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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FIGURES

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
    - Section 2.12 Tidal Rivers & Streams
    - Section 2.13 Riparian & Floodplains
    - Section 2.14 Great Lakes
    - Section 2.15 Lakes & Ponds
    - Section 2.16 Shorelines
    - Section 2.17 Beaches & Dunes
    - Section 2.18 Tidal Wetlands & Flats
    - Section 2.19 Estuaries
    - 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.

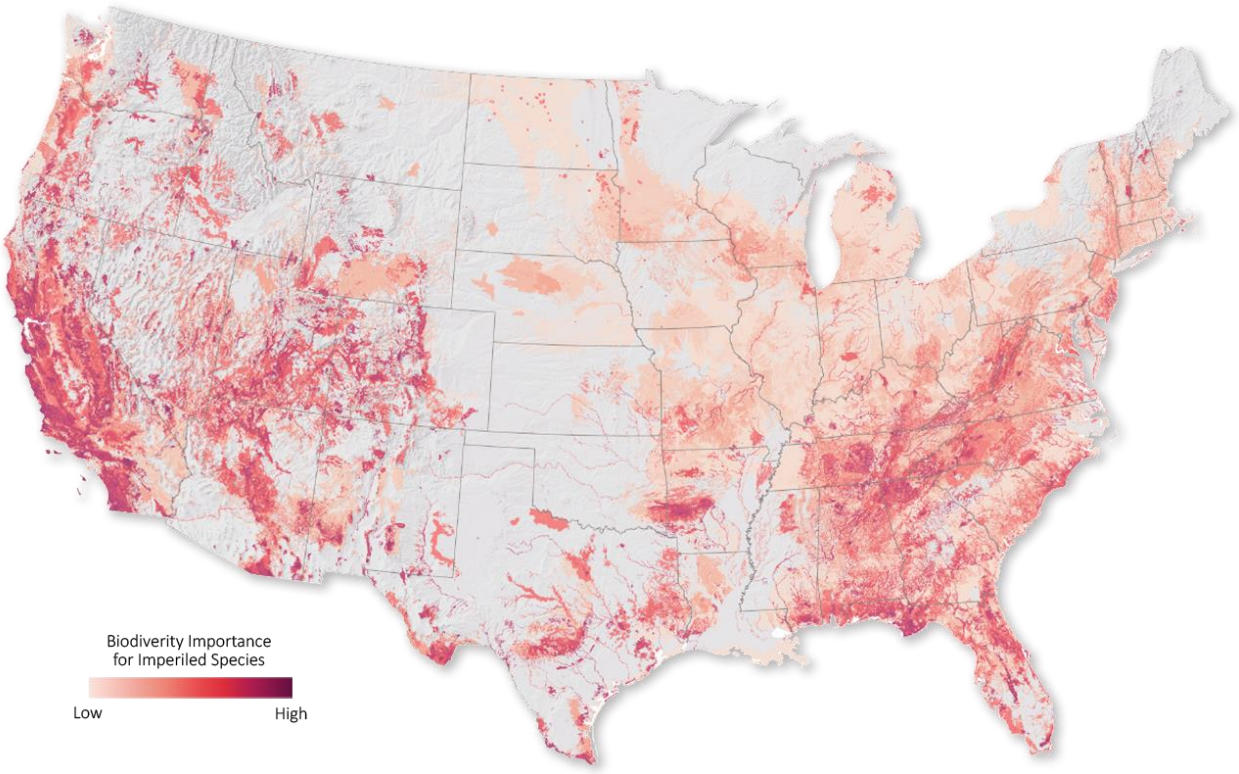

Figure 2.0. 1 NatureServe developed a Map of Biodiversity Importance in 2022 highlighting (darker shades of red) the relative importance of the United States landscape to prevent the extinction of more than 2200 imperiled species (Hamilton et al. 2022).

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.

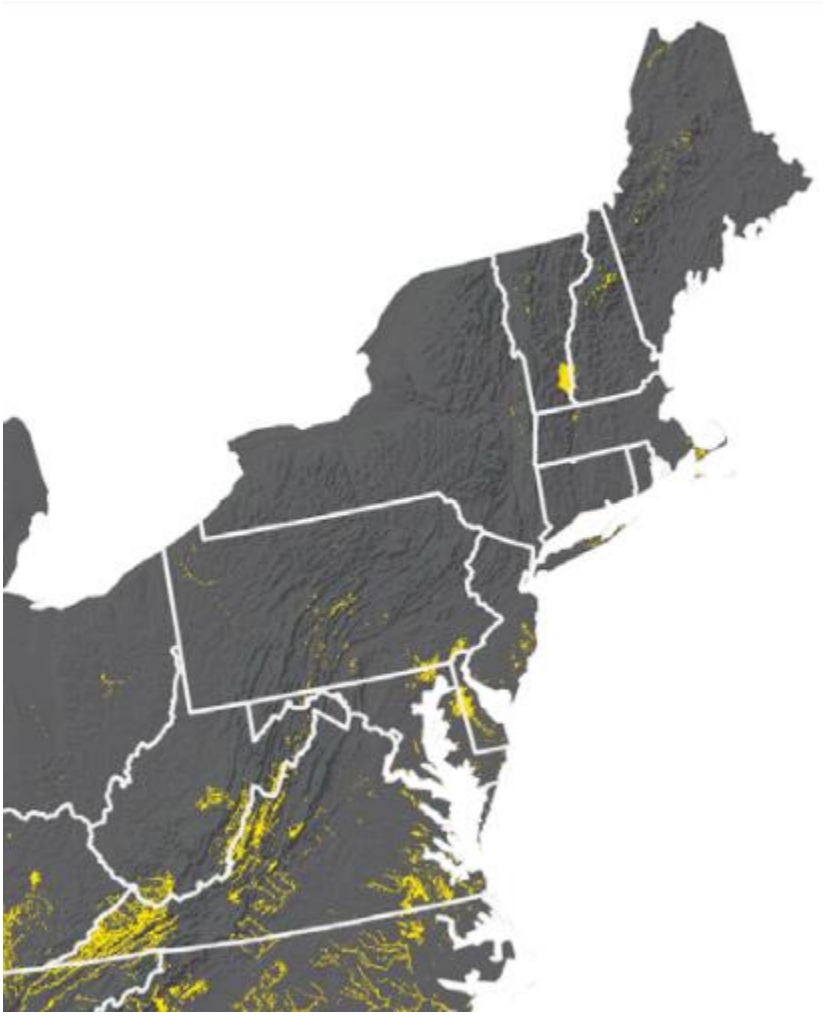

Figure 2.0. 2 Areas of Unprotected Biodiversity Importance in the Northeast (shown in yellow) identified by Hamilton et al. (2022).

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

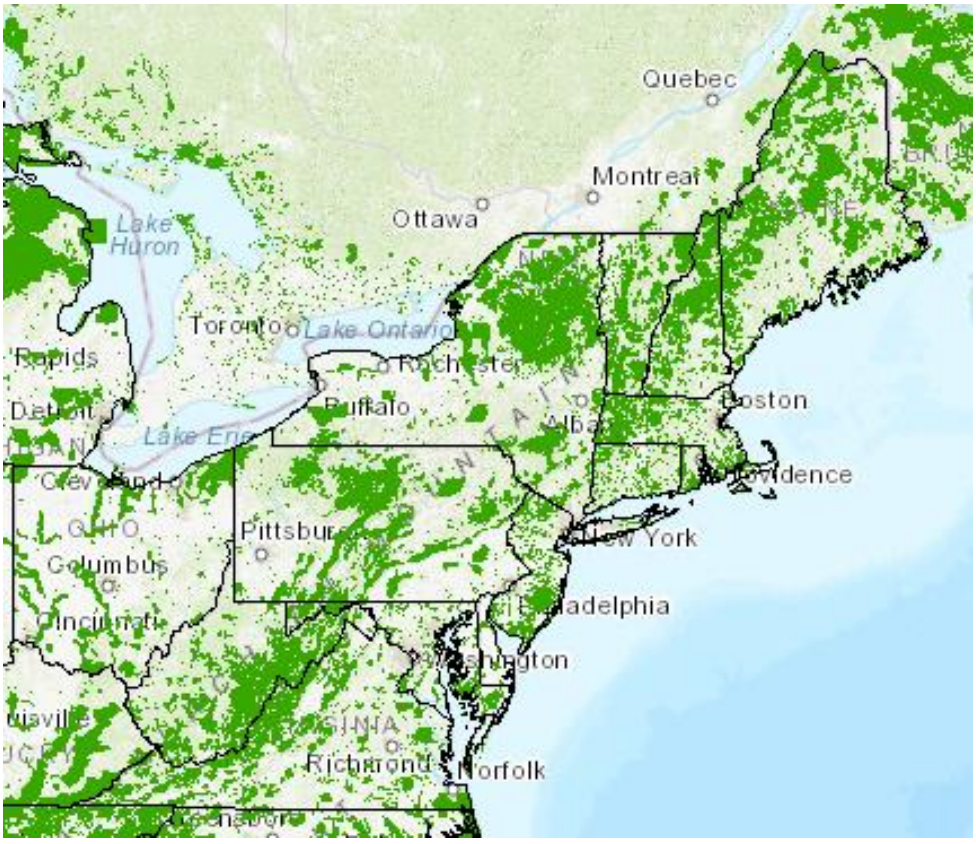

Figure 2.0. 3 Areas of the Northeast region identified with Recognized Biodiversity Value (shown in dark green) as part of the Resilient and Connected Network by Anderson et al. (2016a, 2016b).

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**

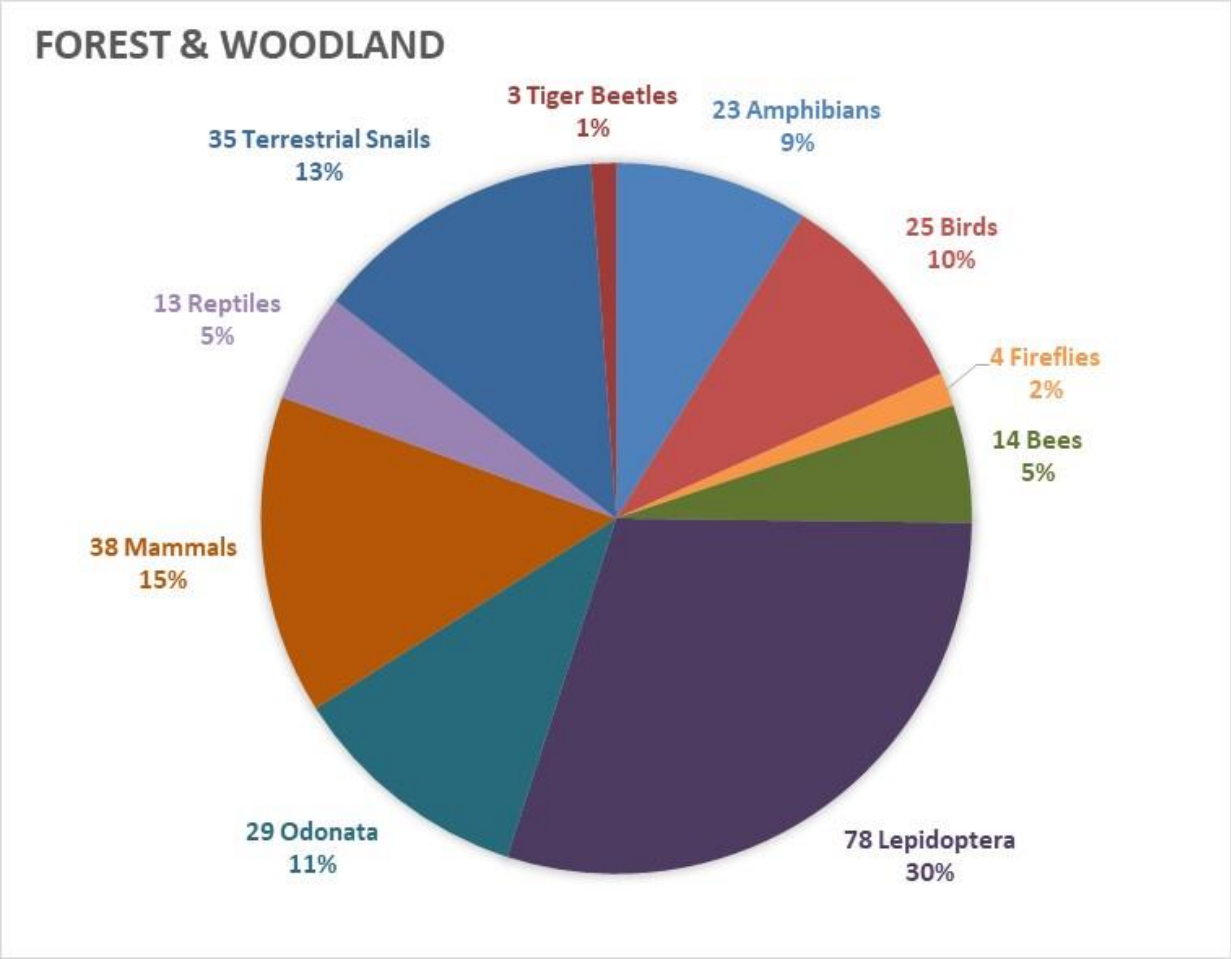

Figure 2.1. 1 Northeast RSGCN and Watchlist species associated with Forest and Woodland habitats represent ten taxonomic groups.

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

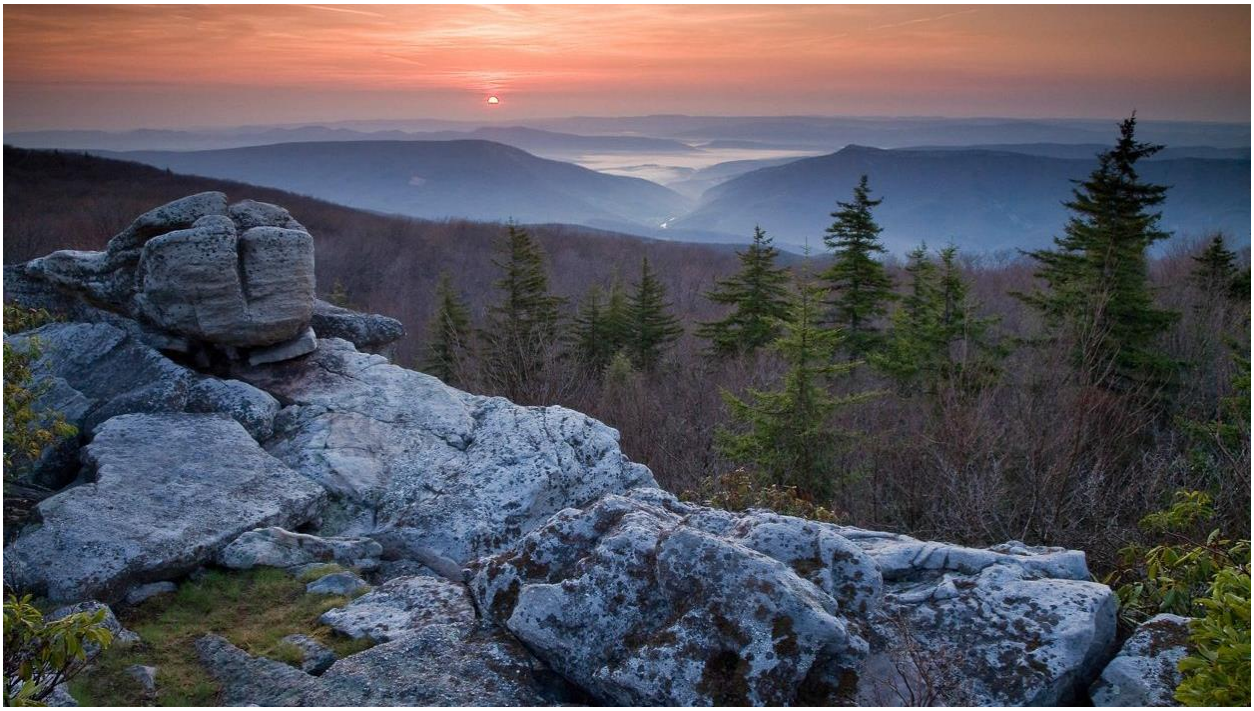

Figure 2.2. 1 High-Elevation Forest habitats support 43 Northeast RSGCN and Watchlist species (Red spruce forest in WV photo credit: Kent Mason).

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**

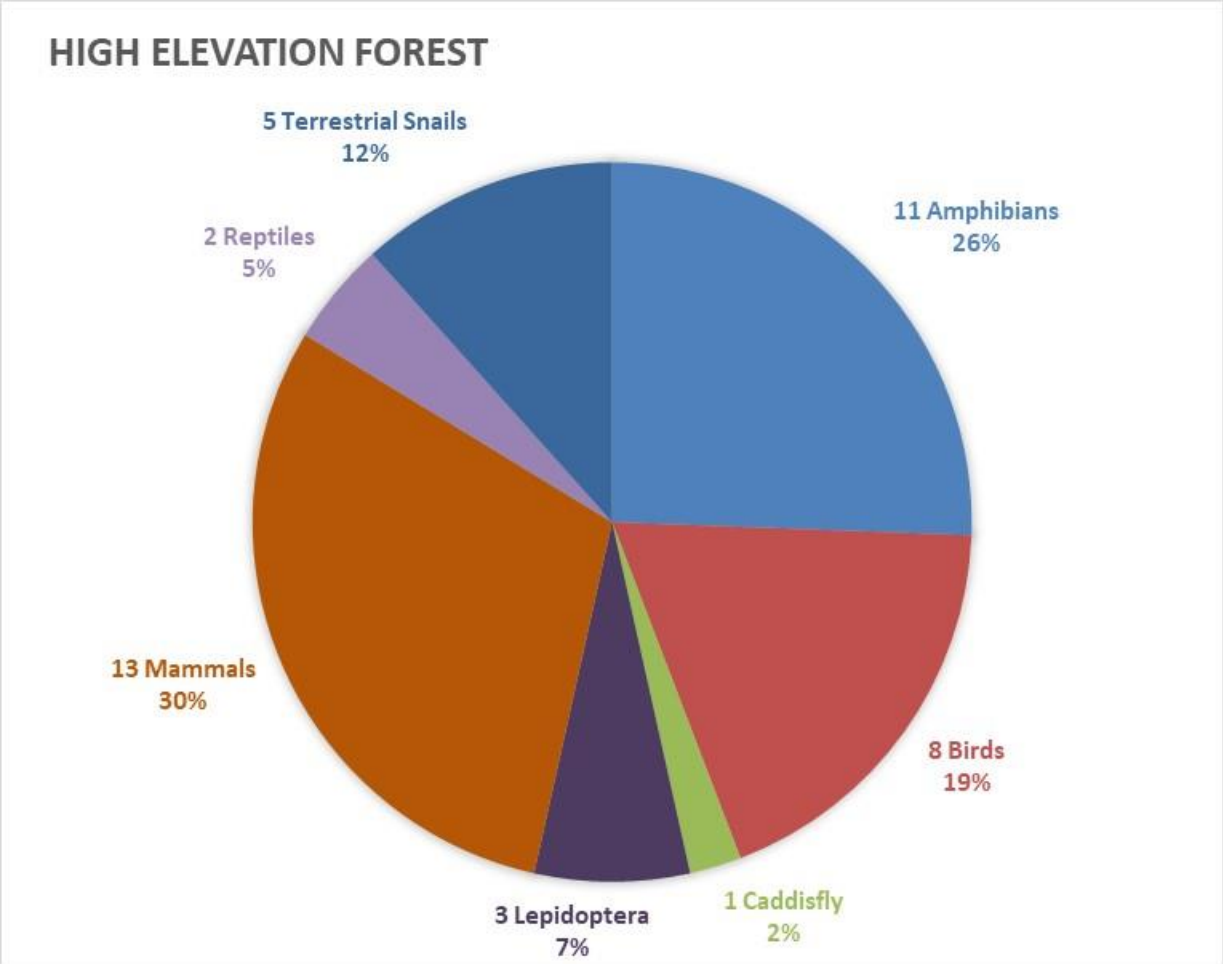

Figure 2.2. 2 Northeast RSGCN and Watchlist species associated with High-Elevation Forest habitats represent five taxonomic groups.

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.

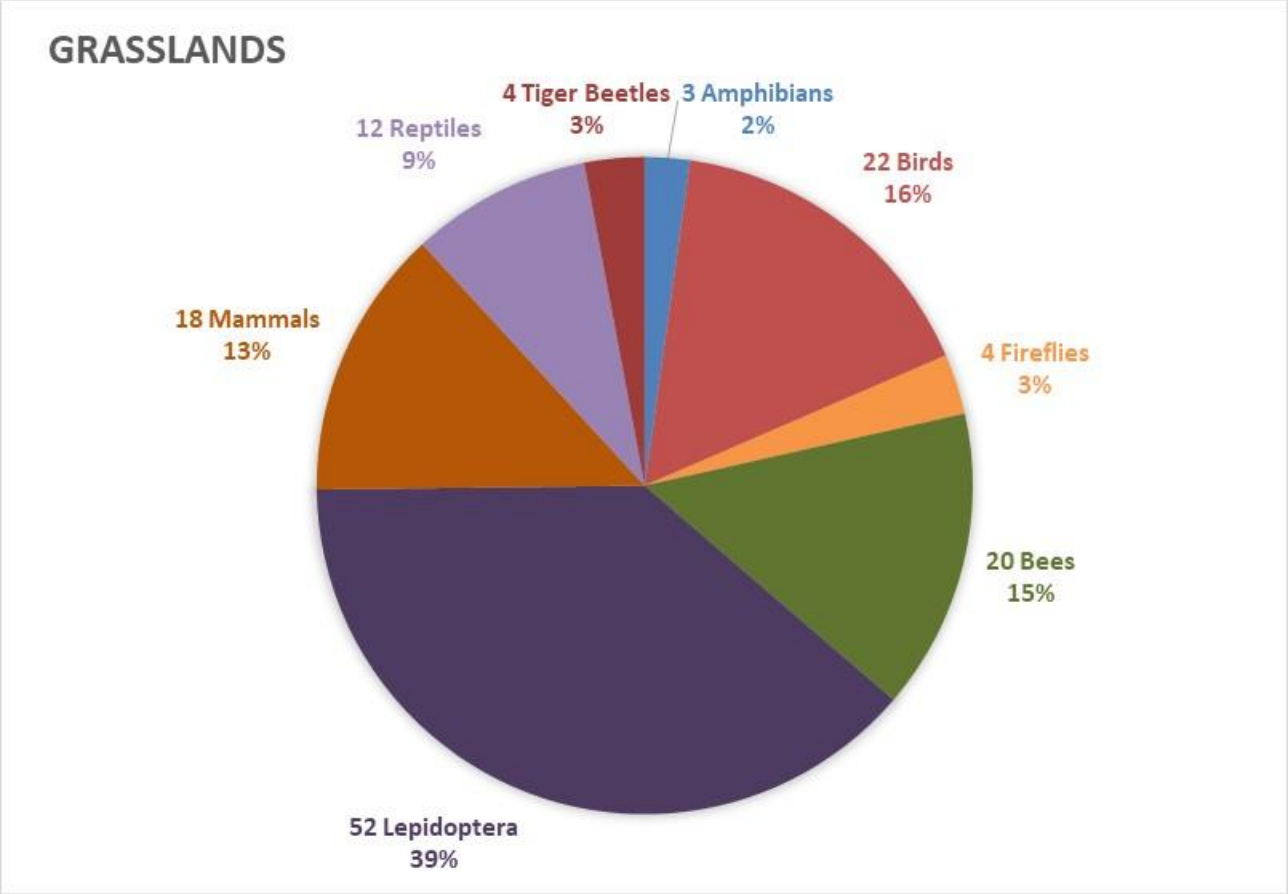

Figure 2.3. 2 Northeast RSGCN and Watchlist species associated with Grasslands habitats represent eight taxonomic groups.

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.

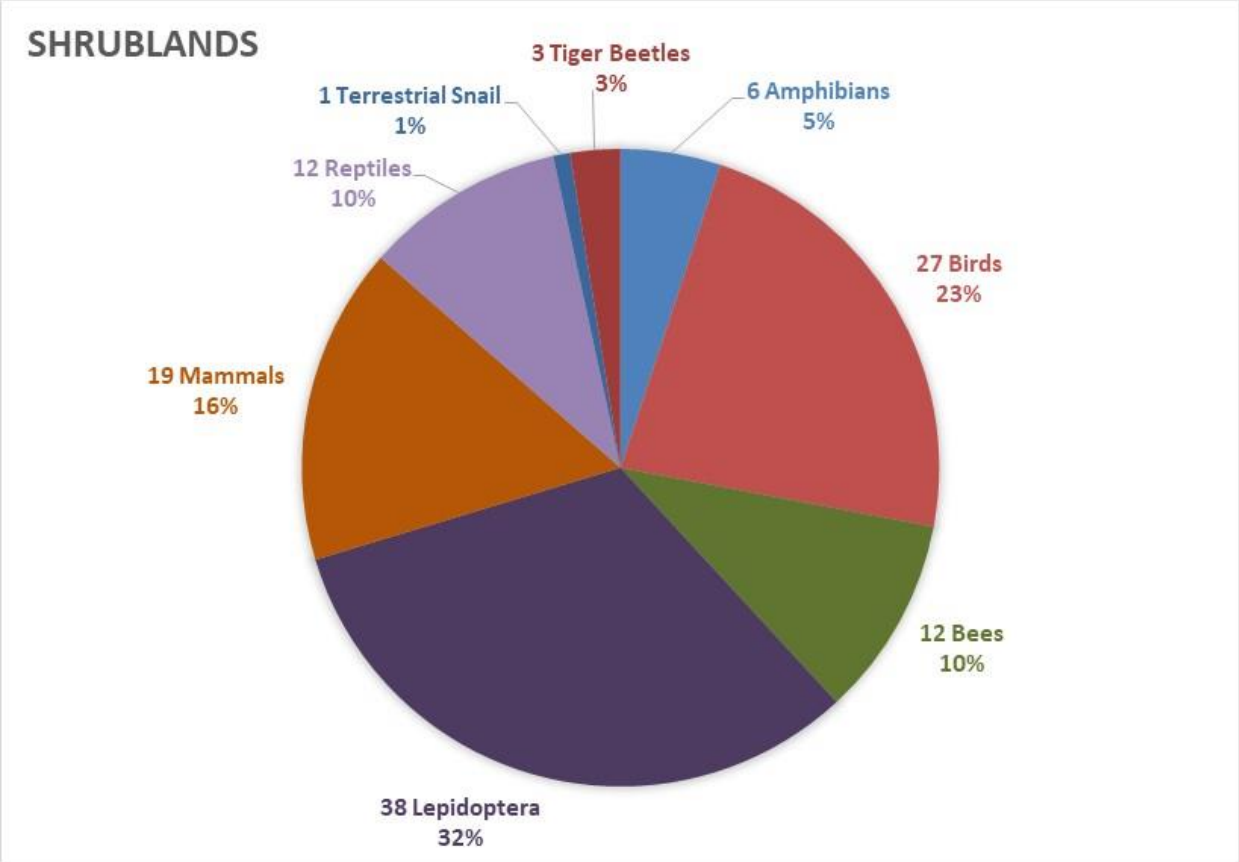

Figure 2.4. 2 Northeast RSGCN and Watchlist species associated with Shrubland habitats represent eight taxonomic groups.

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**

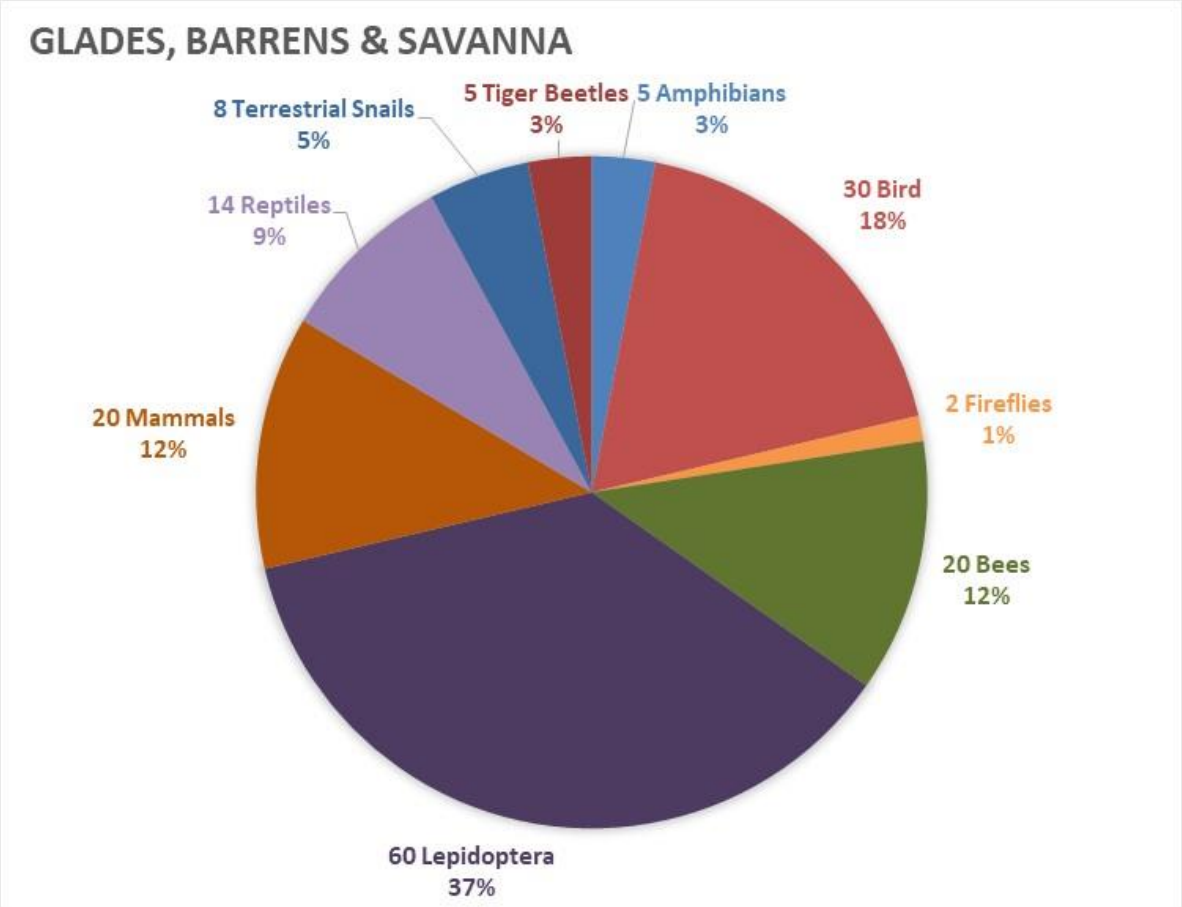

Figure 2.5. 2 Northeast RSGCN and Watchlist species associated with Glades, Barrens and Savanna habitats represent nine taxonomic groups.

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*):

Bees

- *Andrena braccata* (associate)
- *Andrena fulvipennis* (obligate)
- *Anthophora walshii* (obligate)
- *Lasioglossum arantium* (obligate)
- *Colletes bradleyi* (associate)
- *Nomada electa* (associated)

Moths

- *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.

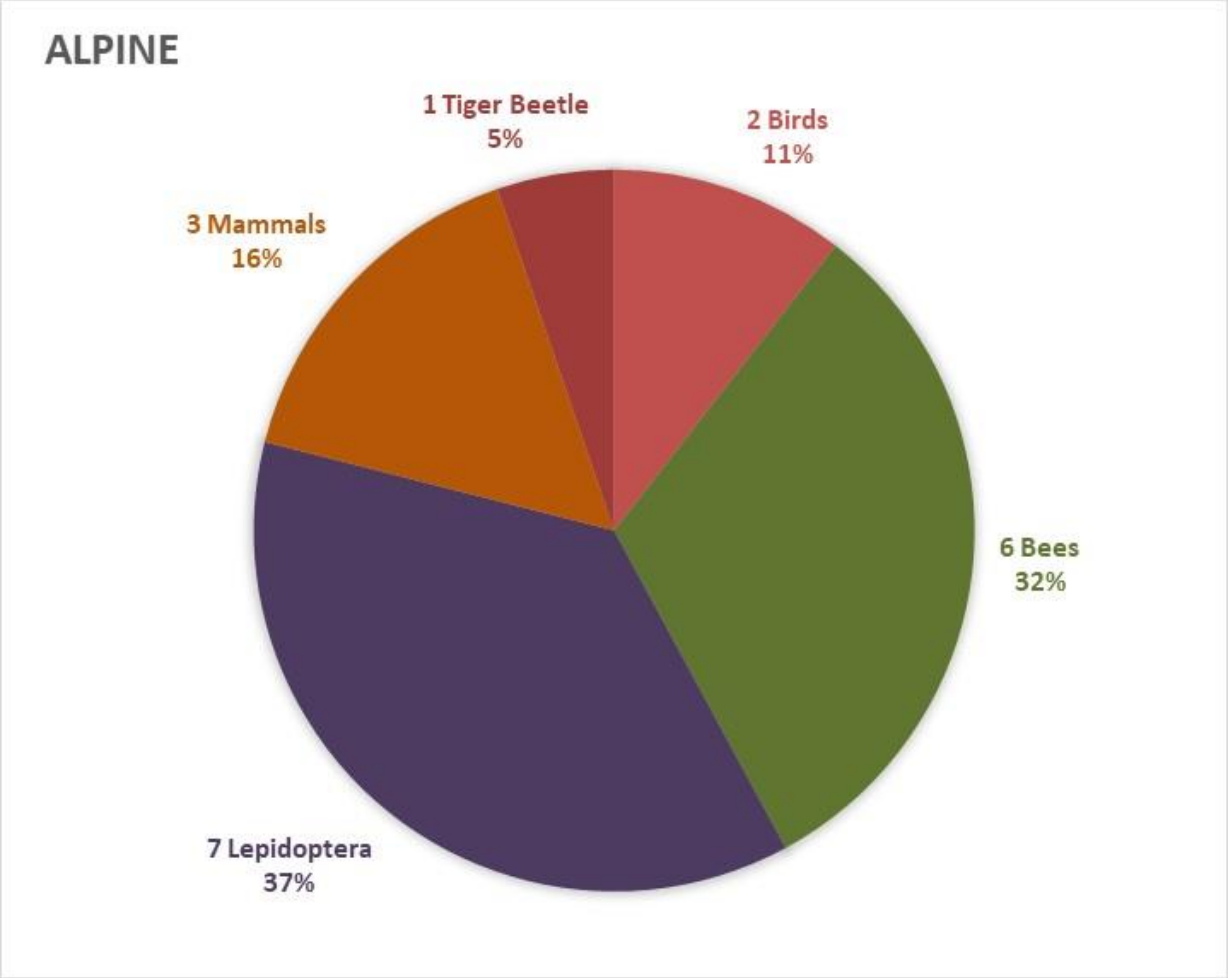

Figure 2.6. 2 Northeast RSGCN and Watchlist species associated with Alpine habitats represent five taxonomic groups.

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**

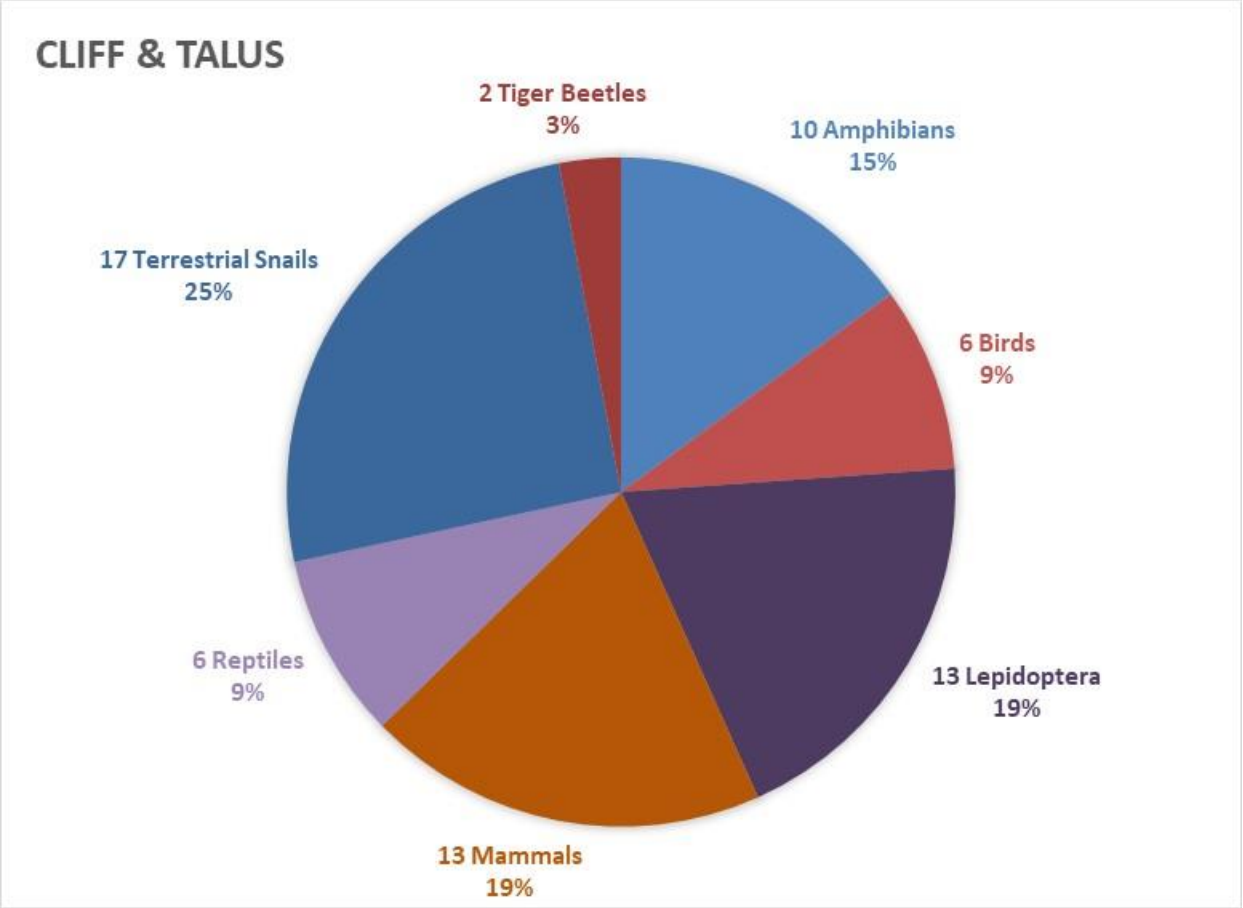

Figure 2.7. 2 Northeast RSGCN and Watchlist species associated with Cliff and Talus habitats represent seven taxonomic groups.

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).

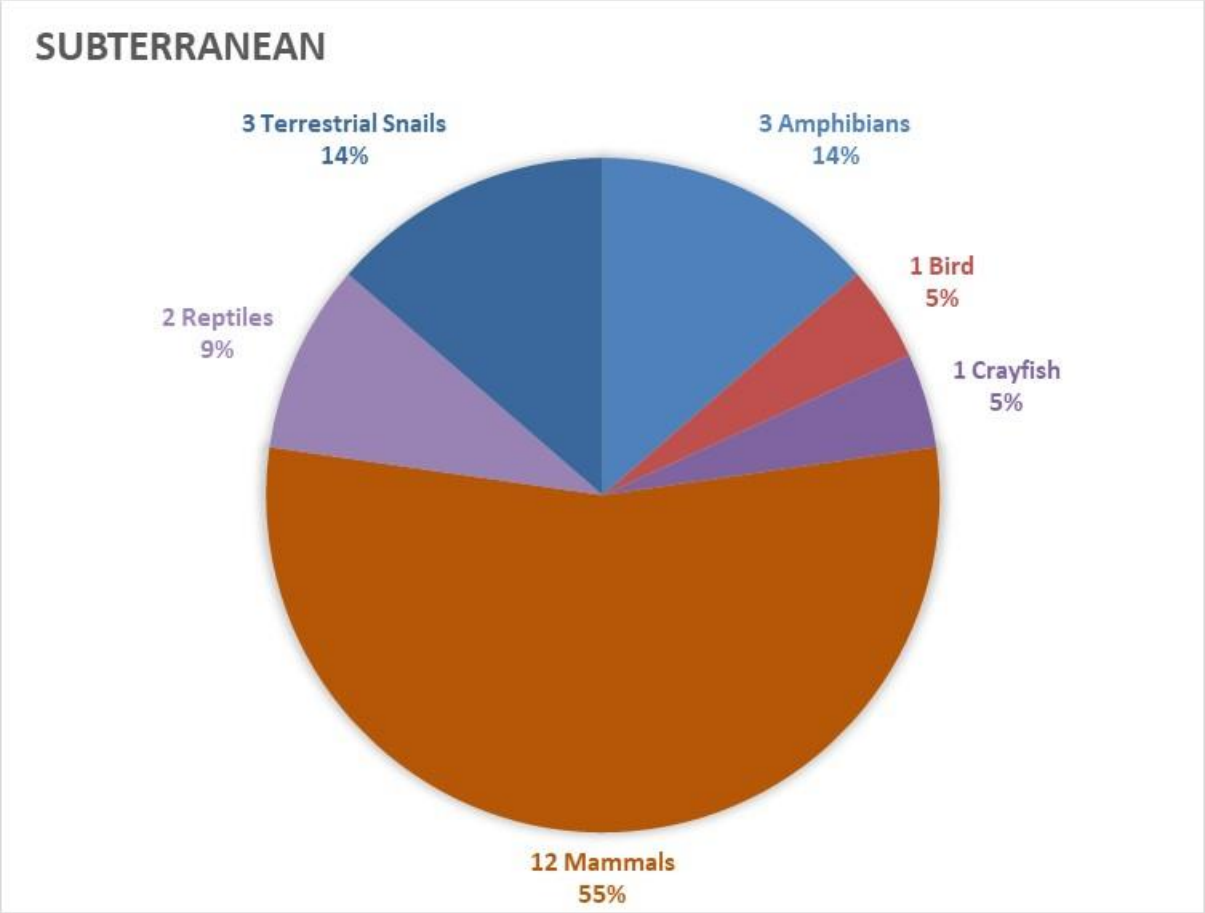

Figure 2.8. 2 Northeast RSGCN and Watchlist species associated with Subterranean Areas habitat represent five taxonomic groups.

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)

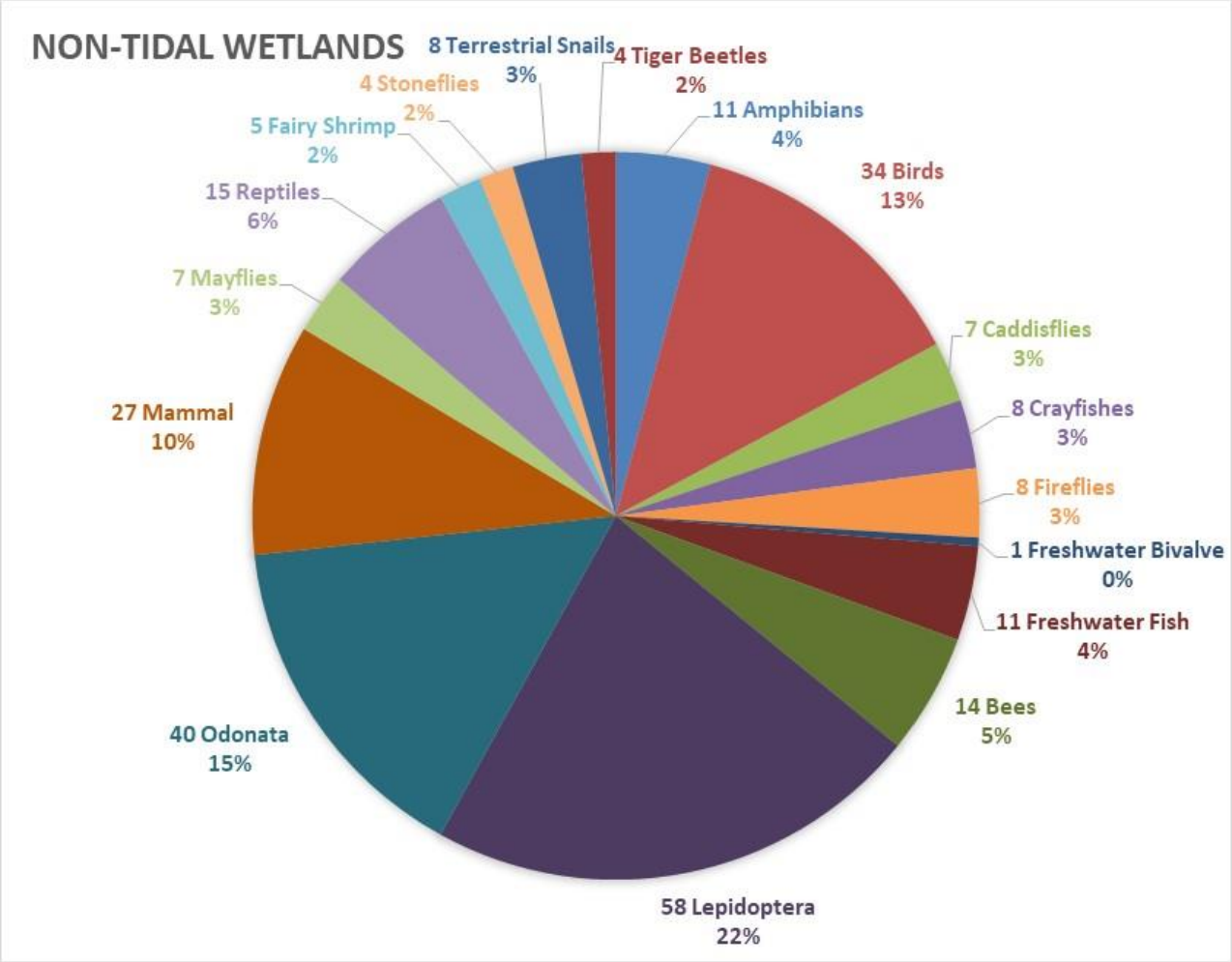

Figure 2.9. 1 Northeast RSGCN and Watchlist species associated with Non-Tidal Wetland habitats represent 17 taxonomic groups.

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.

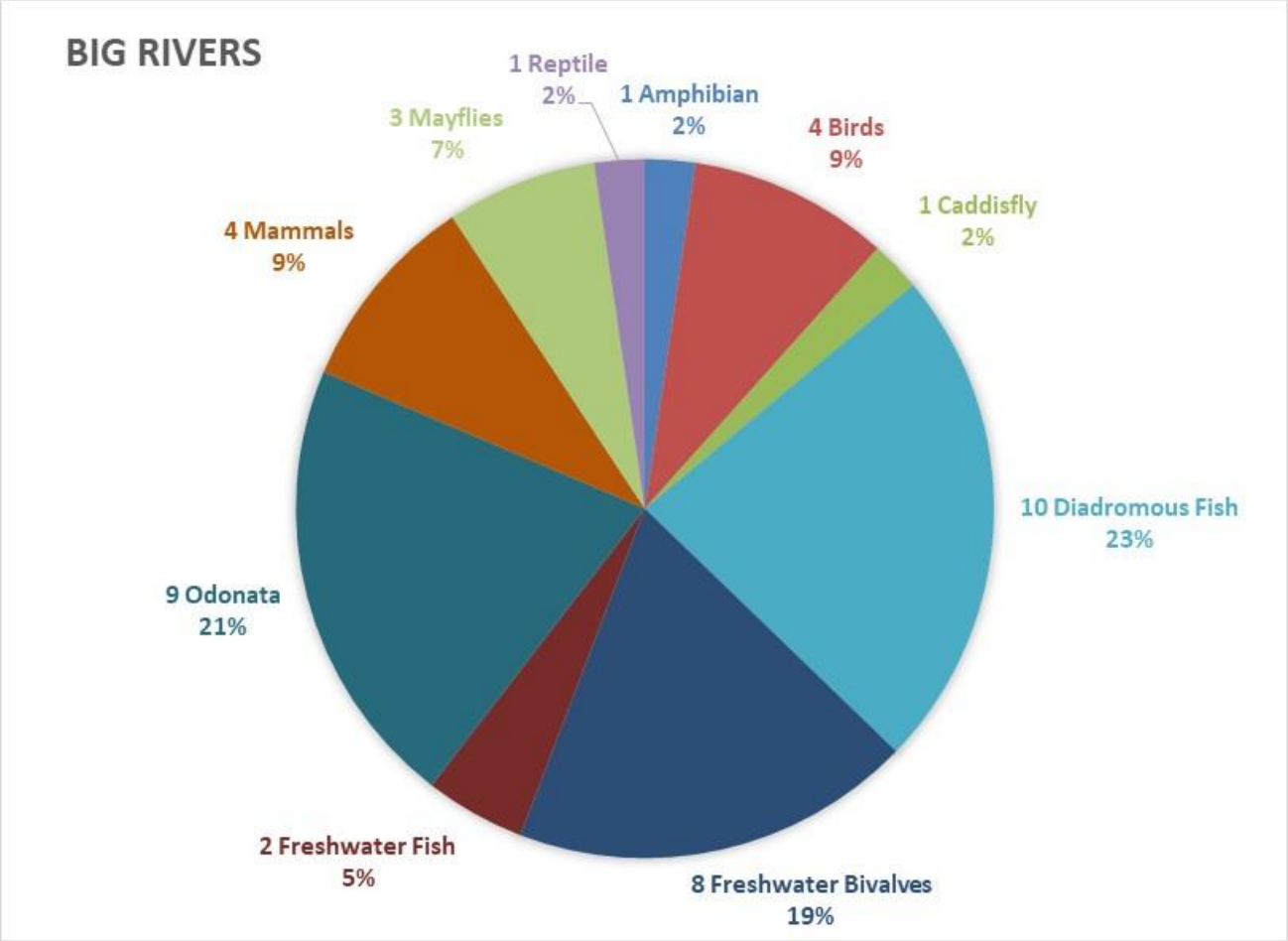

Figure 2.10. 2 Northeast RSGCN and Watchlist species associated with Big Rivers habitats represent ten taxonomic groups.

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

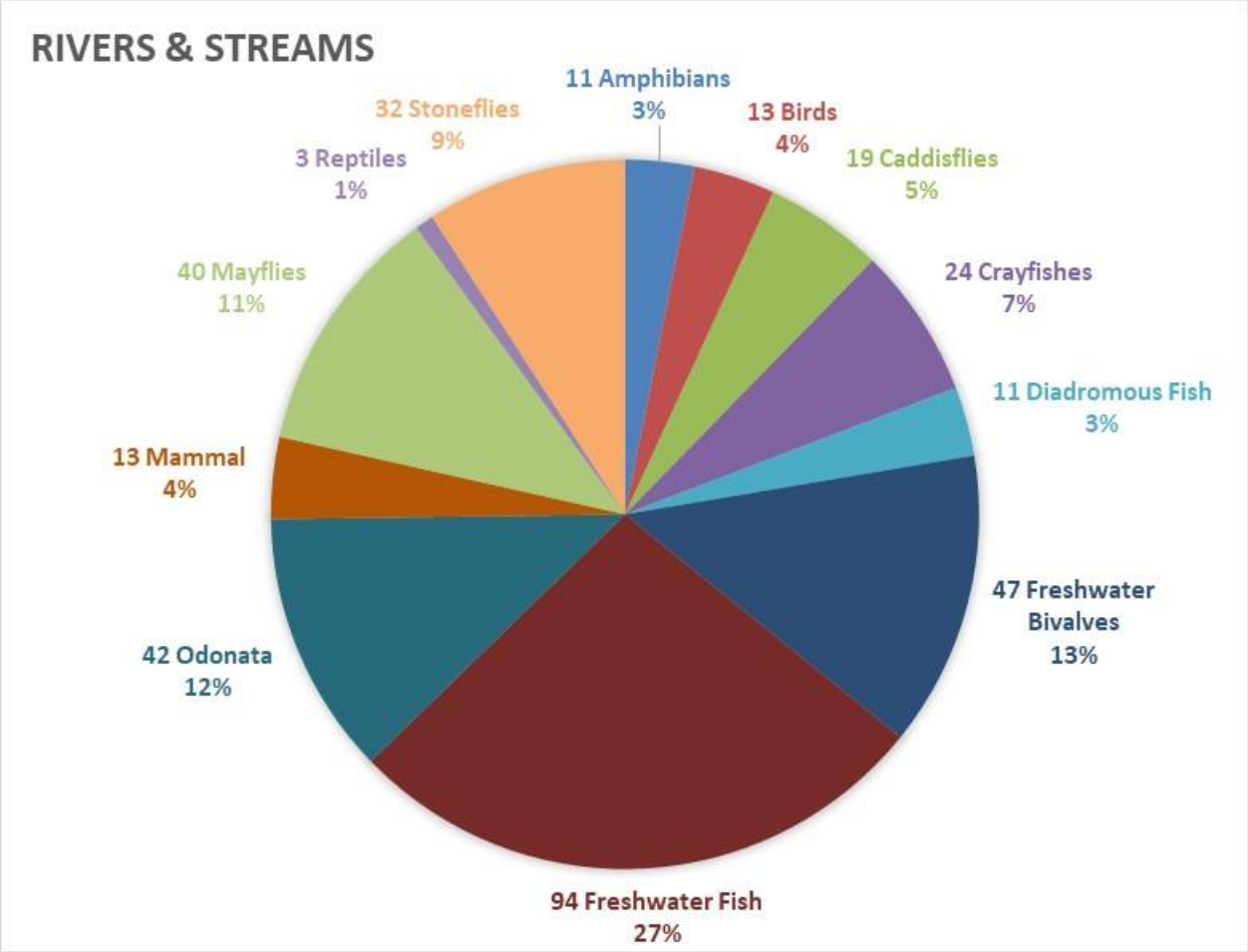

Figure 2.11. 2 Northeast RSGCN and Watchlist species associated with River and Stream habitats represent 12 taxonomic groups.

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**

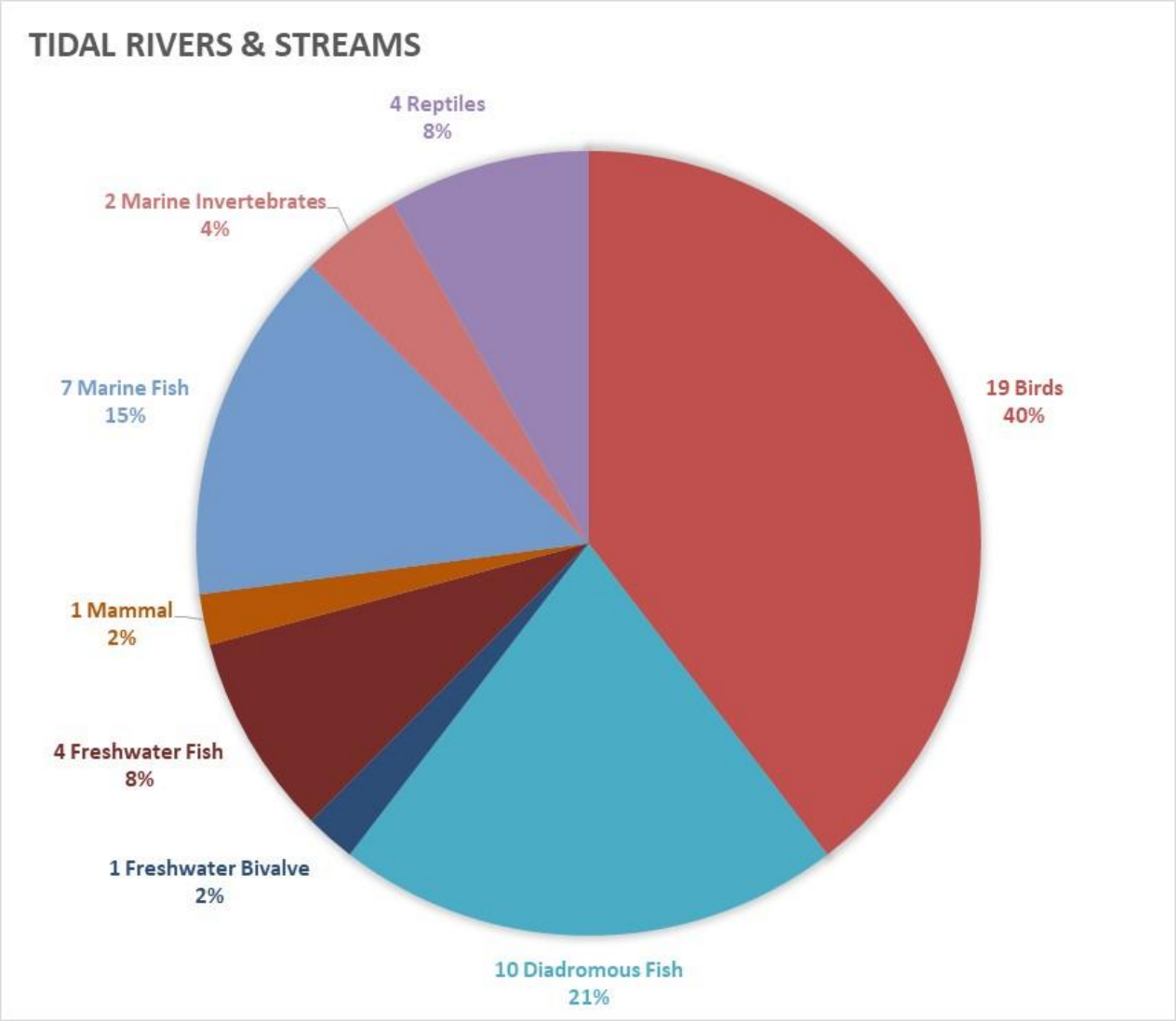

Figure 2.12. 2 Northeast RSGCN and Watchlist species associated with Tidal River and Stream habitats represent 13 taxonomic groups.

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.

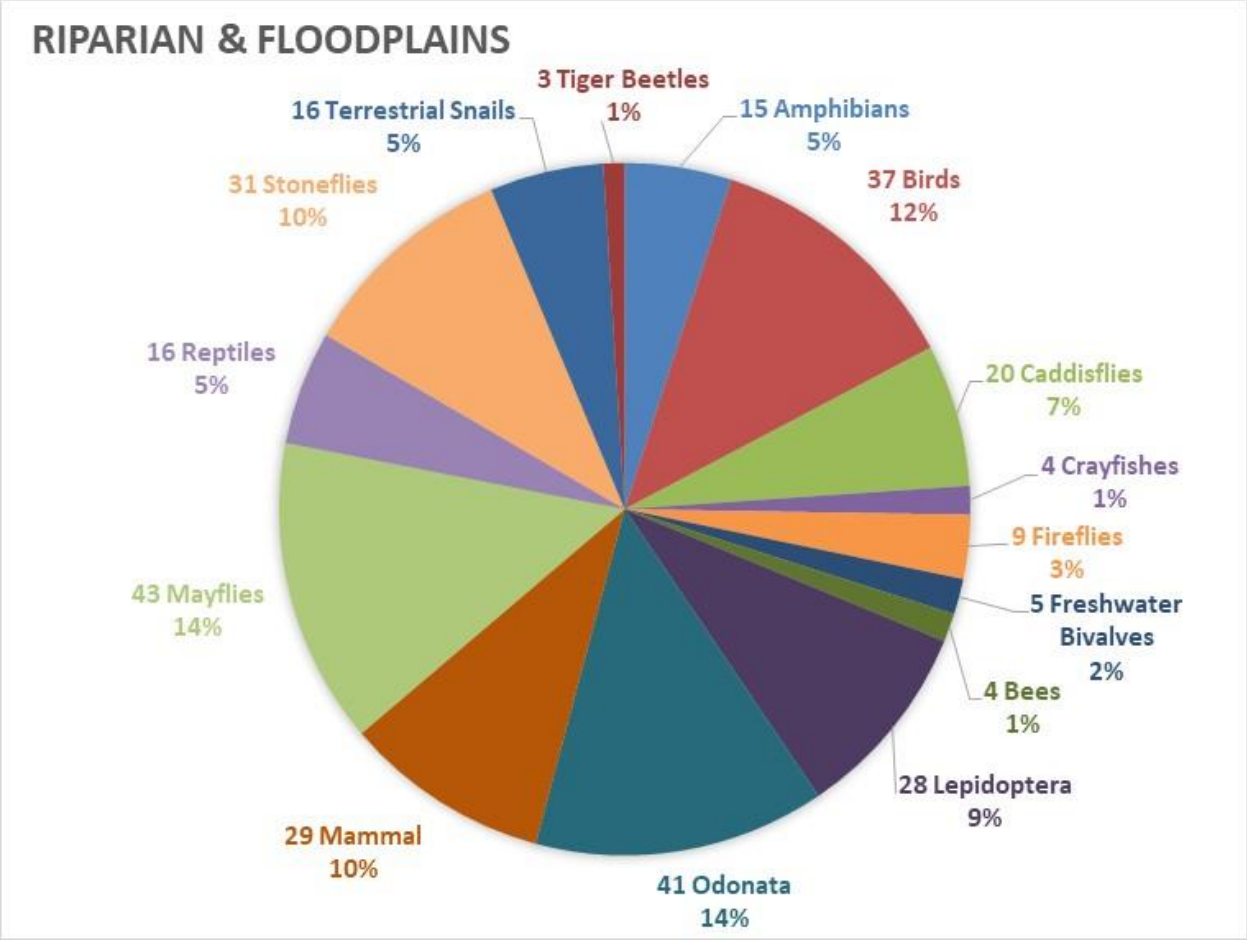

Figure 2.13. 2 Northeast RSGCN and Watchlist species associated with Riparian and Floodplain habitats represent 15 taxonomic groups.

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.

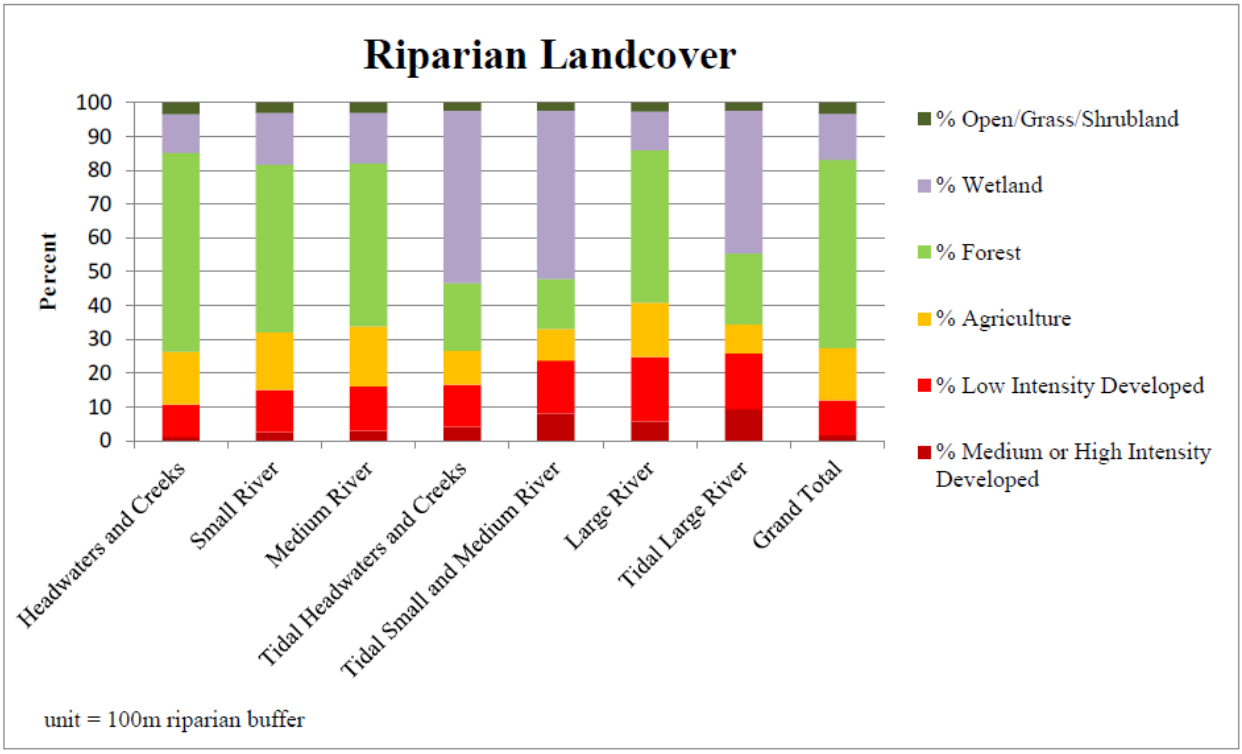

Figure 2.13. 3 Land cover types within the 100-meter Riparian area along Rivers and Streams and Tidal Rivers and Streams of the Northeast as of 2006, from Anderson et al. (2013b).

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.

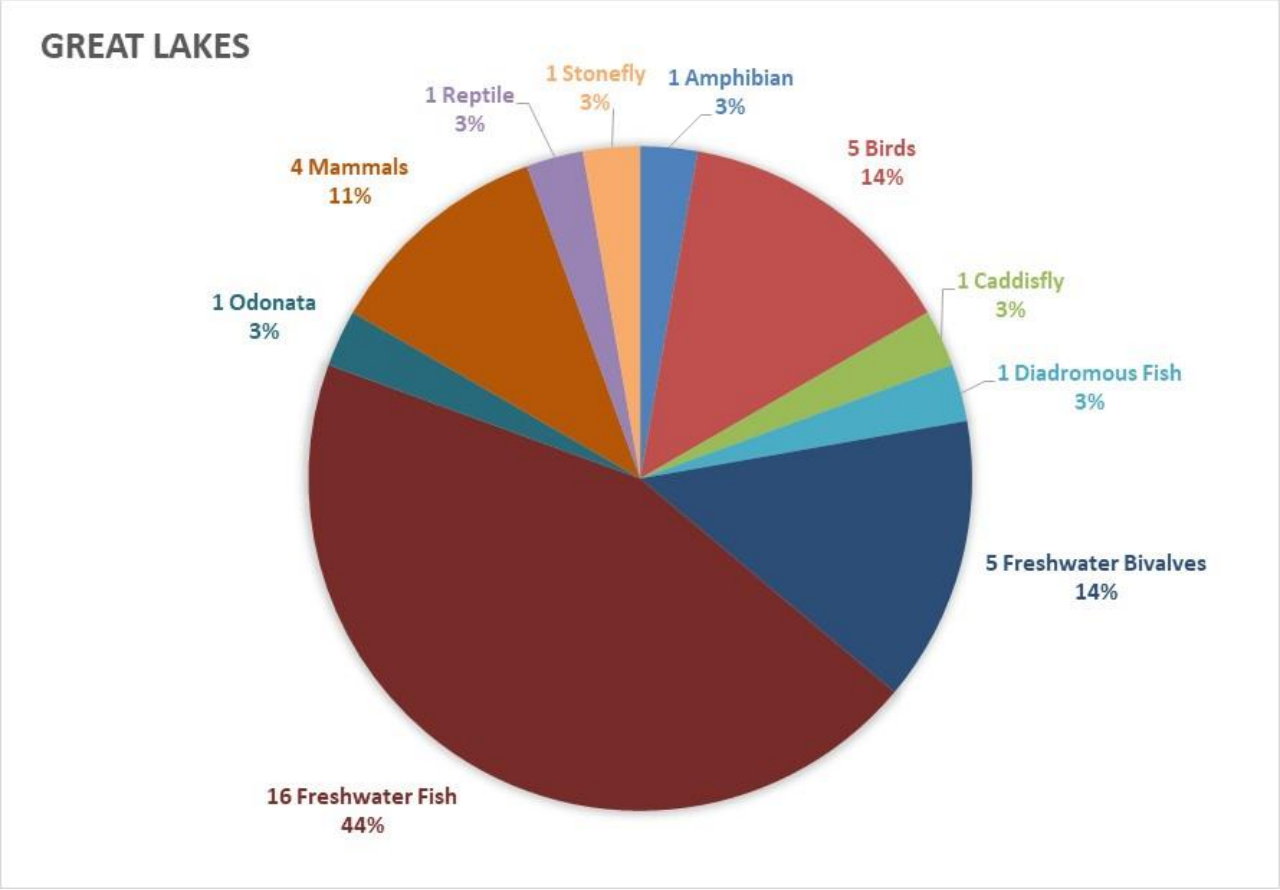

Figure 2.14. 2 Northeast RSGCN and Watchlist species associated with Great Lakes habitat represent ten taxonomic groups.

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**

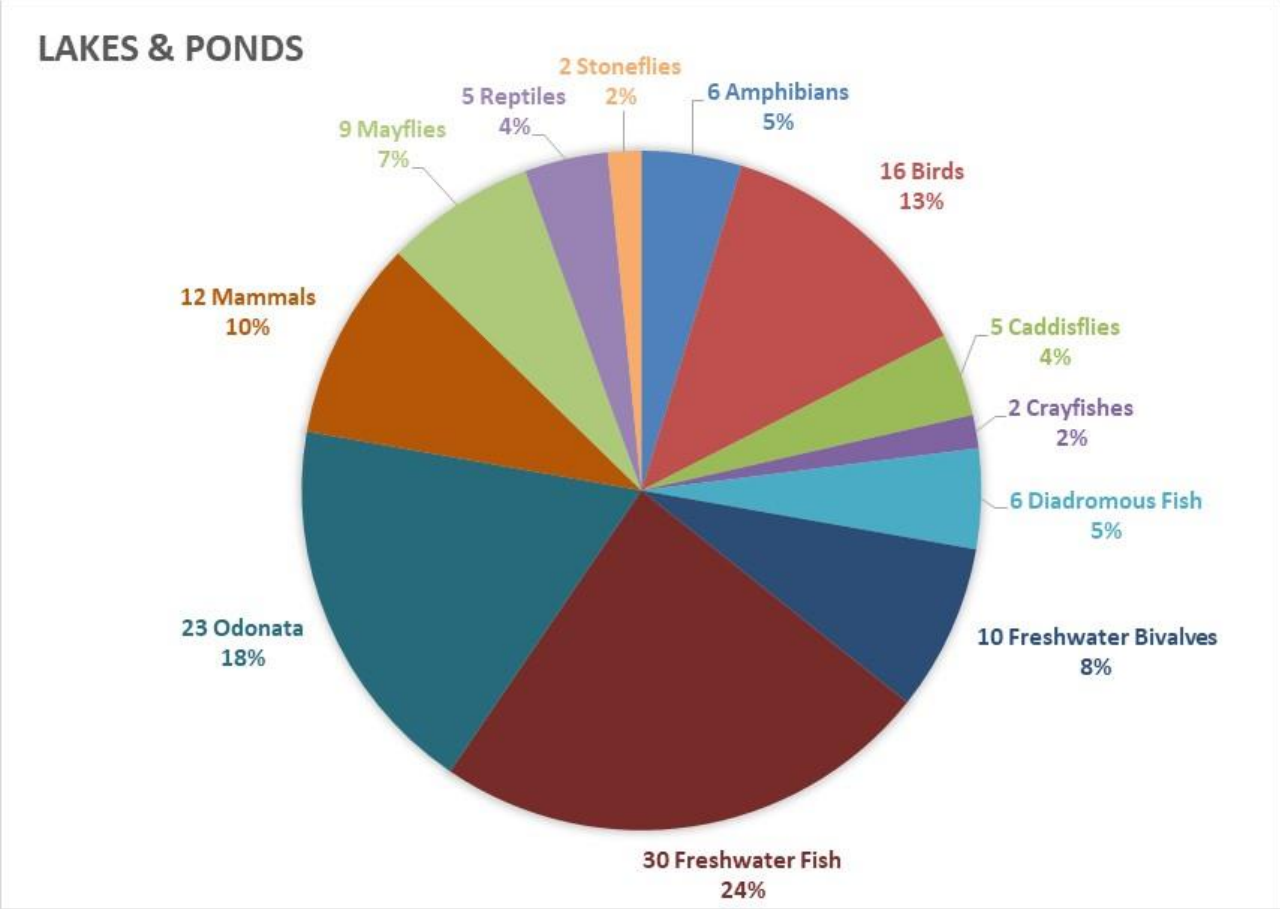

Figure 2.15. 2 Northeast RSGCN and Watchlist species associated with Lake and Pond habitats represent 12 taxonomic groups.

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.

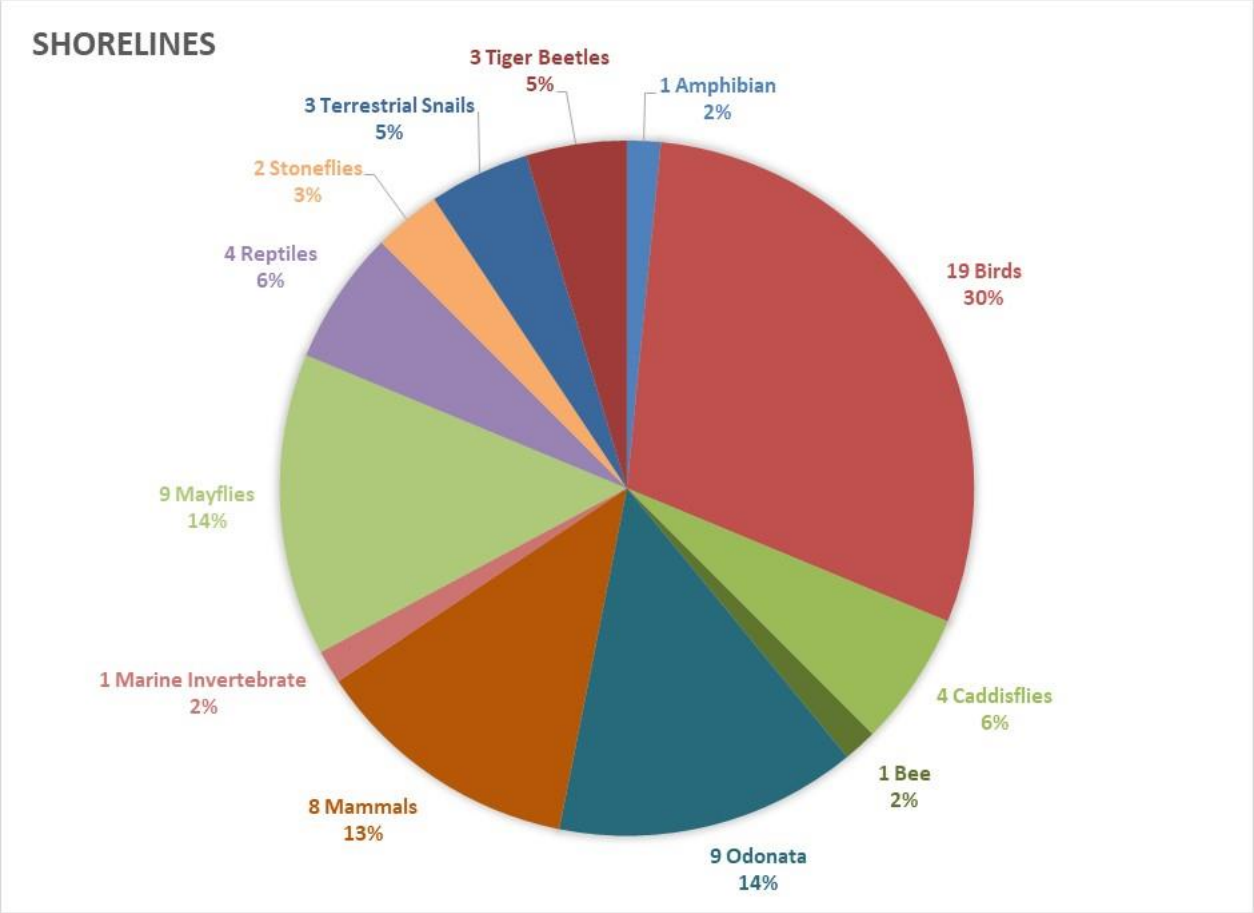

Figure 2.16. 2 Northeast RSGCN and Watchlist species associated with Shorelines habitat represent 12 taxonomic groups.

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*).

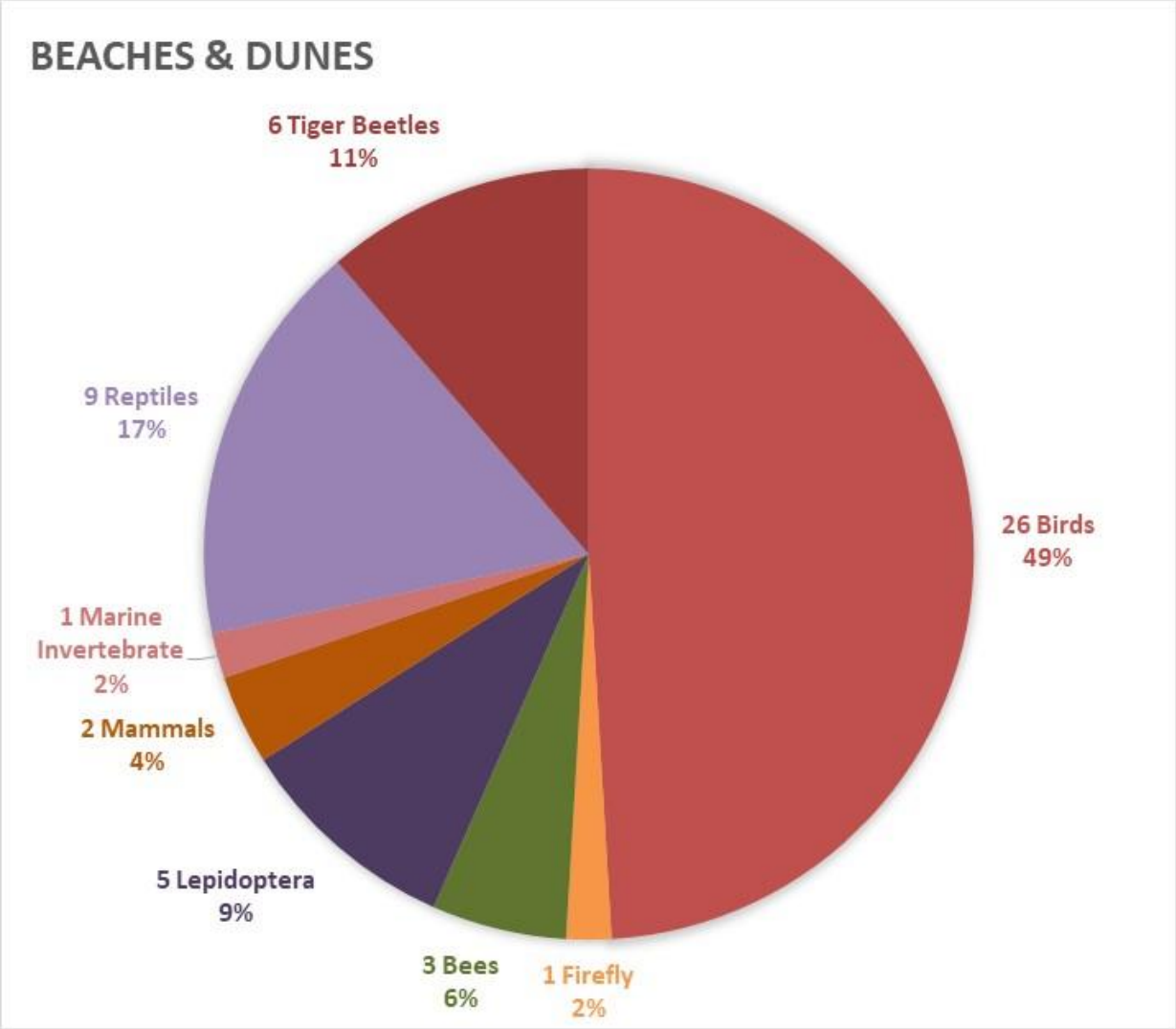

Figure 2.17. 2 Northeast RSGCN and Watchlist species associated with Beach and Dune habitats represent eight taxonomic groups.

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

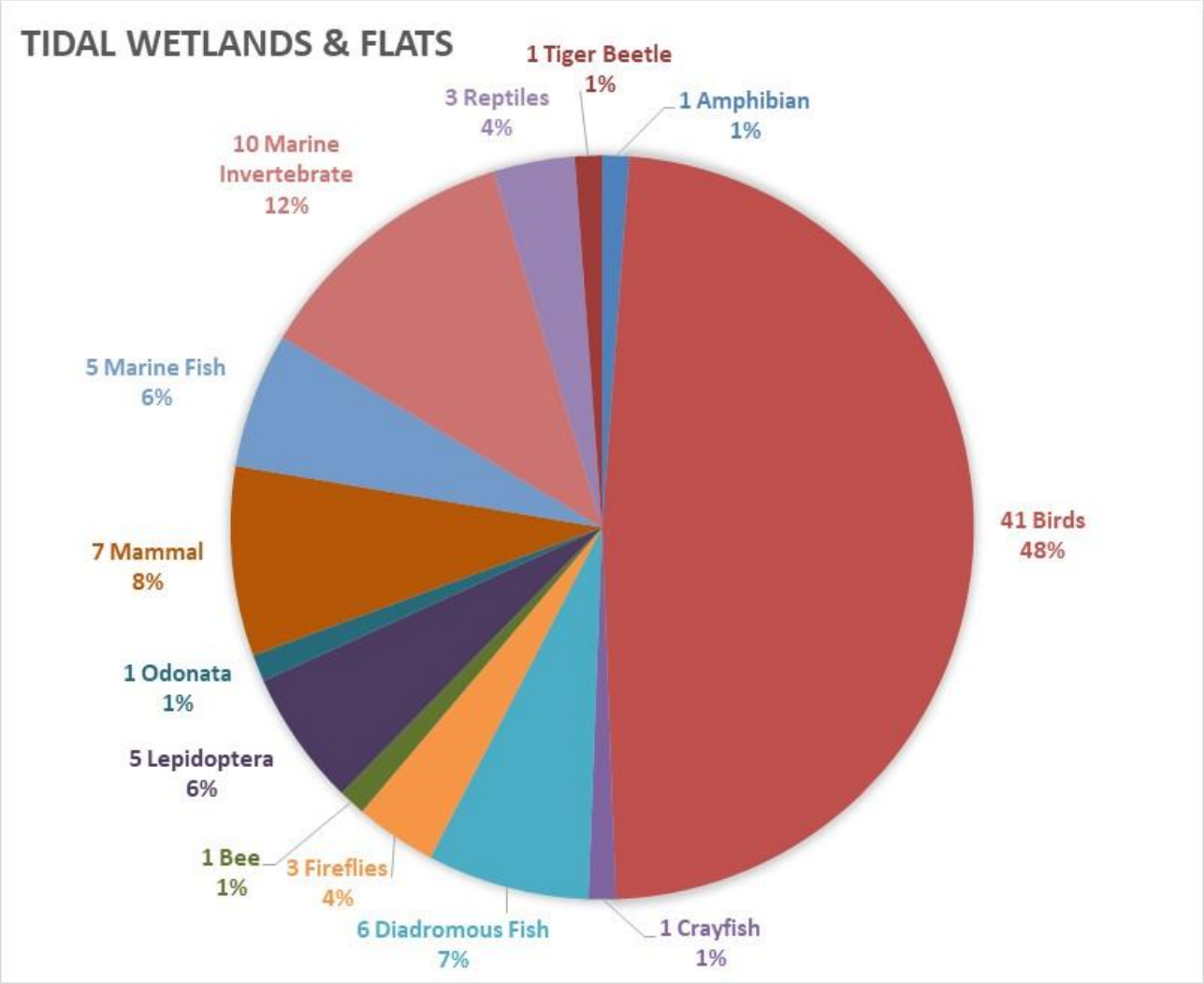

Figure 2.18. 2 Northeast RSGCN and Watchlist species associated with Tidal Wetland habitats represent 13 taxonomic groups.

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**

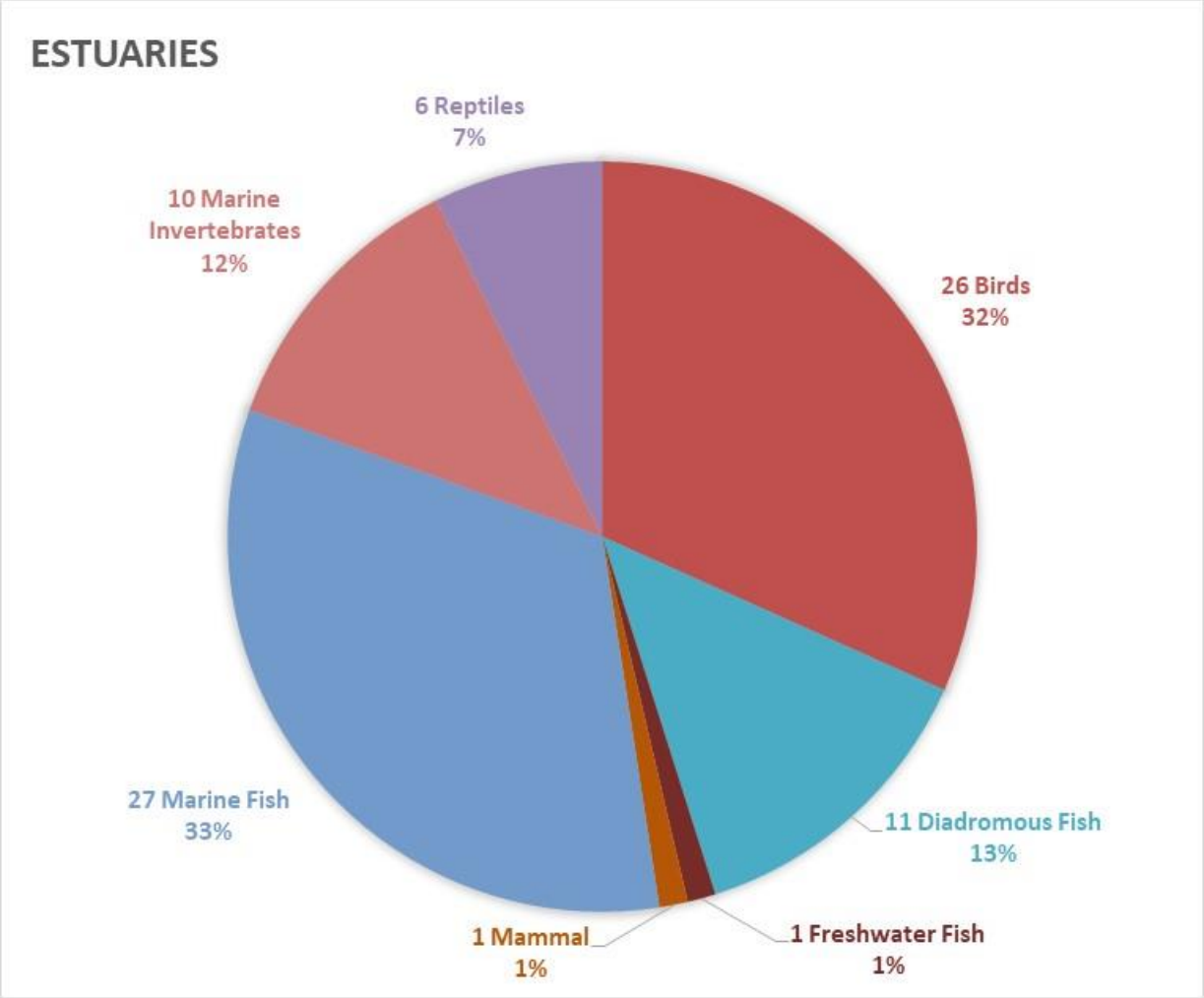

Figure 2.19. 2 Northeast RSGCN and Watchlist species associated with Estuaries habitat represent seven taxonomic groups.

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)

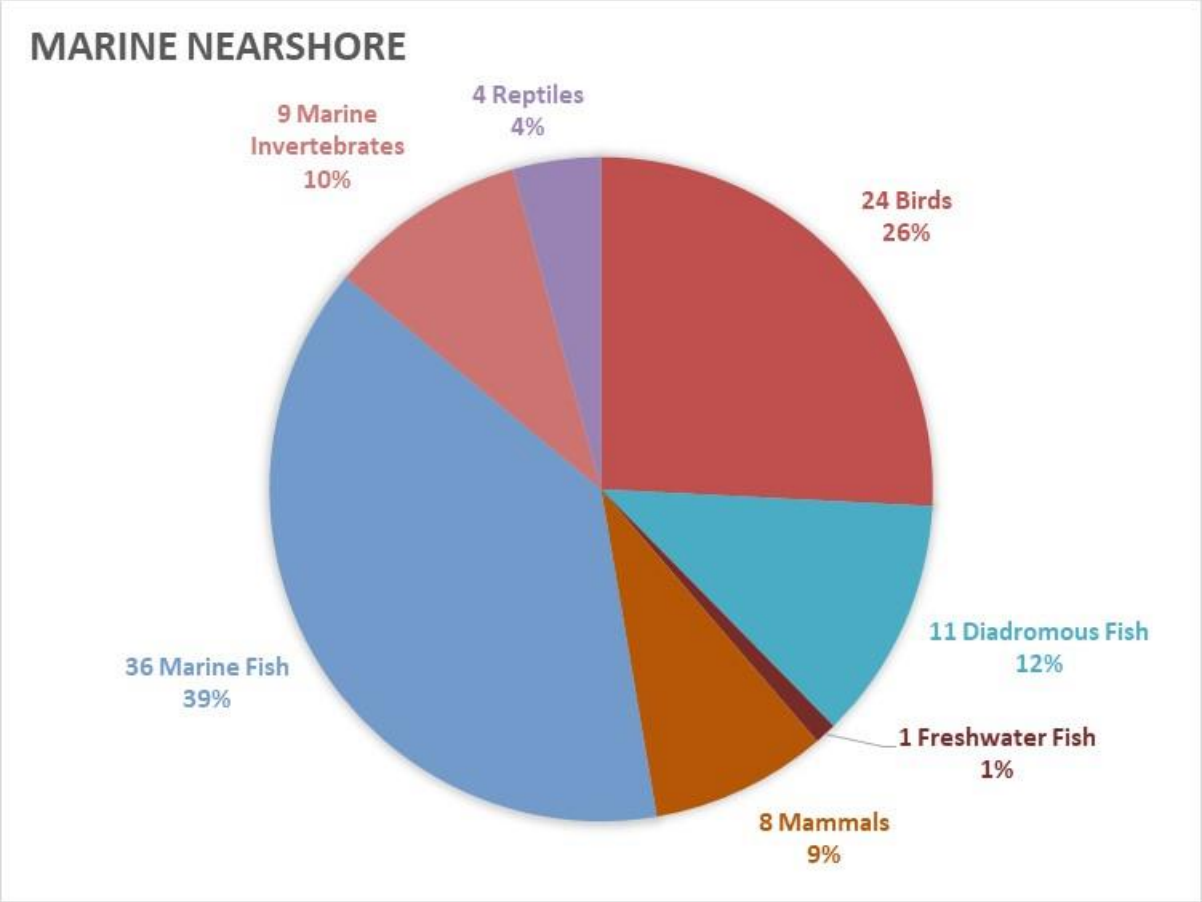

Figure 2.20. 2 Northeast RSGCN and Watchlist species associated with Marine Nearshore habitats represent seven taxonomic groups.

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

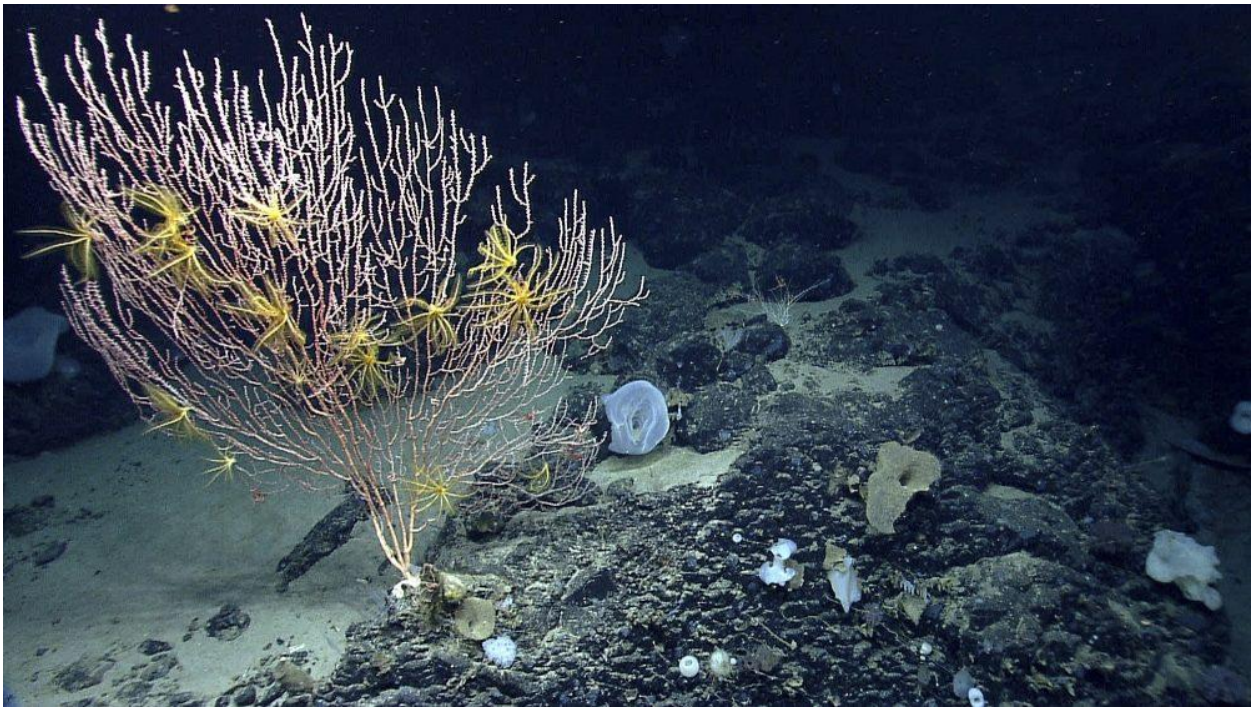

Figure 2.21. 1 Marine Offshore and Oceanic habitats support 75 Northeast RSGCN and Watchlist species. (Canyons and Seamounts National Marine Monument photo credit: NOAA).

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**

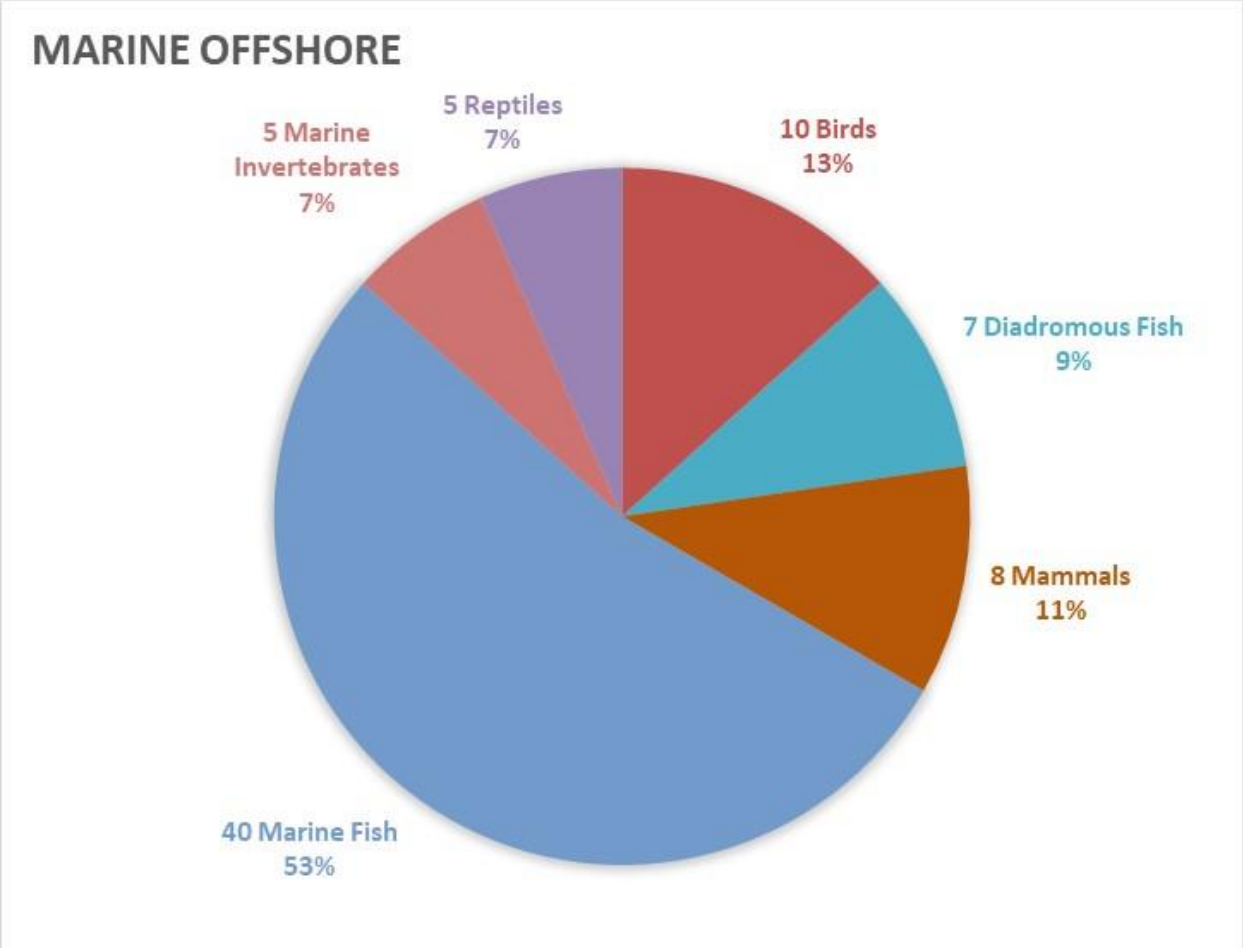

Figure 2.21. 2 Northeast RSGCN and Watchlist species associated with Marine Offshore and Oceanic habitats represent six taxonomic groups.

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**

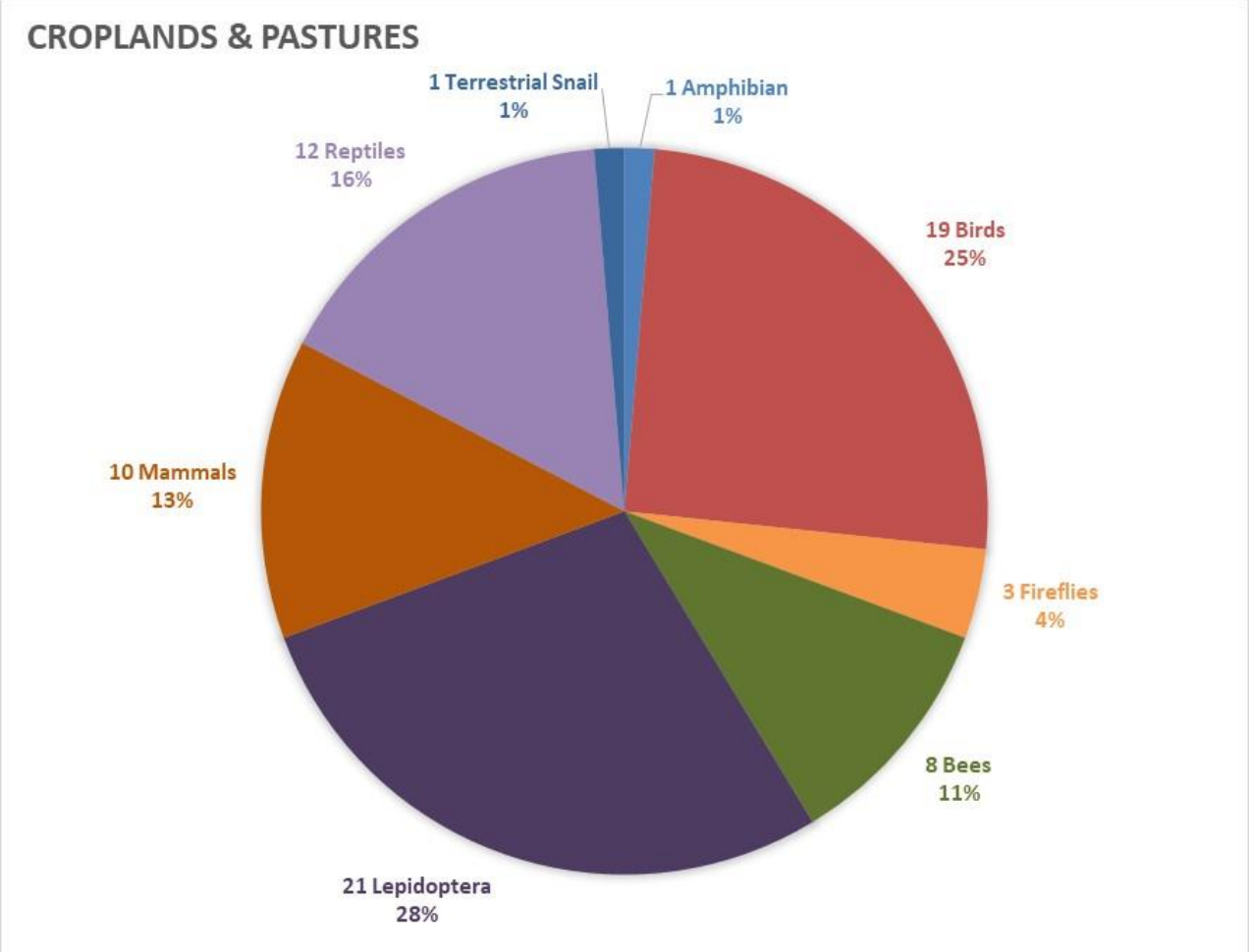

Figure 2.22. 2 Northeast RSGCN and Watchlist species associated with Agriculture: Croplands and Pasture habitats represent eight taxonomic groups.

(*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].

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.

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

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**

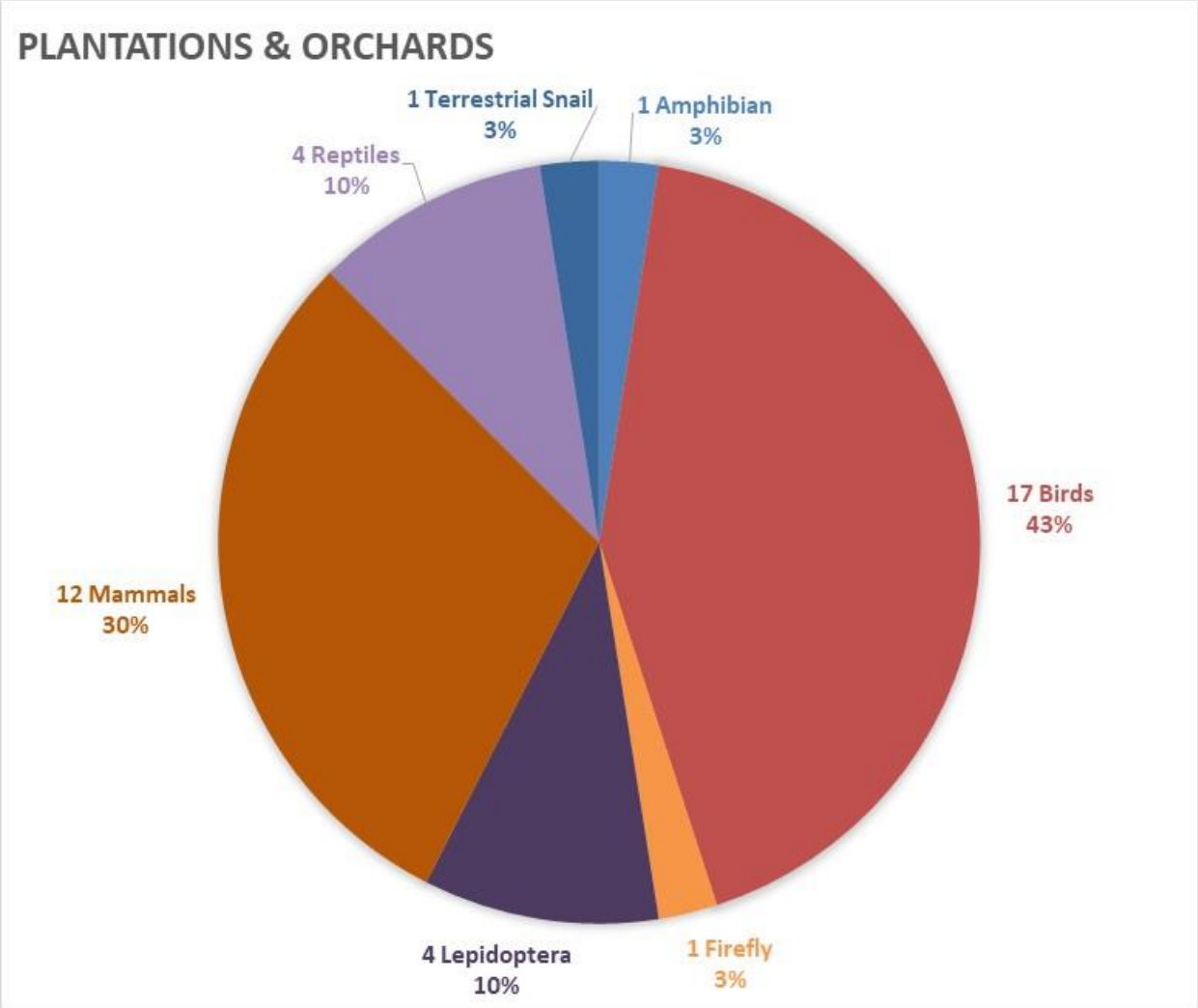

Figure 2.23. 2 Northeast RSGCN and Watchlist species associated with Agriculture: Plantation and Orchard habitats represent seven taxonomic groups.

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**

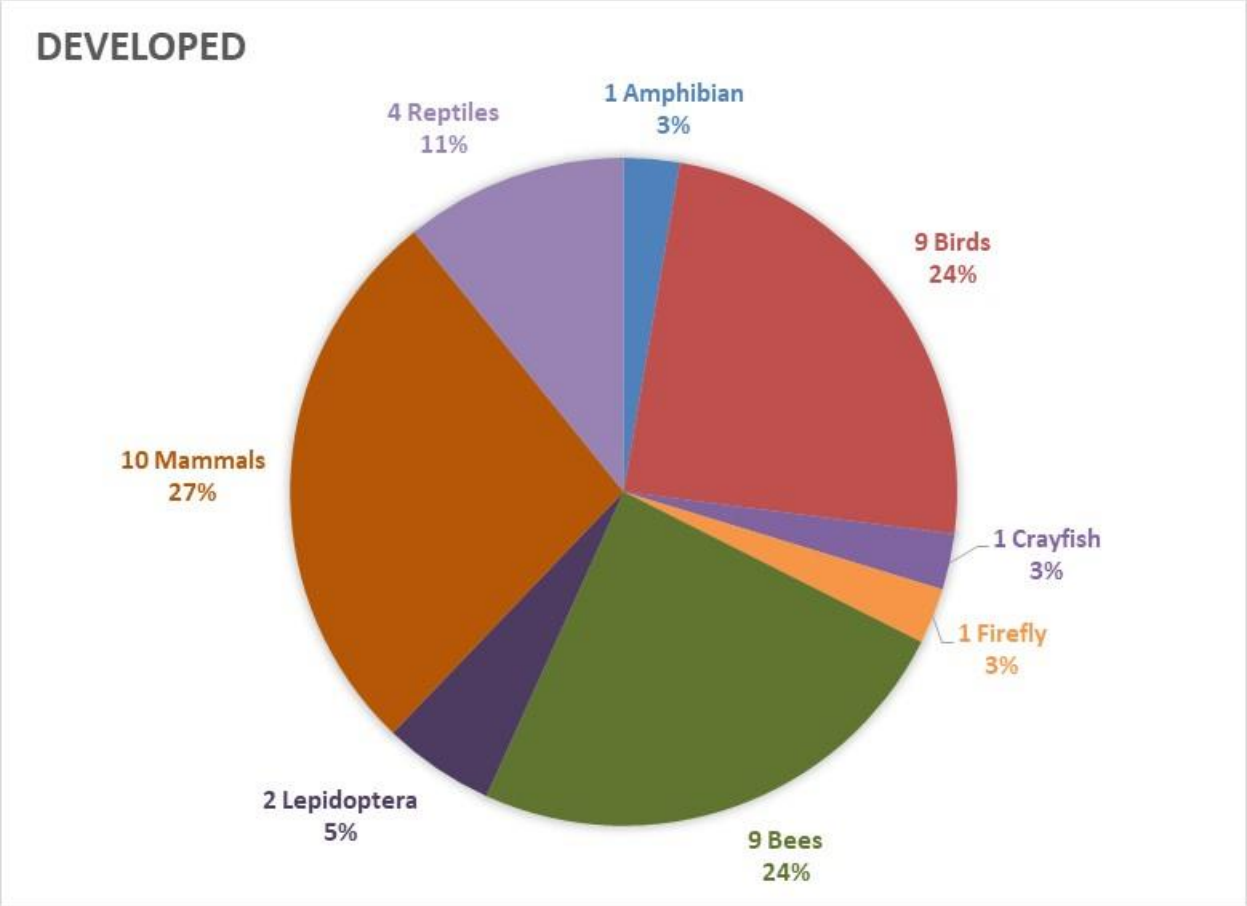

Figure 2.24. 2 Northeast RSGCN and Watchlist species associated with Developed Areas habitats represent eight taxonomic groups.

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

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