConservePA**, formerly the Pennsylvania Land Trust Association, is a partnership of land trust organizations and partners with a common goal to acquire land and conservation easements to advance land and water conservation[217]. More than 80 land trust organizations are members of WeConservePA across the state of Pennsylvania. The **Trust for Public Land** protects land and create park to provide access for everyone to the outdoors, and the national organization has developed tools to assess and plan access to outdoor recreation (see *Chapter 8*)[218]. The **Land Trust Alliance** is a national collaboration of land trust organizations, with more than 950 members across the country that owns and/or manages land in 93% of the nation's counties[219]. This national organization provides policy, standards, training, and education resources to support local land trusts in their conservation efforts. The **North American Land Trust** coordinates with private landowners to conserve their lands, holding more than 500 conservation easements in 23 states[220].

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7.9 ENDNOTES

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CHAPTER 8: PUBLIC ENGAGEMENT

SWAP Element 8

Descriptions of the necessary public participation in the development, revision, and implementation of the plan.

Suggested components:

A. *The state describes the extent of its efforts to involve the public in the development of its Plan.*
B. *The State describes its continued public involvement in the implementation and revision of its Plan.*

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Table 8.5.1. Numerous non-governmental and citizen science databases are publicly available online that contain inventory, monitoring, and status information on fish and wildlife resources of the Northeast.

FIGURES

Figure 8.4.1 Tree Equity Scores from an analysis by American Forests for the urban corridor from Wilmington, Delaware, to Trenton, New Jersey, with green areas with higher tree equity and orange areas with less tree equity, identifying opportunities to create or enhance urban forests to achieve equity and the associated ecosystem service benefits (from https://treeequityscore.org/map).

HOW TO USE THIS CHAPTER:

Chapter 8 of this Regional Conservation Synthesis provides a summary of available information on best practices for engaging the public in the development, revision, and implementation of State Wildlife Action Plans (SWAPs).

- The Regional Overview (Section 8.0) describes the purpose and need for public engagement in fish and wildlife conservation.
- Section 8.1 discusses changes in public values for fish and wildlife and recommendations from the Association of Fish and Wildlife Agencies for agency relevancy.
- Section 8.2 addresses outdoor recreation, the most prominent way that the public is engaged in fish, wildlife, and habitat appreciation and activities. It also addresses public health initiatives that incorporate outdoor recreation activities. State Comprehensive Outdoor Recreation Plans (SCORPs), and growing concerns about high-impact recreational activities on fish, wildlife, and habitats.
- Section 8.3 provides examples of education and outreach recommendations and resources, including extensive resources developed by Project WILD and Project Learning Tree.
- Section 8.4 summarizes resources and tools that address diversity, equity, inclusion, and environmental justice in wildlife conservation and management.
- Section 8.5 describes citizen science projects and programs that engage the public in fish and wildlife conservation in the region.
- Supplemental Information, such as the Threats Classification scheme, can be found in the Excel workbook with *Supplemental Information 3* for Chapter 3.

8.0 REGIONAL OVERVIEW

> *The social and ecological context for fish and wildlife conservation in North America is changing rapidly. Habitat loss, invasive species, declines in biodiversity, and the impacts of climate change are accelerating. At the same time, society is increasingly diverse, urban, and disconnected from nature. The number of hunters and anglers – the historic funding base for state fish and wildlife agencies – is declining. In response to these trends, fish and wildlife agencies must find ways to engage and serve broader constituencies to expand the financial and political support necessary to ensure the future of North America's conservation legacy.* (Association of Fish and Wildlife Agencies [AFWA] and The Wildlife Management Institute 2019, p. 8)

State Wildlife Action Plan (SWAP) Element 8 requires that plans describe how the public is engaged in not only developing but also implementing the plans. Over the past decade, since the 2015 SWAPs were developed, numerous resources and tools have been developed that can inform Element 8 of the 2025 SWAPs. This is particularly important in the Northeast region, with its high population density and levels of urbanization which provide many opportunities for SWAPs to engage the public in both development and implementation of the plans (AFWA and The Wildlife Management Institute 2019).

Guiding Principle 5 of the AFWA landscape conservation guidance states "Make SWAPs more accessible, understandable, and relevant to broad constituencies" (AFWA 2021, page 5). This Regional Conservation Synthesis contributes to two corresponding Recommended Actions:

- **5.1** Make SWAPs more accessible and user-friendly to both technical and general audiences by making them web-based, easily searchable, and by creating targeted products for specific users.
- **5.2** Improve communication and marketing to ensure SWAPs and related landscape conservation efforts are valued as an important tool for conserving biodiversity.

The Northeast Fish and Wildlife Diversity Technical Committee (NEFWDTC) website update (https://northeastwildlifediversity.org[1]) in 2023 allows for web-enabling this Regional Conservation Synthesis, the updated Northeast RSGCN Database (version 1.0), the Northeast SWAP Database, and associated communication tools and products. These tools and resources will be searchable with filters to provide detailed information for specific targets, purposes, or users. By linking with other NEFWDTC programs such as the Regional Conservation Needs (RCN) Grants Program, regional information will be integrated in a centralized online platform available to the states, conservation partners, and the public.

8.1 SHIFTING PUBLIC FISH AND WILDLIFE VALUES

Increasingly, the role of the public is shifting from "stakeholders" in wildlife management to "beneficiaries" of wildlife conservation (Decker et al. 2015, 2019). Many people have associations with certain places, referred to as a "sense of place" in social science literature. Although a sense of place is not quantifiable, it may have defining characteristics that are related to fish and wildlife resources and their habitats. The defining characteristics of coastal communities as a sense of place or identity, for example, include the beach (habitat), the ocean (habitat), and common fish and wildlife like shorebirds, crabs, dolphins, and turtles (species). The undeveloped scenic vistas, forests, and rocky streams of the Appalachian Mountains along with experiences like viewing synchronous fireflies can create a distinctive sense of place for the public, one that is defined by—and in many cases inseparable from--fish and wildlife resources and their habitats. This interconnectedness of social and natural systems can be referred to as "socio-ecological systems" (Young et al. 2006). Colding and Barthel (2019) synthesized twenty years of scientific application of this socio-ecological systems framework, which is often used, in turn, to analyze the resilience of natural resource management systems.

The **Center for Conservation Social Sciences** at Cornell University in New York focuses on the interactions between social and ecological systems through research and outreach programs that advance social science assessment and stakeholder involvement in natural resource management. A list of publications related to the social science of fish and wildlife conservation conducted by the Center is available through its website[2]. Examples of publications from the past five years include studies on a wide variety of topics that can inform SWAP Element 8:

- hunter recruitment and retention,
- landowner views on providing public access for wildlife-dependent recreation,
- black land stewardship in the Northeast,
- response to messages about wildlife disease from hunters,
- incorporating biodiversity in municipal land use planning,
- community-based management approaches,
- inequity in the shale gas industry in the United States,
- good governance principles for environmental policy and planning,

- the effects of aquatic invasive and nuisance species on recreational fishing participation in the Great Lakes,
- public perceptions and attitudes towards large mammals like moose, bears, and wolves,
- integrating social and ecological sciences for natural resource decision making,
- sense of place and place attachments,
- modeling local stakeholder participation in landscape-level wildlife conservation,
- accessibility, and
- education and outreach effectiveness.

Increasing attention and efforts to incorporate social sciences into wildlife management and conservation have resulted in several assessments and analyses that identify shifting perceptions and values of public fish and wildlife values, barriers to public engagement in wildlife-associated recreation and management, barriers to the ability of fish and wildlife agencies to adapt to changing public values, and guidelines and recommendations for maintaining agency relevancy and increasing public engagement.

GOVERNANCE PRINCIPLES FOR WILDLIFE CONSERVATION IN THE 21ST CENTURY

Decker et al. (2015, p. 290) argue that "wildlife conservation is losing ground in the U.S. for many reasons…[with] the net effect [a] decline in species and habitat." Wildlife conservation institutions must adapt to social-ecological conditions to address this trend. Reflecting on the nature of good governance and the challenges governments often face in securing public trust, the authors developed a set of principles for ecologically and socially responsible wildlife conservation that addresses persistent and systemic problems. Challenges and opportunities related to the recommended principles are discussed; and further dialogue among scientists, practitioners, and other leaders in wildlife conservation in the United States is encouraged. The sections below include resources for future discussion developed by the Association of Fish and Wildlife Agencies (AFWA).

THE NATURE OF AMERICANS

The Nature of Americans is a national initiative[3] to understand and connect the American public with nature. It is supported by state and federal agencies, academia, business, and non-governmental organizations (NGO). The initiative addresses the national problem that people are increasingly disconnected from nature, the outdoors, and wildlife; it also describes opportunities for reconnection. Key findings from the national report include (Kellert et al. 2017, pp. 3-5):

- Americans face a significant gap between their interests in nature and their efforts, abilities, and opportunities to pursue those interests.
- Experiences in nature are deeply social.
- Adults and children differ in where they locate unforgettable, authentic nature.
- Access to nature is as much about the quality of places as their quantity.
- Americans value nature in remarkably broad, diverse ways.
- Americans support nature-related programming, funding, and conservation.
- Americans' relationship with nature is complex and nuanced.
- Americans perceive tremendous benefit from experiences in nature.

The Nature of Americans National Report (Kellert et al. 2017) provides 22 actionable recommendations to reconnect Americans with nature, all of which can inform public engagement components of Wildlife Action Plans. These recommendations relate to outdoor recreation, environmental education, outreach, and partnerships.

AMERICA'S WILDLIFE VALUES

The Western Association of Fish and Wildlife Agencies and Midwest Association of Fish and Wildlife Agencies recently administered the **America's Wildlife Values** project, funded by a Multistate Conservation Grant from the U.S. Fish and Wildlife Service, Wildlife and Sport Fish Restoration Program and AFWA. Researchers from Colorado State University and The Ohio State University conducted public and agency culture surveys and developed a multi-level model of the effect of modernization on wildlife management (Manfredo et al. 2018). The purpose of the project was to assess the social context of wildlife management as a way to understand the growing conflict surrounding wildlife management practices.

Four wildlife value orientation types were identified across the United States (Manfredo et al. 2018):

- *Traditionalists*: who believe that wildlife should be used and managed for the benefit of people
- *Mutualists*: who believe that seeing wildlife is a part of their extended social network
- *Pluralists*: whose orientation toward either end of the spectrum (traditionalist vs. mutualist) varies with different situations or in different contexts
- *Distanced*: those with low levels of thought about and interest in wildlife

Nationally the study found 35% of Americans to be mutualists, 28% traditionalists, 21% pluralists, and 15% distanced. Detailed information is available for individual states, illustrating differences in the public's wildlife-related values across regions. The study

RSGCN with Cultural Values

*Seven Northeast RSGCN are identified to have Cultural Values as contributing factors in their identification as RSGCN in 2023: American Shad (*Alosa sapidissima*), Alewife (*Alosa pseudoharengus*), Pale-bellied Brant (*Branta bernicla hrota*), American Black Duck (*Anas rubripes*), American Woodcock (*Scolopax minor*), American Lobster (*Homarus americanus*), and Bay Scallop (*Argopecten irradians*). The Bay Scallop is of particular importance to the Wampanoag Tribe, which is using Tribal Wildlife Grant funds to restore eelgrass habitat in coastal Massachusetts as part of a long-term recovery program for the species.*

also summarizes global shifts in wildlife values over time as the social-ecological environment changes, and how the results of their analyses inform whether shifts are detectable in the United States. The authors conclude that modernization has influenced America's Wildlife Values at the state level, specifically with regard to education, income, and urbanization. They found that higher education, higher income, and living in mid- to large-sized cities is associated with higher proportions of mutualists vs. traditionalists in the population overall. "The primary forces affecting change in values at the state level are population migration and generational replacement" (Manfredo et al. 2018, p. 17).

Shifts in wildlife values were found to affect attitudes towards wildlife management issues, increasing the potential for conflict. The study survey included questions related to the highly controversial topic of lethal control of predators and other high-profile environmental issues such as climate change, private property rights, and protection of declining or endangered species. Support for environmental protection over economic growth is higher in states with a greater proportion of mutualists, and belief that private property rights outweigh conservation of declining or imperiled species is more prominent in states with more traditionalists. The composition of wildlife values in a state had a very strong effect on the level of support for lethal control of predators, with opposition increasing with the proportion of mutualists in a state in all hypothetical scenarios while traditionalists are more supportive but that support varies with the scenario (Manfredo et al. 2018).

The America's Wildlife Values study also evaluated factors relating to public participation in wildlife-related recreation and state fish and wildlife agency funding, public trust, and structure. Recommendations from the national report include measures relating to agency culture and the mission of state fish and wildlife agencies, governance styles, accountability, and public engagement. Manfredo et al. (2018, p. 82) recommend an ongoing dialogue within state fish and wildlife agencies, that asks the following questions:

- How can we envision the situation in the state in 20-30 years given current trends?
- What effect will these changes have on the agency?
- How can we retain our traditional emphasis while embracing new stakeholders?
- What challenges or issues exist today that we need to address in achieving our job more effectively?

The answers to all these questions could inform SWAP planning.

FISH AND WILDLIFE RELEVANCY ROADMAP - AFWA

In 2019 the Association of Fish and Wildlife Agencies released the **Fish and Wildlife Relevancy Roadmap: Enhanced Conservation Through Broader Engagement**, version 1.0 (AFWA and the Wildlife Management Institute [WMI] 2019), hereafter referred to as the *Relevancy Roadmap*. The *Relevancy Roadmap* is a practical guide designed to assist fish and wildlife agencies in their efforts to engage and serve broader constituencies, describing the recommendations of the **Blue Ribbon Panel on Sustaining America's Diverse Fish and Wildlife Resources** (AFWA 2016). The guide identifies 19 barriers to engaging broader constituencies relating to agency culture, agency capacity, constituent culture, constituent capacity, and political and legal constraints. Strategies, steps, and tactics are recommended to overcome each barrier, with examples of current agency efforts that are already working to address this issue.

One of the resources developed by the Blue Ribbon Panel's Relevancy Working Group as part of this initiative was an annotated bibliography of literature addressing transformation in state fish and wildlife agencies (AFWA 2018). The annotated bibliography found multiple summary findings, including that the relevance of wildlife conservation, and thus the relevance of state agencies, is determined from the perspective and judgement of citizens not the agencies themselves. The next section summarizes the subsequent 2019 AFWA report on America's Wildlife Values to inform this issue (AFWA 2019).

8.2 OUTDOOR RECREATION

The public is engaged with nature and its fish and wildlife resources through a variety of outdoor recreation activities. Outdoor recreation offers an opportunity for the public to appreciate fish and wildlife and their habitat, fostering a sense of responsibility and support for wildlife conservation. Too much outdoor recreation, however, can lead to human disturbance that threatens those fish and wildlife resources and their habitats. Several resources are available to assist SWAPs in planning and managing outdoor recreation.

AFWA (2018, p. 1) found that state fish and wildlife agencies need to "recognize and accept that wildlife conservation is in the outdoor recreation business." This literature review of state fish and wildlife agency transformation also found that "wildlife management is the guidance of decision-making processes and implementation of practices to purposefully influence interactions between people, wildlife and habitats to achieve impacts (benefits) valued by stakeholders (citizens)" (AFWA 2018, p. 2). Participation in traditional outdoor recreation activities is declining while at the same time an increasingly diverse and urbanized public creates the need for agencies to adapt to the changing societal context of wildlife management. Traditional stakeholders retain an essential role in wildlife management, however, which should not be diminished (AFWA 2018). This section highlights resources and tools available to address outdoor recreation planning and management, informing the needs identified by AFWA's Blue Ribbon Relevancy Working Group.

8.2.1 OUTDOOR RECREATION PLANNING RESOURCES

TRENDS IN OUTDOOR RECREATION

The **National Survey of Fishing, Hunting, and Wildlife-Associated Recreation** from the USFWS is one of the oldest and most comprehensive wildlife-related recreation surveys in the U.S. First undertaken in 1955, this national survey collects information on anglers, hunters, and wildlife watchers, monitoring the number of people, how often they participate in these activities, and how much money they spend on outdoor wildlife-associated recreation. The survey is conducted every five years, allowing for long-term trend analysis. The monitoring information in the national outdoor recreation survey can inform the status and trends of biological resource use and human disturbance from recreational activities for SWAPs as well as public engagement in wildlife-associated activities. The 2016 survey found a 16% increase in the total number of people over age 16 participating in wildlife-related recreation (USFWS and US Census Bureau 2018). The increase was attributed primarily to those watching wildlife, which increased 20% to more than 86 million people. The most recent survey was conducted in 2022, with results expected to be released mid-2023.

Recent trends indicate that although many Americans still participate in nature-related outdoor recreation, more and more are likely do so through non-consumptive activities and less likely to do so in the context of fishing or hunting (WMI and Responsive Management 2021). The **America's Wildlife Values** project found that "the percentages of people expressing an interest in future hunting (16%) and fishing (32%) are lower than rates of past participation, while wildlife viewing has higher future interest (52%) compared to past participation" (Manfredo et al. 2018, p. 8). Although future interests were lower than in previous surveys, they were still higher than the results of the 2016 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation and thus support a need for increased outdoor recreation planning.

STATE COMPREHENSIVE OUTDOOR RECREATION PLANS (SCORPS)

State Comprehensive Outdoor Recreation Plans (SCORPs) describe a state's goals and priorities for outdoor recreation, updated every five years as required by the federal Land and Water Conservation Fund. Individual SCORPs are not on the same revision cycle across the Northeast, with the current plans covering 2017-2022 for some states and 2020-2025 for others. There is extensive public engagement in the development of SCORPs. Polls, surveys, and focus groups are used to determine the public's outdoor recreation needs and wants. Detailed information includes demographic and public participation data on outdoor recreation in the state. The priorities outlined in a SCORP may be implemented at the local level through state and federal grant programs for parks, trails, and a variety of outdoor recreation related projects. The **Society of Outdoor Recreational Professionals** maintains a directory[4] of SCORPs. The 2020 update of the Pennsylvania SCORP, for example, includes the results of a project undertaken by The Trust for Public Land to map public access to the state's outdoor recreation areas, waterways, and trails with demographic data, spatially identifying areas of the greatest need for improved public access. Collaboration and coordination between SWAPs and SCORPs present an opportunity to address both the needs and the potential threats of public access to wild spaces.

STATE FOREST ACTION PLANS

Forests and Woodlands are managed at the state level through **State Forest Action Plans (SFAPs)**. The SFAPs outline conservation strategies and priorities similar to a SWAP and are eligible to receive federal funding as authorized by the Cooperative Forestry Assistance Act (see *Chapter 2* for more information). SFAPs are required to incorporate SWAP information, which states have done within the framework of their habitat assessments, strategies, and shared priorities or goals. The SFAPs of the Northeast were updated in 2020. The US Forest Service and Northeast-Midwest State Foresters Alliance synthesized the 2020 State SFAPs from the Northeast and Midwest and released a regional summary report in 2022 (USFS and Northeast-Midwest State Foresters Alliance 2022). With SFAPs updated on a 10-year cycle that falls halfway between the 10-year cycle of SWAPs, the regional summary report identified "tremendous opportunities for further collaboration on wildlife habitat strategies with state and regional wildlife and forestry agencies, organizations, and other partners" (USFS and Northeast-Midwest State Foresters Alliance 2022, p. 15).

The regional SFAP summary report identifies more than a dozen common themes across the 21 individual documents, including forest-based recreation (USFS and Northeast-Midwest State Foresters Alliance 2022). Individual state Plans include outdoor recreation and environmental education components, providing an opportunity to jointly address the planning and management needs of recreation and education with SWAPs. Individual State Forest Action Plans are available through the National Association of State Foresters[5].

The **US Forest Service Landscape Scale Restoration Grant Program** is a competitive grant program to address landscape level issues on state, tribal, and private forests and woodlands. Conservation strategies of State Forest Action Plans are prioritized, and projects are evaluated and awarded regionally. A **Landscape Scale Restoration Manual** and **Landscape Scale Restoration Project Planning Tool** are both available to guide conservation projects. The planning tool and shared conservation strategies of SFAP and SWAPs, as related to outdoor recreation and environmental education provide opportunities for collaborative projects potentially fundable by the grant program. An inventory of Landscape Scale Restoration Projects is available[6].

RECREATIONAL OPPORTUNITY SPECTRUM (ROS)

The United States Forest Service (USFS) developed the **Recreational Opportunity Spectrum** (ROS) to classify public access to National Forests. This document has informed the federal agency's planning since the 1970s (Clark and Stanley 1979, Brown 1982, Lee et al. 2013). The classification system incorporates land use, the level of human disturbance at a site, and the distance between the site and roads to determine potential outdoor recreation opportunities that the land can sustainably provide. The premise of the ROS is that people are linked with the landscape, where visitors engage in an activity at a setting land managers choose, resulting in experiences and benefits; or that, by managing for specific setting characteristics, managers will provide specific recreation experience opportunities and beneficial outcomes (Lee et al. 2013).

The **National ROS Inventory Mapping Protocol** includes five ROS setting indicators to monitor and analyze the effects of outdoor recreation on public lands owned by the US Forest Service (Hill 2019):

1. *Remoteness* – distance from motorized use of roads and trails
2. *Size*
3. *Evidence of humans* – evidence of visitor impacts and/or management activities (e.g., roads, oil and gas development, mining, timber harvest, vegetation treatments, livestock grazing, development and facilities infrastructure, etc.)
4. *Visitor density* – number of people encountered

5. *Visitor management* – level of information (i.e., signs), interpretation, and regulations placed on visitor activities

"The size of an area is used [as an indicator in the Recreation Opportunity Spectrum] to indicate greater or lesser potential for self-sufficiency related to a sense of vastness, where large, relatively undeveloped areas tend to provide a sense of vastness and smaller, developed areas less so as one moves across the spectrum" (Hill 2019, p. 3). The other three indicators relate to human use and management of outdoor natural spaces, which affect both the characterization of the outdoor recreational space and visitor experiences and perceptions.

Lands are assessed using available spatial datasets to categorize the following land classes along a spectrum of these five indicators (Hill 2019):

- *Urban*:
    - Areas within 0.5 mile of motorized routes (including roads, railroads, aircraft landing strips, trails, and waterways)
    - Setting strongly dominated by structures, roads, parking lots, etc.
    - High degree of visitor interaction, people are in constant view
    - Intensive on-site management, obvious signage and agency staff
    - Motorized travel restricted to designated routes
    - Route densities greater than 8 miles per square mile of area
- *Rural*:
    - Areas within 0.5 mile of motorized routes
    - Natural setting is culturally modified such that it is dominant to observers, readily apparent structures are small dominant clusters to scattered
    - Moderate to high visitor interaction on roads, trails and in developed sites, people in constant view
    - On-site management obvious and numerous, mostly in harmony with human environment, obvious signage and agency staff
    - Motorized travel common
    - Route densities between 2.5 and 8 miles per square mile of area
- *Roaded Natural*:
    - Areas within 0.5 mile of motorized routes
    - Motorized vehicle use primarily by standard passenger vehicles
    - Natural setting may have modification that ranges from easily noticed to strongly dominant to observers, structures are scattered
    - Moderate evidence of visitor sights and sounds, moderate to high concentrations of visitor use on roads, moderate to low concentrations on trails and at developed sites
    - Amenities and management controls nearby

    - On-site management noticeable but harmonize with the natural environment, moderate likelihood of encountering agency personnel or volunteers/partners
    - Route densities less than 2.5 miles per square mile of area
- *Semi-primitive Motorized*:
    - Size of at least 2500 acres unless adjacent to a wilderness area or isolated due to topography or other permanent landscape features (with informed judgement)
    - Areas within 0.5 mile of motorized routes (including roads, railroads, aircraft landing strips, trails, and waterways)
    - Motorized vehicle use primarily high clearance or four wheel drive vehicles
    - Low to moderate visitor interaction on trails and developed sites
    - On-site management present but subtle with designated motorized routes or areas
- *Semi-primitive Non-motorized*:
    - Size of at least 2500 acres unless isolated due to topography or other permanent landscape features (with informed judgement)
    - Areas between 0.5 and 3.0 miles from motorized routes
    - High probability of solitude, closeness to nature requiring self-reliance
    - On-site management present but subtle
- *Primitive*:
    - Size of at least 5000 acres
    - Areas at least 3 miles from motorized routes
    - Very high probability of solitude, closeness to nature with little evidence of people, requiring self-reliance
    - Low to non-existent on-site management

The resulting geospatial analysis identifies these six land classes, adding informed professional judgement where needed along with the option to add unique or special opportunity features such as cultural or heritage resources, scenic vistas, adjacent national parks and monuments, or a unique activity or type of use. An ROS inventory map and analysis for public land informs management by identifying places that may need additional management actions to improve existing conditions or reach desired conditions (Hill 2019, Lee et al. 2013). Desired conditions take into account management objectives other than recreation, which may include imperiled species populations and their habitat or designated wilderness areas.

The Trust for Public Land adapted the protocol for a recent outdoor recreation and equity analysis of Pennsylvania's public and open access lands (Trust for Public Land 2020). This tool was developed and has been used to inform planning on National

Forests and National Grasslands with the US Forest Service. The designated land classes were defined as:

- *Urban*: low density developed or greater (designated in the US Department of Agriculture Cropland data layer; see *Chapter 2*, *Section 2.22* for details on this geospatial dataset)
- *Crop*: any crop designated in the US Department of Agriculture Cropland data layer
- *Water*: any waterbody in the National Hydrography Dataset except swamps and marshes
- *Disturbed*: abandoned mines, coal mining operations, and industrial mining operations with 100-meter buffers, excluding remediated lands
- *Back Country*: site located more than 0.5 miles from an unpaved road, 1 mile from a local or low volume road, or 2 miles from a high-volume road
- *Mid Country*: site located more than 0.25 miles from an unpaved road, 0.5 mile from a local or low volume road, or 1 mile from a high-volume road
- *Front Country*: site located more than 0.25 mile from a local or low volume road or 0.5 miles from a high-volume road
- *Rural*: sites within 0.5 miles of a high-volume road or 0.25 miles of a local or low volume road

This assessment technique can identify opportunities to improve access to outdoor recreation, as was done at the county level throughout Pennsylvania. The resulting statewide analysis identified numerous recommendations for how its findings could be incorporated into planning for parks, trails, and open space; partnering with private landowners; prioritizing funding opportunities; collaborating with local planning authorities; economic development; and collaborating with the Department of Transportation regarding opportunities with public transit, signage, and safety improvements (Trust for Public Land 2020). This type of outdoor recreation and equity analysis could be used to identify conserved or protected lands with limited public access, should human disturbance be identified as a threat to imperiled resources on those lands as part of SWAP analyses of threats to Key Habitats for Species of Greatest Conservation Need (SGCN).

8.2.2 OUTDOOR RECREATION MANAGEMENT

In recent years there has been "an unprecedented surge in outdoor recreation," which simultaneously creates an increased opportunity to engage the public with fish and wildlife conservation but also poses threats to animal, human, and environmental health (AFWA 2022, p. 20). The US Forest Service recognizes the challenge of outdoor recreation as an economic driver that also carries with it the need to provide high quality recreational access and experiences[7]. With increasing urbanization and population shifts to areas closer to public lands, the agency notes that many forests are now enjoyed as regional and municipal parks, in ways that adds strain to visitor services, facilities, and natural resources. Recreation that is unmanaged contributes to habitat degradation, damaged heritage sites, conflicts between users, and degraded recreation facilities. Existing outdoor recreation facilities and programs may not align with all cultural traditions.

Recently, several states in the NEAFWA region have initiated programs or projects related to outdoor recreation management. During the recent COVID-19 pandemic, visitation to the Adirondack Mountain Reserve of New York exacerbated a long-term trend, leading to issues with parking, trash, and safety concerns. In 2021, the New York Department of Environmental Conservation and the Adirondacks Mountain Reserve initiated a hiking reservation system to manage summer visitation at the most popular trails. Visitation is capped at the number of parking spaces available.

The Vermont Departments of Fish & Wildlife and Forests, Parks & Recreation published a **Wildlife and Recreation: Understanding and Managing the Effects of Trail Use on Wildlife** in 2021 (Naughton 2021). This report includes a literature review of the effects of trail-based recreation on Vermont's wildlife and offers recommendations to minimize those effects. Guidelines for developing a recreation ecology monitoring protocol are also provided.

The New Hampshire Fish and Game Department, with support from the USFWS and other partners, developed a **Trails for People and Wildlife: A Guide to Planning Trails that allow People to Enjoy Nature and Wildlife to Thrive** guidebook and mapping tool that assesses existing trails and informs siting of new trails in the most wildlife-friendly way (New Hampshire Fish and Game Department 2019). The guidebook describes how outdoor recreation can threaten wildlife and how to use the new tool to minimize impacts. It also provides case examples of how conservation organizations have implemented the tool.

Recreational activities are categorized into ten types (see *Supplemental Information 3*, Threat 6.1) that impact a variety of RSGCN and Proposed RSGCN. Only one type of recreational activity, drones (Threat 6.1.6), is not currently known to threaten any Northeast RSGCN or Proposed RSGCN. Motorized vehicle use for recreation (Threat 6.1.1) and recreational boating (Threat 6.1.4) threaten the highest numbers of RSGCN and Proposed RSGCN in the Northeast. Wildlife observation and photography (Threat 6.1.8) and recreational use of beaches (Threat 6.1.10) also threaten a significant number of species.

Recreational activities impact a variety of RSGCN and Proposed RSGCN taxonomic groups in the Northeast. Birds, mammals, and reptiles are the most widely threatened taxonomic groups by multiple forms of recreational activities, with each impacted by six or seven types of human recreational disturbance. Recreational motorized vehicles and boats affect the highest number of taxonomic groups (11 and ten respectively). Nearly 90% of the RSGCN and Proposed RSGCN tiger beetles are threatened by recreational motor vehicle use, as are 56% of the RSGCN and Proposed RSGCN reptiles.

Three habitat types for RSGCN and Watchlist species are particularly sensitive to impacts of outdoor recreation – caves, alpine, and beaches (see *Chapter 2* for detailed information on the extent and condition of these habitats in the Northeast). The following sections describe new management guidelines and resources available for the 2025 SWAPs on this topic.

MANAGEMENT OF HUMAN DISTURBANCE IN CAVES

Caves and karst systems are examples of RSGCN and Watchlist species habitat that are threatened by human disturbance from recreational caving and tourism in the Northeast and beyond (Threat 6.1.7). Seven RSGCN and Proposed RSGCN, including one amphibian and six bats, are threatened by caving. Many large cavern systems are open to the public for tours and exploration and often are referred to as “commercial caves” or “show caves.” These cave and cavern systems have been impacted by human disturbance, sometimes for more than a century. Grand Caverns in Virginia has been open to visitors since 1806 and Howe Caverns in New York since 1843. At least one RCN project and two conservation organizations have developed management guidelines to address human disturbance in cave habitats.

In 2016, the RCN Program awarded funding to Connecticut, New Jersey, New Hampshire, Pennsylvania and Rhode Island to increase the suitability of identified bat winter hibernation sites by reducing human disturbance as part of the **Gating Caves for Bat Conservation and Protection** project. Project funds supported construction or improvements of gates to the openings in caves and mines, structural enhancements to the sites to create better habitats, installation of a sign template for consistent messaging, and the placement of remote site surveillance if needed (see *Chapter 4* for additional project details).

The **National Speleological Society** is an organization[8] that has been exploring, conserving and researching caves in the US since 1941. The organization’s website includes several environmental education resources on cave fish and wildlife, threats like White Nose Syndrome, safety, and responsible caving practices. The Conservation Division of the National Speleological Society focuses on decontamination procedures to reduce the spread of WNS, restoration and repair techniques, and minimizing the impact of caving by humans with recommended conservation and preservation policy guidelines. Communication messaging developed by the National Speleological Society to encourage responsible, low impact caving advises visitors to *Cave Softly. Take nothing but pictures. Kill nothing but time. Leave nothing but footprints*.

Bat Conservation International is an organization whose mission is to conserve bats through science-based conservation, development of new conservation tools and techniques, and the prioritization of conservation strategies and targets[9]. One of the current goals of the organization is to protect and restore roosting and foraging habitat for bats, including in abandoned mines that provide ideal roosting habitat. Their Abandoned Mines Initiative collaborates with government partners to identify significant bat habitat and develop long-term protection and management plans. Guidance has been developed on the installation of bat-compatible gates at mine entrances and more than 5000 mines have been surveyed by the organization since 2008. Bat Conservation International also partners with federal agencies to develop spatial datasets of priority bat habitats and implement BMPs for bat conservation on public lands.

MANAGEMENT OF HUMAN DISTURBANCE TO ALPINE HABITAT

Alpine habitats are threatened by human disturbance, specifically off-trail recreational use and trampling. Alpine plants are not adapted to being walked on, and it may take decades for bare ground that has been impacted by trampling to fully recover with a healthy plant community. In New York the Adirondack Mountain Club established a summit steward program more than 30 years ago that protects alpine areas from visitor impacts using education to help hikers appreciate the uniqueness and value of the habitat and to foster a sense of responsibility for its care. The stewards enlist visitors to carry rocks from trailheads to the alpine areas to line designated trails and restore degraded areas.

Two Northeast RSGCN butterflies, the White Mountain Arctic (*Oeneis melissa semidea*) and the White Mountain Fritillary (*Boloria chariclea monitus*), are endemic to the alpine habitat on Mount Washington in New Hampshire. The USFWS At-Risk Species Program is partnering with New Hampshire Fish and Game, the White Mountain National Forest, the Mount Washington Observatory, and the Appalachian Mountain Club to develop and produce a public awareness and education campaign that informs the public of the presence and predicament of these species and to create signage marking sensitive areas.

MANAGEMENT OF HUMAN DISTURBANCE ON BEACHES

Beaches and dunes are another example of an important habitat for RSGCN and Watchlist species that is threatened by human disturbance from recreational use in the Northeast. USFWS (2020) synthesizes the current state of knowledge on the impacts of recreational disturbance to shorebirds and found that levels of recreational use of beach and dune habitats is increasing.

Human disturbance of beach and dune habitat and associated species occurs in many forms. Motor vehicles and recreational boating threaten more RSGCN and Proposed RSGCN than any other type of recreation, including those taking place on beaches. Off-road vehicles degrade beach habitat with tire ruts. They can crush and kill unfledged shorebird chicks and sea turtle hatchlings, and flush nesting, foraging, and roosting birds (Threat 6.1.1). Recreational boating threatens wildlife when beaching boats come ashore in areas that are foraging habitat, flushing birds, and allowing human and pet access to otherwise undisturbed shoals and salt marsh (Threat 6.1.4).

Special events like fireworks displays during the summer months or as part of July 4th celebrations disturb and flush nesting and roosting shorebirds and waterbirds (Threat 6.1.9). The USFWS has developed management guidelines for fireworks near beach-nesting bird sites (USFWS 1997).

One of the most significant forms of human disturbance to beach and dune wildlife is recreational use of beaches, which threatens at least 18 RSGCN and Proposed RSGCN in the Northeast, including 29% of RSGCN and Proposed RSGCN birds, 31% of the reptiles (sea turtles), and 50% of the tiger beetles. The cumulative effect of recreational use of beaches with shoreline modifications and beach development (Threats 7.3.1 and 7.3.4 respectively) has been shown to decrease survival rates and body condition of the federally-listed and RSGCN Piping Plover (*Charadrius melodus*; USFWS 2012, 2020; Threat 6.1.10). USFWS (2020, p. 14) found that human disturbance from recreation "can be functionally equivalent to habitat loss if the disturbance prevents birds from using the area or extends the time and energy needed to fed and rest." Heavy human use of beaches for swimming, sunbathing, athletic activities, fishing, and dog-walking disturb nesting shorebirds and waterbirds in particular. Natural resource managers typically install symbolic fencing and signage around bird nesting areas to educate the public about imperiled species such as RSGCN Piping Plovers and limit potential trampling of nests or handling of eggs. The USFWS has developed management guidelines for recreational activities near beach-nesting bird sites (USFWS 1994, 2015), yet recreation remains a pervasive threat to many SGCN, RSGCN, and Watchlist birds.

To address this threat, conservation partners in the Northeast have developed new guidelines and best practices for evaluating and managing additional aspects of human disturbance to beach wildlife, including beach walking and dogs (Mengak et al. 2019, Comber et al. 2021). Social scientists at Virginia Tech collaborated with the USFWS, the **Atlantic Flyway Shorebird Initiative (AFSI)**, state wildlife agencies, and other partners to develop a strategic communication plan (USFWS 2017), identifying the most effective ways to educate the public about the potential adverse effects of outdoor recreation on beach wildlife[10]. The AFSI created an online information sharing database to distribute the new guidelines as well as education and outreach materials, signs, infographics, and consistent messaging. These resources provide new information, understanding, and best practices to address threats from recreational use of beach and dune key habitats for SGCN and RSGCN in the Northeast, including consistent messaging and distribution of outreach materials across the region.

8.2.3 PUBLIC HEALTH INITIATIVES

There is "overwhelming evidence [that] shows the physical, psychological, and social wellbeing of humans depends on contact with nature" (Kellert et al. 2017, p. 3). A growing number of programs and initiatives encourage or incorporate outdoor recreation or nature-based activities as part of public health. As the public became increasingly engaged and involved in outdoor recreation, both consumptive and non-consumptive, during the COVID-19 pandemic, it created new opportunities for human interactions with wildlife that have the potential to increase public appreciation for natural resources and the environment. It also created more opportunities for threats such as infectious diseases to spread between humans and animals (AFWA 2022). Holistic public health initiatives are giving new and wider attention to this issue.

ONE HEALTH INITIATIVE

The **One Health Initiative** recognizes the interconnectedness of animal, human, plant, and environmental health with the goal of promoting, improving, and defending the health and well-being of all species through cooperation and collaboration across disciplines[11]. The transdisciplinary approach involves efforts at the local, regional, national, and international scale. Partners in the United States actively participating in the One Health Initiative include the Environmental Protection Agency (EPA), United States Department of Agriculture, Department of the Interior, the Centers for Disease Control and Prevention, multiple professional medical and veterinary associations, academia, and industry. At the state level, the Association of State and Territorial Health Officials, Environmental Council of States, State Environmental Health Directors, and AFWA all support the One Health Initiative.

The **US One Health Commission** creates, connects, and educates networks of partners using the global One Health approach to promote environmental resilience and improve the health outcomes and well-being of animals, humans, and plants[12]. The Commission was created by the American Veterinary Medical Association, American Medical Association, and other partners and issues annual reports that highlight the programs and impacts of the organization's efforts to apply the One Health Initiative in the US and beyond. Some of these programs include an annual **Global One Health**

Day on November 3, hosting One Health Day student event competitions, a monthly newsletter, education and outreach resources and initiatives, a **Bat Rabies Education Team**, and the **One Health Social Sciences Initiative** that encourages collaboration with the social science disciplines. Numerous educational resources and toolkits are available to assist partners in monitoring, managing, and communicating to the public about zoonotic diseases, emerging infectious diseases, antimicrobial resistance, and more.

One of the current strategic and legislative priorities of AFWA is to strengthen the One Health Initiative by incorporating the expertise and resources of state agencies into planning and partnerships, with a particular focus on the prevention of current and emerging zoonotic diseases. AFWA Resolution 2022-02-04 expressly supports the One Health Initiative and encourages application of its principles, including its adoption as a funding priority for the 2022 Multistate Conservation Grant Program. AFWA, the EPA, the Association of State and Territorial Health Officials, and the Environmental Council of States have sponsored informational webinars on One Health, with recordings available[13].

In November 2022 AFWA completed **The Association of Fish and Wildlife Agencies and the One Health Approach: Providing the Foundation for a Leadership Role**. It discusses the opportunity for fish and wildlife agencies to take a leadership role in the One Health Initiative and to fulfill the need for greater representation of the fish, wildlife, and habitat fields in the transdisciplinary approach (AFWA 2022). "At the same time, [this increased role could] capture a wider community of interest in the issues and realities facing wildlife and wildlife agencies. This [opportunity] all comes at a propitious time, considering that there has been increased engagement by the public in outdoor recreation (both consumptive and non-consumptive) because of the social circumstances spurred by the recent Covid-19 pandemic" (AFWA 2022, p. 1). The 2022 white paper provides a comprehensive overview of the One Health approach and the context for AFWA's engagement with it, plus recommendations on how to overcome barriers to implementation of the approach. A list of the jurisdictional One Health institutions and related legislation within the United States and Canada is provided in an appendix, along with a list of resources and toolkits to help implementation of the Initiative.

The Centers for Disease Control and Prevention (CDCP) coordinates federal One Health activities in the United States. Federal efforts related to One Health are described through the agency's website[14]. For example, the CDCP operates a **One Health Harmful Algal Bloom System[15]**. This surveillance system collects information to assist partners in understanding harmful algal blooms and working to prevent associated human and animal illnesses. Health promotion materials and partner toolkits are available for use by the public, physicians, veterinarians, and other interested groups.

The Department of the Interior supports the One Health approach through the wildlife disease surveillance and research efforts of the United States Geological Survey (USGS) and United States Fish and Wildlife Service (USFWS). The USGS is contributing to the national zoonotic disease response by collaborating with the USFWS, AFWA, and other partners to develop a network that includes all aspects of wildlife disease biosurveillance, from predicting threats, assessing their impacts, and selecting management options to quickly apply the most up-to-date scientific findings. The USGS and USFWS are developing a national wildlife disease database that will enhance the **Wildlife Health Information Sharing Partnership-Event Reporting System** (**WHISPers**, see *Chapters 3* and *5*) and create a new **Aquatic Disease and Pathogen database (AquaDePTH)**. The USFWS zoonotic disease grant program has added a requirement that all grant recipients utilize the WHISPers platform to further enhance the database. The **National Wild Fish Health Survey** of the USFWS partners with natural resource managers to monitor and evaluate aquatic diseases (see *Chapter 5*).

The United States Department of Agriculture (USDA) contributes to the One Health Initiative through its programs that seek to maintain or reduce health risks to animals, humans, and the environment[16]. USDA programs and projects incorporating the One Health approach include those related to antimicrobial resistance, avian influenza, and influenza in swine, among others. A new antimicrobial resistance dashboard and a biosecurity tool to help prevent and minimize future pandemics are currently in development. The USDA Animal and Plant Health Inspection Service (APHIS) has established programs to monitor and research animal and plant health and has adopted the One Health approach into much of its work[17]. During the federal Fiscal Year 2023, APHIS offered a $25 million grant program to research SARS-CoV-2, the virus that causes COVID-19, in animals. APHIS maintains a public surveillance dashboard of SARS-CoV-2 detected in animals[18].

EPA contributions to One Health[19] include:

- the **Total Environment Framework** that evaluates children's neurodevelopment and obesity; **Report on the Environment** (see *Chapter 5*);
- the **EnviroAtlas** that combines large geospatial datasets relating to human, animal and environmental health;
- wastewater-based disease surveillance; and
- efforts related to:
    - harmful algal blooms,
    - climate change,

- watershed planning and protection,
- the citizen science project **Smoke Sense** that monitors wildfire smoke exposure,
- the **AirNow** partnership that monitors air quality,
- pesticides exposure and regulation, and
- decontamination of biological contamination events.

CONSERVATION MEASURES PARTNERSHIP (CMP) RESOURCES

The Conservation Measures Partnership (CMP) recently completed two comprehensive socio-ecological projects. The **Population, Health and Environment Collaborative Learning Initiative** sought to improve the understanding of the value of integrating public health and biodiversity conservation[20]. This global project conducted five case studies that gathered real world evidence to improve the population, health and environment model and definition. The **Holistic Approach for Healthy and Resilient Social-ecological Systems Collaborative Learning Initiative** developed a clear definition of "holistic approach;" a situation assessment to determine when more holistic approaches are needed; a working theory of change; and recommendations on when and how to successfully use a holistic approach[21]. The premise of the initiative is that a multifaceted, holistic approach is warranted to achieve and sustain desired conservation and human health objectives because a significant portion of the high conservation value areas of the world are inhabited, surrounded, and/or owned or managed by people. The initiative recommends that public health and natural resource conservation objectives should be integrated within socio-ecological landscapes.

8.3 EDUCATION AND OUTREACH RESOURCES

Education and outreach are identified in the SWAPs as potentially effective tools to address the conservation needs of species and their habitats. Effective engagement of the public and stakeholders to implement SWAP Element 8 can be informed by recent resources, guidelines, and toolkits for shared conservation messaging, environmental education, and outreach activities. The NEAFWA **Northeast Conservation Information and Education Association**, for example, promotes public information, education, and participation in conservation activities in the Northeast region. The **Academics for Land Protection in New England (ALPINE) Network** provides educational resources for educators at the region's colleges and universities, from curriculum and case studies to events and programming[22].

The mission of the **National Environmental Education Foundation (NEEF)** is to cultivate an environmentally conscious and responsible public[23]. Established by the National Environmental Education Act and overseen by the EPA, the organization partners with governmental agencies, corporations, conservation organizations and others to develop and share environmental education resources, training, and opportunities. NEEF sponsors or partners with others to fund several opportunities focusing on public lands. These include accessibility grants to enhance access for people with disabilities, community learning centers, and demonstration projects that partner federal land-owning agencies with middle and high school students to deliver STEM programming. The Foundation co-sponsors the annual National Public Lands Day community event and Climate Superstars Challenge for middle school students, plus other programs to support habitat enhancement projects on public lands.

The **One Health Commission** has developed numerous environmental educational resources and toolkits for grades K-12, designed to strengthen science, health, and related curricula and enhance students' understanding of the interconnectedness of human, animal, and environmental health[12]. The Commission also is developing a **One Health Vector-Borne Diseases Education Initiative** to educate the public about how to protect themselves and their animals from vector-borne diseases.

The **Facilitating Local Stakeholder Participation in Collaborative Landscape Conservation: A Practitioners' Guide** describes the conceptual social science background on public participation and stakeholder influence in landscape conservation (Doyle-Capitman and Decker 2018). Insights into the preferences of local stakeholders for participating in collaborative landscape conservation planning are detailed, from motivations for participation to preferences on how they participate. Challenges associated with insufficient local stakeholder participation in planning include fairness, performance, legitimacy, inclusivity, transparency, and direction. All are addressed in the Guide. Best practices guidance is provided to promote local stakeholder participation and to guide systematic collection of social data. This resource also provides valuable guidance on how to integrate local stakeholder participation and social data into collaborative landscape conservation planning.

The **North American Bird Conservation Initiative (NABCI)** has collected success stories for bird conservation, a resource of successful outreach and education activities that have actively engaged the public[24]. Northeast RSGCN and Watchlist species featured in the success stories include Piping Plover (*Charadrius melodus*) and Golden-winged Warbler (*Vermivora chrysoptera*). Other examples address habitats, such as a New York project to engage private landowners in conserving and managing early successional habitat, or particular stakeholder groups, like land trusts. The Upper Mississippi River and Great Lakes Region Joint Venture has developed a decision-support tool that informs wetland conservation priorities. It integrates development and human demographic data to maximize potential shared benefits to birds and people. These examples of successful approaches drawn from across the nation can inform effective education and outreach activities in SWAPs.

In addition to these resources and examples, three other recent efforts have developed extensive tools to facilitate communication, outreach, and environmental education of fish and wildlife conservation.

THE LANGUAGE OF CONSERVATION - WORDS MATTER

Recent studies have assessed the language of conservation and how it does or does not work to inform education and outreach and engage the public in conservation efforts. In 2018, the Nature Conservancy (TNC) commissioned a survey the American public, resulting in a set of communication guidelines for the **Language of Conservation** (TNC 2018). These guidelines include three critical elements: water, wildlife, and way of life. The primary impact or element of a conservation project should always be water, which Americans prioritize as a critical reason to become engaged in conservation. Benefits to wildlife is the second highest priority for conservation messaging. Communication should also include localized examples to illustrate how conservation efforts contribute to preserving a “way of life” that is unique and important to that area. Recommendations also include list of words and terms to use or to avoid. “Nature’s benefits” versus “ecosystem services” is one example.

The **Words Matter: Determining How to Engage the American Public Through the Language of Conservation** project and report also provides a series of recommendations for effective communication and messaging to engage the public in wildlife conservation (WMI and Responsive Management 2021). This report identifies a need for effective words and messages that affirm the importance of conservation at a time when demographics, wildlife values, and funding sources for wildlife conservation are changing. This public engagement project assessed the language in current use for communicating with the public about conservation issues; qualitative research incorporating the results of focus groups across each of the AFWA regions; and quantitative research using insights gained from the focus groups to conduct a national survey. The survey designs ensured that race, age, gender, and region were accurately represented. The results of the survey were evaluated using the four wildlife value orientations of Manfredo et al. (2018) described in Section 8.1.

The Words Matter project (WMI and Responsive Management 2021, pp. vii-xiii) found that:

- Fish and wildlife agencies should communicate how their conservation work relates to and affects water quality and the health of rivers, lakes, and streams.

Whenever possible, the work of fish and wildlife agencies should be linked to water quality and the health of water resources.

- Key conservation messages should be phrased as simply and unambiguously as possible.
- Fish and wildlife agencies should embrace the word “protect” when communicating about fish and wildlife and conservation.
- Certain terms and phrases may give the impression of an overly controlling approach to fish and wildlife management, which may alienate some audiences.
- The term “healthy” resonates well in conservation messages.
- The adjectives “safe” and “clean” are often used by Americans when describing the benefits provided by state fish and wildlife agencies.
- To build support for solutions to conservation problems, focus on what may be “lost.”
- Conservation messages will be more effective when focused on key outcomes rather than the process of “scientific management.”
- Agencies should use the phrase “responsible recreation” when communicating about hunting, fishing, and other activities.
- Terms that evoke shared resources, such as “future generations,” “coexist,” and “balance,” appear to resonate well with general audiences.
- Most Americans feel it is equally important that fish and wildlife in the United States be “conserved” and “preserved.”
- Among the least important things for agencies to communicate with the public about are the economic benefits associated with fish and wildlife.
- In general, there do not appear to be any conservation words or phrases that a significant percentage of Americans feel are overused.
- Most Americans believe that, in order to thrive, fish and wildlife need some management but should otherwise be left alone.
- Many people do not know the difference between “game” and “nongame” wildlife; in fact, more people think they know the meanings of the two terms than actually do.
- Conservation messages that include the words “we” and “our” will be more effective with some audiences than others.
- Specificity with population numbers will help to increase concern about imperiled species.
- Residents may be more likely to approve of controversial activities like trapping if they know that such activities are sanctioned by their state fish and wildlife agency.

These findings inform the most effective education and outreach messaging actions identified in SWAPs and can help guide their implementation.

PROJECT WILD - AFWA

AFWA developed **Project WILD** with the mission to provide wildlife-based conservation and environmental education resources that cultivates responsible actions towards wildlife and associated natural resources[25]. Curriculum materials for ages pre-K to grade 12 were designed by experts in the fields of education and natural resource management. Training workshops and professional development online courses are available. In addition to the wide range of activities provided by Project WILD that address fish, wildlife, habitats, and threats, three subject concentrations focus on activities relating to particular wildlife and natural resources:

- **Aquatic WILD** – the hydrologic cycle, aquatic species and their habitats
- **Flying WILD** – birds, their life cycles, and habitats
- **Growing Up WILD** - plant and animal activities for early childhood education

Professional program resources for educators are available for Art & Illustration, Climate Change, Inclusion, and Remote Learning. Conceptual framework materials include connections between Project WILD and Next Generation Science Standards, Head Start Early Learning Outcomes, AFWA's K-12 Conservation Education Scope and Sequence, Common Core State Standards for English / Language Arts and Mathematics, Scout Badges, art and music, K-12 Physical Education Standards, and citizen science[26]. Links to other organizations and programs are provided for additional resources related to specific topics.

PROJECT LEARNING TREE

Project Learning Tree provides educational resources and activities to engage children in learning about the environment through the lens of forests and trees[27]. This award-winning environmental education and community-based service-learning program is designed for educators, parents, natural resource managers, and community leaders working with children from preschool to grade 12. Collections of activities are freely available online, including activity guides for grades K-8, nature activities for ages 1-6, and family activities to do at home. Sample lesson plans, educator tips and STEM strategies provide tools and resources to include environmental education in existing curricula. A **Forest Literacy Framework** includes resources and guides to educate about forests and sustainable forest management. Materials and tools focus on forest concepts relating to public health, climate change, urban forests, green jobs, wildfire, and Indigenous connections to the land.

The Branch newsletter is a monthly resource with free tools and resources, professional development and grant opportunities, new lesson plans, and educator tips for reaching about the environment. Professional development training is available both online and through state-level programs. An annual **Green Schools Conference** focuses on the newest trends and innovations is providing healthy, sustainable learning environments and education. Guidance on engaging students in greening their schools and conducting **GreenSchools Investigations** are available, along with grants to implement needed projects identified by the investigations. Project Learning Tree state coordinators can provide localized assistance and resources; local professional development workshops; and networking with mentor teachers, community members, and resource professionals.

8.4 DIVERSITY, EQUITY, INCLUSION, AND JUSTICE RESOURCES

The levels of understanding and the number of resources and tools available to improve diversity, equity, inclusion, and environmental justice have advanced significantly over the past decade. These resources inform SWAP Element 8 to engage a broader audience in fish and wildlife conservation. Diversity, equity, and inclusion can be addressed at the administrative level with agency personnel, through public access to nature, and through education and outreach activities. Environmental justice can be addressed through policies, inclusive public engagement, grant prioritization, and conservation actions.

8.4.1 ADMINISTRATIVE RESOURCES

The AFWA *Relevancy Roadmap* includes an overarching recommended action that "Agency leadership and governing bodies need to demonstrate commitment to being more inclusive of diverse perspectives and interests in fish, wildlife, their habitats and outdoor recreation activities" (AFWA and WMI 2019, p. 11). The Roadmap identified eight barriers that may exist within state fish and wildlife agency culture and capacity related to diversity and inclusion (AFWA and WMI 2019, p. 10):

- Agency culture and values do not align with nature-based values and outdoor interests of broader constituencies.
- Agency is not adaptive to the changing nature-based values and outdoor interests of broader constituencies.
- Agency has competitive and siloed culture that inhibits collaboration.
- Agency lacks sufficient and diverse funding to provide programs and services to broader constituencies.
- Agency lacks capacity to identify, understand, engage with, and serve the needs of broader constituencies.
- Agency lacks capacity to develop and implement plans that engage and serve broader constituencies.

- Agency lacks capacity to create and sustain effective partnerships to serve broader constituencies.
- Agency lacks expertise and knowledge to provide outdoor recreational experiences that serve broader constituencies.

Detailed strategies and tasks to overcome each of these barriers are described in the *Relevancy Roadmap*, which also includes a framework to increase diversity and inclusion in administrative programs.

In December 2021, the **Open Standards for the Practice of Conservation**, or **Conservation Standards**, released a Phase I analysis of **Diversity, Equity, Justice, and Inclusion Approaches** in conservation efforts. Phase II of this project includes an initial situation analysis; consideration of known barriers to adopting diversity, equity, inclusion and justice aspects in conservation projects; and design of tools and strategies with clear objectives and audiences. The latter will allow the **Conservation Measures Partnership (CMP)** to develop Conservation Standards for improving diversity, equity, inclusion, and justice in conservation programs and actions. The Phase I report and survey results for Phase II are currently available on the Conservation Standards website of resources[28].

The Wildlife Society (TWS) is conducting a similar assessment and is preparing a resource guide and library to improve diversity, equity, and inclusion in fish and wildlife management[29]. These tools and resources should be available in 2023.

The **Ohio Division of Wildlife Near-term Relevancy Plan for Engaging Ohio's African Americans and Young Adults**, completed in February 2022, aims to increase the relevance of conservation to a broader audience, focusing on African Americans and young adults in particular (ODOW 2022). The Relevancy Consulting Team that led this effort includes former state fish and wildlife agency experts, academic experts, the Wildlife Management Institute, and others. The team is currently working on a similar project for the Missouri Department of Conservation and in 2022 was awarded a Multi-State Conservation Grant to assist four states across the country in their efforts to implement the AFWA *Relevancy Roadmap*. One of those four states is Connecticut. More information about these projects to advance diversity, equity, and inclusion in state-led conservation efforts is available on the Wildlife Management Institute website[30].

8.4.2 PUBLIC ACCESS RESOURCES

The outdoor recreation planning resources described in Section 8.2 provide opportunities to address the diversity, inclusivity, equity, and justice needs of communities and states. The current Pennsylvania SCORP, for example, is subtitled "Recreation for All," a statement of its commitment to increasing public access to all-inclusive facilities (PA DCNR 2020). This prioritization of inclusivity is incorporated into state grant funding for proposed recreation projects, with the goal of providing universal public access to local outdoor recreation facilities. Integrating the priorities of SCORPs with the priorities of SWAPs provides landscape-scale opportunities to enhance diversity and inclusion in outdoor recreation activities; broaden public perceptions of the values of fish and wildlife resources; and manage human disturbance of imperiled species and their habitats in a more inclusive way.

PARKSCORE AND PARKSERVE

The Trust for Public Land has conducted a national assessment of public parks, using criteria of equity, access, per capita investment, amenities, and acreage that calculate a **ParkScore** rating[31]. Interactive maps and downloadable reports are available at the municipal level, identifying opportunities to improve equitable access to park spaces. Washington, D.C., had the highest ParkScore of the 100 largest cities in the country, and Arlington, Virginia, New York City, and Boston, Massachusetts, were also in the top 12 cities nationally. To the extent that RSGCN and Watchlist species utilize developed areas as habitat (see *Chapter 2*), this equitable access assessment informs opportunities to engage large segments of the public with urban wildlife conservation.

The Trust for Public Land's **ParkServe** program identifies areas within cities that have the greatest need for parks, focusing on the Census Block scale[32]. The ParkServe methodology starts with identifying areas that are not within a 10-minute walk or drive to designated recreational access (e.g., parks, open access lands, trails, or water access points). Populated areas that are outside of a 10-minute walking or driving radius (depending on the analysis) are assigned a level of park need, ranging from 3 (moderate) to 5 (very high). Three demographic variables from the from the spatial software and analysis company Esri's 2018 Forecast Census Block Groups are used to generate weighted calculations and to assign the level of need:

- Population density (weighted at 50%),
- Density of children age 19 and younger (weighted at 25%), and
- Density of households with income less than 75% of the median household income for the county (weighted at 25%).

The Pennsylvania Department of Conservation and Natural Resources recently partnered with The Trust for Public Land to assess public access to outdoor recreation areas for the entire state using this approach[33]. Analyses and interactive maps were developed for all public parks, trailheads, and open access recreation areas within a 10-minute walk; for state parks, local parks, and trailheads within a 10-minute walk; for trailhead access within a 10-minute drive; for water access within a 10-minute drive;

and for drive times to the Appalachian Trail which traverses the state (30-, 60-, 90-, and 120-minute ranges), which traverses the state. The assessment also identified ways for adjacent communities to connect to the Appalachian Trail by locating areas where new trails of half a mile or less in length would connect existing public lands to the national trail. The statewide assessment found that 53% of Pennsylvania's residents resided within a 10-minute walk to open access recreational lands (Trust for Public Land 2020). Supplemental analyses compared the access of historically marginalized versus non-marginalized groups (both racial and economic) to outdoor recreational spaces, providing an equity assessment at the County level.

The forthcoming Midwest Conservation Blueprint of the Midwest Landscape Initiative incorporates these ParkServe scores as one of its indicators to identify priority lands for conservation across the Midwest region, recognizing its value as a tool to inform inclusive landscape level conservation planning.

SOCIETY OF OUTDOOR RECREATION PROFESSIONALS

The **Society of Outdoor Recreation Professionals** is a national organization of outdoor recreation and related professionals whose goal is to protect natural and cultural resources while providing sustainable public access to recreation[34]. The organization provides training, technical guidance, and networking. The **2021-2025 Strategic Plan for the Society of Outdoor Recreational Professionals** outlines goals and objectives to provide justice, equity, diversity, and inclusion in sustainable outdoor recreation opportunities that contribute to the overall sustainability of communities, ecosystems, and economies. A library collection of technical resources for topics from diversity, equity, inclusion, and accessibility to environmental education, responsible recreation, recreation conflict, heritage recreation, visitor use management, and access to public lands is available through the organization's website[35].

8.4.3 OUTREACH AND EDUCATION RESOURCES

Environmental education and outreach programs can incorporate features or target particular audiences to enhance diversity, equity, and inclusion for everyone. At parks and other public spaces, interpretive programs and tours can include features designed specifically to serve the needs of blind, deaf, or hard of hearing individuals. Providing facilities that incorporate Americans with Disabilities Act (ADA) features (e.g., trails, boardwalks, fishing docks) allows individuals and groups with disabilities to participate in programming and enjoy natural spaces and their wildlife. Specific events may target Spanish-speaking communities, African-Americans, or LGBTQ communities. For example, **Black Birders Week** was organized by The BlackAFInSTEM Collective in 2020 and is now supported by many partners like the National Audubon Society, the

Cornell Lab of Ornithology, the National Oceanic and Atmospheric Administration, and many others. It is held in late May and early June.

The **Children & Nature Network** is a nonprofit organization whose mission is to increase equitable access to nature for children across the globe[36]. The Network offers a Resources Hub and a research library with free toolkits, infographics, reports, and advocacy tools to facilitate connecting families, children, and communities to nature. More than 45 resources in the collection address diversity and equity, from research detailing inequalities in opportunities for children to engage with nature to the importance of incorporating the Traditional Ecological Knowledge of Indigenous peoples in conservation. A weekly newsletter provides information on new research, resources, and stories connecting children with nature. The Children & Nature Network has partnered with **Nappy**, a free stock photography company, to add to their collection of stock photos that include people of color engaged in outdoor activities. These photos can be useful in a broad range of media, educational, and outreach materials.

Numerous national organizations and programs are working to create a more inclusive and representative engagement with the outdoors and natural resources, offering multiple opportunities to partner with SWAP planning and implementation:

- Outdoor Afro[37]
- Latino Outdoors[38]
- Outdoor Asian[39]
- Center for Native American Youth[40]
- LGBTQ+Outdoors[41]
- Out in the Field[42]
- Fresh Tracks[43]
- Justice Outside[44]
- Rethink Outside[45]
- Amplify the Future[46]

Programs and projects that engage urban and suburban residents in wildlife conservation and outdoor recreation are described in *Chapter 2, Section 2.24* (Developed Areas habitat). Resources to increase engagement with Tribal communities are described in Section 8.5 below.

Project WILD offers numerous resources to enhance inclusivity and diversity in environmental education. They include educational training webinars by subject matter experts, universal design principles and lessons, differentiated instruction, culturally responsive teaching, outdoor learning, environmental education for second language learners of English, and activity modifications for students with autism spectrum disorder[26].

8.4.4 ENVIRONMENTAL JUSTICE RESOURCES

Environmental justice is commonly defined as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, policies, and regulations. One of its core principles is that everyone should enjoy the same degree of protection from environmental and health hazards and have equal access to the decision-making process to have a healthy environment in which to live, learn, and work[47]. The following resources are available to assist SWAPs in their efforts to incorporate and address environmental justice issues.

TREE EQUITY SCORES

American Forests developed **Tree Equity Scores** to differentiate the amount of tree cover between wealthy and impoverished communities[48]. Tree Equity Scores are calculated on a scale of 0 to 100 (with 100 = tree equity) based on a neighborhood's existing tree canopy, population density, employment, income, surface temperature, race, age, and health. Scores are measured at the Census Block level and aggregated into scores at the municipality level. The baseline target for tree canopy varies with the location of the municipality (selected in partnership with the US Forest Service), with 40% tree canopy cover in forested areas, 20% in grassland areas, and 15% in desert areas. The target tree canopy metric was adjusted depending on the population density to set more achievable targets. Areas of higher population density were assigned an adjustment factor of 0.5, and those with very low population density were adjusted by 1.5 (based on research conducted by The Nature Conservancy).

A Priority Index is calculated to highlight the need for planting to reach Tree Equity, taking into account income (people living in poverty), unemployment rate, urban heat island severity, race, ratio of seniors and children to working-age adults, and a composite health index. Where data are available, a history of redlining is also incorporated into the index. The Priority Index is applied to the gap between the existing tree canopy and target tree canopy to generate the Tree Equity Score. A **Tree Equity Score National Explorer** includes a calculation of the annual ecosystem service benefits from the proposed tree canopy cover at the county level[49]. A landscape level view of Tree Equity Scores for the urbanized region from Wilmington, Delaware, through Philadelphia, Pennsylvania, to Trenton, New Jersey, shows the areas of inequity in urban tree canopy cover (Figure 8.4.1).

In 2020, American Forests received a Coordination and Collaboration in the Resilience Ecosystem Program grant from the National Oceanic and Atmospheric Administration to apply the Tree Equity Score approach to the entire state of Rhode Island; conduct a community-based urban heat field campaign in four municipalities; scale the empirical municipal results statewide; and integrate the results into the Tree Equity Scores. Over

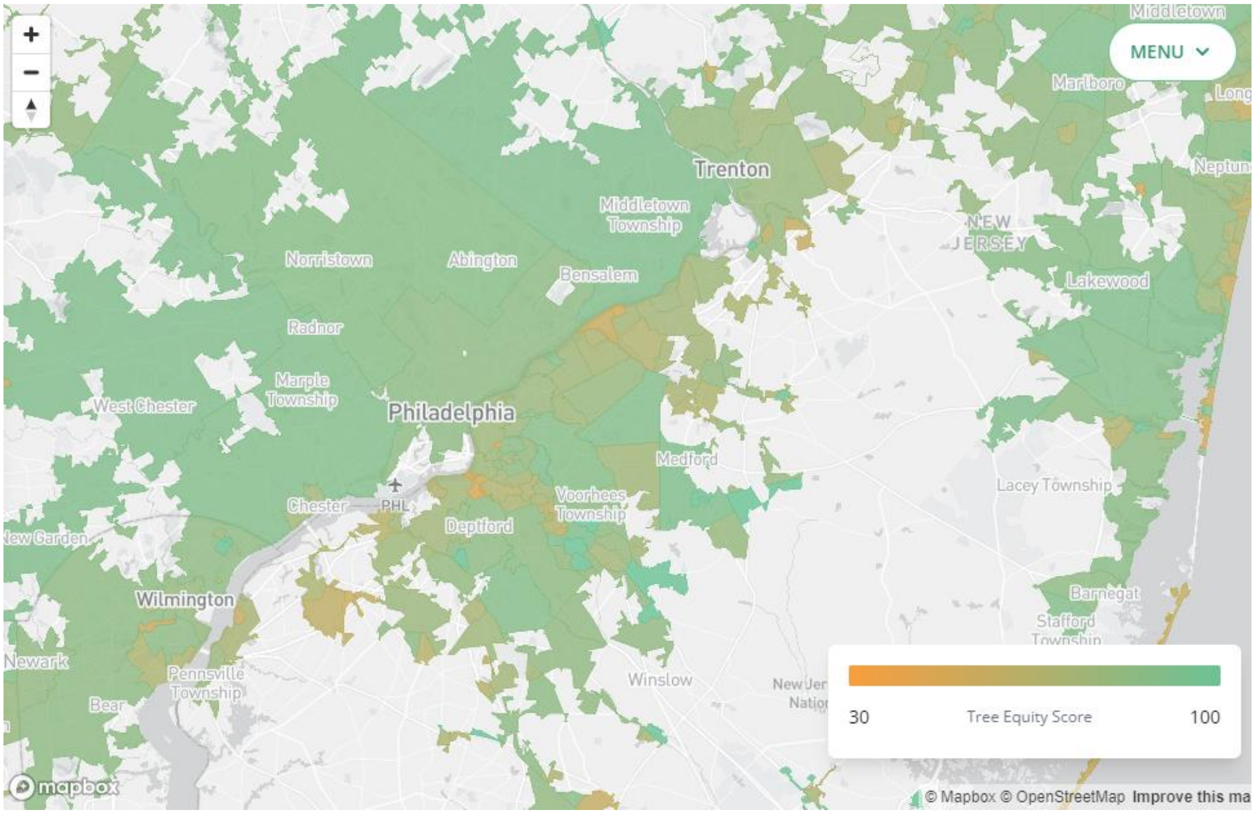

Figure 8.4.1 Tree Equity Scores from an analysis by American Forests for the urban corridor from Wilmington, Delaware, to Trenton, New Jersey, with green areas with higher tree equity and orange areas with less tree equity, identifying opportunities to create or enhance urban forests to achieve equity and the associated ecosystem service benefits (from https://treeequityscore.org/map).

time the urban heat campaigns (i.e., planting trees to mitigate urban heat islands) will provide the data needed to create a national ambient temperature and humidity dataset, ultimately contributing to climate resilience (and environmental justice) by mitigating the localized effects of extreme heat.

The forthcoming Midwest Conservation Blueprint of the Midwest Landscape Initiative incorporates Tree Equity Scores as one important indicator in its efforts to identify priority lands for conservation across the Midwest region, recognizing its value as a tool to inform equitable landscape level conservation planning.

ENVIRONMENTAL JUSTICE RESOURCES – EPA

The Environmental Protection Agency addresses environmental justice in numerous ways. To achieve environmental justice, the federal agency states that everyone must receive the same degree of protection from environmental and health risk, and that there must be equal access to the decision-making process, allowing everyone to have a healthy environment in which to live, work, and learn.

The EPA provides several strategic planning resources related to environmental justice as well as links to collaborative partnerships (e.g., the International Human Rights and Rights of Indigenous People)[47]. The **EJScreen** online screening and mapping tool allows the public to search environmental justice issues by location[50]. Information available on EJScreen includes environmental justice indices, pollution sources, socioeconomic indicators, health disparities, climate change data, critical service gaps (i.e., Broadband gaps, food deserts, medically underserved), and additional demographic and supplemental data. The environmental justice indices provide information on diesel and non-diesel particulate matter, ozone, air toxics cancer risk, air toxics respiratory hazards, traffic proximity, lead paint, Superfund site proximity, Risk Management Plan facility locations (i.e., sites with potential chemical accident management plans), hazardous waste proximity, underground storage tanks, and wastewater discharge. Comparisons between local (Census Block Group) and state or national averages can be generated.

The agency also offers technical assistance and grant funding for environmental justice projects. For example, the Fiscal Year 2023 grant funding opportunity is providing $100 million nationwide to help underserved and overburdened communities address environmental justice issues. Environmental justice grants are available through the Collaborative Problem-Solving Cooperative Agreement Program, Government-to-Government Program, Thriving Community Technical Assistance Centers Program, Small Grants Program, and Communities Pass-through Funder Program. Additional grant programs related to environmental justice include Brownfields Grants, Environmental Workforce Development and Job Training Grants, Urban Waters Small Grants, Diesel Emissions Reduction Act Grants, and Extramural Research Grants.

ENVIRONMENTAL JUSTICE RESOURCES – NOAA

The National Oceanic and Atmospheric Administration (NOAA) offers numerous environmental justice resources and tools[51]. The environmental justice activities of NOAA relate to weather and climate disasters in vulnerable communities. From thawing permafrost to rising sea level, from droughts to wildfires, from worsening heat waves to flooding, the federal agency recently created a NOAA Climate Council to enhance the equitable delivery of the climate science and services that NOAA provides. NOAA Fisheries developed a series of social climate change indicators focusing on the wellbeing of coastal communities engaged in fishing activities. A **Practitioner's Guide to Fisheries Social Impact Assessment**, published in 2020, presents the legal and policy framework for social impact assessments, guidelines on conducting the assessments, and tools to assist in developing assessments (Clay and Colburn 2020). The NOAA Coordination and Collaboration in the Resilience Ecosystem (CCRE) Program offers competitive grants for climate adaptation and resilience projects, with special consideration given to projects that incorporate and address social justice and equity issues or that prioritize diverse and/or vulnerable communities[52]. Among the projects recently funded by this program is a statewide application of the Tree Equity Score and Mapping Tool described above across Rhode Island.

ENVIRONMENTAL JUSTICE RESOURCES – CDCP

The federal Centers for Disease Control and Prevention and its Agency for Toxic Substances and Disease Registry developed the **Social Vulnerability Index**. It uses 16 US Census factors to characterize the potential negative effects of external stressors, such as natural or human-caused disasters and disease outbreaks on human health[53]. The index ranks vulnerability on a scale of zero (lowest) to one (highest). An interactive national map and associated databases help communities be better prepared for and recover from emergency events. Thematic maps highlight specific vulnerabilities for a selected geographic area and data year at the county and census tract level.

The forthcoming Midwest Conservation Blueprint of the Midwest Landscape Initiative incorporates the CDC Social Vulnerability Index as one of its indicators to identify priority lands for conservation across the Midwest region, recognizing its value as a tool to inform equitable landscape level conservation planning.

ENVIRONMENTAL JUSTICE RESOURCES - US DOT

The federal Department of Transportation (DOT) incorporates environmental justice considerations into all its policies, programs, and activities. The agency ensures opportunities for low-income and minority communities to influence transportation planning and decision-making. Each of the federal Administrations within the agency is governed by the DOT Environmental Justice Strategy. The environmental justice programs of the DOT are supported by the **Rebuilding American Infrastructure with Sustainability and Equity (RAISE Grants) Program**[54]. RAISE Grants fund projects that assist communities by improving equity and safety in transportation projects that have significant local or regional impact, with dedicated funding and no cost sharing requirements for projects located in Areas of Persistent Poverty or Historically Disadvantaged Communities.

8.5 CITIZEN SCIENCE

In 2012 the Association of Fish and Wildlife Agencies (AFWA) released **Best Practices for State Wildlife Action Plans – Voluntary Guidance to States for Revision and Implementation**, a national guidance for SWAPs (AFWA 2012). One of the best practice recommendations is to augment state fish and wildlife programs with citizen science programs as appropriate to expand capacity.

Citizen science has grown dramatically in recent years, allowing the public to engage in fish and wildlife conservation in innumerable ways. *Chapter 1* describes citizen science projects that are species-based, many of which address Northeast RSGCN and Watchlist species. *Chapter 2* describes citizen science projects that are habitat-based for each of the 24 habitats for RSGCN and Watchlist species in the Northeast. *Chapter 5* discusses data resources that compile publicly generated information to inform regional conservation efforts (Table 8.5.1).

Citizen science project directories are available online, with projects associated with federal agencies or funding listed at citizenscience.gov, and those associated with non-governmental programs at scistarter.org and anecdata.org.

Table 8.5.1. Numerous non-governmental and citizen science databases are publicly available online that contain inventory, monitoring, and status information on fish and wildlife resources of the Northeast.

Informational Database	Location and Description
Discover Life	https://www.discoverlife.org/ International database and encyclopedia of plant and animal species observations and profiles for more than 1.4 million species with 822,000+ known distribution maps.
FishBase	https://www.fishbase.se/search.php International database of 35,000+ fish species profiles with taxonomy, location, conservation status, habitat, biological use, protection status, trophic ecology, life history, identification keys, citations, and imagery.
Global Biodiversity Information Facility (GBIF)	https://www.gbif.us/ National species database for animals, plants, and fossils in the US and its Territories. More than 825 million observation records with taxonomy, occurrence status, location, date, issues and flags, source dataset, and publisher (e.g., USGS, NatureServe, NOAA). Previously known as the Biodiversity Information Serving Our Nation (BISON) database.
Global Invasive Species Database	http://www.iucngisd.org/gisd/ International database of invasive species with species profiles that include taxonomy, species description, native distribution, alien distribution, impacts, life cycle stages, reproduction, spread pathways, management techniques, references, and photographs.

Informational Database	Location and Description
iNaturalist	https://www.inaturalist.org/ Public observations of animal and plant species across the world, which are searchable by name or location with information on the seasonality, number, life stage, and sex of observations. Includes more than 411,000 species and 125 million observations contributed by 5.9 million people.
Invasive and Exotic Species of North America	https://invasive.org Database of invasive and exotic species profiles that include taxonomy, origin, life cycle, distribution, imagery, and invasive listing sources. Includes plants, insects, pathogens, and other species.
ITIS	https://www.itis.gov/ Integrated Taxonomic Information System (ITIS) is the authoritative taxonomic information source on animals, plants, fungi, and microbes of North America and the world and is the taxonomic reference standard for RSGCN and the national SGCN database maintained by the USGS.
IUCN Red List of Threatened Species	https://www.iucnredlist.org/ International Union for Conservation of Nature (IUCN) maintains a Red List of Threatened Species with comprehensive information on the global extinction risk status of animal, fungus, and plant species. Information on more than 153,000 species includes taxonomy, conservation status, status assessments, geographic range, population trends, habitat and ecology, threats, use and trade, and needed conservation actions.

Informational Database	Location and Description
NatureServe Explorer	https://www.natureserve.org/ NatureServe Explorer includes detailed information on the taxonomy, distribution, conservation status, ecology, life history, population, management and monitoring needs, threats, habitat, and biological research needs of more than 100,000 species of plants, animals, and ecosystems.
World Register of Marine Species (WoRMS)	https://www.marinespecies.org/ International authoritative classification and catalog of marine species names with more than 241,500 species recognized. Species profiles include taxonomy, distribution, attributes, images, conservation status, and associated datasets. Taxonomic reference standard for marine RSGCN.
Ocean Biodiversity Information System (OBIS)	https://obis.org/ International database of marine species observational records with more than 108 million records for nearly 180,000 species searchable by taxa, species, location, dataset, or data source. Species profiles include taxonomy, distribution, observation dates, number of observation records, environmental conditions of the observations, data quality, and associated datasets. Taxonomic reference standard for marine RSGCN.
SeaLifeBase	https://www.sealifebase.ca/ International database of 85,000 marine species searchable by species, location, taxonomic group, or ecosystem with information on life history, trophic ecology, data source, photographs, and more.

Informational Database	Location and Description
AmphibiaWeb	https://amphibiaweb.org/ AmphibiaWeb includes nearly 8600 amphibian species profiles from around the world that are searchable by species, location, taxa, or photograph. Species profiles in the database include taxonomy, distribution, reasons for decline, and conservation status.
Amphibian Disease Portal	https://amphibiandisease.org/ International database monitoring the distribution of amphibian pathogens *Batrachochytrium dendrobatidis* (Bd) and *B. salamandrivorans* (Bsal).
Birds of the World	https://birdsoftheworld.org/bow/home International database of birds across the world with comprehensive life history profiles searchable by species or family. Includes identification, taxonomy, systematics, distribution, habitat, movements and migration, diet and foraging, sounds and vocal behavior, behavior, breeding, demography and populations, conservation and management, priorities for future research, and photographs. Integrated with eBird database.
eBird	https://ebird.org Public observations of bird species across the world, which are searchable by species name or location in a database that includes species maps, photographs, and sounds.
Audubon Christmas Bird Count	https://www.audubon.org/conservation/science/christmas-bird-count Database of December bird observations across the US and Canada since 1900 with location, species counts, weather conditions, sponsoring organization, and participants.

Informational Database	Location and Description
Botanical Information and Ecology Network (BIEN)	https://bien.nceas.ucsb.edu/bien/ International database of georeferenced plant locations, plot inventories and surveys, species geographic distribution maps, plant traits, species-level phylogeny, and cross-continent, continent, and country-level species lists with more than 464,000 species.
BugGuide	https://bugguide.net/node/view/15740 Database of insects, spiders, and related species with identification keys, imagery, taxonomy, and species profiles with information on range, habitat, season, food, and citations.
Bumble Bee Watch	https://www.bumblebeewatch.org/ Database of 122,000+ observations of bumble bees and their nests across North America with verified identification of species, location, conservation status, observation date, and related information.
Butterflies and Moths of North America (BAMONA)	https://www.butterfliesandmoths.org/ International database of Lepidoptera observations across North America with regional species checklists, taxonomy, and species profiles for more than 7000 species with distribution maps, identification, life history, flight, caterpillar hosts, adult food, habitat, conservation status, management needs, verified sightings, and imagery.
eButterfly	https://www.e-butterfly.org/#/ Database of butterfly 491,000+ observations across North and Central America for 1,250+ species with species profiles including weekly frequency of observations, taxonomy, distribution, imagery, and citations.

Informational Database	Location and Description
North American Butterfly Association Butterfly Count	https://www.naba.org/butter_counts.html International database of butterfly observations since 1993 across 400+ 15-mile count circles in North America.
Land Snails and Slugs of the Mid-Atlantic and Northeastern US	https://www.carnegiemnh.org/science/mollusks/index.html Database of known terrestrial snails and slugs of the Northeast and Mid-Atlantic regions with imagery, taxonomy, and species profiles.
Atlas of Common Freshwater Macroinvertebrates of Eastern North America	https://www.macroinvertebrates.org/#/ Database of freshwater macroinvertebrate species for eastern North America with identification keys, diagnostic characteristics, high resolution imagery, genus overview, habitat, pollution tolerance, feeding habits, movements, and distribution. Integrated with the PocketMacros app.
Mayfly Central	https://www.entm.purdue.edu/mayfly/ Database of Ephemeroptera (mayfly) species across North America, including records for 573 species in the US organized by taxonomy.
Freshwater Mussel Host Database	https://mollusk.inhs.illinois.edu/57-2/ Database of more than 2700 known host interdependent relationships for freshwater mussels searchable by mussel or host species or family with location, data source, and natural or lab evidence for the relationship.
Nature's Notebook	https://www.usanpn.org/natures_notebook National database of 500,000+ phenology records for plants and animals tracking seasonal changes, with featured campaigns to track nectar sources for pollinators, the emergence of mayflies, flowers for bats, insect pests, and non-native invasive plants.

Informational Database	Location and Description
Odonata Central	https://www.odonatacentral.org/#/ Database of Odonata (dragonflies and damselflies) observations in the Western Hemisphere including species, location, date, level of confidence in identification, and imagery with more than 300,000 records.

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8.7 ENDNOTES

Many online resources are available for learning about topics in this chapter. However, URLs are not permanent resources; pathways may be changed or removed over time. These endnotes were all accessed in January and February of 2023, and were active at that point in time.

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[12] US One Health Commission, https://www.onehealthcommission.org/.
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[34] Society of Outdoor Recreation Professionals, https://recpro.org.
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[50] EJScreen, https://www.epa.gov/ejscreen.
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[52] NOAA Coordination and Collaboration in the Resilience Ecosystem (CCRE) Program – Grants, https://www.climateresiliencefund.org/grants/.
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[54] US DOT RAISE Grants Program, https://www.transportation.gov/RAISEgrants.

NORTHEAST CONSERVATION SYNTHESIS APPENDICIES

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ES1 – ACRONYMS

AFS – American Fisheries Society

ACFHP- Atlantic Coast Fish Habitat Partnership

ACJV- Atlantic Coast Joint Venture

AFWA – Association of Fish and Wildlife Agencies

AMJV- Appalachian Mountains Joint Venture

ARS- At-Risk Species

ASMFC- Atlantic States Marine Fisheries Commission

BCR- Bird Conservation Region

BMP – Best Management Practice

CMP – Conservation Measures Partnership

COA- Conservation Opportunity Area

CSWG – Competitive State Wildlife Grant

DNR – Department of Natural Resources

DOD- Department of Defense

DOT- Department of Transportation

DSL- Designing Sustainable Landscapes

EBTJV- Eastern Brook Trout Joint Venture

EPA- Environmental Protection Agency

EPT – Ephemeroptera (Mayflies), Plecoptera (Stoneflies), and Trichoptera (Caddisflies)

ES- Ecological Services

ESA- Endangered Species Act

FHP – Fish Habitat Partnership

GIS – Geographic Information System

ITIS – Integrated Taxonomic Information System

IUCN – International Union for the Conservation of Nature

JV – Joint Venture

LCC – Landscape Conservation Cooperative

LE- Law Enforcement

MAFWA – Midwest Association of Fish and Wildlife Agencies

MLI – Midwest Landscape Initiative

MPA- Marine Protected Areas

NAFO- National Alliance of Forest Owners

NEAFWA – Northeast Association of Fish and Wildlife Agencies

NE CASC – Northeast Climate Adaptation Science Center

NEFWDTC – Northeast Fish and Wildlife Diversity Technical Committee

NEPARC – Northeast Partners for Amphibian and Reptile Conservation

NERR- National Estuarine Research Reserve

NGO- Non-Governmental Organization

NHP- Natural Heritage Program

NLCD – National Land Cover Dataset

NMFS- National Marine Fisheries Service

NOAA – National Oceanographic and Atmospheric Administration

NRCS- Natural Resource Conservation Service

NWF – National Wildlife Federation

NWI – National Wetlands Inventory

PAD US- Protected Areas Database- U.S.

PARC- Partners in Amphibian and Reptile Conservation

PIF – Partners in Flight

RAWA – Restoring America's Wildlife Act

RCP- Regional Conservation Partnerships

RCN – Regional Conservation Needs

RISCC- Regional Invasive Species and Climate Change

RR – Regional Responsibility

RSGCN – Regional Species of Greatest Conservation Need

SA- Science Applications

SCORP- State Comprehensive Outdoor Recreation Plan

SDM- Structured Decision Making

SEAFWA – Southeast Association of Fish and Wildlife Agencies

SECAS – Southeast Conservation Adaptation Strategy

SFAP- State Forest Action Plan

SGCN – Species of Greatest Conservation Need

SSA- Species Status Assessment

SWAP – State Wildlife Action Plan

SWG- State Wildlife Grant

TCI – Terwilliger Consulting, Inc.

TNC – The Nature Conservancy

TWG- Tribal Wildlife Grant

TWS- The Wildlife Society

USFS- U.S. Forest Service

USFWS – U.S. Fish and Wildlife Service

USGS – U.S. Geological Survey

WDC or Committee – Wildlife Diversity Committee

WDPM – Wildlife Diversity Program Managers

WMA- Wildlife Management Area

WMI- Wildlife Management Institute

WNS – White-nose Syndrome

1A RSGCN METHODS

Northeast RSGCN Method Advancement Summary for the 2022 List Update

One of the first tasks needed to update the RSGCN list is the evaluation and updating of the method. This revision, we benefit from both the Southeast (2019) and Midwest (2022) applications of the original Northeast process. Each application resulted in advancements in thinking and data processing efficiencies that are now available to the Northeast for this current list update process.

TCI met with the Invertebrate Overview Team and the RSGCN Method Team to get their input and guidance. These teams consisted of NEFWDTC and SWAP coordinators who worked on previous RSGCN list updates as well as several new state representatives. Progress was reported to the NEFWDTC monthly. A survey was sent to all states for input into improving the method. After several meetings and versions over a six-month period, the following process guidance and summary was developed.

RSGCN Purposes:

Maintain a non-regulatory list of RSGCN to provide focus, resources, and collaboration to conserve these species of mutual conservation concern (and their habitats) for current and future generations in the northeast.

Recognize *regional stewardship responsibility*. Implement proactive measures to prevent further declines of common species with conservation concerns.

Prioritize imperiled *species*. Spotlight species with population declines or emerging issues for collective conservation action.

Fill *data gaps*. Enhance knowledge of a species range-wide distribution, imperilment status, threats, and needed actions.

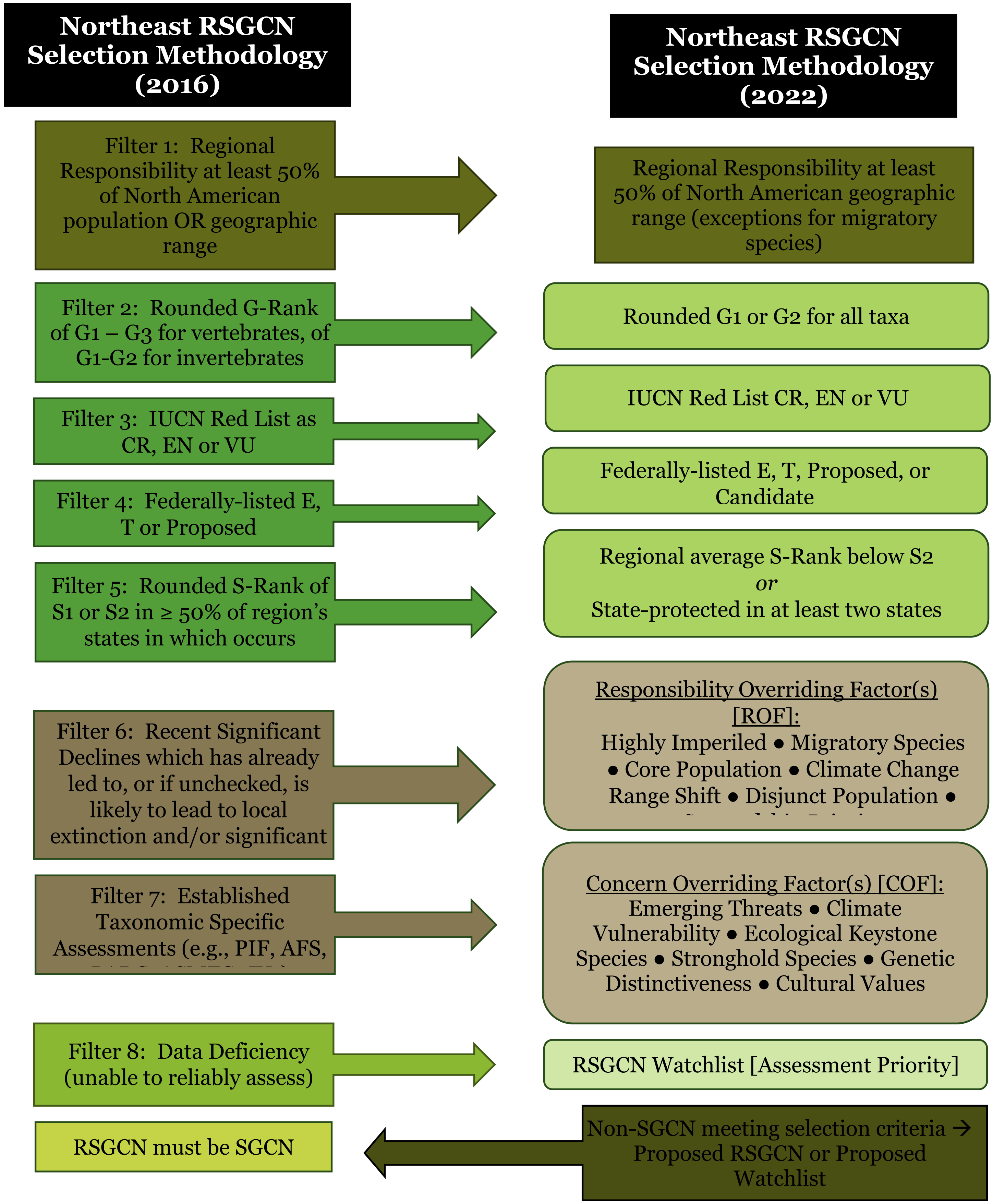
RSGCN Goal: *Secure and restore Regional Species of Greatest Conservation Need (and their habitats) across the region's lands and waters through strategic, collaborative action.*

RSGCN Objective: *NEAFWA's NEFWDTC will update the Regional Species of Greatest Conservation Need list every 5 years using the following criteria:*

Regional stewardship responsibility (proportion of the species range that occurs in the NE region)

Conservation concern status (imperilment)

The diagram below depicts the RSGCN selection criteria, filters, and process that will be used in the 2022 update. Differences and advancements are listed that compare the original Northeast and new proposed methods.


Northeast RSGCN Selection Methodology (2016)
Northeast RSGCN Selection Methodology (2022)
Filter 1: Regional Responsibility at least 50% of North American population OR geographic range
Regional Responsibility at least 50% of North American geographic range (exceptions for migratory species)
Filter 2: Rounded G-Rank of G1 – G3 for vertebrates, of G1-G2 for invertebrates
Rounded G1 or G2 for all taxa
Filter 3: IUCN Red List as CR, EN or VU
IUCN Red List CR, EN or VU
Filter 4: Federally-listed E, T or Proposed
Federally-listed E, T, Proposed, or Candidate
Filter 5: Rounded S-Rank of S1 or S2 in ≥ 50% of region's states in which occurs
Regional average S-Rank below S2
or
State-protected in at least two states
Filter 6: Recent Significant Declines which has already led to, or if unchecked, is likely to lead to local extinction and/or significant
Responsibility Overriding Factor(s) [ROF]:
Highly Imperiled • Migratory Species • Core Population • Climate Change Range Shift • Disjunct Population •
Filter 7: Established Taxonomic Specific Assessments (e.g., PIF, AFS,
Concern Overriding Factor(s) [COF]:
Emerging Threats • Climate Vulnerability • Ecological Keystone Species • Stronghold Species • Genetic Distinctiveness • Cultural Values
Filter 8: Data Deficiency (unable to reliably assess)
RSGCN Watchlist [Assessment Priority]
RSGCN must be SGCN
Non-SGCN meeting selection criteria → Proposed RSGCN or Proposed Watchlist

KEY DIFFERENCES/ADVANCEMENTS:

The pre-screening process begins with *all* species that occur in the Northeast, not just SGCN.
The Regional Responsibility calculation no longer considers population density or distribution but is limited to the geographic range in North America. Population density and distribution characteristics are taken into consideration in the **ROF (Core Population, Disjunct Population)** and **COF (Stronghold Species, Genetic Distinctiveness)**.
Vertebrate and invertebrate taxa are screened with the same selection criteria. Previously, qualifying rounded G-Ranks for vertebrate taxa were G1 – G3 while invertebrate taxa were G1 - G2. All taxa are now screened for G1 and G2 as a filter. Species with lower G-Ranks may still be identified as RSGCN if they meet other selection criteria (i.e., average S-Rank in the region, IUCN Red List category, Federal listing status).
The Federal listing status criteria has expanded to include Candidate species as well as Endangered, Threatened, or Proposed. Species that do not meet these criteria (i.e., At-Risk, Under Review) may still be identified as RSGCN if they meet other selection criteria (i.e., rounded G-Rank, average S-Rank in the region, IUCN Red List category). Taxa teams often consider all Federal listing status categories when determining RSGCN recommendations and RSGCN Concern Levels.
The S-Rank filter has been adjusted to be a regional average of all the states with an S-Rank for that species. A regional average S-Rank of less than S2 remains the primary filter.
A new secondary filter of State Protected Status is now included for species prescreened as Possible RSGCN. This filter includes state endangered or threatened in individual states. Special concern as well as protected statuses unique to individual states, including non-regulatory designations by various state agencies, are not included in this filter.
Filter 6 that previously considered recent significant declines that is or could lead to local extinction(s) or range contraction(s) are now formalized in the **ROF (Highly Imperiled, Core Population, Climate Change Range Shift, Disjunct Population)** and **COF (Emerging Threats, Climate Vulnerability, Stronghold Species, Genetic Distinctiveness)**. ROF and COF can be identified by the taxa teams to document the reasons for identifying a species as RSGCN when it does otherwise meet either the Regional Responsibility or Concern Selection Criteria.
Filter 7 that considered established taxonomic-specific assessments has now been formalized in the **ROF (all)** and **COF (all)**. Taxa teams also consider these assessments, conservation plans, and focal species designated by other organizations or initiatives when identifying RSGCN Concern Levels.
Species that are not currently identified as SGCN by at least one state in the region may now be considered as **Proposed RSGCN** or **Proposed Watchlist** species. Some species were previously identified as SGCN but taxonomic revisions now technically

make them Non-SGCN until a state updates or revises their list of SGCN or SWAP. Other species are those with new information or emerging threats that are likely to be recommended as SGCN in the next round of SWAP updates. Proposed RSGCN and Proposed Watchlist species meet the selection criteria for RSGCN or Watchlist species with the exception that they are not currently SGCN. States may reference these Proposed RSGCN and Proposed Watchlist species as potential SGCN when updating their SWAPs.

A RSGCN **Watchlist** has been added for species that are of concern to the taxa teams but for which:

The species are data deficient or are showing varying trends in different parts of the region, prioritizing them for additional survey or research efforts = **Watchlist [Assessment Priority]**

The species is interdependent with a RSGCN but does not qualify as RSGCN on its own = **Watchlist [Interdependent Species]**

The region has low regional responsibility but high concern = **Watchlist [Deferral to adjacent region]**

Taxa teams remain the definitive authority on reviewing, confirming or revising prescreened RSGCN recommendations, identifying Overriding Factor(s), determining RSGCN Concern Levels, and recommending species for the Watchlist.

2A CROSS-WALK OF SWAP KEY HABITATS WITH THE 24 HABITATS

The key habitats for SGCN identified in the 2015 Northeast SWAPS associated with each of the regional habitats for the 2023 updated list of RSGCN and Watchlist species in the NEAFWA region.

Table 2A.1 Forest and Woodland Key Habitats identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Boreal Upland Forest: Acadian Low Elevation Spruce-Fir-Hardwood Forest; Acadian Sub-boreal Spruce Flat; Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest; Boreal Jack Pine-Black Spruce Forest Central Oak-Pine: Central Appalachian Dry Oak-Pine Forest; Central Appalachian Pine-Oak Rocky Woodland; North Atlantic Coastal Plain Hardwood Forest; North Atlantic Coastal Plain Maritime Forest Exotic Upland Forest Northern Hardwood & Conifer: Appalachian (Hemlock)-Northern Hardwood Forest; Laurentian-Acadian Northern Hardwoods Forest; Laurentian-Acadian Pine-Hemlock-Hardwood Forest; Laurentian-Acadian Red Oak-Northern Hardwood Forest; Northeastern Coastal and Interior Pine-Oak Forest
Vermont	Early Succession Boreal Conifers; Early Succession Boreal Hardwoods; Early Succession Northern Hardwoods; Early Succession Other Types; Early Succession Pine and Hemlock; Early Succession Spruce-Fir; Early Succession Upland Oak; Northern Hardwood; Oak-Pine Northern Hardwood; Spruce-Fir Northern Hardwood
New Hampshire	Appalachian Oak Pine Forest; Hemlock Hardwood Pine Forest; Lowland Spruce-Fir Forest; Northern Hardwood-Conifer Forest
Massachusetts	Central Hardwoods-White Pine Upland Forest; Large Unfragmented Landscape Mosaics; Northern Hardwoods-Spruce-Fir Upland Forest; Pitch Pine-Oak Upland Forest; Transition Hardwoods-White Pine Upland Forest; Young Forests and Shrublands
Rhode Island	Upland, Coniferous Woodlands & Forests: Hemlock/Hardwood Forest; Pitch Pine Woodland Upland, Deciduous Woodlands & Forests: Beech/Sugar Maple/Red Oak Forest; Chestnut Oak

State	SWAP Key Habitat
	Forest; Maritime Woodland; Mixed Oak – American Holly Forest; Mixed Oak/Hickory Forest; Oak Forest; White Oak/Mountain Laurel Forest Upland, Mixed Deciduous/Coniferous Forests: Mixed Oak/Pitch Pine Forest; Mixed Oak/White Pine Forest
Connecticut	Upland Forest: Calcareous Forests*; Coniferous Forests; Maritime Forests; Mixed Hardwood Forest; Northern Hardwood Forest; Oak Forests; Old Growth Forest; Young Forest Upland Woodland and Shrub; Pitch Pine – Scrub Oak Woodlands
New York	Boreal Upland Forest; Coastal Hardwoods; Mixed Northern Hardwoods; Mountain Spruce-Fir Forests; Northeast Upland Forest; Oak Forest; Oak-Pine Forest; Spruce-Fir Forests and Flats
Pennsylvania	Allegheny-Cumberland Dry Oak Forest and Woodland; Appalachian (Hemlock)-Northern Hardwood Forest; Central Appalachian Dry Oak-Pine Forest; Central Appalachian Pine-Oak Rocky Woodland; Central Oak-Pine; North Atlantic Coastal Plain Hardwood Forest; Northeastern Interior Dry-Mesic Oak Forest; Northern Hardwood & Conifer; South-Central Interior Mesophytic Forest
New Jersey	Forest
Delaware	Basic Mesic Forest; Coastal Plain Modified / Successional Forests; Coastal Plain Oak-Pine Forest; Early Successional Forest (Seedling/Sapling); Maritime Forest and Shrubland*; Mesic Mixed Hardwood Forest; Natural Forested Uplands; Piedmont; Piedmont Modified / Successional Forests; Piedmont Oak Forest; Xeric Sand Ridge Forest and Woodland
Maryland	Basic Mesic Forest; Coastal Plain Oak-Pine Forest; Coastal Plain Pitch Pine Forest; Cove Forest; Hemlock-Northern Hardwood Forest; Maritime Forest and Shrubland*; Mesic Mixed Hardwood Forest; Montane - Piedmont Oak-Pine Forest; Oak-Hickory Forest
D.C.	Central Appalachian Dry Oak-Pine Forest; Northern Atlantic Coastal Plain Hardwood Forest; Southern Atlantic Coastal Plain Mesic Hardwood Forest; Southern Interior Low Plateau Dry-Mesic Oak Forest; Successional Virginia Pine Forest
West Virginia	Dry Oak (-Pine) Forests; Dry-Mesic Oak Forests; Mixed Mesophytic Forests; Montane Red Oak Forests; Northern Hardwood Forests; Pine-Oak Rocky Woodlands; Red Spruce Forests
Virginia	Central Atlantic Coastal Plain Maritime Forest; Mixed Hardwood and Conifer; North Atlantic Coastal Plain Maritime Forest; Southern Appalachian Low Elevation Pine Forest; Southern Atlantic

State	SWAP Key Habitat
	Coastal Plain Upland Longleaf Pine Woodland; Spruce-Fir Forest

Table 2A.2 High Elevation Forest Key Habitats identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Alpine: Acadian-Appalachian Subalpine Woodland and Heath-Krummholz
New Hampshire	High Elevation Spruce-Fir Forest

Table 2A.3 GRASSLANDS KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Coastal Grassland & Shrubland*; Grassland-shrubland-early Successional*; Northern Atlantic Coastal Plain Dune and Maritime Grassland* Ruderal Shrubland & Grassland: Powerline Right-of-Way*; Ruderal Upland - Old Field*
Vermont	Grasslands and Hedgerows; Outcrops and Upland Meadows*; Powerlines / RR / Roadsides
New Hampshire	Grasslands
Massachusetts	Grasslands
Rhode Island	Upland, Open Uplands (Grassland & Shrubland): Maritime Grassland; Ruderal Grassland/Shrubland – Clearcut* Upland, Open Uplands (Grassland & Shrubland): Ruderal Grassland/Shrubland - Utility Rights-of-Way
Connecticut	Unique, Natural or Man-made: Public Utility Transmission Corridors Upland Herbaceous: Cool Season Grasslands; Warm Season Grasslands
New York	Old Field/Managed Grasslands; Powerline
Pennsylvania	Shrubland & grassland (NLCD 52/71)*
New Jersey	Grassland
Delaware	Early Successional Herbaceous; Maritime Dune and Grassland*
Maryland	Managed Grassland; Maritime Dune and Grassland*; Roadside and Utility Right-of-way
D.C.	Ruderal Upland - Old field
West Virginia	Anthropogenic Shrubland & Grassland*
Virginia	Open - Grassland and Retired Agriculture Fields

Table 2A.4 SHRUBLANDS KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Coastal Grassland & Shrubland*; Grassland-shrubland-early Successional* Ruderal Shrubland & Grassland: Introduced Shrubland; Powerline Right-of-Way*; Ruderal Upland - Old Field*
New Hampshire	Shrublands
Massachusetts	Young Forests and Shrublands
Rhode Island	Upland, Open Uplands (Grassland & Shrubland): Maritime Shrubland; Ruderal Grassland/Shrubland – Clearcut*; Ruderal Grassland/Shrubland – Hedgerow Ruderal Grassland/Shrubland - Old Field
Connecticut	Upland Woodland and Shrub: Maritime Shrublands; Reverting Fields and Early Successional Shrublands
New York	Non-native Shrublands
Pennsylvania	Shrubland & grassland (NLCD 52/71)*
New Jersey	Shrub
Delaware	Early Successional Shrubland; Maritime Forest and Shrubland*; Ruderal Introduced Shrubland / Old Field
Maryland	Maritime Forest and Shrubland*
D.C.	Introduced Shrubland
West Virginia	Anthropogenic Shrubland & Grassland*

Table 2A.5 GLADES, BARRENS AND SAVANNA KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Central Oak-Pine: Northeastern Interior Pine Barrens; Glade, Barren and Savanna: Central Appalachian Alkaline Glade and Woodland; Pine Barrens
Vermont	Outcrops and Upland Meadows*
New Hampshire	Pine Barrens
Massachusetts	
Rhode Island	Upland, Open Uplands (Grassland & Shrubland): Inland Rocky Outcrop*; Pitch Pine Woodland/Barren – Barren
Connecticut	Upland Forest: Calcareous Forests* Upland Herbaceous: Grassy Glades and Balds; Sand Barrens and Sparsely Vegetated Sand and Gravel Upland Woodland and Shrub: Red Cedar Glades
New York	Coastal Coniferous Barrens, Native Barrens and Savanna, Pine Barrens
Pennsylvania	Appalachian Shale Barrens; Central Appalachian Alkaline Glade and Woodland; Eastern Serpentine Woodland; Glade, Barren and Savanna
New Jersey	Barren and Exposed Rock*
Delaware	Diverse Herb Layer; Exposed Upland Sands; Natural Unforested Uplands; Roadside; Serpentine Barren
Maryland	Acidic Glade and Barren; Basic Glade and Barren; Serpentine Barren; Shale Barren
D.C.	
West Virginia	Dry Calcareous Forests, Woodlands, and Glades; Heath-Grass Barrens; Shale Barrens
Virginia	Open - Glade and Barren; Open - Pine and Oak Savanna

Table 2A.6 ALPINE KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Alpine: Acadian-Appalachian Alpine Tundra
Vermont	Outcrops and Alpine
New Hampshire	Alpine
New York	Alpine

Table 2A.7 CLIFF AND TALUS KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Cliff and Talus: Laurentian-Acadian Acidic Cliff and Talus; Laurentian-Acadian Calcareous Cliff and Talus; North-Central Appalachian Acidic Cliff and Talus; North-Central Appalachian Circumneutral Cliff and Talus Outcrop & Summit Scrub: Laurentian-Acadian Calcareous Rocky Outcrop; Northern Appalachian-Acadian Rocky Heath Outcrop Rocky Summits-Outcrops-Mountaintops
Vermont	Cliffs and Talus
New Hampshire	Rocky Ridge, Cliff, and Talus
Massachusetts	Rock Cliffs, Ridgetops, Talus Slopes, and Similar Habitats
Rhode Island	Upland, Open Uplands (Grassland & Shrubland): Inland Rocky Outcrop*
Connecticut	Unique, Natural or Man-made: Cliffs and Talus Slopes; Traprock Ridges
New York	Cliff and Talus; Rocky Outcrop
Pennsylvania	North-Central Appalachian Acidic Cliff and Talus; North-Central Appalachian Circumneutral Cliff and Talus
New Jersey	Barren and Exposed Rock*
Maryland	Cliff and Rock Outcrop; Coastal Bluff*
West Virginia	Acidic Rock Outcrops, Cliffs, and Talus; Calcareous Cliffs and Talus
Virginia	Cliff and Talus; Open - outcrop, summit scrub

Table 2A.8 SUBTERRANEAN AREA KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Extractive: Subsurface Mines & Caves, Quarries-Pits-Stripmines
Vermont	Mine; Subterranean
New Hampshire	Caves and Mines
Massachusetts	Springs, Caves, and Mines
Connecticut	Unique, Natural or Man-made: Caves and Other Subterranean Habitats
New York	Caves and Tunnels
Pennsylvania	Cave; Karst & Mines
Delaware	Extractive – Sand/Gravel Active, Sand/Gravel Inactive
Maryland	Artificial Structure - Mine and Tunnel; Cave and Karst
West Virginia	Caves and Karst
Virginia	Caves / Karst

Table 2A.9 NON-TIDAL WETLANDS KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Boreal Forested Peatland: Boreal-Laurentian Conifer Acidic Swamp; Central Hardwood Swamp: North-Central Interior Wet Flatwoods; Coastal Plain Peat Swamp: North Atlantic Coastal Plain Basin Peat Swamp; Emergent Marsh: Laurentian-Acadian Freshwater Marsh; Freshwater Marshes; Modified-Managed Marsh: Modified-Managed Marsh; Northern Forests and Swamps Northern Peatland & Fens: Acadian Maritime Bog; Boreal-Laurentian Bog; Boreal-Laurentian-Acadian Acidic Basin Fen; Laurentian-Acadian Alkaline Fen; North-Central Interior and Appalachian Acidic Peatland Northern Swamp: Acadian-Appalachian Conifer Seepage Forest; Laurentian-Acadian Alkaline Conifer-Hardwood Swamp; North-Central Appalachian Acidic Swamp; North-Central Interior and Appalachian Rich Swamp; Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp South-Central Forests and Swamps; Vernal Pools Wet Meadow-Shrub Marsh: Introduced Wetland and Riparian Vegetation; Laurentian-Acadian Wet Meadow-Shrub Swamp
Vermont	Hardwood Swamps; Marshes and Sedge Meadows; Open Peatlands; Seeps and Vernal Pools; Shrub Swamps; Softwood Swamps; Wet Swales and Ditches
New Hampshire	Marsh and Shrub Wetlands; Northern Swamps; Peatlands; Temperate Swamps; Vernal Pools
Massachusetts	Forested Swamps; Marshes and Wet Meadows; Peatlands and Associated Habitats; Shrub Swamps; Vernal Pools
Rhode Island	Palustrine, Forested Mineral Soil Wetlands: Hemlock/Hardwood Swamp; Red Maple Swamp; Seeps, Springs, Vernal Pools; Swamp White Oak Swamp Palustrine, Forested Peatlands: White Cedar Swamp; White Cedar-Rhododendron Swamp Palustrine, Open Mineral Soil Wetlands: Modified/Managed Marsh – Impoundment; Modified/Managed Marsh - Ruderal Marsh; Seasonally flooded (shallow) Marsh; Semi-permanently Flooded (Deep) Marsh; Shrub Swamp/Wet Meadow - Shrub Swamp; Shrub Swamp/Wet Meadow - Wet Meadow Palustrine, Open Peatlands: Coastal Plain Peatlands - Coastal Plain Quagmire; Coastal Plain Peatlands - Graminoid Fen; Coastal Plain Peatlands - Sea Level Fen; Northern Peatlands - Black Spruce Bog; Northern Peatlands - Dwarf Shrub Fen/Bog
Connecticut	Forested Inland Wetland: Atlantic White Cedar Swamps; Northern White Cedar Swamps; Red Maple Swamps; Red/Black Spruce Swamps

State	SWAP Key Habitat
	Herbaceous Inland Wetland: Calcareous Spring Fens; Freshwater Marshes; Wet Meadows Shrub Inland Wetland: Bogs and Fens; Shrub Swamps Unique, Natural or Man-made: Surface Springs and Seeps; Vernal Pools
New York	Atlantic White Cedar Swamp; Boreal Forested Peatland; Boreal Wetland Forest; Coastal Red Maple-Black Gum Swamp; Conifer Forest Swamp; Freshwater Marsh; Great Lakes Freshwater Estuary Marsh; Hardwood Swamp; Mixed Hardwood Swamp; Northeast Wetland Forest; Northern White Cedar Swamp; Open Acidic Peatlands; Open Alkaline Peatlands; Vernal Pool; Wet Meadow/Shrub Marsh
Pennsylvania	Emergent Marsh; Laurentian-Acadian Freshwater Marsh; Laurentian-Acadian Wet Meadow-Shrub Swamp; North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest; North-Central Appalachian Acidic Swamp; North-Central Interior and Appalachian Acidic Peatland; North-Central Interior and Appalachian Rich Swamp; Wet Meadow / Shrub Marsh
New Jersey	Wetlands
Delaware	Bald Cypress Swamp; Coastal Plain Flatwood and Depression Swamp; Coastal Plain Seepage Fen; Coastal Plain Seepage Swamp; Coastal Plain White Cedar Peat Swamp; Emergent Freshwater Marsh; Forested Non-tidal Wetlands; Freshwater Shrub Swamp; Freshwater Tidal Swamp; Interdunal Wetlands; Maritime Swamp; Modified Wetlands; Open Non-tidal Wetlands; Piedmont Seepage Meadow; Piedmont Seepage Swamp; Sea Level Fen; Springhead/Springhouse; Vernal Pool; Wetlands
Maryland	Coastal Plain Flatwood and Depression Swamp; Coastal Plain Seepage Bog and Fen; Coastal Plain Seepage Swamp; Maritime Swamp; Montane - Piedmont Basic Seepage Swamp; Montane - Piedmont Acidic Seepage Swamp; Montane Bog and Fen; Piedmont Seepage Wetland; Piedmont Upland Depression Swamp; Spring; Vernal Pool
D.C.	Acidic Bogs; Acidic Seeps; Freshwater Emergent Wetland; Freshwater Forested/Shrub Wetland; Introduced Wetland and Riparian Vegetation; Northern Atlantic Coastal Plain Swamp; Springs and Seeps; Successional Woody Wetland; Vernal Pools
West Virginia	High Allegheny Wetlands
Virginia	Non-Tidal Wetlands

Table 2A.10 BIG RIVERS KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Vermont	Lower Connecticut River
Massachusetts	Connecticut and Merrimack Mainstems
Connecticut	Freshwater Aquatic: Large Rivers and their Associated Riparian Zones*
New York	Large/Great River*: 5 Key Habitats categorized by gradient (low, low-moderate), alkalinity (assume moderately buffered) and temperature (transitional cool, warm)
D.C.	Great River

Table 2A.11 RIVERS AND STREAMS KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Rivers and Streams: Ephemeral; Headwaters and Creeks; Large River; Medium River; Small River Streams, Rivers, Lakes, and Ponds*
Vermont	Fluvial; Large Lake Champlain Tributaries Below Falls
New Hampshire	Coldwater Rivers and Streams; Large Warmwater Rivers; Warmwater Rivers and Streams
Massachusetts	Large and Mid-sized Rivers; Small Streams
Rhode Island	Lower Perennial: River - Cold Water, slower flowing stream; River - Cold Water, swiftly flowing stream; River - Warm Water, slower flowing stream; River - Warm Water, swiftly flowing stream Upper Perennial: River - Cold Water, slower flowing stream; River - Cold Water, swiftly flowing stream; River - Warm Water, slower flowing stream; River - Warm Water, swiftly flowing stream
Connecticut	Freshwater Aquatic: Cold Water Streams; Head-of-tide and Coastal Streams; Large Rivers and their Associated Riparian Zones; Unrestricted, Free-flowing Streams
New York	Headwater Creek: 17 Key Habitats categorized by gradient (low, low-moderate, moderate, moderate-high, high), alkalinity (low buffered acidic, highly buffered calcareous, moderately buffered neutral, moderately buffered calcareous) and temperature (cold, transitional cool, warm) Large/Great River*: 5 Key Habitats categorized by gradient (low, low-moderate), alkalinity (assume moderately buffered) and temperature (transitional cool, warm) Medium River: 14 Key Habitats categorized by gradient (low, low-moderate, moderate, moderate-high, high), alkalinity (assume moderately buffered) and temperature (cold, transitional cool, warm) Small River: 17 Key Habitats categorized by gradient (low, low-moderate, moderate, moderate-high, high), alkalinity (low buffered acidic, highly buffered calcareous, moderately buffered neutral, moderately buffered calcareous) and temperature (cold, transitional cool, warm)
Pennsylvania	Cool, Medium River; Headwaters and Creeks; High Gradient, Cold, Headwaters and Creeks; High Gradient, Cool, Headwaters and Creeks; Large Rivers; Lotic; Low Gradient, Cool, Headwaters and Creeks; Low Gradient, Cool, Small River; Low Gradient, Warm, Headwaters and Creeks; Low Gradient, Warm, Small River; Medium Rivers; Moderate Gradient, Cold, Headwaters and Creeks; Moderate Gradient, Cool, Headwaters and Creeks; Moderate Gradient,

State	SWAP Key Habitat
	Cool, Small River; Moderate Gradient, Warm, Small River; Small Rivers; Warm, Large River; Warm, Medium River
New Jersey	Coldwater Stream, Warmwater Stream
Delaware	Coastal Plain Headwaters and Creeks Non-tidal; Coastal Plain Small and Medium River; Coastal Plain Small and Medium River Non-tidal; Freshwater Aquatic Substrate: Embedded rock, bedrock*; Freshwater Gravel/Cobble*; Freshwater Non-tidal SAV; Headwaters and Creeks; Large River; Low Gradient; Moderate Gradient; Piedmont Headwaters and Creeks Non-tidal; Piedmont Small and Medium River Non-tidal; Riverine Aquatic Habitat Systems; Small and Medium River
Maryland	Blackwater Stream; Coastal Plain River; Coastal Plain Stream; Coldwater Stream; Highland River; Highland Stream; Limestone Stream; Piedmont River
D.C.	Central Appalachian Stream and Riparian*; Creek & Headwater Creek; Northern Atlantic Coastal Plain Stream and River; Riverine; Small River
West Virginia	Headwater Creek, High Gradient, Cold; Headwater Creek, High Gradient, Cool; Headwater Creek, High Gradient, Warm; Headwater Creek, Low Gradient, Warm; Headwater Creek, Low Gradient, Cool; Headwater Creek, Moderate Gradient, Cold; Headwater Creek, Moderate Gradient, Cool; Headwater Creek, Moderate Gradient, Warm; Large River, Low Gradient, Warm; Large River, Moderate Gradient, Warm; Medium River, Low Gradient, Warm; Medium River, Moderate Gradient, Warm; Small River, Low Gradient, Warm; Small River, Low Gradient, Cool; Small River, Moderate Gradient, Cool; Small River, Moderate Gradient, Warm; Embayment, Low Gradient, Warm
Virginia	Aquatic – general* Aquatic/ Riparian - Blackwater streams and rivers; Coldwater streams and rivers; Non-tidal warm streams and rivers

Table 2A.12 TIDAL RIVERS AND STREAMS KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Streams, Rivers, Lakes, and Ponds*
Rhode Island	Estuarine, Subtidal: Tidal Creek/River - Tidal Creek; Tidal Creek/River - Tidal River/Stream Tidal, Coastal Stream: River - Warm Water, Slower Flowing Stream
New York	Estuarine Brackish Intertidal Benthic Geomorphology Tidal Creek; Estuarine Freshwater Intertidal Benthic Geomorphology Tidal Creek
Pennsylvania	Tidal Large River; Tidal Small and Medium River
Delaware	Coastal Plain Large River Tidal; Coastal Plain Small and Medium River Tidal; Fresh and Oligohaline (0 - 5 ppt)*; Headwaters and Creeks Tidal; Large River Tidal; Piedmont Small and Medium River Tidal; Small and Medium River Tidal; Tidal Riverine Open Water (Salinity <0.5, depth >4m)
Virginia	Aquatic/ Riparian - Tidally Influenced Warm Water Streams and Rivers

Table 2A.13 RIPARIAN AND FLOODPLAIN KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Floodplain Forests; Northeastern Floodplain Forest; Northeastern Floodplain Forest: Laurentian-Acadian Floodplain Systems
Vermont	Floodplain Forests, Riparian
New Hampshire	Floodplain Habitats
Massachusetts	Riparian Forest
Rhode Island	Palustrine, Forested Mineral Soil Wetlands: Silver Maple/Sycamore Floodplain Forest; Red Maple/Pin Oak Floodplain Forest; Upland, Deciduous Woodlands & Forests: Mixed Hardwood Riverside Forest
Connecticut	Forested Inland Wetland: Floodplain Forests; Freshwater Aquatic: Large Rivers and their Associated Riparian Zones*
New York	Floodplain Forest; Riparian
Delaware	Coastal Plain Stream and River Floodplain; Piedmont Stream and River Floodplain
Maryland	Coastal Plain Floodplain; Montane - Piedmont Floodplain
D.C.	Central Appalachian River Floodplain; Central Appalachian Stream and Riparian*; Floodplain
West Virginia	River Floodplains; Small Stream Riparian Habitats

Table 2A.14 GREAT LAKES KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Vermont	Lake Champlain
New York	Great Lakes Aquatic Bed; Lake Very Large
Pennsylvania	Lake Erie

Table 2A.15 LAKES AND PONDS KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Coastal Plain Pond: Northern Atlantic Coastal Plain Pond Lakes and Ponds: Dystrophic, Eutrophic, Mesotrophic or Intermediate, Oligotrophic Streams, Rivers, Lakes, and Ponds*
Vermont	Lacustrine, Man-Made Water Bodies
New Hampshire	Lakes and Ponds with Coldwater Habitat; Warmwater Lakes and Ponds
Massachusetts	Coastal Plain Ponds; Lakes and Ponds
Rhode Island	Estuarine; Subtidal: Salt Pond - Coastal Salt Pond; Lake/Pond; Eutrophic: Lake – shallow; Lake/Pond; Oligotrophic: Lake – deep; Lake/Pond; Shoreline: Inland Pond and River Shore – shallow; Palustrine; Open Mineral Soil Wetlands: Coastal Plain Pond/Pondshore
Connecticut	Freshwater Aquatic: Coastal Plain Ponds; Lakes and their Shorelines; Unique, Natural or Man-made: Offshore Islands*
New York	Coastal Plain Pond; Lake; Lake Large; Lake Medium; Lake Medium Oligotrophic; Lake Small; Lake Small Eutrophic; Pond; Pond Eutrophic; Pond Oligotrophic; Reservoir
Pennsylvania	Eutrophic, High Alkalinity Lake; Eutrophic, Medium Alkalinity Lake; Hypereutrophic, High Alkalinity Lake; Hypereutrophic, Medium Alkalinity Lake; Lakes and Ponds; Mesotrophic, High Alkalinity Lake; Mesotrophic, Low Alkalinity Lake; Mesotrophic, Medium Alkalinity Lake; Oligotrophic, High Alkalinity Lake; Oligotrophic, Low Alkalinity Lake
Delaware	Coastal Plain Seasonal Pond; Freshwater Aquatic Substrate: Embedded rock, bedrock*; Freshwater Gravel/Cobble*; Impoundment; Lake / Reservoir; Mill Pond; Small Pond
Maryland	Artificial Impoundment and Wetland
D.C.	Embayed River Area; Freshwater Pond; Reservoir; Riverine Pond
West Virginia	Lentic, Low Gradient, Warm; Sinkhole and Depression Ponds; Small Lentic Water Bodies

Table 2A.16 SHORELINE KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Intertidal Bedrock: High Intertidal; Low-Intertidal; Mid-Intertidal Lake & River Shore; Rocky Coast: Acadian-North Atlantic Rocky Coast
Vermont	Upland Shores; Wet Shores
New Hampshire	Coastal Islands/Rocky Shores
Massachusetts	Rocky Coastlines
Rhode Island	Estuarine, Intertidal: Intertidal Shore - Rocky Shore Upland, Open Uplands (Grassland & Shrubland): Maritime Bluff; Maritime Rocky Cliff
Connecticut	Unique, Natural or Man-made: Coastal Bluffs and Headlands
New York	Erosional Bluff; Estuarine Brackish Intertidal*; Marine Intertidal Benthic Geomorphology Rocky Intertidal
Delaware	Intertidal*
Maryland	Coastal Bluff*

Table 2A.17 BEACHES AND DUNES KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Coastal Grassland & Shrubland: Northern Atlantic Coastal Plain Dune and Maritime Grassland; Northern Atlantic Coastal Plain Sandy Beach Intertidal Sandy Shore: Sand Beach; Lake & River Shore: Laurentian-Arcadian Lakeshore Beach Intertidal Gravel Shore: High Intertidal; Low Intertidal; Mid-intertidal Rocky Coast: North Atlantic Cobble Shore
New Hampshire	Dunes
Massachusetts	Coastal Dunes, Beaches and Small Islands
Rhode Island	Upland, Open Uplands (Grassland & Shrubland): Maritime Beach Strand; Maritime Herbaceous Dune; Maritime Shrub Dune
Connecticut	Upland Herbaceous: Coastal Beaches and Dunes; Tidal Wetland: Intertidal Beaches, Flats and Rocky Shores; Unique, Natural or Man-made: Offshore Islands*
New York	Estuarine Brackish Intertidal*; Estuarine Brackish Intertidal Benthic Geomorphology; Estuarine Brackish Intertidal Benthic Geomorphology Bar; Great Lakes Dune and Swale; Lake and River Beach; Marine Dredge Spoil Shore; Marine Intertidal Benthic Geomorphology Bar; Marine Intertidal Gravel/Sand Beach; Maritime Dunes
Pennsylvania	Great Lakes Dune and Swale
New Jersey	Beach and Dune
Delaware	Intertidal*; Maritime Dune and Grassland*; Unvegetated Sandy Beach
Maryland	Maritime Dune and Grassland*; Coastal Beach
Virginia	Beaches, Dunes and Mudflats

Table 2A.18 TIDAL WETLANDS AND FLATS KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Emergent Marsh; Intertidal Sandy Shore: Sand Flat; Tidal Marsh Intertidal Mudflat: Freshwater Tidal Marsh; Non-Vascular Mudflat Intertidal Tidal Marsh (peat-forming): Acadian Coastal Salt Marsh; Coastal Plain Tidal Marsh
New Hampshire	Salt Marshes
Massachusetts	Salt Marsh
Rhode Island	Estuarine, Intertidal: Brackish Marsh; Intertidal Shore - Mud Flat/Sand Flat; Intertidal Shore - Sand Flat; Tidal Salt Marsh - Low Salt Marsh, High Salt Marsh, Salt Panne, Salt Scrub Palustrine, Open Mineral Soil Wetlands: Freshwater Tidal Marsh
Connecticut	Tidal Wetland: Salt and Brackish Marshes
New York	Estuarine Brackish Intertidal Benthic Geomorphology Tidal Flat; Estuarine Brackish Intertidal Tidal Wetland; Estuarine Brackish Intertidal Tidal Wetland High Marsh; Estuarine Brackish Intertidal Tidal Wetland Low Marsh; Estuarine Freshwater Intertidal Benthic Geomorphology Tidal Flat; Estuarine Freshwater Intertidal Tidal Wetland; Estuarine Freshwater Intertidal Tidal Wetland Freshwater Tidal Marsh; Estuarine Freshwater Intertidal Tidal Wetland Freshwater Tidal Swamp; Marine Intertidal Benthic Geomorphology Shellfish Bed; Marine Intertidal Benthic Geomorphology Tidal Flat
Pennsylvania	North Atlantic Coastal Plain Tidal Swamp; Salt Marsh; Tidal Marsh
New Jersey	Tidal Mudflat
Delaware	Brackish Tidal Marsh and Shrubland; Fresh and Oligohaline Tidal Marsh and Shrubland; Intertidal*; Intertidal Mud Bank; Intertidal Mud Flat; Intertidal Sand Flat; Salt Marsh Pond; Salt Panne; Tidal Salt Marsh (Low); Tidal Salt Marsh and Shrubland (High); Tidal Wetlands
Maryland	Intertidal Mudflat and Sand Flat; Tidal Brackish Marsh and Shrubland; Tidal Freshwater Marsh and Shrubland; Tidal Salt Marsh and Shrubland; Tidal Forest
D.C.	Intertidal Mudflat; Northern Atlantic Coastal Plain Fresh/Oligohaline Tidal Marsh and Created Marsh; Northern Atlantic Coastal Plain Tidal Swamp
Virginia	Tidal Wetlands

Table 2A.19 ESTUARIES KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Intertidal Mollusc Reefs*: Gastropod Reef, Mussel Reef, Oyster Reef Intertidal Mudflat*: Submerged Aquatic Vegetation Intertidal Sandy Shore*: Submerged Aquatic Vegetation Intertidal Water Column*: Confined Channel, Embayment Subtidal Bedrock Bottom*: Bedrock, Erect Epifauna, Kelp Bed Subtidal Coarse Gravel Bottom*: Coarse Gravel, Erect Epifauna, Kelp Bed Subtidal Mollusc Reefs*: Gastropod Reef, Mussel Reef, Oyster Reef Subtidal Mud Bottom*: Submerged Aquatic Vegetation, Unvegetated Subtidal Sand Bottom*: Submerged Aquatic Vegetation, Unvegetated Subtidal Pelagic (Water Column)*: Confined Channel, Nearshore
New Hampshire	Estuarine
Massachusetts	Marine and Estuarine Habitats*
Rhode Island	Estuarine, Nearshore: Marine Soft Sediment - Nearshore Soft Sediment; Estuarine, Pelagic: Pelagic - Estuarine Pelagic; Estuarine, Subtidal: Brackish Tidal Aquatic Vegetation - Brackish Subtidal Aquatic Bed; Estuarine, Nearshore: Mulluscan Shellfish Reef - Nearshore Rocky Reef Estuarine, Offshore: Marine Soft Sediment - Offshore Soft Sediment; Mulluscan Shellfish Reef - Offshore Rocky Reef Pelagic - Coastal Pelagic*
Connecticut	Estuarine Aquatic: Algal Beds; Coastal Rivers, Coves and Embayments; Hard Bottoms; Open Water; Sedimentary Bottoms; Shellfish Reefs/Beds; Sponge Beds; Vegetation Beds Unique, Natural or Man-made: Navigational Channels, Breakwaters, Jetties and Piers
New York	Estuarine Brackish Deep; Estuarine Brackish Deep Shellfish Bed; Estuarine Brackish Intertidal*; Estuarine Brackish Intertidal Benthic Geomorphology Shellfish Bed; Estuarine Brackish Shallow Subtidal; Estuarine Brackish Shallow Subtidal Aquatic Bed; Estuarine Brackish Shallow Subtidal Aquatic Bed Rooted Vascular; Estuarine Brackish Shallow Subtidal Artificial Structure Jetties; Estuarine Brackish Shallow Subtidal Artificial Structure Reefs; Estuarine Brackish Shallow Subtidal Benthic Geomorphology Bar; Estuarine Brackish Shallow Subtidal Benthic Geomorphology Shellfish Bed; Estuarine Freshwater Deep Sub-tidal; Estuarine Freshwater Intertidal; Estuarine Freshwater Intertidal Artificial Structure; Estuarine Freshwater Shallow Subtidal

State	SWAP Key Habitat
Delaware	Estuarine Coastal (Salinity >0.5, depth to 4 m); Estuarine Open Water (Salinity >0.5, depth >4 m); Fresh and Oligohaline (0 - 5 ppt)*; Mesohaline (5-18 ppt); Mesohaline and Polyhaline SAV; Oyster aggregation / reef; Polyhaline (18-30 ppt); Shell Accumulation; Subtidal*; Tidal Fresh and Oligohaline SAV
Maryland	Delmarva Bay; Hard bottom (Living and Non-living); Shellfish Bed; Submerged Aquatic Vegetation
D.C.	Rocky Shoals

Table 2A.20 MARINE NEARSHORE KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Intertidal*; Subtidal Mollusc Reefs*: Gastropod Reef; Subtidal Mud Bottom*; Subtidal Sand Bottom*: Submerged Aquatic Vegetation Intertidal Water Column*: Confined Channel, Embayment, Exposed Shore Subtidal Bedrock Bottom*: Bedrock, Erect Epifauna, Kelp Bed Subtidal Coarse Gravel Bottom*: Coarse Gravel, Erect Epifauna, Kelp Bed Subtidal Pelagic (Water Column)*: Confined Channel, Nearshore
New Hampshire	Marine*
Massachusetts	Marine and Estuarine Habitats*
Rhode Island	Coastal, Nearshore: Marine Rocky Reef - Hard, Rocky Bottom; Marine Soft Sediment - Soft Bottom Marine, Nearshore: Marine Rocky Reef; Nearshore Soft Sediment Pelagic - Coastal Pelagic*
New York	Marine*; Marine Intertidal; Marine Intertidal Artificial Structure; Marine Intertidal Artificial Structure Groins; Marine Intertidal Artificial Structure Jetties; Marine Intertidal Benthic Geomorphology; Marine Shallow Subtidal; Marine Shallow Subtidal Aquatic Bed; Marine Shallow Sub-tidal Aquatic Bed Rooted Vascular
New Jersey	Marine Nearshore Zone
Delaware	Artificial Reef / Wreck*; Breakwater/Jetty*; Intertidal*; Macroalgae*; Marine Aquatic Substrate: Embedded rock, bedrock*; Marine/Estuarine System*; Marine Gravel/Cobble*; Marine Nearshore (<30 m depth); Marine Structured Sand*; Subtidal*; Tubeworm Reef*
Maryland	Pelagic – Open Water*
Virginia	Marine*

Table 2A.21 MARINE OFFSHORE AND OCEANIC KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Subtidal Mollusc Reefs*: Gastropod Reef; Subtidal Mud Bottom*; Subtidal Sand Bottom*: Submerged Aquatic Vegetation Subtidal Bedrock Bottom*: Bedrock, Erect Epifauna, Kelp Bed Subtidal Coarse Gravel Bottom*: Coarse Gravel, Erect Epifauna, Kelp Bed Subtidal Pelagic (Water Column)*: Confined Channel, Offshore, Upwelling Zones
New Hampshire	Marine*
Massachusetts	Marine and Estuarine Habitats*
Rhode Island	Coastal, Offshore: Marine Rocky Reef - Hard, Rocky Bottom; Marine Soft Sediment - Soft Bottom Marine, Offshore: Offshore Rocky Reef; Offshore Soft Sediment Pelagic - Marine Pelagic
New York	Marine Deep Subtidal
New Jersey	Marine Offshore Zone
Delaware	Marine/Estuarine System*; Marine Oceanic (shelf break to deep ocean); Marine Offshore (30 m depth to shelf break); Ocean (30+ ppt); Subtidal*
Maryland	Pelagic - Open Water*
Virginia	Marine*

Table 2A.22 AGRICULTURE: CROPLANDS / PASTURES KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Agricultural: Cultivated Crops; Pasture-Hay
Vermont	Lawns, Gardens, and Row Crops*
Rhode Island	Upland, Agricultural: Agricultural Lands – Hayfields; Pasture Upland, Agricultural: Agricultural Lands – Vegetables, Turf, Nursery, Orchard, Vineyard, Christmas Trees*
Connecticut	Unique, Natural or Man-made: Agricultural Lands
New York	Cultivated Crops; Pasture/Hay
Pennsylvania	Agriculture (NLCD 81-82)
Delaware	Agricultural - Buffers / Filter Strips; Fallow; Pasture; Row Crops
West Virginia	Agriculture

Table 2A.23 AGRICULTURE: PLANTATIONS / ORCHARDS KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Exotic Upland Forest: Introduced Upland Vegetation – Tree, Plantation and Ruderal Forest Plantation and Ruderal Forest: Managed Tree Plantation; Ruderal Forest - Northern and Central Hardwood and Conifer
Rhode Island	Upland, Agricultural: Agricultural Lands – Vegetables, Turf, Nursery, Orchard, Vineyard, Christmas Trees* Upland, Plantation & Ruderal Forest: Plantation, Upland, Plantation & Ruderal Forest: Ruderal Forest
New York	Plantation Disturbed Land Pioneer Forest
Delaware	Loblolly Pine Plantation; Mature Forest (Sawtimber); White Pine Plantation
Maryland	Managed Successional Forest; Montane Managed Conifer Forest
D.C.	Northern and Central Hardwood and Conifer – Ruderal Forest
Virginia	Agricultural/Plantation

Table 2A.24 DEVELOPED AREAS KEY HABITATS identified in 2015 SWAPs in the NEAFWA region. SWAP habitats noted with (*) are associated with multiple RSGCN habitats.

State	SWAP Key Habitat
Maine	Maintained Grasses and Mixed Cover: Urban & Recreational Grasses; Ruderal Shrubland & Grassland* Urban-Suburban Built: Commercial-Industrial; Residential - High Intensity; Residential - Low Intensity; Residential - Medium Intensity; Residential - Rural-Sparse
Vermont	Building or Structure; Lawns, Gardens, and Row Crops*; Other Cultural
New Hampshire	Developed Habitats
Connecticut	Unique, Natural or Man-made: Urban and Man-made Features
New York	Commercial/Industrial and Residential; Residential Rural; Urban and Recreational Grasses; Urban/Suburban
Pennsylvania	Developed (NLCD 21-24 & 31); Ruderal Shrubland & Grassland*
Delaware	Buildings/Structures; Developed; Developed - Commercial / Industrial
Maryland	Artificial Structure - Buildings and Other Structures
D.C.	Canopy Trees and Recreational Grasses; Commercial/Industrial; Residential - High Intensity; Residential - Medium Intensity; Urban and Recreational Grasses
West Virginia	Anthropogenic Shrubland & Grassland*; Developed
Virginia	Urban/Suburban Built

2B CROSS-WALK OF DSLLAND FORMATIONS AND ECOSYSTEMS WITH THE 24 HABITATS

Ecosystems of the DSLland, Version 5.0, associated with each of the 24 coarse habitat types for Northeast RSGCN and Watchlist species.

Northeast RSGCN Database Habitat Type	DSLland Formation	DSLland Ecosystem
Developed Area	Developed	Motorway
Developed Area	Developed	Primary road
Developed Area	Developed	Secondary road
Developed Area	Developed	Tertiary road
Developed Area	Developed	Local road
Developed Area	Developed	Active train
Developed Area	Developed	Abandoned train
Developed Area	Developed	Developed- open space
Developed Area	Developed	Developed- low intensity
Developed Area	Developed	Developed- medium intensity
Developed Area	Developed	Developed- high intensity
Developed Area	Developed	Barren land
Developed Area	Developed	Dam
Developed Area	Developed	Culvert/bridge
Agriculture: Cropland & Pasture	Agriculture	Pasture/hay
Agriculture: Cropland & Pasture	Agriculture	Cultivated crops
River & Stream	Stream (headwater/creek)	Stream (headwater/creek) cold low
River & Stream	Stream (headwater/creek)	Stream (headwater/creek) cold moderate
River & Stream	Stream (headwater/creek)	Stream (headwater/creek) cold high

Northeast RSGCN Database Habitat Type	DSLland Formation	DSLland Ecosystem
River & Stream	Stream (headwater/creek)	Stream (headwater/creek) cool low
River & Stream	Stream (headwater/creek)	Stream (headwater/creek) cool moderate
River & Stream	Stream (headwater/creek)	Stream (headwater/creek) cool high
River & Stream	Stream (headwater/creek)	Stream (headwater/creek) warm low
River & Stream	Stream (headwater/creek)	Stream (headwater/creek) warm moderate
River & Stream	Stream (headwater/creek)	Stream (headwater/creek) warm high
River & Stream	Stream (small)	Stream (small) cold low
River & Stream	Stream (small)	Stream (small) cold moderate
River & Stream	Stream (small)	Stream (small) cool low
River & Stream	Stream (small)	Stream (small) cool moderate
River & Stream	Stream (small)	Stream (small) warm low
River & Stream	Stream (small)	Stream (small) warm moderate
River & Stream	Stream (medium)	Stream (medium) cold
River & Stream	Stream (medium)	Stream (medium) cool
River & Stream	Stream (medium)	Stream (medium) warm
River & Stream	Stream (large)	Stream (large) cool
River & Stream	Stream (large)	Stream (large) warm
Tidal River & Stream	Stream (tidal)	Freshwater Tidal Riverine
Great Lakes	Lentic	Great Lakes
Lake & Pond	Lentic	Very Cold Lake
Lake & Pond	Lentic	Cold Lake
Lake & Pond	Lentic	Cold Pond
Lake & Pond	Lentic	Cool Eutrophic Lake

Northeast RSGCN Database Habitat Type	DSLland Formation	DSLland Ecosystem
Lake & Pond	Lentic	Cool Oligo-Mesotrophic Lake
Lake & Pond	Lentic	Cool Eutrophic Pond
Lake & Pond	Lentic	Cool Oligo-Mesotrophic Pond
Lake & Pond	Lentic	Warm Eutrophic Lake
Lake & Pond	Lentic	Warm Oligo-Mesotrophic Lake
Lake & Pond	Lentic	Warm Eutrophic Pond
Lake & Pond	Lentic	Warm Oligo-Mesotrophic Pond
Lake & Pond	Lentic	Small Pond
Estuaries	Estuarine Subtidal	Estuarine Subtidal Sheltered
Estuaries	Estuarine Subtidal	Estuarine Subtidal Unconsolidated Bottom
Estuaries	Estuarine Subtidal	Estuarine Subtidal Aquatic Bed
Marine Nearshore or Marine Offshore & Oceanic	Marine Subtidal	Marine Subtidal Unconsolidated Bottom
Marine Nearshore or Marine Offshore & Oceanic	Marine Subtidal	Marine Subtidal Aquatic Bed
Tidal Wetlands & Flats	Estuarine Intertidal	Estuarine Intertidal Aquatic Bed
Tidal Wetlands & Flats	Estuarine Intertidal	Estuarine Intertidal Reef
Tidal Wetlands & Flats	Estuarine Intertidal	Estuarine Intertidal Unconsolidated Shore
Tidal Wetlands & Flats	Estuarine Intertidal	Estuarine Intertidal Emergent
Tidal Wetlands & Flats	Estuarine Intertidal	Estuarine Intertidal Scrub Shrub
Tidal Wetlands & Flats	Estuarine Intertidal	Estuarine Intertidal Forested
Tidal Wetlands & Flats	Northeastern Wetland	North Atlantic Coastal Plain Tidal Swamp
Tidal Wetlands & Flats	Northeastern Wetland	Southern Atlantic Coastal Plain Tidal Wooded Swamp
Shorelines	Estuarine Intertidal	Estuarine Intertidal Rocky Shore

Northeast RSGCN Database Habitat Type	DSLland Formation	DSLland Ecosystem
Shorelines	Marine Intertidal	Marine Intertidal Rocky Shore
Riparian & Floodplain	Northeastern Wetland	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest
Riparian & Floodplain	Northeastern Wetland	Central Appalachian Stream and Riparian
Riparian & Floodplain	Northeastern Wetland	Laurentian-Acadian Large River Floodplain
Riparian & Floodplain	Northeastern Wetland	North Atlantic Coastal Plain Stream and River
Riparian & Floodplain	Northeastern Wetland	North-Central Appalachian Large River Floodplain
Riparian & Floodplain	Northeastern Wetland	North-Central Interior Large River Floodplain
Riparian & Floodplain	Northeastern Wetland	Piedmont-Coastal Plain Large River Floodplain
Riparian & Floodplain	Northeastern Wetland	Southern Piedmont Lake Floodplain Forest
Riparian & Floodplain	Northeastern Wetland	Southern Piedmont Small Floodplain and Riparian Forest
Non-tidal Wetland	Northeastern Wetland	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest
Non-tidal Wetland	Northeastern Wetland	Central Interior Highlands and Appalachian Sinkhole and Depression Pond
Non-tidal Wetland	Northeastern Wetland	Glacial Marine & Lake Wet Clayplain Forest
Non-tidal Wetland	Northeastern Wetland	High Allegheny Headwater Wetland
Non-tidal Wetland	Northeastern Wetland	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp
Non-tidal Wetland	Northeastern Wetland	Laurentian-Acadian Freshwater Marsh
Non-tidal Wetland	Northeastern Wetland	Laurentian-Acadian Wet Meadow-Shrub Swamp
Non-tidal Wetland	Northeastern Wetland	North Atlantic Coastal Plain Basin Peat Swamp
Non-tidal Wetland	Northeastern Wetland	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest
Non-tidal Wetland	Northeastern Wetland	North Atlantic Coastal Plain Pitch Pine Lowland
Non-tidal Wetland	Northeastern Wetland	North-Central Appalachian Acidic Swamp

Northeast RSGCN Database Habitat Type	DSLland Formation	DSLland Ecosystem
Non-tidal Wetland	Northeastern Wetland	North-Central Interior and Appalachian Rich Swamp
Non-tidal Wetland	Northeastern Wetland	North-Central Interior Wet Flatwoods
Non-tidal Wetland	Northeastern Wetland	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp
Non-tidal Wetland	Northeastern Wetland	Piedmont Upland Depression Swamp
Non-tidal Wetland	Northeastern Wetland	Piedmont-Coastal Plain Freshwater Marsh
Non-tidal Wetland	Northeastern Wetland	Piedmont-Coastal Plain Shrub Swamp
Non-tidal Wetland	Northeastern Wetland	Ruderal Shrub Swamp
Non-tidal Wetland	Peatland	Acadian Maritime Bog
Non-tidal Wetland	Peatland	Atlantic Coastal Plain Northern Bog
Non-tidal Wetland	Peatland	Atlantic Coastal Plain Peatland Pocosin and Canebrake
Non-tidal Wetland	Peatland	Boreal-Laurentian Bog
Non-tidal Wetland	Peatland	Boreal-Laurentian-Acadian Fen
Non-tidal Wetland	Peatland	North-Central Interior and Appalachian Acidic Peatland
Cliff & Talus	Cliff & Rock	Acidic Cliff and Talus
Cliff & Talus	Cliff & Rock	Calcareous Cliff and Talus
Cliff & Talus	Cliff & Rock	Circumneutral Cliff and Talus
Alpine	Alpine	Acadian-Appalachian Alpine Tundra
Beach & Dune	Marine Intertidal	Marine Intertidal Aquatic Bed
Beach & Dune	Marine Intertidal	Marine Intertidal Unconsolidated Shore
Beach & Dune	Coastal Scrub-Herb	Atlantic Coastal Plain Beach and Dune
Beach & Dune	Coastal Scrub-Herb	Great Lakes Dune and Swale
Beach & Dune	Coastal Scrub-Herb	North Atlantic Coastal Plain Heathland and Grassland
Grassland & Shrubland	Grassland & Shrubland	Shrubland & grassland (NLCD 52/71)

Northeast RSGCN Database Habitat Type	DSLland Formation	DSLland Ecosystem
Glades, Barrens & Savanna	Grassland & Shrubland	Acidic Rocky Outcrop
Glades, Barrens & Savanna	Grassland & Shrubland	Appalachian Shale Barrens
Glades, Barrens & Savanna	Grassland & Shrubland	Central Appalachian Alkaline Glade and Woodland
Glades, Barrens & Savanna	Grassland & Shrubland	Mafic Glade and Barrens
Glades, Barrens & Savanna	Grassland & Shrubland	Southern Appalachian Grass and Shrub Bald
Glades, Barrens & Savanna	Northeastern Upland Forest	Central Appalachian Pine-Oak Rocky Woodland
Glades, Barrens & Savanna	Northeastern Upland Forest	North Atlantic Coastal Plain Pitch Pine Barrens
Glades, Barrens & Savanna	Northeastern Upland Forest	Northeastern Interior Pine Barrens
Glades, Barrens & Savanna	Northeastern Upland Forest	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland
Grassland & Shrubland	Grassland & Shrubland	Southern Ridge and Valley Calcareous Glade and Woodland
Grassland & Shrubland	Grassland & Shrubland	Calcareous Rocky Outcrop
Grassland & Shrubland	Grassland & Shrubland	Eastern Serpentine Woodland
Grassland & Shrubland	Grassland & Shrubland	Great Lakes Alvar
Agriculture: Plantation & Orchard	Northeastern Upland Forest	Pine plantation / Horticultural pines
Forest & Woodland	Boreal Upland Forest	Acadian Low Elevation Spruce-Fir-Hardwood Forest
Forest & Woodland	Boreal Upland Forest	Acadian Sub-boreal Spruce Flat
Forest & Woodland	Boreal Upland Forest	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest
Forest & Woodland	Boreal Upland Forest	Central and Southern Appalachian Spruce-Fir Forest
Forest & Woodland	Northeastern Upland Forest	Allegheny-Cumberland Dry Oak Forest and Woodland
Forest & Woodland	Northeastern Upland Forest	Appalachian (Hemlock)-Northern Hardwood Forest
Forest & Woodland	Northeastern Upland Forest	Central and Southern Appalachian Montane Oak Forest
Forest & Woodland	Northeastern Upland Forest	Central Appalachian Dry Oak-Pine Forest
Forest & Woodland	Northeastern Upland Forest	Central Atlantic Coastal Plain Maritime Forest

Northeast RSGCN Database Habitat Type	DSLland Formation	DSLland Ecosystem
Forest & Woodland	Northeastern Upland Forest	Glacial Marine & Lake Mesic Clayplain Forest
Forest & Woodland	Northeastern Upland Forest	Laurentian-Acadian Northern Hardwood Forest
Forest & Woodland	Northeastern Upland Forest	Laurentian-Acadian Northern Pine-(Oak) Forest
Forest & Woodland	Northeastern Upland Forest	Laurentian-Acadian Pine-Hemlock-Hardwood Forest
Forest & Woodland	Northeastern Upland Forest	Laurentian-Acadian Red Oak-Northern Hardwood Forest
Forest & Woodland	Northeastern Upland Forest	North Atlantic Coastal Plain Hardwood Forest
Forest & Woodland	Northeastern Upland Forest	North Atlantic Coastal Plain Maritime Forest
Forest & Woodland	Northeastern Upland Forest	North-Central Interior Beech-Maple Forest
Forest & Woodland	Northeastern Upland Forest	Northeastern Coastal and Interior Pine-Oak Forest
Forest & Woodland	Northeastern Upland Forest	Northeastern Interior Dry-Mesic Oak Forest
Forest & Woodland	Northeastern Upland Forest	Piedmont Hardpan Woodland and Forest
Forest & Woodland	Northeastern Upland Forest	South-Central Interior Mesophytic Forest
Forest & Woodland	Northeastern Upland Forest	Southern and Central Appalachian Cove Forest
Forest & Woodland	Northeastern Upland Forest	Southern Appalachian Low Elevation Pine Forest
Forest & Woodland	Northeastern Upland Forest	Southern Appalachian Montane Pine Forest and Woodland
Forest & Woodland	Northeastern Upland Forest	Southern Appalachian Northern Hardwood Forest
Forest & Woodland	Northeastern Upland Forest	Southern Appalachian Oak Forest
Forest & Woodland	Northeastern Upland Forest	Southern Atlantic Coastal Plain Mesic Hardwood Forest
Forest & Woodland	Northeastern Upland Forest	Southern Piedmont Dry Oak-Pine Forest
Forest & Woodland	Northeastern Upland Forest	Southern Piedmont Mesic Forest
Forest & Woodland	Northeastern Upland Forest	Southern Ridge and Valley / Cumberland Dry Calcareous Forest

4A Regional Project Summary Table (Includes RCN, USFWS, CSWG, AND SA) Projects

Project ID	Brief Title	Principal Investigator/Lead Organization	SWAP Element & Synthesis Chapter #	NE States included	Final Product/link Links will sync with the new website (www.northeastwildlifediversity.org)when it is enabled.	Product Release Date
NETWHCS	Northeastern Terrestrial Wildlife Habitat Classification	VDGIF	2	All	main Excel spreadsheet of classification with supporting documents www.northeastwildlifediversity.org	2008
NEAHCS	Northeastern Aquatic Habitat Classification	VDGIF	2	All	GIS database, final report and supporting documents, www.northeastwildlifediversity.org	2008
NERPMF	Regional Monitoring and Performance Framework	NYDEC	5	All	2 Final reports and appendices, www.northeastwildlifediversity.org	2008
RCN 2007-01	Regional Habitat Maps: NE Terrestrial Habitat Class. System	TNC	2	All	Terrestrial Ecosystem and Habitat Map of NE, www.northeastwildlifediversity.org	2012
RCN 2007-02	Northeast Regional Connectivity Assessment Project	TNC	2,3,4	All	NE Aquatic Connectivity report and NCAT tool, www.northeastwildlifediversity.org	2012
RCN 2007-03	Identifying Relationships between Invasive Species and SGCN	CMI	3	All	Final report, Excel spreadsheets, example, www.northeastwildlifediversity.org	2012
RCN 2007-	Development of Avian	ABC	5	All	Protocol, SOP, and data for mountain, tidal and grassland birds	2009

Project ID	Brief Title	Principal Investigator/Lead Organization	SWAP Element & Synthesis Chapter #	NE States included	Final Product/link Links will sync with the new website (www.northeastwildlifediversity.org)when it is enabled.	Product Release Date
04	Indicators and Measures				www.northeastwildlifediversity.org	
RCN 2007-05	Conservation Status of Key Habitats and Species	TNC	1,2,3,5	All	Conservation Status report with maps and tables www.northeastwildlifediversity.org,	2011
RCN 2007-06	GIS based Application to Estimate Stream Flow	USGS	3	NH, VT, MA, CT	Report, Manuscript, GIS-based Tool, User Manual www.northeastwildlifediversity.org,	2012
RCN 2007-07	Regional Initiative Biomass Successional SGCN	CMI	3,4	All	Final report www.northeastwildlifediversity.org,	2011
RCN 2007-08	Grassland/Shrubland Conservation Initiatives	NEAFWA	1,2,3,4	All	4 final reports, BMPs www.northeastwildlifediversity.org,	2010-2011
RCN 2007-09	WNS in Bats	Bucknell Univ	1,3	All	Manuscript, report, www.northeastwildlifediversity.org,,	2012
RCN 2008-01	GIS Application to Estimate Target Fish Comm.	Rushing Rivers	1,2	All	GIS Application	2012
RCN 2008-02	Model Guidelines for Local Planning Boards	NatureServe	3	All	Final report and Excel spreadsheet of guidelines www.northeastwildlifediversity.org,	2012

Project ID	Brief Title	Principal Investigator/Lead Organization	SWAP Element & Synthesis Chapter #	NE States included	Final Product/link Links will sync with the new website (www.northeastwildlifediversity.org)when it is enabled.	Product Release Date
RCN 2008-03	Focal Area Resilience and Adaptive Capacity	TNC	2, 3	All	Final report, www.northeastwildlifediversity.org,	2011
RCN 2008-04	Implementation of Bird Monitoring	ABC	1,5	All	Monitoring Implementation	2011
RCN 2008-05	Key Habitat and Species Indicators and Measures	TNC	1,2,3,5	All	Project merged with RCN 2007-05, final report www.northeastwildlifediversity.org,	2011
RCN 2009-01	Assessing Impacts of Climate Change on SGCN	Manomet	1,3	All	3 Final reports www.northeastwildlifediversity.org,	2011
RCN 2009-02	Condition Analysis for NE Habitats	TNC	2,3,5	All	Report 2010, 2011 www.northeastwildlifediversity.org,	2011
RCN 2009-03	Invertebrate Online Database	CMNH	1,2,3,4,5	All	web-accessible database http://iz.carnegiemnh.org/sgcninverts/default.asp www.northeastwildlifediversity.org,	2012
RCN 2009-04	Noninvasive Monitoring Tools for NE Cottontail	UNH	1,2,3,4,5	ME, NH, MA, CT, RI, NY	3 Final reports www.northeastwildlifediversity.org,	2012
RCN 2010-01	Lab and Field Testing of Treatments for WNS	Bucknell Univ.	1, 3	All	Report	2012

Project ID	Brief Title	Principal Investigator/Lead Organization	SWAP Element & Synthesis Chapter #	NE States included	Final Product/link Links will sync with the new website (www.northeastwildlifediversity.org)when it is enabled.	Product Release Date
					www.northeastwildlifediversity.org,	
RCN 2010-02	Instream Flow for Great Lakes Basin of NY and PA	TNC	3	NY, PA	Report and database www.northeastwildlifediversity.org,	2012
RCN 2010-03	Identification of Tidal Marsh Bird Focal Areas BCR 30	U of DE	1,2,3,4,5	NJ, DE, MD, DC, VA	Report www.northeastwildlifediversity.org,	2013
RCN 2010-04	Regional Analysis of Frog Monitoring	USGS	1, 5	All	Website, report www.northeastwildlifediversity.org,	2013
RCN 2011-01	Conservation Action Plan for the Eastern Black Rail	Ctr for Cons. Bio.	1,2,3,4,5	NY, NJ, PA, DE, MD	Report www.northeastwildlifediversity.org	2013
RCN 2011-02	Wood Turtle Conservation Strategy	UMass CRU	1,2,3,4,5	All	Report, website, https://www.northeastturtles.org/ www.northeastwildlifediversity.org	2013
RCN 2011-03	Conservation Assessment of Odonata	NY Natural Heritage	1,2,3,4,5	All	Report www.northestwildlifediversity.org	2013
RCN 2011-05	Terrestrial Map Guidance	TNC	2	All	Report, website https://www.northeastturtles.org/	2013

Project ID	Brief Title	Principal Investigator/Lead Organization	SWAP Element & Synthesis Chapter #	NE States included	Final Product/link Links will sync with the new website (www.northeastwildlifediversity.org)when it is enabled.	Product Release Date
RCN 2011-06	Aquatic Habitat Map Guidance	TNC	2	All	Report, https://www.conservationgateway.org/	2013
RCN 2011-07	RCN Regional Synthesis	TCI	1,2,3,4,5	All	Report www.northestwildlifediversity.org	2013
RCN 2011-08	Northeast State Wildlife Action Plans: Database Framework for Common Elements	NJ DFW	all	All	Report www.northestwildlifediversity.org	2015
RCN 2012-01	Rana Virus in Amphibians	MD DNR	3	All	Report www.northestwildlifediversity.org	2013
RCN 2012-02	Conservation Status of Brook Floater Mussel	Saint Anselm College	1,2,3,4,5	All	Report www.northestwildlifediversity.org	2013
RCN 2012-03	Fungal Dermatitis in New England Timber Rattlesnake	RI Zoological Society	3	ME, NH, VT, MA	Report www.northestwildlifediversity.org	2013
RCN 2013 (1)	Hellbender Conservation	Kim Terrell Smithsonian Zoological Park	1-5,7,8	all	Report www.northestwildlifediversity.org	2014
RCN 2013	Northern Diamondback Terrapin Conservation	Stephanie Egger,	1-5,7,8	All coastal	Report	2014

Project ID	Brief Title	Principal Investigator/Lead Organization	SWAP Element & Synthesis Chapter #	NE States included	Final Product/link Links will sync with the new website (www.northeastwildlifediversity.org)when it is enabled.	Product Release Date
(2)	Strategy	SUNY			www.northestwildlifediversity.org	
RCN 2013 (3)	Leopard Frog in Coastal NE	Matthew Schlesinger, SUNY	1-5,7,8	All coastal	Report www.NortheastWildlifeDiversity.org	2017
RCN 2014 (1)	Best practices wildlife populations NE forests	Dan Lambert, High Branch Conservation Services	1-5	All	Report www.NortheastWildlifeDiversity.org	2013-2017
RCN 2014 (2)	Coordination and I&E support	TCI	all	All	Annual reports www.NortheastWildlifeDiversity.org/	2018-2022
RCN 2014 (3)	Database	TCI	all	All	Database, report www.NortheastWildlifeDiversity.org/	2018-2022
RCN 2015 (1)	Determining effects of Landlocked Alewives on Anadromous Alewife Restoration	Eric Palkovacs, Santa Cruz	1-5	New England	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2015 (2)	Conservation and Management of Rare Butterfly	Jennifer Selfridge, MD DNR	1-5		Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2015 (3)	Strategies for Allegheny Woodrat Recovery	Sunshine Brosi, Frostburg State	1-5		Report www.NortheastWildlifeDiversity.org/	2019-2022

Project ID	Brief Title	Principal Investigator/Lead Organization	SWAP Element & Synthesis Chapter #	NE States included	Final Product/link Links will sync with the new website (www.northeastwildlifediversity.org)when it is enabled.	Product Release Date
RCN 2015 (4)	Wildlife Diversity Conservation Coordination	TCI	1-5		Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2016 (1)	Conservation Genetics of the Wood Turtle from ME to VA	Lisabeth Willey U of New England	1-5	All	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2016 (2)	Five-Factor Analysis of Petitioned Species	Scott Klopfer, VA Tech	all	All	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2016 (3)	Facilitate State SWAP Data Delivery and Population of RCN Regional Database	TCI	all	All	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2016 (4)	Bat Cave Gating	Armstrong et al	1,2,4	CT, NJ, NH, PA	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2016 (5)	Northern and Peripheral Populations of the Timber Rattlesnake	Christopher Jenkins, Orianne Society	1-5	All	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2016 (6)	Assessing the Status of Land Snails in the Northeast Region	Ken Hotopp Carnegie	1,4	All	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 1	Spotted Turtle Spatial Structure and Genetic	Rodney Dyer	1,4	All	Report	2019-

Project ID	Brief Title	Principal Investigator/Lead Organization	SWAP Element & Synthesis Chapter #	NE States included	Final Product/link Links will sync with the new website (www.northeastwildlifediversity.org)when it is enabled.	Product Release Date
Job 1 GSA 00040	Connectivity				www.NortheastWildlifeDiversity.org/	2022
RCN 2 Project 1 Job 1 GSA 00041	Spotted Turtle Assessment in MD/DE	Eric Liebgold	1,4	MD, DE	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 1 Job 1 GSA 00042	Assessment of Spotted Turtles in NJ	Jason Tesauro	1,4	NJ	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 1 Job 1 GSA 00043	Spotted Turtle Assessment Protocol	Donald Brown	1,4	All	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 1 Job 1 GSA 00045	Assessment of Spotted Turtles in NY	Glenn Johnson	1,4,5	NY	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 1 Job 1 GSA 00046 Amend 1	Spotted Turtle Population Monitoring and DNA Collection	Brandon Ruhe	1,4,5	all	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 1 Job 2 GSA	Eastern Box Turtle Status Assessment, Conservation Plan and BMPs	Brandon Ruhe	1-5	all	Report www.NortheastWildlifeDiversity.org/	2019-2022

Project ID	Brief Title	Principal Investigator/Lead Organization	SWAP Element & Synthesis Chapter #	NE States included	Final Product/link Links will sync with the new website (www.northeastwildlifediversity.org)when it is enabled.	Product Release Date
00046						
RCN 2 Project 1 Job 2 GSA 00047	Eastern Box Turtle Status Assessment, Conservation and BMPs	Patrick Roberts	1-5	all	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 1 Job 3 GSA 00033	Targeted Road Mitigation Assessment and BMPs	Tom Langen	1-5	all	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 1 Job 4 GSA 00046 Amend 2	Implementation of the Conservation Plan for the Wood Turtle in the NE	Brandon Ruhe	1-5	all	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 1 Job 4 GSA 00057	Northeast Turtle Conservation Database	Daniel Martinelli	1-5	all	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 1 Job 4 GSA 00074	Conservation Plan for the Blanding's Turtle and Associated SGCN in the NE	Kiley Briggs	1-5	all	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 2 Job 1 GSA 00031	Identification of Pollinator Species in the Northeast	Steve DeStefano	1-5	all	Report www.NortheastWildlifeDiversity.org/	2019-2022

Project ID	Brief Title	Principal Investigator/Lead Organization	SWAP Element & Synthesis Chapter #	NE States included	Final Product/link Links will sync with the new website (www.northeastwildlifediversity.org)when it is enabled.	Product Release Date
RCN 2 Project 2 Job 1 GSA 00032	Identification of Pollinator Species in the northeast	Joan Milam	1-5	all	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 2 Job 1 GSA 00050	Process Bee Samples	Michael Veit	1-5	all	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 2 Job 1 GSA 00078	Bee Identification	Clare Maffei	1-5	all	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 2 Job 1 GSA 00078 Amend 1	Bee Identification	Clare Maffei	1-5	all	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 2 Job 1 GSA 00096	Preparatory Phase for Data Analysis	Helen Poulos	1-5	all	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 2 Job 2 GSA 00030	Vegetation Monitoring Protocols to Inform LTLongterm anagement	Lori Cookman	1-5	all	Report www.NortheastWildlifeDiversity.org/	2019-2022

Project ID	Brief Title	Principal Investigator/Lead Organization	SWAP Element & Synthesis Chapter #	NE States included	Final Product/link Links will sync with the new website (www.northeastwildlifediversity.org)when it is enabled.	Product Release Date
RCN 2 Project 2 Job 3 GSA 00060A, Amend 1	Green Ridge Xerics Site	Jen Selfridge	1-5	MD	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 2 Job 3 GSA 00060B, Amend 1	Pocomoke Xerics Site	Jen Selfridge	1-5	MD	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 2 Job 3 GSA 00061, Amend 1	Linda Loring Xerics Site	Sarah Bois	1-5		Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 2 Job 3 GSA 00067, Amend 1	Albany Pine Bush Xerics Site	Neil Gifford	1-5	NY	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 2 Job 3 GSA 00073	Concord Pine Barrens Site #3 Xerics Site	Heidi Holman	1-5	NH	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 2 Job 3 GSA 00076	Pre- and Post-Burning Vegetation Surveys, Nicholas Farm and Pratt	Brian Maynard	1-5		Report www.NortheastWildlifeDiversity.org/	2019-2022

Project ID	Brief Title	Principal Investigator/Lead Organization	SWAP Element & Synthesis Chapter #	NE States included	Final Product/link Links will sync with the new website (www.northeastwildlifediversity.org)when it is enabled.	Product Release Date
Amend 1	Farm Xerics Site					
RCN 2 Project 2 Job 3 GSA 00084	Sandbar WMA Xerics Site	Leif Richardson	1-5		Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 2 Job 4 GSA 00029 Amend 1	Habitat for Pollinators: Improve Management Xeric Grasslands, Barrens and Woodlands	Elizabeth Crisfield	1-5	all	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 2 Job 4 GSA 00070, Amend 1	Communication and Project Support	Elizabeth Crisfield	1-5	All	Report www.NortheastWildlifeDiversity.org/	2019-2022
RCN 2 Project 3 Job 1 GSA 00029, Amend 1,2,3,4,5	Technical Support and NE SWAP and RSGCN database management RSGCN List Update, Limiting Factors Report, NE Regional Conservation Synthesis	TCI	1-5	All	RSGCN Database, RSGCN list, limiting factors report, regional conservation synthesis, annual reports	2018-2023
RCN 2 Project 1 Amend	Northeast Lexicon	SSI	1-5	All	Report-NE Regional Lexicon	2022

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RCN 2 Project 1 Amend	NE Habitat Condition Analysis	TNC	1-5	All	Report-NE Habitat Condition Assessment	2023
	CSWG Projects	Lead State		Grant Active		
CSWG	Rangewide New England Cottontail Initiative, Conservation Strategy	NHF&G	1-5	CT, ME, MA, NY, RI	Report https://newenglandcottontail.org/	2008
CSWG	Staying Connected in the N Appalachians	NH	1-5	ME, NY, VT	Report www.NortheastWildlifeDiversity.org	2008-2013
CSWG	WNS: Multistate Coordination, Investigation, and Response	PA	1-5	CT, DE, ME, NH, NJ, NY, WI, WV, VA	Report www.NortheastWildlifeDiversity.org	2008-10
CSWG	Conservation of Tidal Marsh Birds	ME	1-5	CT, DE, MD	Report www.NortheastWildlifeDiversity.org	2010-2011
CSWG	Rangewide New England Cottontail Expansion	MA	1-5	CT, ME, NH, NY, RI	Report https://newenglandcottontail.org	2011
CSWG	Conservation of Blanding's Turtles and Associated NE Wetland	NH	1-5	ME, MA, NY, PA	Report	2012

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	SGCN				www.northeastturtles.org	
CSWG	Rangewide New England Cottontail Phase 3	CT	1-5	NH, MA, ME, NY, RI	Report https://newenglandcottontail.org	2013
CSWG	The Gulf of Maine Coastal Marine Ecosystem Survey: Mapping Biological Hotspots	ME	1-2	ME, NH, MA	Report, publications	2018
CSWG	Integrating Vulnerability Science into a Strategic Conservation Plan for Maine's Species of Greatest Conservation Need	ME	1-3	ME	Report	2013
CSWG	Conserving Snake Species of Greatest Conservation Need Threatened by an Emerging Fungal Skin Disease	MA	1-5	NH, CT, VT, NJ, TN, MN, WI, IL	Report	2015
CSWG	Pennsylvania Wildlife Action Plan 2.0 – Prioritization and Mapping Enhancements	PA	1-4		Report	2013
CSWG	Conservation Planning and Implementation for the Wood Turtle (*Glyptemys insculpta*) and Associated	MA	1-5	ME, NH, CT, NJ, PA, MD, VA	Report – Conservation Plan for the Wood Turtle in the Northeastern US	2014, 2018

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	Riparian Species of Greatest Conservation Need from Maine to Virginia					
CSWG	Rangewide New England Cottontail Initiative (2014)	ME	1-5	NH, MA, CT	Report	2014
CSWG	Multistate Recovery Actions for Bog Turtle	PA Fish & Boat Commission	1-5	CT, MD, MA, NJ	Report https://www.fws.gov/sites/default/files/documents/Bog_Turtle_Conservation_Plan_2019_508C_0.pdf	2015, 2019
CSWG	Comprehensively Evaluating New Jersey's Bee Pollinators for the State Wildlife Action Plan	NJ	1, 5	NJ	Report	2015
CSWG	Adaptive Implementation of the Regional Conservation Plan for Blanding's Turtle and Associated Wetland SGCN in the Northeast	NH	1-5	MA, ME, PA	Report	2016
CSWG	Brook Floater: Rangewide Conservation and Restoration Initiative	MA	1-5	NY, ME, VA, NH	Report	2017
CSWG	MD Portion of Ohio and Maryland Bat Research Proposal	OH	1,2	MD	Report	2017

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CSWG	Spotted Turtle Conservation	VA	1-5	CT, DC, MA, PA, NH, ME	Report	2017
CSWG	Recovery of the Chesapeake Logperch, *Percina bimaculata*	PA	1-5	Chesapeake Watershed, MD	Report	2018
CSWG	Motus I: Overcoming Geographic and Temporal Barriers to Identifying Landscape-scale Habitat Use of Multiple SGCN in the Mid-Atlantic Region Using Nanotag Technology	PA	1,5	MD	Report, installed receiver stations	2018
CSWG	Implementation of the Bog Turtle Conservation Plan for the Northern Population, With Benefits to Associated Headwater Wetland Species of Greatest Conservation Need	PA	1-4	MD, MA, CT, DE	Report, implementation	2019-2023
CSWG	Motus II: Using Nanotag Technology to Identify Landscape-scale Habitat Use of Multiple SGCN in New England	NH	1,2,5	MA, ME, PA	Report	2019
CSWG	Testing Salt Marsh Restoration Practices for	CT	1-4	CT, ME, MD,	Report	2020

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	Saltmarsh Sparrow Conservation			RI, VA, MA		
CSWG	Wetland Habitat for Black Rails	MD	1-4	MD	Report, https://bioone.org/journals/waterbirds/volume-44/issue-2/063.044.0211/Mapping-Habitat-Quality-and-Threats-for-Eastern-Black-Rails-Laterallus/10.1675/063.044.0211.full	2020
CSWG	Regional Conservation for Wood Turtles and Related Emydine Turtles	CT, ME, MD, NH, NJ, PA, RI, VA, WV, NY	1-5	all	Report	2020
CSWG	Advancing Conservation and Restoration of Brook Floater and Associated Freshwater Mussels	MA	1-5	NJ, SC, VA	Report	2021-2024
CSWG	Updating Vermont's 2025 Action Plan with Vermont Conservation Design	VT	1-5	VT	Report	2021
CSWG	Eastern Shore Conservation Initiatives	VA	2,4	VA	Report, land acquisition	2021, 2022
CSWG	Addressing Population Declines Due to Loss of Adult and Juvenile Turtles to Illegal Wildlife Trade	VA	1-5	all	Report	2021

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CSWG	Conserving Vermont's Spotted Turtles: Using Novel Techniques to Detect a Cryptic Species and Identify Unknown Populations		1-5	VT	Report	2022
CSWG	Creating a Comprehensive Conservation and Management Plan for the Southern Lineage of the Bog Turtle and its Associated Habitats	VT	1-5	all	Report	2021
CSWG	Distribution and Demography of Saltmarsh Sparrows in the Understudied, Southern Extent of the Species' Breeding Range	VA	1-5	VA	Report	2022
CSWG	Modernizing the Northeast Wildlife Action Plan Database	NEAFWA	1-5	CT, DE, ME, MD, MA, NH, NJ, NY, PA, RI, VT,DC, WV	www.NortheastWildlifeDiversity.org	2022-2026
CSWG	Motus III: PA and VT portion of Identifying SGCN Habitat Use Across Multiple Scales Throughout the Eastern U.S. Using the Motus	AL	1-5	WV, VA, KY, TN, NC, SC, GA, FL, CT, DE, ME, MD, MA,RI, PA, NH, NJ,	Report	2022

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	Wildlife Tracking System			NY		
ARS At Risk Species Program (ARS)-USFWS	USFWS- SA Team leads assembled to address these topic areas	USFWS			Report	2021-22
	ARS Chesapeake Logperch	SA/ USFWS	1-5	Chesapeake watershed	Report	2021-22
	ARS New England Cottontail	SA/ USFWS	1-5	NE England	Report	2021-22
	Saltmarsh Sparrow	SA/ USFWS	1-5	All but VT,WV	Report	2021-22
	Atlantic Coast Beach and Shorebirds (AMOY, RUTU, WHIM)	SA/ USFWS	1-5	All but VT, WV	Report	2021-22
	Forest Songbirds (GWWA, CEWA, WOTH)	SA/ USFWS	1-5	all	Report	2021-22
	Pine Barrens Species	SA/ USFWS	1-5	all	Report	2021-22
	Diadromous Fishes (Alewife, Blueback	SA/ USFWS	1-5	all	Report	2021-22

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	Herring)					
	Farmland Pollinators (Bees and Butterflies)	SA/ USFWS	1-5	all	Report	2021-22
	Freshwater Mussels (Brook Floater, Cumberland Moccasinshell, Pheasantshell, Tennessee Clubshell, Tidewater Mucket, Yellow Lampmussel)	SA/ USFWS	1-5	all	Report	2021-22
	Mountain Butterflies-White Mountain Arctic, White Mountain Fritillary	SA/ USFWS	1-4	NH	Report	2021-22
	NE Turtles (Blandings, Spotted and Wood Turtles	SA/ USFWS	1-5	all	Report	2021-22
Early LCC projects pre- 2014						
LCC - 1	Virginia Piedmont and Coastal Plain Updates to Northeast Habitat Map	TNC		VA, MD	Extension of the Terrestrial Ecosystem and Habitat Map of NE https://www.landscapepartnership.org/projects/north-atlantic-projects/virginia-piedmont-and-coastal-plain-updates-to-northeast-habitat-map	Jun-12

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LCC - 2	Extending the Northeast Terrestrial Habitat Map to Atlantic Canada	TNC		Canada - Quebec, New Brunswick, Prince Edward Island, Nova Scotia		2015
LCC - 3	Revisions to the Northeastern Aquatic Habitat Classification	TNC		All		2015
LCC - 4	Application of the Coastal and Marine Ecological Classification Standards (CMECS) to the Northeast	TNC		ME, NH, MA, CT, RI, NY, NJ, PA, DE, MD, DC,VA		2014
LCC - 5	Rapid Update to the National Wetlands Inventory for Selected Areas of Intertidal Wetlands in the North Atlantic LCC	Conservation Management Institute		ME, MD, MA, NY, PA, and VA		2017
LCC - 6	Vulnerabilities to Climate Change of Northeast Fish and Wildlife Habitats, Phase II	Manomet Center for Conservation Sciences		All		2013
LCC - 7	Completing Northeast Regional Vulnerability Assessment Incorporating	NatureServe		All		2013

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	the NatureServe Climate Change Vulnerability Index					
LCC - 8	Permeable Landscapes for Species of Greatest Conservation Need	TNC		All	https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/terrestrial/resilience/Pages/default.aspx	2016
LCC - 9	Designing Sustainable Landscapes: Assessment of Landscape Changes in the North Atlantic Landscape Conservation Cooperative: Decision-Support Tools for Conservation	University of Massachusetts, Amherst		All	https://umassdsl.org/	2015-2016
LCC - 10	Decision Support Tool to Assess Aquatic Habitats and Threats in North Atlantic Watersheds and Estuaries	Downstream Strategies		All		2015
LCC - 11	Mapping the Distribution, Abundance and Risk Assessment of Marine Birds in the Northwest Atlantic Ocean	North Carolina State University		ME, NH, MA, CT, RI, NY, NJ, PA, DE, MD, VA		2017
LCC - 12	Forecasting Changes in Aquatic Systems and Resilience of Aquatic Populations in the	USGS/ University of Massachusetts Amherst		All		2017

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	NALCC: Decision-support Tools for Conservation					
LCC - 13	Forecast Effects of Accelerating Sea-level Rise on the Habitat of Atlantic Coast Piping Plovers and Identify Responsive Conservation Strategies	Virginia Tech		ME, NH, MA, CT, RI, NY, NJ, DE, MD, VA		2014
LCC - 14	Assessing Priority Amphibian & Reptile Conservation Areas (PARCAs) and Vulnerability to Climate Change in the North Atlantic Landscape Conservation Cooperative (LCC)	Association of Fish and Wildlife Agencies		All		2017
LCC - 15	Identifying Important Migratory Landbird Stopover Sites in the Northeast	University of Delaware		All		2014
LCC - 16	Northeast Regional Conservation Design, Regional Synthesis and Delivery of Conservation Information and Tools for SWAP updates	North Atlantic LCC		All		2013

APPENDIX 4B PRIORITY ACTIONS COMPILED FROM THE 14 2015 NE SWAPS AND PRIORITIZED THROUGH ANALYSIS AND FINAL INPUT FROM NEFWDTC/SWAP COORDINATORS IN 2017

	Development	Pollution	Dams and Water Management	Invasives and Disease	Climate Change
Direct Management of Natural Resources	**Overarching Actions** ✓ Inform, guide, implement, and evaluate strategic conservation of RSGCN and key habitats in the Northeast. ✓ Promote and implement recommendations from previous RCN and Competitive SWG funded conservation projects that developed conservation strategies for RSGCN.				
	• Develop and Implement incentives, BMPs and more cost-effective designs and green infrastructure. • Install transportation crossing structures (e.g., turtle crossing), fencing, protecting key areas etc. (Partner with DOTs). • Provide incentives, tools and information on land management to increase native pollinators and supporting habitats.	• Engage partners and landowners to develop effective, consistent implement BMPs to reduce pollution from development. • Incorporate SWAP priorities into standards of practice for residential and commercial development, service, and transportation to reduce impacts of pollution (e.g., the lawn care, road salting).	• Improve aquatic connectivity by Upgrade or remove barriers to provide passage and flow. • Improve buffer condition. • Provide guidance to prioritize conservation on the ground by applying SWAP, RCN and partner tools and data as a framework to guide a regional conservation land/water network enhanced with state and local level data.	• Collaborate with Wildlife Disease Cooperatives to implement *B. sal* testing at ports of entry for the pet trade. • Develop and Implement BMPs for treatment of invasives to avoid harm to non-target species. • Protect native populations (i.e., SGCN RSGCN) from the introduction and spread of diseases (e.g., *B. sal*) as they emerge.	• Manage for shifting habitats and to provide refugia.

Develop Partnerships	**Overarching Actions** ✓ Cultivate existing partnerships and build new partnerships. ✓ Reduce impacts of all top threats to preserve, protect, and restore habitats. ✓ Incorporate SWAP information and priorities into partner plans and programs at the local, state and regional levels				
	• Provide incentives, and tools to enhance existing efforts with SWAP priorities and on-the-ground delivery of conservation for RSGCN and habitat in the region (e.g., APPLCC, NALCC restoration tools). • Link core areas across the region (Like the *Staying Connected* Initiative)	• Incorporate SWAP priorities into standards of practice in the lawn care industry. • Work with NRCS, EPA, state and local water control entities, and other partners to reduce non-point source **pollution** by helping communicate the benefits and needs of SGCN species.	• Aquatic connectivity is accomplished with support from public and private partners. • Departments of Transportations, Trout Unlimited and other NGOs and watershed groups, and other public and private partners to improve aquatic connectivity and pollution.	• Work with USDA to develop BMPs to reduce the risk of disease transmission from captive bees to wild bees. • Build regional and state-level partnership with Xerces Society. • Work with: ○ Disease Cooperatives ○ USGS Wildlife Health Center Lab ○ USDA ○ Wildlife Conservation Society ○ Cornell, Brown, Tufts	
Data Collection and Analysis	• Apply key regional tools and data to guide a regional network. • Nature's Network (NALCC) provides several development layers including predicted development. • Inform development and implementation of effective on-the-ground management and conservation tools and techniques	• Measure results of pollution reduction through long-term monitoring. • Document species' vulnerabilities to **pollution, (development, invasives and disease, natural systems modifications and climate change)** and response to implemented actions to document changes.	• Inventory barriers. • Document species' vulnerabilities to **pollution, (development, invasives and disease, natural systems modifications and climate change)** and response to implemented actions to document changes.	• Amphibian research and monitoring (work with USGS. • Develop standardized monitoring protocols for grassland RSGCN invertebrate pollinators • Engage citizen scientists (like Maryland Statewide Eyes program) • Facilitate rapid and coordinated response to new **disease and invasive introductions.**	• Develop regionally coordinated and cost-effective monitoring protocols that meet multiple objectives across states. • Improve agreements for data sharing to support adaptive and iterative management decisions across jurisdictions (better ways to collect, compile, curate, and distribute data). • Determine how pollution affects the impacts of ocean acidification.

	that address the needs of SGCN and key habitats.				• Better understand species' responses to ecological dynamics including stresses associated with **climate change.**
Communication (Education and Technical Assistance)	**OVERARCHING ACTIONS** ✓ Develop and deliver regionally consistent messaging of SWAP priorities and conservation needs. ✓ Develop improved communication approaches including outreach, education and technical assistance to target audiences including land use decision-makers, stakeholders and the public to address the top five threat impacts on SGCN and key habitats. Include benefits and risks to wildlife species and humans. ✓ Explain how threats cause RSGCN population declines or habitat degradation, to motivate partner engagement and develop more effective actions to address them. ✓ Promote regional actions in this report and in RCN project results. ✓ Promote public awareness of and support for state wildlife diversity conservation programs (e.g., SWAPs, BioMap, Beginning with Habitat).				
	• Provide clear and consistent dissemination of information to land use decision-makers and home/building/land owners and developers. • Develop effective state environmental review process, land use planning, and conservation policies to incorporate the needs of SGCN/RSGCN and key habitats to advance regional consistency (including regulations and policies for each top	• Standardize and promote buffer guidance and other BMPs. • Include large landowners such as military bases and corporate/industrial parks, USDA programs, to take advantage of opportunities to **restore important grassland and early successional habitats and minimize pollution.**	• Benefits of aquatic connectivity to SGCN. • Costs and risks of degrading dams. • Best practices for dam/culvert upgrading or removal. • Importance of minimum flows or levels to SGCN.	• Communicate SWAP priorities to groups involved with native species promotion and invasive species eradication. • Apply lessons learned from fighting white-nose syndrome – increased communication and coordination. • Develop targeted outreach and education messages and need for conservation actions (for priority species and habitats) for target audiences to prevent the introduction and spread of invasives and disease.	• Explain how states are working together toward objectives. • Explain how climate change interacts with other persistent threats. • Explain how regional stewardship of vulnerable species can be accomplished and why it is important.

	threat (water management).				
Planning and Coordination	**Overarching Actions** ✓ Develop feasible plans for effectiveness measures to improve project reporting and adaptive management. ✓ Build funding and capacity to protect the nearly 3000 SGCN listed in NE SWAPs. ✓ Incorporate SWAP Priorities and Regional (Nature's Network) into all levels of planning to conserve RSGCN and Key Habitats				
	• Implement smart growth planning initiatives such as the Staying Connected initiative (VT, ME, NH). • Provide regional SWAP and partner priorities highlighting RSGCN and key habitats for incorporation n local, state and regional planning efforts.	• Provide regional SWAP and partner priorities for incorporation into local, state and regional water and watershed planning efforts highlighting RSGCN and key habitats.	• Consider SGCN requirements when regulating wells near SGCN habitats. • Consider Regulations & Policies for Dam and Water Management. • Consider SGCN Life-History Requirements with Dam Flow-Release Schedules and Practices. • Consider SGCN Life-History Requirements for wells in proximity to SGCN habitats. • Reduce Impact of Aquifer Withdrawals in Coastal Areas.	• Identify target areas for disease prevention (e.g., Appalachia endemics). • Identify next steps for Ranavirus prevention and treatment based on RCN project results. • Develop plans for prevention and treatment of emerging fish (and other taxa) diseases. • Develop regionally coordinated early detection/rapid response plans for both invasives and disease. • Develop protocols for treatment, containment, mitigation of diseases. • Improve disease prevention strategies (quarantine and risk assessment). • Customize the National Invasive species strategy ○ Prevention. ○ Early Detection and Rapid Response.	• Develop maps of refugia for vulnerable RSGCN for more strategic and long-standing SWAP implementation. • Collaborate to refine the role of State Fish and Wildlife Agencies in conserving SGCN ○ Determine management objectives for species or habitats. ○ Determine prioritization factors to direct limited funds to SGCN for long-term benefit. ○ Develop use of tools to manage uncertainty in action planning. • Develop position papers and inter-state strategies for: ○ Considering the feasibility of assisted migration of species to new suitable habitats, potentially across state lines. ○ Communication and coordination when states begin or cease to conserve

				○ Control and Management ○ Rehabilitation and restoration.	a species that has shifted into or out of the state. ○ More frequently convening experts to review emerging threats and population trends.
Law, Regulation, and Policy	**OVERARCHING ACTIONS** ✓ Review incentives, laws and policies region-wide (e.g., endangered species protection, invasive animal and plant introductions or use) ✓ Use state environmental review process to incorporate the needs of SGCN/RSGCN and key habitats.				
	• Guide acquisition, easements, and management based on RSGCN key habitats. • Develop effective habitat protection policies and zoning for RSGCN and Key habitats	• Develop effective wetland and riparian buffer incentives, policies and regulation to reduce pollution.	• Improve dam regulation discharges to provide more natural flow regimes. • Regulate water withdrawals to preserve wetlands, particularly in coastal areas where saltwater intrusion is a concern. • Inventory, assess and monitor compliance and condition of structures.	• Strengthen regulations on invasive animal and plant species. • Develop incentives and polices to reduce invasive species impacts on native species, particularly pollinators, reptiles and amphibians, fish and invertebrates or other RSGCN, as needed.	• Develop effective incentives, policies and regulations to provide for habitat shifting and to prevent loss of key coastal and upland habitats.