CHAPTER 5: MONITORING

SWAP Element 5

Descriptions of the proposed plans for monitoring species identified in 1st Element and their habitats, for monitoring the effectiveness of the conservation actions proposed in the 4th Element, and for adapting these conservation actions to respond appropriately to new information or changing conditions.

Suggested components:

A. *The Plan describes plans for monitoring species identified in Element 1, and their habitats.*
B. *The Plan describes how the outcomes of the conservation actions will be monitored.*
C. *If monitoring is not identified for a species or species group, the Plan explains why it is not appropriate, necessary, or possible.*
D. *Monitoring is to be accomplished at one of several levels including individual species, guilds, or natural communities.*
E. *The monitoring utilizes or builds on existing monitoring and survey systems or explains how information will be obtained to determine the effectiveness of conservation actions.*

CONTENTS

TABLES

HOW TO USE THIS CHAPTER:

This Chapter provides national and regional information addressing State Wildlife Action Plan Element 5 (above) for monitoring. The resources included in this Chapter inform species abundance and status (Element 1), habitat availability and condition (Element 2), threats (Element 3), and evaluation of the effectiveness of conservation actions (Element 4). It also identifies monitoring partners for collaborative conservation and leveraging of limited resources (Element 7) and opportunities for public engagement through citizen science (Element 8).

- The Regional Overview (Section 5.0) describes the Northeast Association of Fish and Wildlife Agencies' Monitoring and Performance Reporting Framework (NEAFWA 2008), the Northeast Lexicon (Crisfield and NEFWDTC 2022), and Association of Fish and Wildlife Agencies' Best Practices (AFWA 2012) related to SWAP Element 5.
- Section 5.1 describes national research, inventory and monitoring programs that contribute to addressing SWAP Element 5.
- Section 5.2 highlights regional monitoring networks and programs in the Northeast.
- Section 5.3 provides examples of state monitoring programs and projects.
- Section 5.4 describes monitoring resources for species with a summary of available standardized monitoring protocols in Section 5.4.2 (and Appendix 5A) and the Watchlist Assessment Priority species in Section 5.4.3.
- Section 5.5 lists databases and related inventory resources.
- Appendix 5A provides a list of available standardized monitoring protocols.

Additional information on programs and projects that monitor the availability and condition of habitats are described in *Chapter 2*. Monitoring programs for threats are described in *Chapter 2* when addressing habitat condition, in *Chapter 3* when addressing singular threats (e.g., invasive species, disease), and this *Chapter 5* when addressing multiple species, taxa, and/or habitats.

5.0 REGIONAL OVERVIEW

The Northeast region has a rich history of landscape, watershed, and seascape scale monitoring programs and projects that can inform Element 5 of the 14 Northeast State Wildlife Action Plans (SWAPs) of 2025. NEAFWA member states have long recognized the value of regional-scale monitoring and the region's SWAPs reflect the value of these regional efforts to provide improved consistency and effectiveness in monitoring.

Monitoring the Conservation of Fish and Wildlife in the Northeast: A Report on the Monitoring and Performance Reporting Framework for the Northeast Association of Fish and Wildlife Agencies identifies a regional monitoring framework report on the status of Species of Greatest Conservation Need (SGCN) and their habitats and the effectiveness of conservation projects implemented as part of SWAPs and the State Wildlife Grants program (NEAFWA 2008). The monitoring framework includes eight conservation targets (see Section 5.2.1 for detailed information):

1. Forests
2. Freshwater streams and river systems
3. Freshwater wetlands
4. Highly migratory species
5. Lakes and ponds
6. Managed grasslands and shrublands
7. Regionally significant SGCN
8. Unique habitats in the Northeast

The monitoring framework report noted at the time that additional work was needed to include coastal and marine systems in the framework, which focused limited time and resources on terrestrial and freshwater systems. Specific indicators and stressors are identified for monitoring to assess each of the eight conservation targets, except for the managed grasslands and shrublands targets where information was lacking.

In 2011 The Nature Conservancy (TNC) assessed these eight conservation targets as part of the **Conservation Status of Fish, Wildlife, and Natural Habitats in the Northeast Landscape: Implementation of the Northeast Monitoring Framework** (Anderson and Olivero-Sheldon 2011). The Nature Conservancy updated this condition assessment in 2023 with new information and analysis tools (Anderson et al. 2023), except for RSGCN conservation target which is addressed in *Chapter 1* of this Regional Conservation Synthesis instead. *Chapter 2* of this Regional Conservation Synthesis supplements the 2023 condition assessment by addressing the information

needed to assess the status and condition of the region's coastal and marine systems that are not currently included in the monitoring framework.

In 2012 the Association of Fish and Wildlife Agencies (AFWA) released national guidance for SWAPs, the **Best Practices for State Wildlife Action Plans – Voluntary Guidance to States for Revision and Implementation**, hereafter referred to as AFWA Best Practices (AFWA 2012). The AFWA Best Practices defines monitoring under Element 5 "as the collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a management objective" (AFWA 2012, p. 16). Best practice recommendations addressed in this Chapter of the Regional Conservation Synthesis include:

- the use of standardized techniques and protocols,
- participating in existing national monitoring programs,
- assessing the effectiveness of conservation actions,
- collaborating with partners in regional monitoring efforts,
- participating in research and conservation alliances, and
- augmenting with citizen science programs as appropriate to expand capacity.

The AFWA Best Practices incorporate monitoring information into adaptive management approaches. Adaptive management techniques and resources are discussed in *Chapter 2* of this Regional Conservation Synthesis for specific habitat types.

To most effectively monitor or measure conservation targets or actions, consistent terms are important. The NEFWDTC and SWAP Coordinators recognized the need for a standard lexicon that provides a uniform terminology that accurately and adequately describes the work of state fish and wildlife agencies. Therefore, the NEFWDTC developed a regional conservation lexicon in 2013 (Crisfield and NEFWDTC 2013) and updated it in 2022 (Crisfield and NEFWDTC 2022). The **Northeast Lexicon** enables state fish and wildlife agencies and partners to better describe and monitor their conservation projects. For example, the Northeast Lexicon describes the three distinct purposes for monitoring to address Element 5:

- Measuring population status and trends,
- Describing habitat quality, and
- Assessing conservation project results.

Different formats and approaches may be appropriate for each of these monitoring purposes. "Status assessments of species or habitats are referred to as 'surveys'; 'research' includes monitoring to understand links between species, their habitats, and threats impacting both; and assessing the results of 'actions' implies a more dynamic

situation resulting from implementing a project to mitigate a threat, improve habitat, or otherwise support a Species of Greatest Conservation Need" (Crisfield and NEFWDTC 2022, p. 27).

In 2015, an annual international effort to review the effectiveness of conservation interventions began called **Conservation Evidence: Providing Evidence to Improve Practice**[1]. Actions taken to benefit amphibians, bats, birds, and other conservation targets are reviewed on a near annual basis to indicate the degree to which studies indicate the action is effective in achieving project goals. Projects with inconclusive evidence are also included. The international nature of the analysis can make translation of conclusions more uncertain, but the database provided along with the **What Works in Conservation** summary publications (Sutherland et al. 2020) can provide methods for measuring effectiveness for a broad range of common conservation actions. Two databases inventory conservation actions and scientific studies of their effectiveness and are available online[1]. The studies database included more than 8400 scientific studies evaluating conservation actions as of January 2023 and is searchable by keyword, category (e.g., control of freshwater invasive species, butterfly and moth conservation, marsh and swamp conservation), species, habitat, threat, action type, or geographic location. The similarly searchable actions database included nearly 3700 actions distilled from the literature, each with an effectiveness rating and the number of related studies available. Links to the Conservation Evidence databases are now integrated on the species profile pages of the **International Union for Conservation of Nature (IUCN) Red List**[2].

The 2017 **SWAP Synthesis** drew from the 14 individual Northeast SWAPs to identify the monitoring needs for priority threats, species, and habitats (TCI and NEFWDTC 2017). State specific actions and monitoring needs can all be found in searchable format in the **Northeast SWAP Database**[3]. These are summarized below and presented in the SWAP Synthesis:

- Develop regionally coordinated and cost-effective monitoring protocols that meet multiple objectives across states and monitor changes to the Northeast's land and water resources and how those changes impact wildlife and people.
- Measure and report the effectiveness of actions to improve and enhance future conservation efforts; improve competitive grant applications; and recruit new partners by demonstrating the utility and efficacy of conservation programs.

The SWAP Synthesis and the **Limiting Factors** report both found common, recurring threads reported across multiple taxa (TCI and NEFWDTC 2017, TCI and NEFWDTC 2020). One focused on the need for adequate research, surveys, and then monitoring to determine baseline status and detect changes in SGCN, RSGCN, and their key habitats before they reach critical levels beyond which they cannot be recovered. Multiple taxa

recommendations included the need for consistent monitoring protocols range wide. This approach provides for improved status assessments as well as additional opportunities for conservation, thus avoiding the need to list target species at the federal level. Priority needs identified in the 14 Northeast SWAPs and flagged for further investigation and monitoring in relation to RSGCN and Watchlist species and their habitats include:

- Invertebrate biomass decline. There is a need to understand invertebrate biomass declines and the thresholds of food availability required to maintain or increase populations, particularly those of vertebrate RSGCN.
- Insecticide toxicity for the high number of RSGCN invertivores. Taxa experts cited concerns about the impact of insecticide spraying on forest-dwelling vertebrate RSGCN including bats, birds, reptiles, amphibians, fish, and aquatic invertebrates, especially ingestion through food or water.
- Disease. There is an ongoing need to track the impacts of disease in RSGCN, particularly reptiles and amphibians, freshwater mussels, crayfish, and mammals.
- Loss of genetic diversity in RSGCN. In addition to other data deficient species, these species in particular need monitoring: the New England Cottontail, Allegheny Woodrat, Northern Right Whale, and the sturgeon.
- Wintering RSGCN vulnerabilities. These are either poorly understood or increasing due to climate change.
- Take and collection. The impact of collection is dynamic and responsive to changes in world markets.
- Changes in hydrologic regimes. Because of the large number of RSGCN associated with hydrologically defined habitats, changes in precipitation regimes, evapotranspiration, and water management structures will affect many RSGCN.
- Coastal habitats. These habitats have been degraded or reduced in size by intensive development and are now further threatened by sea level rise and storm surge.

This Chapter 5 of the Regional Conservation Synthesis summarizes the inventory, monitoring, and research projects and resources currently available to inform these monitoring and investigation needs in the Northeast and the corresponding regional priority action discussed in *Chapter 4*.

The 2023 NEFWDTC website update (www.northeastwildlifediversity.org) allows for web-enabling this Regional Conservation Synthesis, the updated Northeast RSGCN Database, and associated communication tools and products. These tools and resources will be searchable with filters to provide detailed information for monitoring protocols and programs for RSGCN, Watchlist species and their habitats. Resources described in

Chapter 5 of this Regional Conservation Synthesis plus supplemental materials developed as part of the RCN 3.0 Technical Services project will be centralized on one user-friendly platform.

5.1 NATIONAL INVENTORY AND MONITORING PROGRAMS

AFWA Best Practices recommend that SWAPs participate in national monitoring programs and utilize national scale inventory, monitoring, and research programs to inform SWAPs (AFWA 2012). The Northeast Lexicon describes how survey and research programs can inform Element 5 in SWAPs by increasing understanding of the extent, distribution, and degree of impacts of factors affecting SGCN, RSGCN, and their key habitats (Crisfield and NEFWDTC 2022). The SWAP Synthesis supported collaboration to collect and compile effectiveness data for the diversity of conservation efforts being implemented within the Northeast region and that potential partners be identified to determine how existing data could be used to enhance the SWAPs, monitor threats, and/or inform the adaptive management of State Wildlife Grant funded efforts (TCI and NEFWDTC 2017).

The following federal inventory and monitoring programs, and their associated research projects, contribute to fulfilling these goals to inform Element 5 of the Northeast SWAPs.

5.1.1 EPA PROGRAMS

The Environmental Protection Agency (EPA) monitors a number of environmental conditions across the United States (US). The EPA maintains a **Report on the Environment** with indicators that track the state of the country's environment and human health over time[4]. Monitoring indicators include several that are relevant to State Wildlife Action Plans:

- Air
    - Outdoor air quality
    - Greenhouse gases
    - Indoor air quality
- Water
    - Fresh surface waters
    - Ground water
    - Wetlands
    - Coastal waters

    - Drinking water
    - Recreational water
    - Consumable fish and shellfish
- Land
    - Land cover
    - Land use
    - Chemicals used on land
    - Wastes
    - Contaminated lands
- Human exposure and health
    - Exposure to environmental contaminants
    - Health status
    - Disease and conditions
- Ecological condition
    - Extent and distribution
    - Diversity and biological balance
    - Ecological processes
    - Physical and chemical attributes
    - Ecological exposure to contaminants

Data on these monitoring indicators is available through the EPA website[4].

The EPA monitors water quality and ecological conditions in estuarine waters along the coasts and the freshwater of the Great Lakes in the **National Coastal Condition Assessment** (NCCA)[5]. The NCCA is conducted every five years and uses standardized sampling procedures and quality assurance protocols to assess coastal conditions at the regional and national scale. Ecological indicators monitored as part of the NCCA include: biological condition of benthic invertebrates including mollusks, worms and crustaceans; eutrophication; sediment contaminant levels; fish tissue contamination; Enterococci bacteria levels; and microcystin toxin levels. The 2020 NCCA expanded to include new indicators of total alkalinity and the level of microplastics and nitrogen isotopes in sediments (EPA 2021)[6]. Detailed results of the NCCA monitoring are available on the NCCA Dashboard at https://coastalcondition.epa.gov. The EPA released a mobile app in 2021 called the **Sanitary Survey App for Marine and Fresh Waters** to help communities track beach water quality with the assistance of citizen scientists[7].

The EPA monitors the condition of physical, chemical, and biological integrity of wetlands as part of the **National Wetlands Condition Assessment**[8]. The condition of water quality and ecological conditions of rivers and streams is monitored as part of the **National Rivers and Streams Assessment**[9]. The EPA **StreamCat** database provides data on the condition of more than 2.65 million stream segments across the

country[10]. The StreamCat dataset currently contains over 600 metrics related to rivers and streams and their condition. Both natural and anthropogenic information is included. Anthropogenic condition variables include the percent urbanization within the watershed, dam reservoir volumes, the mean application rate of synthetic nitrogen fertilizer on agricultural lands, the erodibility of agricultural soils, the density of coal mines within the watershed, the mean pesticide use within the watershed, and many more that impact the condition of rivers and streams for fish and wildlife.

The EPA monitors the condition of water quality and ecological conditions of lakes as part of the **National Lakes Assessment**[11]. The EPA **LakeCat** database provides data on the condition of more than 378,000 Lakes and Ponds across the country[12]. The LakeCat dataset currently contains over 300 metrics related to lakes and ponds and their condition. Both natural and anthropogenic information is included. Anthropogenic condition variables include the percent urbanization and agriculture within the watershed, dam reservoir volumes, the mean application rate of synthetic nitrogen fertilizer on agricultural lands, the erodibility of agricultural soils, the density of coal mines within the watershed, the mean pesticide use within the watershed, and many more that impact the condition of lakes and ponds for fish and wildlife.

The **EPA monitors several indicators of climate change**. Ecological monitoring data from the Northeast tracks shifting ranges of marine species as climate change indicators[13]. The range shifts of RSGCN American Lobster (*Homarus americanus*) and Black Sea Bass (*Centropristis striata*) are two of the indicator species, with maps available that illustrate the northward shifts from 1973 to 2019. The EPA also uses monitoring data for lake water levels and surface temperatures in the Great Lakes as climate change indicators[14]. Data show how the water levels in each of the Great Lakes have fluctuated since 1860 and average lake surface temperature has increased slightly since 1995.

Ice cover monitoring data (both area and duration) for the Great Lakes serves as another indicator of climate change for the EPA[15]. Data are available since 1973 and indicate a long-term decrease in the maximum area of ice cover for all Great Lakes, although individual lakes significantly vary year to year. The duration of ice cover has also declined since 1973, by almost a full day per year in Lake Ontario, and the declines are concentrated on the land edges of the lakes. Overall the five Great Lakes are covered in ice by eight to 46 fewer days now than in the early 1970s.

Monitoring data for lake ice for another nine lakes in the US is an EPA climate change indicator[16]. Monitoring data are available from 1850 to 2019. The lake ice indicator shows that lakes generally are freezing later in the year than in the past (at a rate of approximately 0.5 – 1.5 days per decade) and thawing earlier in the spring (at a rate of 0.8 days per decade), shortening the period when the lakes are covered in ice annually

by several weeks. The EPA also uses lake temperature monitoring data as a climate change indicator, with data available from 1985 to 2009[17]. Data from 34 lakes across the US and Canada for the average July to September surface temperatures document an increase in average temperature for 32 of the 34 lakes, with 24 lakes warming by more than 1 degree Fahrenheit and 15 by more than two degrees.

The EPA also uses **monitoring data of streamflow** as a climate change indicator across the US[18]. Indicator rivers and streams data from 1940 to 2018 include the seven-day minimum annual streamflow, three-day annual high streamflow, annual average streamflow, timing of winter-spring runoff, and number of days with very low streamflow. In the Northeast, the seven-day low streamflows have generally increased, indicating on the days with the lowest streamflows the Rivers and Streams are carrying more water than previously. High streamflows have generally increased or not changed much in the Northeast since 1940. The average annual streamflow has increased at most sites in the Northeast. The timing of the winter-spring runoff is five to ten days earlier across most of the Northeast. And the number of days when streamflow is very low has decreased overall in the Northeast but increased in some streams of the Mid-Atlantic.

The EPA uses **monitoring data of stream temperatures** as a climate change indicator in the Chesapeake Bay region[19]. Data from 1960 to 2014 from 129 stream gauges document warming temperatures at 79% of the sites and decreasing temperatures at 5% of the sites. The overall Chesapeake Bay region has increased stream water temperatures since 1960 by an average of 1.2 degrees Fahrenheit across all sites and by 2.2 degrees at sites where the long-term trends are statistically significant. The largest stream temperature increases are in the southern part of the region (e.g., Virginia).

The EPA regulates point and non-point source pollution under the federal Clean Water Act, designating waters that are impaired due to pollution under Section 303(d) and providing **National Water Quality Inventory Reports**[20]. States are required to assess water pollution and report to the EPA every two years on the waters that have been evaluated or assessed. Impaired waters have Total Maximum Daily Loads of pollutants allowed to address the water quality impairments. The EPA uses this state monitoring information in the **Assessment and Total Maximum Daily Load Tracking and Implementation System (ATTAINS)** to monitor water quality conditions of surface waters across the country. Monitoring data on the ATTAINS platform is publicly available[21]. The public can access water quality monitoring data from ATTAINS through the **How's My Waterway?** online platform that provides a user-friendly resource for determining water quality at the community, state, and national scales[22].

5.1.2 USFWS PROGRAMS

The United States Fish and Wildlife Service (USFWS) conducts monitoring of both species and habitats with the scale and scope variable with the species, habitat, and location. The USFWS monitors federally-listed species populations and status, but monitoring techniques and frequency vary by species. Reviews of federally-listed species status are conducted every five years and summarize available monitoring data across the species' range.

The USFWS **Fish and Aquatic Conservation Program**[23] leads the agency's aquatic conservation efforts. Major projects and initiatives of the program include the conservation of high priority aquatic species; the conservation, restoration, and enhancement of aquatic habitats; management of aquatic invasive species; enhancement of recreational uses of aquatic resources; fulfillment of Tribal trust and subsistence responsibilities; and education and outreach. This federal program conducts early detection surveillance and monitoring of aquatic invasive species. USFWS Fish Health Centers monitor the health of amphibians and fish in captivity and in the wild, with seven regional centers across the country; the **Northeast Fishery Center** is located in Lamar, Pennsylvania[24]. The **National Wild Fish Health Survey** and its associated **National Wild Fish Health Database** and **National Wild Fish Health Survey Mapper** offer real-time surveillance of pathogens in populations of wild aquatic animals[25]. This database and mapping tool includes information on the movement of fish in wild environments, the distribution of pathogens, which fish are susceptible to pathogens and where they are located, site selection to source broodfish, and an assessment on the risk of pathogen spread.

The USFWS **National Fish Passage Program**[26] monitors aquatic connectivity projects that restore or enhance fish passage across the country. An interactive dashboard displaying an inventory of proposed projects under the Bipartisan Infrastructure Law with detailed information on location, cost, project type, partners involved, stream miles to be reopened, and number of barriers to be removed is available[27].

The **Migratory Bird Program**[28] of the USFWS conducts surveys and other monitoring efforts to track the status of migratory bird populations. The annual **Waterfowl Breeding Population and Habitat Survey** (also known as the **Breeding Population Survey**) is conducted by the USFWS and the Canadian Wildlife Service every May and June through aerial breeding bird surveys[29]. Since 1955 this monitoring survey provides information on the spring population size and trend of 19 North American duck species or species groups. The number of waterfowl breeding ponds in Prairie-Parkland Canada is also monitored. **Waterfowl Population Status Reports** generated by this survey are available[30].

The **North American Bird Conservation Initiative (NABCI)** is a partnership supported by the USFWS between federal and state agencies, private organizations, and bird initiatives to collaborate on the conservation of more than 1150 bird species[31]. The NABCI Monitoring Subcommittee provides technical expertise and recommendations for effective and efficient integrated bird monitoring programs to support bird conservation at the regional and landscape scale. Monitoring best practices and protocols developed are available[32].

Since 2009 the USFWS, NABCI, and partners have prepared **State of the Birds** reports every two years that monitor long-term bird population trends[33]. The most recent State of the Birds report was issued in late 2022 and is discussed in *Chapters 1* and *2* of this Regional Conservation Synthesis. The bird status and trends information contained in the State of the Birds reports inform the current conservation status and long-term population trends of species of concern in SWAPs.

The USFWS and partners conduct annual monitoring surveys of American Woodcock (*Scolopax minor*) via the **American Woodcock Singing-ground Survey**[34]. Throughout the species' breeding range in the U.S. and Canada, partners survey the breeding population every spring to provide an index of species abundance and estimate population trends at the state, province, management region, and continent scales. American Woodcock is identified as a Species of Greatest Conservation Need (SGCN) in all 14 Northeast SWAPs of 2015, which this annual survey can inform.

The **National Migratory Bird Harvest Survey** began in 1955 and monitors the harvest of migratory birds, the number of active hunters, the number of days hunted, and the number of birds bagged per hunter by state[35]. Working in partnership with state wildlife agencies, the USFWS selects a statistical sample of registered migratory bird hunters to participate in the annual survey. Five separate types of surveys focus on particular groups of species: 1) doves and band-tailed pigeons, 2) waterfowl, 3) American Woodcock, 4) snipe, rails, gallinules, and coots, and 5) sandhill cranes. Results of the National Migratory Bird Harvest Survey informs decision-marking on hunting seasons at the state and federal levels. The **Parts Collection Survey** invites hunters to submit the wings of bird they shoot to provide species-specific estimates of bird sex and age ratios (when combined with the results of the National Migratory Bird Harvest Survey). Monitoring information in the National Migratory Bird Harvest Survey and Parts Collection Survey can inform the status and trends of biological resource use and bird population information in SWAPs.

The **National Survey of Fishing, Hunting, and Wildlife-Associated Recreation** from the USFWS is one of the oldest and most comprehensive wildlife-related recreation surveys in the US[36]. First given in 1955, this national survey collects information on anglers, hunters, and wildlife watchers, monitoring the number of

people, how often they participate in these activities, and how much money they spend on outdoor wildlife-associated recreational activities. The survey is conducted every five years, allowing for long-term trend analysis. The monitoring information in the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation can inform the status and trends of biological resource use and human disturbance from recreational activities for SWAPs as well as public engagement in wildlife-associated activities. The most recent survey was conducted in 2022, with results expected to be released mid-2023.

The **National Wetlands Inventory (NWI)**, administered by the USFWS, monitors the status and trends of non-tidal wetlands, tidal wetlands and flats, and riparian wetlands throughout the country. The NWI maintains maps and geospatial datasets on the location and distribution of all wetland types, using the **Classification of Wetlands and Deepwater Habitats of the United States** for tidal and non-tidal wetlands plus permanently submerged aquatic substrates, originally developed in 1979 (Cowardin et al. 1979) and updated in 2013 (FGDC 2013). National and regional analyses on the status and trends of wetlands are periodically updated and inform SWAP Key Habitat assessments; the monitoring reports are available[37].

The USFWS **Natural Resource Program Center** conducts inventory and monitoring programs of National Wildlife Refuge lands, waters, air, wildlife, and plants as well as their responses to management actions[38]. The Center's **Wildlife Health Office** monitors the health of wildlife and conducts disease surveillance, response, and management for birds, ungulates, and other species. The program monitors wildlife morbidity and mortality events, harmful algal blooms, and animal diseases with the potential to spread to humans. The USFWS Wildlife Health Office partners with the United States Geological Survey's National Wildlife Heath Center (see next Section 5.1.3).

5.1.3 USGS PROGRAMS

The United States Geological Survey (USGS) operates several research, inventory, and monitoring programs that can inform SWAPs. The USGS **Amphibian Research and Monitoring Initiative** provides scientific information to wildlife managers to halt or reverse population declines in amphibians. This program issued a **State of the Amphibians** report based on 25 years of monitoring data documenting an average 3.7% annual rate of decline in the proportion of sites occupied by amphibians and predicting that the average amphibian species will be extirpated from half of the places it occurred in 2016 in less than 20 years[39]. The **North American Amphibian Monitoring Program**, led by the USGS with 26 state, university, and organizational partners, operated from 1997 to 2015. Standardized amphibian monitoring protocols developed by the program and publications of population status and trends in various regions, including the Northeast, are available[40].

The USGS **Eastern Ecological Science Center** (formerly the Patuxent Wildlife Research Center and Leetown Science Center)[41] conducts several research, inventory, and monitoring programs relevant to SWAPs in the Northeast, including a project underway to develop new survey techniques for small mammals in the region. The **North American Bird Breeding Survey** is supported by the Eastern Ecological Science Center and the Canadian Wildlife Service to monitor the status and trends of bird populations across North America[42]. Annual surveys for more than 420 species of birds are conducted, generally in June, using standardized monitoring protocols at over 4100 survey routes. Long-term population trends and relative abundances are available since 1955. The Eastern Ecological Science Center also operates the **Bird Banding Laboratory**, which is the central repository of bird banding data since 1920. The Laboratory collects, curates, archives, and disseminates bird banding data through the **North American Bird Banding Program's Bander Portal**[43]. The public can report band sighting information online[44]

The USGS, USFWS, US Army Corps of Engineers, and other partners have coordinated a **Midwinter Bald Eagle Survey** during the first two weeks of January since 1979. The long-term, national database associated with the survey recently transferred from the USGS to the US Army Corps of Engineers for analysis and maintenance[45]. Citizen scientists count Bald Eagles (*Haliaeetus leucocephalus*) using standardized survey techniques along standard, non-overlapping survey routes across the country.

The **North American Bat Monitoring Program** is coordinated by a partnership between the USGS, USFS, US Forest Service, National Park Service, Bat Conservation International Canadian Wildlife Service, and other partners[46]. Standardized monitoring protocols are used to survey multiple species of bats across North America. Results of long-term status and trends and a data inventory are available on the program's website[46] and through the USGS ScienceBase[47].

The USGS **Native Bee Inventory and Monitoring Lab** within the Eastern Ecological Science Center designs and develops small and large scale surveys for native bee species[48]. This program continues to develop identification tools and keys for native bee species, including accurate and detailed photographs of native bees and the plants and insects that they interact with, and protocols for processing bee specimens. The **Bee Database** created and maintained by the Laboratory focuses on the Mid-Atlantic region and is available as part of the **Discoverlife Global Mapper**[49]. The native bee photography collection is available on flickr[50].

The **Science Data Catalog** of publications and datasets produced by the USGS is available free online[51]. Detailed information on recent USGS scientific research, inventory and monitoring projects related to biological and ecosystem resources is available online as well[52]. Other monitoring programs conducted by the USGS include

those dedicated to water resources, climate change, natural hazards, shoreline erosion, sea level rise, and energy development.

The USGS **Water Resources Program** monitors surface water and groundwater resources across the country, collecting water quality, water use, and water level data at approximately 1.5 million locations across all 50 states[53]. The **Water Availability and Use Science Program** conducts inventory and monitoring studies on the quantity and quality of the nation's water, long-term trends in the availability of water, and forecasts for future water availability for human and ecological uses[54]. These water resources programs provide several inventory and monitoring resources that can inform SWAPs:

- The **National Water Dashboard** provides real-time information from more than 13,000 stream, lake, reservoir, precipitation, water quality, and groundwater stations[55].
- The **Water Quality Portal**, operated by the National Water Quality Monitoring Council in partnership with the USGS, EPA and more than 400 other data sources, provides downloadable water quality data for any selected location in the country[56].
- The **National Groundwater Monitoring Network Data Portal** compiles data from groundwater monitoring wells across the United States, with more than 17,800 water level wells and 4000 water quality wells participating in the network as of early 2023[57].
- The USGS National Water Information System's **Water Data for the Nation** collates water resources monitoring data from all 50 states, the District of Columbia, and five territories into one tool[58].
- **StreamStats** provides statistics on streamflow and spatial analysis tools for water resources applications[59]. Users select an area of interest from an interactive online map, delineate a catchment area of interest, select parameters of interest (e.g., basin characteristics), and download a summary report.
- The **National Water Census** is a national water availability and use assessment that includes components for streamflow, groundwater, water use, environmental flows, and evapotranspiration[60].

Integrated Water Availability Assessments under development by the USGS provide a nationally consistent but regional assessment of water availability for human and ecological needs and identify factors that may limit availability or lead to conflict[61]. One of the pilot reginal assessments is the Delaware River basin in the Northeast. The **Delaware River Basin Integrated Water Availability Assessment**[62] includes trends in water quality for 16 priority parameters from 1978 to 2018, collated datasets from multiple organizations, maps of monitoring sites that visually display surface water quality trends, an Algal Assessment that characterizes and forecasts the probability of

harmful algal blooms in four subwatersheds, characterizing the drought history of the basin and identify future drivers of drought, and an assessment of streamflow baseflow contributions from groundwater from 1950 to 2015. Ongoing research and analysis will simulate groundwater dynamics to create a basin-specific groundwater flow model to hindcast and forecast monthly variation in groundwater conditions within the Delaware River basin. Overall the pilot project in this major Northeast river basin will take ten years to complete, with an anticipated completion date in 2031.

The USGS **Dam Removal Information Portal (DRIP)** monitors dam removal projects in the US and offers a searchable database of scientific studies that evaluate the environmental response of dam removals[63]. As of January 2023, the DRIP inventory of dam removal projects numbered 1796, with 203 of the removals associated with evaluation studies. This monitoring dataset shows an increasing trend in dam removal projects, with data for projects removed since 1980.

The USGS conducts research and monitoring of natural hazards and disasters across the country, providing resources to reduce risk and build resilience[64]. Although this program's efforts related to earthquake and volcanic hazards are not relevant to the Northeast region, other natural hazards work related to floods, drought, extreme weather (e.g., hurricanes, nor'easters, blizzards), wildland fires, landslides, and biological threats are regionally applicable. The USGS monitors flooding from thunderstorms, storm surge, and tsunamis and maintains current flood and high-flow stream conditions through its **WaterWatch** platform[65]. Historical flood data and information on droughts are also available through WaterWatch. The **Flood Event Viewer** provides geospatial information on specific flood and storm events, such as individual hurricanes[66]. Flood data from rain and tidal gages are integrated with observational sensors and measurements for barometric pressure, water level, wave height, high water, and meteorological parameters.

The USGS maintains national resources related to coastal storms. The **Coastal Change Hazards Portal** combines geospatial information resources on tropical storms and hurricanes, extreme storms, shoreline change, and sea level rise into one online interactive map[67]. Users can search by location and topic, with the available datasets shown and selectable for exploration or downloading (e.g., historical locations of shorelines in New Jersey, the probability of sandy beach erosion or inundation during a nor'easter in Massachusetts). The experimental **Total Water Level and Coastal Change Forecast Viewer**, a partnership between the USGS and the National Oceanic and Atmospheric Administration (NOAA), offers geospatial data on the combined total water level from tides, storm surge, and wave runup forecast for a particular section of coastline during current and near-future conditions[68]. The USGS also tracks coastal hazards through a **National Assessment of Storm-Induced Coastal Change Hazards** through oblique aerial photography missions to inventory baseline and

storm-response conditions. The **Oblique Aerial Photography Viewer** provides access to this photographic database[69].

The Fire Science program of the USGS works to improve scientific understanding of wildland fires to inform decision-making by fire and land managers. The **Inttera National Fire Situation** map tool monitors current wildfires and provides related information for each in an interactive online map[70]. The USGS is also a partner in **LANDFIRE** spatial datasets of land cover and wildfire related information[71], which are described in *Chapter 2*.

The USGS **Landslide Hazard Program** has developed an inventory of landslides across the US, recording the date, causes, number of fatalities, and a confidence rating for each landslide. The **US Landslide Inventory**, most recently updated in 2019, is available with an interactive online map viewer[72].

The USGS **Biological Threats and Invasive Species Research Program** monitors several biological threats at the national level. A database of nonindigenous aquatic species with spatially referenced biogeographic accounts of each, with distribution maps, spatial datasets, and scientific reports[73]. The Program has integrated the **Nonindigenous Aquatic Species Database** with storm surge and flood events information to assess the potential spread of nonindigenous freshwater species due to flooding associated with storms, creating **Flood and Storm Tracker (FaST)** maps[74]. The **Invasive Species Habitat Tool (INHABIT)** provides an online interactive national map of known and modeled distributions for selected species of interest with risk management information[75]. An inventory of USGS invasive species research to improve detection, awareness, decision support, and control of invasive species is available online[76].

The USGS **National Wildlife Health Center** partners with state, tribal, other federal agencies, and academic institutions to conduct disease surveillance, diagnostic services, and holistic research studies[77]. Wildlife diseases currently monitored and researched by the National Wildlife Heath Center include avian influenza, avian botulism, *Batrachochytrium salamandrivorans* (Bsal), chronic wasting disease, coronaviruses, rabbit hemorrhagic disease, salmonellosis, snake fungal disease, sylvatic plague, toxoplasmosis, trichinosis, West Nile virus, white-nose syndrome, and diseases in ducks, sea turtles, fish, cranes, and coral. The Center facilitates information sharing to quickly identify and mitigate wildlife health issues through the **Wildlife Health Information Sharing Partnership**, or **WHISPers**, event reporting system[78]. An index of wildlife disease information sources, including quarterly monitoring reports on wildlife mortality, is available online[79].

The USGS and EPA collaborated with other federal agencies to develop a web tool that provides a mapped inventory of the presence of microbes in soil, namely the bacterium

that causes anthrax (*Bacillus anthracis*) and other *Bacillus* species. The national datasets available include soil physical, chemical, and mineralogical data, historical and current climate data, land cover, and biological surveys. The **Presence of Microbes and the Distribution of Climatic, Environmental, and Geochemical Variables** interactive map is available online[80]. Sampling protocols for bacterial pathogens in surface soil, including *Bacillus anthracis*, are available[81].

The USGS supports the **National Climate Adaptation Science Center** and nine regional centers across the nation[82], including the **Northeast Climate Adaptation Science Center (NE CASC)** within the NEAFWA region based at the University of Massachusetts, Amherst[83] (UMass). The Northeast collaboration with the NE CASC / USGS / UMass consortium includes a team of climatologists, biologists, ecologists, and hydrologists with cutting-edge approaches to address major challenges posed by climate change. The Center's robust scientific contributions have produced valuable tools and information on addressing climate change in the Northeast. One of the most significant contributions was the 2015 **Northeast Climate Change Synthesis** to support the 2015 Northeast SWAP revisions (Staudinger et al. 2015). NECASC has again initiated a project to assist the 2025 SWAP revision process and to update the 2015 Synthesis which will be available in late 2023 (Staudinger et al. 2023, *in prep*).

Collaboration with natural and cultural resource managers in the Northeast has provided the climate change science to help inform fish and wildlife management decision-making and produce actionable products and results including more than 160 research projects and tools to facilitate climate change adaptation strategies for the Northeast as of 2022. A searchable inventory of research projects and assessments prepared by NE CASC is available online[84]. Recent NECASC projects relating to inventorying and monitoring the region's natural resources and the effectiveness of conservation actions include:

- **Science to Inform the Reconnection of Floodplains and Restoration of Green Space to Minimize Risk in the Future**: This project identifies opportunities to manage flows, connections, and landscapes in ways that increase the resilience of human communities and ecosystems. This research identifies dynamic and adaptive solutions to managing river flows that support continuation of valuable infrastructure services (Palmer and Nislow 2019).
- **Small Dam Removal as a Tool for Climate Change Resilience**: Across the United States, millions of small dams fragment the landscape and alter stream ecosystems. This project is evaluating the effectiveness of removal of obsolete dams and related structures as a way to eliminate or reverse the negative impacts on humans and ecosystems[85].
- **Framework for Protecting Aquatic Biodiversity in the Northeast Under Changing Climates**: This project uses an analytical, iterative process to

evaluate aquatic biodiversity protection and management scenarios across four northeastern states (Connecticut, Massachusetts, New Hampshire, and Vermont). It directly integrates climate change and management to identify land protection and restoration actions that optimize aquatic biodiversity protection into the future. Ultimately, the results will help managers to promote aquatic ecosystem health and prioritize climate adaptations[86].

- **Rethinking Lake Management for Invasive Plants Under Future Climate: Sensitivity of Lake Ecosystems to Winter Water Level Drawdowns**: Small lakes are important to local economies as sources of water supply and places of recreation. Commonly, lakes are considered more desirable for recreation if they are free of the thick weedy vegetation, often comprised of invasive species, that grows around the lake edge. This project is evaluating the effectiveness of winter water level drawdowns to control vegetation along lake edges[87].
- **Mapping Salt Marsh Response to Sea Level Rise and Evaluating 'Runneling' as an Adaptation Technique to Inform Wildlife Habitat Management in New England**: Loss of saltmarsh habitat is one of the greatest threats to coastal sustainability in the Northeast. Salt marsh has been identified as an essential fish and wildlife habitat, and loss of saltmarsh corresponds with precipitous declines in marsh-dependent wildlife. This project is testing the effectiveness of runneling, or creating micro-channels, as a management technique to restore saltmarsh[88].
- **Future Aquatic Invaders of the Northeast**: Currently, hundreds of invasive aquatic species occur in the Southeast and the Western US and can potentially move into the Northeast region. This project will help guide future monitoring efforts and bring attention to high-risk areas that could be invaded by southern and western invasive aquatic species[89].
- **Putting the Sampling Design to Work: Enhancing Species Monitoring Programs in the Face of Climate Change**: Established sampling protocols for monitoring wildlife are designed to evaluate the effects of non-climate stressors and related management actions. This project will develop an optimal sampling design that enables monitoring programs to track climate change impacts and provide early indicators for fish and wildlife responses[90].
- **Designing Wabanaki Adaptive Capacity for Climate Change***:* The Wabanaki Tribal Nations and other Tribal Nations of the Northeast face a disproportionate impact from climate change. This project will use Indigenous research methods and programs to build a regional tribal network for climate change adaptation and create a Wabanaki Climate Adaptation and Adaptive Management Workbook[91].

The USGS **Coastal and Marine Hazards and Resources Program** researches and monitors the nation's coastlines, estuaries, and marine environments[92]. In the

Northeast, the regional program office is based at the Woods Hole Coastal and Marine Science Center in Massachusetts, which maintains a repository of geological, geochemical, and biological samples as scientific collections. **The US Coastal Wetland Synthesis** is a national map of unvegetated and vegetated coastal wetlands and adjacent lands for the conterminous United States using satellite imagery from 2014-2018 at 30-meter resolution[93]. Regional wetland syntheses are available for the estuarine coastline from Massachusetts to Virginia on the same platform. Other recent work relevant to SWAPs from the USGS Coastal and Marine Hazards and Resources Program include geospatial modeling to forecast the impacts of sea level rise impacts on barrier island characteristics and habitat availability for nesting shorebirds; monitoring long-term shoreline change in the estuaries of Barnegat and Great Bay, New Jersey; and predicted coastal change at Fire Island, New York, resulting from storms. Detailed information about these projects and others are available through the **Coastal and Marine Geoscience Data System**[94].

The USGS maintains several inventories of the marine environment of the Northeast. The **National Archive of Marine Seismic Surveys** collects and archives data collected by US Department of the Interior agencies, including the USGS and the Bureau of Ocean Energy Management, of the marine seafloor within the federal Exclusive Economic Zone (EEZ). This inventory can be explored (and downloaded) through an online map[95]. **Maps of America's Submerged Lands** are maintained by the USGS, with associated reports and geospatial datasets depicting bathymetry, surficial geology, and/or subsurface structure at various scales[96]. The **Cold-Water Coral Geographic Database** has an inventory of coral records in the Northwest Atlantic and Gulf of Mexico from 1880 to 2008[97].

National shoreline change is monitored by the USGS Coastal and Marine Hazards and Resources Program using historical maps, field measurements, and remote sensing survey techniques. The **Digital Shoreline Analysis System** provides a standardized methodology for monitoring shoreline change. The methodology and datasets created by state and regional applications, including to the coast of Massachusetts, are available online[98].

The rate of global mean sea level rise is measured and monitored by the National Aeronautics and Space Administration (NASA)[99]. The USGS monitors national and regional sea level rise along the US coast, with an **Interactive Guide to Global and Regional Sea Level Rise Scenarios for the US** jointly developed with NOAA in 2017. Detailed information about this project and an interactive map of its datasets are available[100].

The USGS maintains a spatial dataset of mineral resources in the US, including an inventory of known locations and types of mines, in their **Mineral Resources Online**

interactive map viewer[101]. The USGS also has spatial data layers of prospect- and mine-related landform features identified on topographic maps, including prospect pits, mine shafts and adits (horizontal mine entry shafts), open-pit mines, quarries, tailings ponds and piles, gravel and borrow pits, and related features (Horton and San Juan 2022). Data layers are available for every state except West Virginia[102]. These datasets include an inventory of historical and active mine and quarry operations, to the extent that they have readily identifiable surface features. The Vermont dataset, for example, includes 1172 prospect- and mine-related features on the landscape, from granite and marble quarries to talc and asbestos mines. Altogether 35,732 mine-related features are identified on the Northeast landscape, excluding West Virginia (see *Chapter 2*, Table 2.8.2).

The USGS inventories and monitors several environmental resources through citizen science projects. **CrowdHydrology** is a USGS public project that began in the Northeast and has since spread across the country to monitor stream levels[103]. Citizen scientists submit water level data from stream gaging staffs or stations to the CrowdHydrology database via text messages. The database is publicly available for researchers, students, resource managers and others to use. The USGS developed the **iPlover** mobile app that collects information about beach and dune habitat and their surrounding environments[104]. The USGS **iCoast** online resource engages the public in annotating aerial photographs taken along the country's coastlines following extreme storms[105]. **Nature's Notebook** tracks seasonal changes in plants and animals across the US in a citizen science project sponsored by the USGS and the **National Phenology Network**[106].

5.1.4 UNITED STATES FOREST SERVICE PROGRAMS

The United States Forest Service (USFS) monitors forest and woodland habitats across the country. The federal agency conducts an annual census of forests and woodlands with its **Forest Inventory and Analysis (FIA) Program**[107]. The program assesses forests and woodlands by collecting data on tree species composition, size and health as well as tree growth, mortality and removals by harvest. There are 6,952 sample points in the FIA dataset within the Northeast region. The US Forest Service also monitors forests and woodlands via remote sensing and has developed a field sampling protocol to pair with remote sensing data to monitor carbon in forests and woodlands[108].

US Forest Service PRISM allows an interactive exploration of key accomplishments of the USFS State and Private Forestry Programs and discover a current assessment of landscape impact[109]. It can be queried by state, region, county, watershed, or congressional district. PRISM presents information in a dashboard format to provide the number and acres of accomplished projects, as well as the number of acres and percentage of priority land impacted. As of January 2023, almost 425 million acres of

priority lands were identified nationally with 19.1 million acres impacted with projects, stewardship plans, landscape plans, and other plans.

The USFS **Wildfire Hazard Explorer** portal contains the spatial footprints and associated metadata for known wildfire risk, threat, hazard, and burn probability maps[110]. The project was commissioned by the USFS and National Association of State foresters (NASF) to better catalog the existing wildfire data resources available to states, federal agencies, and private and NGO partners. The site does not house the actual data for the risk / threat / hazard maps, but instead, provides metadata and links to the sources (where available). Users can submit project information to be added to the dataset. The site was designed to be easy to use with simple filters and the ability to search by text or map.

5.1.5 USDA PROGRAMS

The United States Department of Agriculture (USDA) offers several national monitoring programs and projects informative for Northeast SWAPs. The **Animal and Plant Health Inspection Service (APHIS)** of the USDA, for example, conducts animal disease surveillance of both wildlife and agricultural and aquacultural animals through the **National Animal Health Monitoring System** and the **Animal Health Surveillance System**[111]. The APHIS **Plant Protection and Quarantine Program** protects the nation's natural and agricultural resources from the entry, establishment, and spread of environmentally and economically significant pests through detection and monitoring programs for pests[112]. The National Veterinary Services Laboratories monitors animal diseases, offers diagnostic services, and hosts an international reference library for animal diseases of importance to the Americas[113]. The APHIS Wildlife Services program operates the **National Wildlife Research Center**, which conducts research and develops techniques for managing wildlife damage, nuisance and pest animals, invasive species, wildlife disease, overabundant wildlife, and other issues affecting ecosystem health[114]. The National Wildlife Research Center maintains a regional Field Station in Philadelphia, Pennsylvania.

The USDA maintains the **Plant List of Attributes, Names, Taxonomy, and Symbols (PLANTS) Database**[115]. This inventory provides a standardized information about the vascular plants, liverworts, mosses, lichens, and hornworts of the US and its territories. The **2020 National Wetland Plant List** identifies wetland indicator species (8000+) and is included in the PLANTS Database with species profile pages, searchable by region[116]. The PLANTS Database website now includes related resources and tools for pollinators, ecosystem dynamics, plant identification keys, culturally significant plants, invasive and noxious weeds, federally and state-listed plants, and technical publications from the Plant Materials Program. The Natural Resources Conservation Service maintains state plant lists available online[117].

The **National Invasive Species Information Center** is within the USDA, providing invasive species information from local, state, federal, and international sources[118]. The Center maintains an **Invasive Species Profiles List** for aquatic and terrestrial species declared as invasive, noxious, prohibited, or otherwise harmful or potentially harmful in the United States[119]. Species profiles include taxonomy, imagery, native range, the date of introduction to the US, how it was introduced, current known distribution, and the location of any quarantine areas.

The USDA National Agricultural Statistics Service monitors agricultural lands with **CropScape**, an interactive online mapping tool and associated data layer of cropland across the country[120]. Datasets are available for every year starting from 1997 and distinguish croplands by type (e.g., corn, cotton, rice, soybeans), pasture, wetlands, forest, developed, and other land cover types.

The National Statistics Service conducts a **Census of Agriculture**[121] every five years that is a complete count of all farms and ranches in the country, with the most recent census underway in 2022. A series of atlas maps illustrate the data from the Census of Agriculture and are publicly available. Census of Agriculture data are available by state, county, tribal reservation, watershed and zip code.

The USDA conducts regular monitoring assessments and evaluations of the agency's programs and initiatives, such as bird conservation benefits from the Conservation Reserve Program, the benefits of prairie strips and saturated buffers, Chesapeake Bay benefits from Conservation Reserve Enhancement Program, water quality and quantity studies, pollinator studies, and other wildlife studies (e.g., Northern Bobwhite, grassland birds, amphibians). Monitoring, assessment and evaluation reports related to wildlife benefits are available online[122].

5.1.6 NOAA PROGRAMS

The National Oceanic and Atmospheric Administration (NOAA) has been monitoring the marine ecosystem of the Northeast for more than 40 years[123]. Multiple programs and projects within this federal agency monitor aspects of the marine habitats and their species in the Northeast. The **Marine Mammal Health and Stranding Response Program** coordinates emergency responses to injured, distressed, sick, or dead marine mammals[124]. The program maintains a network of volunteer, local, tribal, state, and federal agencies responding to marine mammal strandings and entanglements, with reported data collected in the **National Stranding Database**[125]. The **Greater Atlantic Marine Mammal Stranding Network** provides a consistent framework for monitoring and responding to marine mammal strandings and entanglements in the NEAFWA region. The Marine Mammal Health and Stranding Response Program conducts biosurveillance and baseline health research on marine mammals, maintaining

a **National Marine Mammal Tissue Bank** with standardized protocols and techniques for the long-term storage of samples for retrospective analyses[126].

The **Sea Turtle Stranding and Salvage Network** similarly monitors and responds to sea turtle strandings[127]. Sea turtle standardized and verified stranding data are available in an online database[128].

NOAA Fisheries monitors recreational and commercial fishing in the marine system, including for several species that are RSGCN or Watchlist species in the Northeast. The NOAA **Northeast Fisheries Science Center (NEFSC)** conducts several ecosystem surveys in the Marine Nearshore of the region, including a database of biannual fisheries-independent bottom trawl surveys, from the 1960s to present[129]. The NEFCS **Marine Resources Monitoring, Assessment and Prediction Program (MARMAP)** conducted periodic standardized surveys of the Northeast Marine Nearshore and Marine Offshore and Oceanic areas at 193 stations from Cape Sable, Nova Scotia, to Cape Hatteras, North Carolina from 1977 to 1988. Since 1992 portions of the MARMAP survey design were continued with the **Ecosystem Monitoring Program (EcoMon)** for long-term monitoring at 120 stations[130].

NOAA also maintains a **Digital Coast** resource that provides data, tools and training resources for addressing coastal issues, including data and maps for land cover, sea level rise, elevation, hurricanes, coastal flooding, imagery, socioeconomics, weather and climate, marine habitat and species, ocean uses and planning areas, water quality, infrastructure, oceanography and more[131]. NOAA monitoring data on environmental conditions, marine habitat, and biological resources are publicly available through the **National Centers for Environmental Information** at https://www.ncei.noaa.gov/. The NOAA **Tides and Currents** data portal includes local water levels, tide and current predictions, and other oceanographic and meteorological conditions, which is searchable by monitoring station, city, state or zip code[132]. These monitoring datasets include both real-time observational data and historical data.

Other seascape level monitoring programs supported by NOAA address particular threats or species. For example, NOAA maintains the **Invasive Lionfish Web Portal** to monitor the spread of invasive Lionfish (*Pterois volitans*) in the Atlantic Ocean and Gulf of Mexico[133]. The **National Centers for Coastal Ocean Science** at NOAA monitors eutrophication levels in the nation's estuaries as part of the periodic **National Estuarine Eutrophication Assessment**, but the frequency of the assessment is dependent on the availability of funding[134]. NOAA maintains the **National Deep-Sea Corals and Sponges Database**, with a digital map of deep-sea coral and sponge locations, site characterization reports, and habitat suitability models[135]. The **Deep-sea**

Coral National Observation Database for the Northeast Region is publicly available[136].

The NOAA **Ocean Acidification Program** operates a national monitoring program with vessel surveys, stationary buoys and moorings, and wave gliders that measure a number of physical and oceanographic indicators of coastal and marine system health and acidification levels[137]. The primary goal of this national monitoring program is to measure and understand the exposure and effects of ocean acidification on marine resources like shellfish and coral. The NOAA Ocean Acidification Program operates 19 monitoring buoys across the world's oceans, one of which is located in the Gulf of Maine within the NEAFWA region. Research ship surveys monitor temperature, salinity, conductivity, depth and other indicator metrics at multiple depths along designated survey routes every five years, contributing to the **Global Ocean Acidification Network**[138]. The monitoring program also collects data on Ships of Opportunity and Volunteer Observing Ships (e.g., commercial cargo ships, ferries), which are at sea for other research or monitoring purposes but provide an opportunity to collect ocean acidification data.

Several research and monitoring projects supported by the NOAA Ocean Acidification Program are currently underway in the Northeast to assess the threat and impacts of ocean acidification on coastal and marine systems[139]:

- The **Low pH in Coastal Waters of the Gulf of Maine: A Data Synthesis-driven Investigation of Probable Sources, Patterns and Processes Involved** project synthesized decades of monitoring data on unusually high acidic conditions in the subsurface waters of Maine's estuaries.
- The **Interactions Between Ocean Acidification and Metal Contaminant Uptake by Blue Mussels (*Mytilis edulis*)** project includes ten research locations in the NEAFWA region to understand how changing ocean acidification conditions affect the accumulation and toxicity of metals, with potential implications for seafood safety and aquaculture.
- The **Assessing Vulnerability of the Atlantic Sea Scallop Social-Ecological System in the Northeast Waters of the United States** project is refining previous assessments that the biomass of Atlantic Sea Scallop (*Placopecten magellanicus*), may decline by more than 50% by the end of the century, informing fishery management of this Northeast RSGCN species of High Concern.
- The **Optimizing Ocean Acidification Observation for Model Parameterization in the Coupled Slope Water System of the U.S. Northeast Large Marine Ecosystem** project seeks to improve understanding of the region's greater susceptibility to ocean acidification in the Gulf of Maine and Mid-Atlantic regions by adding seasonal deployments of underwater gliders

with new sensor technologies, optimizing the location of monitoring stations, and integrating existing ocean acidification datasets.

- The **Assessment of the Observing Network to Identify Processes Relevant to the Predictability of the Coastal Ocean of the Northeast on Centennial Time Scales** project is evaluating the factors influencing the difference between the global and regional acidification rates, evaluating the existing monitoring network's ability to detect changes in ocean acidification rates in the Northeast region and corresponding stressors on the RSGCN Atlantic Sea Scallop.
- The **Ocean and Coastal Acidification Thresholds from Long Island Sound to the Nova Scotian Shelf** project is assessing how the Northeast's nearshore and coastal ecosystems will respond to ocean and coastal acidification and how those changes will impact human communities by expanding the Northeast Coastal Ocean Forecast System to develop actionable guidance for coastal water quality and marine resource managers.
- The **Strategy for Ocean and Coastal Acidification Education and Citizen Science Monitoring in the Northeast** project is calibrating citizen science monitoring protocols and training for ocean acidification with those of independent organizations in accordance with the Environmental Protection Agency's recent **Guidelines for Measuring Changes in Seawater pH and Associated Carbonate Chemistry in Coastal Environments of the Eastern United States**.
- The **Tracking Ocean Alkalinity using New Carbon Measurement Technologies** is expanding the quantity and quality of ocean acidification monitoring by installing new monitoring sensors on the **Northeastern Regional Association of Coastal Ocean Observing Systems** monitoring network.
- The **Interactions Between Ocean Acidification and Eutrophication in Estuaries: Modeling Opportunities and Limitations for Shellfish Restoration** project is integrating existing monitoring and experimental work with biogeochemical model frameworks to delineate the drivers of acidification in Chesapeake Bay, develop a spatial framework to identify shellfish restoration areas the most and least prone to impacts of acidification, and improve understanding of future environmental conditions for shellfish restoration.
- The **Sensitivity of Larval and Juvenile Sand Lance (*Ammodytes dubius*) on Stellwagen Bank to Predicted Ocean Warming, Acidification, and Deoxygenation** project is quantifying the sensitivity of this Northeast Watchlist [Interdependent] species to the individual and interactive effects of ocean warming, acidification, and deoxygenation.

- The **Probing Molecular Determinants of Bivalve Resilience to Ocean Acidification** project is assessing the resilience of the Blue Mussel and two Northeast Watchlist [Assessment Priority] species - Eastern Oyster (*Crassostrea virginica*), Northeast Hard Clam (*Mercenaria mercenaria*) - to ocean acidification.
- The **Genetic and Phenotypic Response of Larval American Lobster to Ocean Warming and Acidification Across New England's Steep Thermal Gradient** project will fill knowledge gaps regarding the sensitivity and resilience of American Lobster (*Homarus americanus*), a Northeast RSGCN of High Concern, to ocean acidification.
- The **Synthesis and Understanding of Ocean Acidification Biological Effects Data by Use of Attribute-Specific, Individual-Based Models** project seeks to identify the potential or realized effects of ocean acidification on Winter Flounder (*Pseudopleuronectes americanus*), a Northeast RSGCN of High Concern.
- The **Monitoring of Water Column Dissolved Inorganic Carbon, Total Alkalinity and pH on the Northeast U.S. Shelf and the Development of Ocean Acidification Indicators to Inform Marine Resource Managers** project expands the four annual ecosystem monitoring cruises of the Northeast Fisheries Science Center to include sampling for ocean acidification indicators.

These research and monitoring projects inform the needs of multiple Northeast RSGCN and Watchlist species, inform understanding of their threats from climate change, and allow for long-term monitoring of these effects of climate change at the regional and national scale.

5.2 REGIONAL INVENTORY AND MONITORING PROGRAMS

The Northeast states of NEAFWA participate in several regional, national, and international inventory and monitoring programs. These collaborative partnerships advance the conservation of RSGCN and Watchlist species and their habitats within the region and beyond, oftentimes addressing life cycle needs more wholistically. Monitoring partnerships that are species-based are discussed in *Chapter 1* under specific taxonomic groups, that are habitat-based are discussed in *Chapter 2* under specific habitat types, and that are threat-based are discussed in *Chapter 3* under specific threat types. The following regional partnerships are multi-taxa and/or landscape or seascape scale programs.

5.2.1 NORTHEAST MONITORING AND PERFORMANCE REPORTING FRAMEWORK

Monitoring the Conservation of Fish and Wildlife in the Northeast: A Report on the Monitoring and Performance Reporting Framework for the Northeast Association of Fish and Wildlife Agencies identifies a regional monitoring framework for the status of SGCN and their habitats and the effectiveness of conservation projects implemented as part of SWAPs and the State Wildlife Grants program (NEAFWA 2008). The monitoring framework includes eight conservation targets:

1. Forests
2. Freshwater streams and river systems
3. Freshwater wetlands
4. Highly migratory species
5. Lakes and ponds
6. Managed grasslands and shrublands
7. Regionally significant SGCN
8. Unique habitats in the Northeast

The monitoring framework report noted at the time that additional work was needed to include coastal and marine systems in the framework, which focused limited time and resources on terrestrial and freshwater systems. Specific indicators and stressors are identified for monitoring to assess each of the eight conservation targets, with the exception of the managed grasslands and shrublands target where information was lacking (Table 5.2.1).

The Nature Conservancy assessed these eight conservation targets as part of the **Conservation Status of Fish, Wildlife, and Natural Habitats in the Northeast Landscape: Implementation of the Northeast Monitoring Framework** (Anderson and Sheldon 2011). The Nature Conservancy updated this condition assessment in 2023 with new information and analysis tools (Anderson et al. 2023), with the exception of the RSGCN conservation target which is addressed in *Chapter 1* of this Regional Conservation Synthesis instead. *Chapter 2* of this Regional Conservation Synthesis supplements the 2023 condition assessment by addressing the need to assess the status and condition of the region's coastal and marine systems not currently included in the monitoring framework.

The updated condition assessment identifies trends in the conservation targets and indicators over the past decade, but also incorporates new data resources to identify long-term trends across multiple decades (Anderson et al. 2023). By utilizing standardized techniques and datasets, the Northeast Monitoring and Performance

Reporting Framework provides a consistent and regional assessment of priority species and their habitats for landscape level collaboration and the regional context in SWAPs.

Table 5.2. 1 List of conservation targets and proposed indicators in the Monitoring and Performance Reporting Framework for the Northeast Association of Fish and Wildlife Agencies (NEAFWA 2008).

Targets	Recommended Indicators
1. Forests	1a. Forest area - by forest type
	1b. Forest area - by reserve status
	2. Forest composition and structure - by seral stage
	3. Forest fragmentation index
	4. Forest bird population trends
	5. Acid deposition index
2. Freshwater streams and river systems	1. % impervious surface
	2. Distribution and population status of native Eastern brook trout
	3. Stream connectivity (length of open river) and number of blockages
	4. Index of biotic integrity
	5. Distribution and population status of non-indigenous aquatic species
3. Freshwater wetlands	1. Size/area of freshwater wetlands
	2. % impervious surface flow
	3. Buffer area and condition (buffer index)
	4a. Hydrology - upstream surface water retention
	4b. Hydrology - high and low stream
	5. Wetland bird population trends
	6. Road density
4. Highly migratory species	1. Migratory raptor population index
	2. Shorebird abundance
	3. Bat population trends
	4. Abundance of diadromous fish (indicator still under development)
	5. Presence of monarch butterfly
5. Lakes and ponds	1. % impervious surface/landscape integrity
	2. % shoreline developed (shoreline integrity)

Targets	Recommended Indicators
	3. Overall Productivity of Common Loons
6. Managed grasslands and shrublands	To be developed
7. Regionally Significant Species of Greatest Conservation Need	1. Population trends and reproductive productivity of federally listed species
	2. State-listing status and heritage rank of highly imperiled wildlife
	3. Population trends of endemic species
8. Unique habitats in the Northeast	1. Proximity to human activity/roads
	2. Wildlife presence/absence
	3. Wildlife population trends
	4. Land use/land cover changes

5.2.2 THE MOTUS WILDLIFE TRACKING SYSTEM

The **Motus Wildlife Tracking System** network is an international program that uses nanotag technology to track and monitor migratory wildlife via telemetry receiver stations at the landscape scale, targeting species that are too small for satellite tracking equipment. As of 2022, there were more than 1550 Motus receiver stations located in 34 countries on five continents[140]. More than 300 species (with more than 36,500 individuals) have been tagged as part of 573 projects. Nearly 1700 partners collaborate as part of the international Motus network.

In the eastern United States, the network was initially developed to monitor shorebirds, seabirds, and coastally migrating songbirds, with most of the array located in coastal areas and along the Great Lakes shorelines. Since 2017, the **Northeast Motus Collaboration** has expanded the array throughout the interior Northeast, filling a geographic gap along a key migratory route in the western hemisphere[141]. More than 470 Motus stations exist in the NEAFWA region as of 2022, the densest concentration of receiver stations in the world. Wildlife that is tracked in the Northeast with the Motus network includes songbirds, seabirds, raptors, bats, bumble bees, Monarch butterfly (*Danaus plexippus plexippus*), and migratory dragonflies. A Motus project in Tennessee tracked the movements of the RSGCN Bog Turtle (*Glyptemys muhlenbergii*).

The Northeast Motus Collaboration has been supported by three competitive State Wildlife Grants (CSWG) projects[141]:

- (2018) **Motus I: Overcoming Geographic and Temporal Barriers to Identifying Landscape-scale Habitat Use of Multiple SGCN in the Mid-Atlantic Region Using Nanotag Technology** [Birds, Mammals (bats); lead state Pennsylvania]
- (2019) **Motus II: Using Nanotag Technology to Identify Landscape-scale Habitat Use of Multiple SGCN in New England** [Birds, Insects (Monarch); lead state New Hampshire]
- (2022) **Motus III: Identifying SGCN habitat use across multiple scales throughout the eastern U.S. using the Motus Wildlife Tracking System** [Birds, Mammals (bats), Reptiles (Bog Turtle); lead state Alabama, funded efforts in Pennsylvania and Vermont]

Recent Motus projects in the Northeast have tracked and monitored the movements of RSGCN Wood Thrush (*Hylocichla mustelina*), Bicknell's Thrush (*Catharus bicknelli*), Rusty Blackbird (*Euphagus carolinus*), American Woodcock (*Scolopax minor*), Northern Long-eared Bat (*Myotis septentrionalis*), and Watchlist [Assessment Priority] species Peregrine Falcon (*Falco peregrinus anatum*)[142].

The Motus network can identify migratory routes, stopover sites, and wintering areas of migratory species as well as inform habitat use, phenology, and hazards such as window collisions. Numerous Motus studies have monitored the movements of RSGCN and Watchlist species at the hemispheric scale[143].

5.2.3 GREAT LAKES OBSERVATION SYSTEMS

The Great Lakes have multiple monitoring and research programs and partnerships. The **Great Lakes Observing System (GLOS)**, part of the national **Integrated Ocean Observing System**, maintains a network of observational monitoring stations and projects across the Great Lakes and their watersheds[144]. Data collected include physical, biogeochemical, and biological data, including a number of metrics relevant to State Wildlife Action Plans regarding species, habitats, and threats. Much of the data is real-time from observation platforms and models are used to generate short-term and long-term projections on a number of indicators. Monitoring data are shared publicly and free on the Seagull and GLOS apps, including lake temperature, waves and currents, and water quality parameters. The Seagull information sharing platform was launched in 2022 in support of the **Smart Great Lakes Initiative**, which intends to improve understanding, conservation, use, and management of the Great Lakes in both the United States and Canada through the use of advanced technology applications[145]. Another priority of GLOS is to complete mapping of the entire lakebed with high-resolution bathymetric surveys, which is currently only 15% mapped, by 2030.

The **Great Lakes Acoustic Telemetry Observation System (GLATOS)** is a monitoring network of receiver stations on the lakebeds of the Great Lakes that tracks tagged fish using acoustic telemetry[146]. Established by the Great Lakes Fishery Commission with funding from the **Great Lakes Restoration Initiative**[147] in 2010, GLATOS is a collaborative monitoring and research program that includes Canadian and American partners. Participating researchers represent state, provincial and federal agencies, universities, and tribal nations. Data are shared within the GLATOS project membership in accordance with individual partners' data sharing policies.

As of 2022, GLATOS receiver stations were present throughout Lake Champlain, Lake Ontario, Lake Erie, and portions of the St. Lawrence Seaway, Niagara River, and several Great Lakes tributaries in New York within the Northeast region. Recent projects that monitored the movements and habitat use of Northeast RSGCN and Watchlist species include Lake Trout (*Salvelinus namaycush*), Lake Sturgeon (*Acipenser fulvescens*), American Eel (*Anguilla rostrata*), Lake Whitefish (*Coregonus clupeaformis*), and Burbot (*Lota lota*). A directory of GLATOS research and monitoring projects with detailed information about each is available online[148].

GLATOS is the Great Lakes node within the global **Ocean Tracking Network**[149]. The Ocean Tracking Network is an aquatic animal tracking, technology, data management, and partnership platform that as of 2022 has been implemented to track over 300 endangered, keystone, and commercially important species through nearly 2500 acoustic receivers across five oceans. Based out of Dalhousie University in Canada, this global network has allowed seascape level monitoring of marine fish, sharks, sea turtles, and marine mammals, including the RSGCN White Shark (*Carcharodon carcharias*), Porbeagle (*Lamna nasus*), Blue Shark (*Prionace glauca*), Atlantic Salmon (*Salmo salar* pop. 5), American Eel, Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*), and Leatherback Sea Turtle (*Dermochelys coriacea*). Research informed by the use of the Ocean Tracking Network includes species distribution, habitat use, seasonal movements, spawning behavior, species interactions, and assessing the impacts of climate change. Detailed information about these global ocean projects is available online[150].

5.2.4 GREAT LAKES RESTORATION INITIATIVE

The **Great Lakes Restoration Initiative (GLRI)** monitors several performance measures for conservation projects funded by the program[147]. The current 2020-2024 GLRI Action Plan has five focus areas (GLRI 2019):

- Toxic substances and areas of concern
- Invasive species
- Nonpoint source pollution impacts on nearshore health

- Habitats and species
- Foundations for future restoration actions

Each focus area has targets and objectives which are monitored as performance measures, many of which address the effectiveness of management actions. Monitoring indicators relevant to species, habitats, and threats assessed in Northeast SWAPs include:

- Acres of coastal wetland, nearshore and other habitats protected, restored, or enhanced
- Miles of connectivity established for aquatic species
- Miles of Great Lakes shorelines and riparian corridors restored or protected
- Acreage of aquatic and terrestrial habitats controlled for invasive species
- Estimated pounds of phosphorus reductions from implementation of conservation practices throughout Great Lakes watersheds
- Acres of land receiving financial or technical assistance for nutrient management in priority watersheds
- Estimated gallons of untreated stormwater runoff captured or treated
- Number of discrete chemical monitoring and assessment activities conducted to fill data gaps on "chemicals of mutual concern" identified in the Great Lakes Water Quality Agreement between the United States and Canada
- Number of species benefited where actions have been completed to significantly protect or promote population recovery of state, tribal, and Great Lakes native species of importance (including fish, birds, mussels, snails, Lepidoptera, mammals, bumble bees, and plants)
- Number of youth impacted through education and stewardship projects

The GLRI provides annual results on these monitored measures of conservation progress[151]. Through Fiscal Year 2021, cumulatively project partners have:

- protected, restored, or enhanced more than 479,000 acres of habitat, including 65,000+ acres of coastal wetlands,
- improved aquatic connectivity on more than 6700 river miles,
- protected or restored 43.6 miles of Great Lakes shoreline or riparian corridors,
- conducted invasive species control activities on more than 216,000 acres,
- provided technical and financial assistance for nutrient management on over 1.8 million acres of Great Lakes watersheds,
- reduced more than 2 million pounds of phosphorous loads in priority watersheds,
- captured more than 413 million gallons of untreated urban runoff annually,

- salvaged 53 Piping Plover eggs from historically high flooding in 2020, successfully incubating and hatching 85% of the eggs and releasing 39 captively reared chicks,
- conducted education and stewardship projects with more than 627,000 youth.

5.2.5 CHESAPEAKE BAY WATERSHED

Multiple partners in the **Chesapeake Bay Program**[152] monitor conservation efforts, species status, and habitat conditions in the estuary and its watershed. Monitoring information is collated and provided to oversight partners and the public through **Chesapeake Progress**[153]. More than two dozen indicators track progress on meeting the goals and outcomes of the **Chesapeake Bay Watershed Agreement** among six states and the District of Columbia[154]:

- *Vital habitats*
    - Black Duck (*Anas rubripes*) population [a Northeast RSGCN]
    - Area of headwater streams occupied by wild populations of Brook Trout (*Salvelinus fontinalis*) [the wild population is a Northeast Watchlist Assessment Priority species]
    - Length of rivers and streams habitat with restored fish passage
    - Length of riparian forest buffers restored and protected
    - Length of rivers and streams with improved stream health above 2008 baseline, as measured by the Chesapeake Basin-wide Index if Biotic Integrity
    - Area of submerged aquatic vegetation (SAV) habitat in the estuary
    - Increase in urban tree canopy area
    - Area of tidal and non-tidal wetlands restored or created
- *Sustainable fisheries*
    - Blue Crab (*Callinectes sapidus*) abundance [a Northeast Watchlist Assessment Priority species]
    - Fish habitat – identify and track key habitat areas
    - Forage fish – track abundance of key invertebrates and factors influencing the abundance of forage
    - Protect and restore Oyster (*Crassostrea virginica*) populations and habitats [a Northeast Watchlist Assessment Priority species]
- *Water quality*
    - Number of pollution best management practices (BMPs) and controls identified in the 2025 Watershed Implementation Plans of participating states implemented
    - Attainment of water quality standards for Chesapeake Bay Total Maximum Daily Loads

- *Toxic contaminants*
    - Identify and characterize the occurrence, concentrations, sources, and effects of mercury, polychlorinated biphenyls (PCBs), and other contaminants of emerging and widespread concern; identify stormwater BMPs that may reduce toxic contaminants as well as reducing nutrient and sediment pollution through pollutant removal efficiency studies
    - Number of impaired waters for toxic contaminants under Section 303(d) of the Clean Water Act
- *Healthy watersheds* – proportion of state-identified healthy waters and watersheds retaining healthy status
- *Land conservation*
    - Develop methodology and indicator metrics to measure the rate of farmland, forest, and wetland conversion; extent and rate of change in impervious surface cover per capita; and quantify potential impacts of land conversion on water quality
    - Local adoption of the Conservation Land-Use Policy Toolkit and associated resources to slow the conversion of forests, wetlands, and agricultural lands by incentivizing conservation and dis-incentivizing development
    - Acres of protected lands throughout the watershed
- *Public access* – number of new sites developed
- *Environmental literacy*
    - Degree of environmental literacy preparedness among school districts as measured by the Environmental Literacy Indicator Tool
    - Proportion of schools providing at least one Meaningful Watershed Educational Experience to school students in elementary, middle, and high schools
    - Number of schools identified as sustainable through reducing the impact of their buildings and grounds on their local watershed, environment, and human health through best practices, including student-led protection and restoration projects
- *Stewardship*
    - Improvement of the Stewardship Index of watershed residents, which measures personal actions, volunteering, and advocating of individuals
    - Improvement of the diversity of Chesapeake Bay Program participants and leaders
    - Number of local government elected officials and staff reached for engagement and education of restoration and protection issues related to the estuary and number of local governments participating in restoration activities

- *Climate resiliency*
    - Number of climate adaptation and resiliency projects identified and implemented
    - Climate change indicators developed, monitored, and assessed to prioritize conservation efforts and resources

Detailed information on recent progress and the future outlook (i.e., completed, on course, uncertain, off course) of each of these performance measures is available, including discussions of factors influencing progress[155]. The Chesapeake Bay Program performs an annual review of the watershed's environmental health and restoration, called the **Bay Barometer**, that summarizes the status of these indicators[156].

The Chesapeake Bay Foundation also monitors efforts to conserve the estuary and its watershed, releasing **State of the Bay** reports every two years. The most recent monitoring report was issued in late 2022, the **State of the Bay 2022** (Chesapeake Bay Foundation 2022). Thirteen indicators are monitored for pollution, habitat, and fisheries:

- *Pollution*
    - Nitrogen
    - Phosphorus
    - Dissolved oxygen
    - Water clarity
    - Toxics Release Inventory chemical pollution levels
- *Habitat*
    - Forest buffers
    - Wetlands
    - Underwater grasses
    - Resource land conversion
- *Fisheries*
    - Rockfish (Striped Bass [*Morone saxatilis*], a Northeast Watchlist Assessment Priority species)
    - Oysters (a Northeast Watchlist Assessment Priority species)
    - Blue Crabs (a Northeast Watchlist Assessment Priority species))
    - Shad (both Hickory Shad [*Alosa mediocris*] and American Shad [*Alosa sapidissima*] are Northeast RSGCN species)

Each indicator is given a score compared to pre-Colonial conditions, based on available monitoring data and field observations. A report card for the Chesapeake Bay averages the scores of the three indicator categories which are translated into letter grades for communication purposes. The organization's report card issued a health index score of 32 out of 100 for 2022, equivalent to a D+ letter grade and unchanged from the previous

assessment. Failing grades, or the poorest indicators, were nitrogen, water clarity, oysters and shad. A health index score of 50 is considered stable and 70 is considered "saved."

The Chesapeake Bay Foundation also monitors progress of meeting the goals and objectives of the Chesapeake Bay Watershed Agreement, releasing a **2022 Chesapeake Bay State of the Blueprint**[157] monitoring report in late 2022. Although monitoring indicates a 42% reduction in nitrogen pollution levels and 64% in phosphorous since 2010, the organization found overall efforts are not on track to meet 2025 pollution reduction targets.

5.2.6 DELAWARE RIVER WATERSHED

The **Delaware River Basin Commission** is a partnership between the states of New York, New Jersey, Pennsylvania, and Delaware and federal agencies to protect the Delaware River watershed and estuary with both regulatory and non-regulatory programs and initiatives[158]. The Commission collates monitoring reports, surveys, and research findings, particularly on water quality[159]. Every two years the Delaware River Basin Commission compiles a **Delaware River and Bay Water Quality Assessment** for the EPA, which includes four surface water quality monitoring programs on the non-tidal and tidal portions of the river, plus chronic toxicity monitoring in the estuary and macroinvertebrate monitoring in the non-tidal portion of the river[160]. The biennial assessment supplements Commission monitoring data with monitoring program data from each of the four participating states, the United States Geological Survey, National Oceanic and Atmospheric Administration, and Environmental Protection Agency.

The **Delaware River Watershed Initiative** also conducts monitoring throughout the watershed of this Big River[161]. This Initiative of more than 50 organizations and academic institutions works to conserve the terrestrial and aquatic resources of the watershed across four states. The partnership's monitoring program intends to detect incremental changes in the health of the basin's waters through the collaboration of research teams, conservation partners, and citizen scientists. Monitoring data is then incorporated into modeling efforts to evaluate the effectiveness of on-the-ground conservation projects.

The **Stroud Water Research Center** is a lead partner in the Delaware River Watershed Initiative's monitoring and modeling efforts[162]. The Center and other Initiative partners have numerous continuous water quality monitoring stations throughout the Delaware River watershed and provide support to citizen scientists and local community partner organizations to install and maintain monitoring stations for both water quality and aquatic macroinvertebrates. Monitoring data is collected and

available through the online **Monitor My Watershed** platform[163]. The monitoring data collated on Monitor My Watershed is incorporated into **Model My Watershed**, an interactive online mapping and analysis tool that provides collated data for the upstream catchment of any point or shape drawn on the map[164]. Data provided in this application include medium and high-resolution stream networks, land use / land cover from the most recent National Land Cover Dataset (NLCD), soils, terrain, climate, point sources of pollution, the number and types of farm animals present, and multiple water quality parameters. Models are available for stormwater runoff during storm events, water quality over time, and the potential effects of different conservation and development scenarios. The Model My Watershed datasets and analyses are the most comprehensive for the Delaware River basin, but some of the datasets are national in extent.

5.2.7 LONG ISLAND SOUND

The **Long Island Sound Study**[165], a National Estuary Program with multiple state and federal partners, monitors several indicators as part of its **Comprehensive Conservation and Management Plan for Long Island Sound**. Ecosystem Indicators that measure the health of the estuary and measure performance to achieve Ecosystem Targets include[166]:

- Extent of hypoxia
- Duration of hypoxia
- Severely hypoxic and anoxic areas
- Nitrogen loads
- Water clarity
- Extent of impervious cover
- Extent of riparian buffers
- Area of approved shellfish areas
- Sediment quality index
- Industrial chemical discharges
- Water quality index
- Extent of coastal habitat
- Eelgrass abundance
- Acres of tidal wetlands restored
- Miles of river restored for fish passage
- Shellfish harvested
- Habitat connectivity restored
- Area of open space protected
- Changes in forest cover in New York and Connecticut

- Index of anadromous fish runs
- Counts of river herring and shad in tributaries with completed fishway projects [Alewife (*Alosa pseudoharengus*), Blueback Herring (*A. aestivalis*), American Shad (*A. sapidissima*), and Hickory Shad (*A. mediocris*) are Northeast RSGCN]
- Horseshoe Crab (*Limulus polyphemus*) abundance [a Northeast RSGCN]
- American Lobster (*Homarus americanus*) abundance [a Northeast RSGCN]
- Forage fish abundance (14 species, including Northeast RSGCN Bluefish [*Pomatomus saltatrix*], Weakfish [*Cynoscion regalis*], and Blueback Herring) in open water and along the New York and Connecticut coastlines
- Invertebrate biomass index (15 species, including Northeast RSGCN Horseshoe Crab and American Lobster, plus Northeast Watchlist Assessment Priority species Blue Crab [*Callinectes sapidus*], Knobbed Whelk [*Busycon carica*], Channeled Whelk [*Busycotypus canaliculatus*], and Eastern Oyster)
- Game fish abundance (eight species, including Northeast RSGCN Black Sea Bass [*Centropristis striata*], Bluefish, Tautog [*Tautoga onitis*], Weakfish, and Winter Flounder [*Pseudopleuronectes americanus*], plus Northeast Watchlist Assessment Priority species Striped Bass [*Morone saxatilis*])
- River herring abundance (American Shad, Blueback Herring – both Northeast RGCN)
- Least Tern (*Sternula antillarum*) abundance [a Northeast RSGCN]
- Piping Plover (*Charadrius melodus*) abundance [a Northeast RSGCN]
- Number of beach day closures due to water quality impairments
- Pounds of marine debris collected annually
- Number of public access points to the Sound and its tributary rivers
- Number of federal navigation channels maintained in a sustainable manner in accordance with the Long Island Sound Dredged Material Management Plan
- Human population in the watershed and within 50 miles of the Sound
- Number of volunteers at coastal cleanups
- Number of coastal municipalities with plans for shoreline resiliency and infrastructure sustainability and resiliency

The **Long Island Sound Water Quality Monitoring Program** is conducted by the state of Connecticut and the Interstate Environmental Commission, collecting water quality data in both surface and bottom waters of the estuary[167]. Monitoring indicators include water temperature, salinity, dissolved oxygen, particulate nitrogen, and dissolved nitrogen, which is collected both by research vessels (monthly from October to May plus bi-weekly hypoxia surveys from June to September) and continuously on monitoring station buoys throughout the estuary. The **Unified Water Study** monitoring protocol enables citizen scientists and community organizations to collect

and contribute water quality data to the Long Island Sound Study monitoring program[168].

The **Long Island Sound Study Climate Change and Sentinel Monitoring Program[169]** is a part of the **Integrated Sentinel Monitoring Network** (see next Section). This research and monitoring program includes several climate change indicators in the estuary and its watershed[170]:

- Frequency of heavy precipitation events that exceed normal frequency
- Length of growing season
- Timing and temperature of the spring freshet on the Connecticut River
- Sea level rise
- Water temperature
- Species richness index of Warm Water Fish (38 species) to Cold Water Fish (33 species) annually

Monitoring data collected as part of the Long Island Sound Study Climate Change and Sentinel Monitoring Program are available at the **Sentinel Monitoring Data Citation Clearinghouse**[171]. As of 2019 more than 2000 acres of habitat, including forest and tidal wetlands, have been restored in the Long Island Sound watershed in New York and Connecticut as part of the Long Island Sound Study program, as has more than 400 miles of river connectivity for anadromous fish passage.

5.2.8 MARINE SEASCAPE

The North Atlantic Ocean is home to numerous regional monitoring partnerships and programs that can inform Northeast State Wildlife Action Plans and offer opportunities for implementation of the plans. These research, inventory, and monitoring programs and projects inform not only coastal and marine species (*Chapter 1*) and coastal and marine habitat status and condition (*Chapter 2*) but also the regional priority threats of pollution, climate change, development, natural system modifications, invasive and problematic species and disease, and biological resource use described in *Chapter 3*, as well as the threats of transportation (both terrestrial and maritime), renewable energy development, and mining (of seafloor sediments).

The NEAFWA region includes three of the 11 regional authorities within the national **Integrated Ocean Observing System: Northeastern Regional Association of Coastal Ocean Observing System**, **Mid-Atlantic Regional Association Coastal Ocean Observing System**, and **Great Lakes Observing System**[172]. These regional monitoring and research networks support information sharing, collaboration, and partnerships across federal and state agencies, academia, industry, and non-governmental conservation and planning partners.

The **Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS)** collects ocean information with a regional network, consolidating information in one place and supporting long-term ecosystem monitoring projects[173]. NERACOOS operates a network of monitoring stations, buoys, high-frequency radars, models and other ocean observing assets from the Canadian Maritime Provinces to New York. Real-time observational data collected by NERACOOS exceeds more than 21,500 observations daily across New England, with historical datasets available since 2001. Integrated datasets are collated and available through the **Mariners' Dashboard** and an interactive map server and on the **Northeast Ocean Data Portal[174]**. Fact sheets on the activities and impacts of NERACOOS projects are available for each of the five New England states in its region[175].

The **Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS)** is a regional monitoring network across ten states and five estuaries (from Cape Cod, Massachusetts, to Cape Hatteras, North Carolina) with more than 70 government, academic, industry, and non-governmental partners[176]. The network has five focus areas: fisheries, water quality, coastal hazards, energy, and maritime commerce and safety. Monitoring data collected by MARACOOS include air and water temperature, oceanographic variables, carbon dioxide, chlorophyll, dissolved oxygen, pH, salinity, and the locations and abundance of numerous marine animals.

The MARACOOS **OceansMap** is a data visualization tool that integrates near real-time observational data with model forecasts to facilitate monitoring of the coastal and marine system of the Mid-Atlantic region[177]. The interactive map allows customized filtering and analysis of monitoring and modeling data collected by the network's partners. The MARACOOS partnership recently launched a **Storm Resource Center** to track storms and collect related data for storms and extreme events along the eastern coast of the United States, using data from gliders, drifters, buoys, satellites, radars, weather stations, and buoys to inform potential impacts in the Mid-Atlantic region. MARACOOS monitoring data also is available on the **Mid-Atlantic Ocean Data Portal[178]** and the **NOAA Center for Operational Oceanographic Products and Services (CO-OPS) portal**[179].

The Great Lakes Observing System is discussed in Section 5.2.3 above for the Great Lakes.

The **Integrated Sentinel Monitoring Network** is supported by numerous Northeast conservation partners, including the Northeast Regional Ocean Council, Marine Biodiversity Observation Network (MBON), NERACOOS, Bureau of Ocean Energy Management, Environmental Protection Agency, National Oceanic and Atmospheric Administration, the states of Connecticut and New Hampshire, and numerous academic and non-governmental organizations[171]. Established in 2019, this

"network of networks" aims to convene the Northeast region's ocean monitoring projects into one resource with three objectives:

- Find and fill gaps in present ecosystem observation activities,
- Facilitate data sharing, integration, and communication among existing monitoring efforts, and
- Synthesize results to make individual project results more impactful

An inventory of regional sentinel monitoring projects in the marine seascape of the Northeast is available online[180].

The **Marine Biodiversity Observer Network** is a national network of monitoring programs, with the NERACOOS program through the Integrated Sentinel Monitoring Network, administering the MBON project in the Gulf of Maine ecosystem[181]. The goal of this monitoring effort is to identify and understand long-term changes in the Gulf of Maine ecosystem, with a focus on plankton biodiversity. The copepod *Calanus finmarchicus* serves as the primary indicator species because of its important role in the marine food web, serving as a dominant food source for RSGCN herring and North Atlantic Right Whale (*Eubalaena glacialis*) plus the Watchlist [Interdependent] Sand Lances (*Ammodytes americanus* and A. *dubius*).

Partners in the Integrated Sentinel Monitoring Network periodically convene **Centers for Analysis, Prediction and Evaluation (CAPE)** to conduct expert analysis and interpretation of monitoring data. The scope, scale, and duration of a thematic CAPE varies, as does membership among the expert partners. One current CAPE is currently analyzing monitoring datasets on the abundance of zooplankton to develop spatial maps and predictions of change for key marine species, thus informing foraging habitat for marine fish and whales. Analysis results from CAPE assessments are publicly available[182].

The **Northeast Regional Ocean Council (NROC)** is a state and federal partnership in New England facilitating regional collaborations to address coastal and marine issues and resources[183]. The **Northeast Ocean Data Portal**[174] provides a collection of research and monitoring products and datasets focused on ocean and coastal ecosystem health, coastal hazards resilience, and ocean planning. The Ocean and Coastal Ecosystem Health standing committee of NROC is a key partner with the NERACOOS Ecosystem Health Committee to develop the Integrated Sentinel Monitoring Network. A collaborative **Integrated Sentinel Monitoring Plan for Ecosystem Change in the Northeast Ocean and Coastal Waters** is currently under development, covering the region's seascape from the Canadian Maritime Provinces to Long Island Sound. The NROC Ocean and Coastal Ecosystem Health standing committee is also developing guidance on standardized data collection protocols, including use of the

Coastal and Marine Ecological Classification Standard and regionally consistent methodology to map and monitor salt marshes and manage monitoring data to support habitat conservation and restoration projects.

The **Ocean Health Index** framework (Halpern et al. 2012) was applied to the Northeast region in 2021 (Montgomery et al. 2021), implementing one of the assessment needs identified by NROC to inform decision-making and compatibility among ocean uses. More than 50 datasets were synthesized to monitor trends in ocean health in the North Atlantic from 2005 to 2017. Monitoring indicators identified by Northeast stakeholders and NROC partners with eight distinct goals for ocean health were evaluated across 11 subregions, providing annual scores and trends. The eight goals are: biodiversity, clean waters, food provision, habitat services, livelihoods and economies, resource access opportunities, sense of place, and tourism and recreation. Reference targets and monitoring indicators for these ocean and coastal health goals include several relevant to State Wildlife Action Plans and can be used to identify management priorities.

The biodiversity goal is divided into habitat and species subgoals. The habitats subgoal indicators are the extent of salt marsh habitat (as compared to pre-1920 historical estimates), the proportion of eelgrass beds with good water quality conditions (as defined by the EPA), and the level of disturbance of unvegetated seabed habitats from fishing activities. The species subgoal indicators are the number of species present in the region that are not at risk of extinction or classified as Least Concern by the IUCN. Indicators for the clean waters goal include the level of water pollution from pathogens and trash in coastal waters and sediment and water quality levels that exceed EPA thresholds. The habitat services goal uses monitoring indicators related the proportion of nearshore biogenic habitats in good condition that support carbon storage and coastal protection. The sense of place goal is evaluated partially by the number of iconic species present in the nearshore that have an IUCN conservation status of Least Concern, and partially by the percentage of coastal waters and lands within one kilometer of the shoreline that are protected (Montgomery et al. 2021).

Over the 13-year evaluation period, overall index scores for biodiversity remained stable or increasing but the clean water index showed a steady and significant downward trend. The level of habitat protection did not change for marine areas but increased by 3% for inland areas, with some parts of the region having already met the conservation targets for habitat protection. The status of iconic species was unchanged over the period and remains below the conservation target (Montgomery et al. 2021). Detailed information and results from this assessment, including all of the monitoring indicators, is available on the **Ocean Health Dashboard for the US Northeast**[184].

The **Northeast Coastal Acidification Network (NECAN)**[185] monitors coastal and ocean acidification in the region, established by NERACOOS in 2013. A map of regional conditions from Maine to New York with monthly data is available online[186]. NECAN provides a reference library for resources on coastal and ocean acidification, education and outreach resources, reports from monitoring workshops, monitoring guidelines for citizen scientists, and links to monitoring datasets for alkalinity, dissolved inorganic carbon, pH, and other metrics related to acidification. The **NECAN Implementation Plan** identifies regional priorities for monitoring, modeling, and research[187]. NROC is supporting the development of a regional ocean acidification action plan, in partnership with NECAN, based on the results of a forthcoming **Strategic Plan for Federal Research and Monitoring of Ocean Acidification** from the **NOAA Ocean Acidification Program**[188].

The **Mid-Atlantic Regional Council on the Ocean (MARCO)** is the southern counterpart to NROC within the NEAFWA region, extending from New York to Virginia[189]. Established in 2009, MARCO is a partnership led by the Governors of the Mid-Atlantic states with an interstate agreement on ocean conservation that has four shared regional priorities: climate change adaptation, renewable energy, marine habitats, and water quality. To assist achievement of these ocean planning goals, MARCO maintains the **Mid-Atlantic Ocean Data Portal** as an online toolkit and resource center to collate data in a shared information management system for multiple uses[178]. The data portal includes federal, state, academic and other datasets, including monitoring data from the Mid-Atlantic Regional Association Coastal Ocean Observing System that provides real-time oceanographic monitoring data. Hundreds of datasets include inventories and locations of marine life and their habitats, from cold water corals and marine mammals to sea grasses and salt marshes; datasets are available for several Northeast RSGCN and Watchlist species, including marine and diadromous fish, marine mammals, sea turtles, birds, and marine invertebrates. Some of the datasets cover the entire NEAFWA region (Maine to Virginia) while others are limited to the Mid-Atlantic area (New York to Virginia). Water quality monitoring datasets available include acidification, marine debris, wastewater, and EPA attainment areas for Total Maximum Daily Loads. A catalog of the datasets available on the Mid-Atlantic Ocean Data Portal[190].

The **New England and Mid-Atlantic Fishery Management Councils** monitor the status of the Northeast marine ecosystems, collaborating with NOAA to issue annual **State of the Ecosystem Reports** on the Mid-Atlantic and New England shelf systems (NOAA 2022a, 2022b). These monitoring reports assess the trends and status of several indicators related to seascape scale fishery management objectives. Monitoring indicators include:

- Seafood production (landings)

- Commercial fishery profits
- Recreational fishing opportunities
- Fishery and ecosystem diversity indices
- Social and cultural (community fishery engagement, reliance, and environmental justice vulnerability)
- Protected species (juvenile and adult population, bycatch, and mortality)
- Biomass or abundance by feeding guild
- Climate change (marine heatwaves, ocean warming, changes in the Gulf Stream, acidification, circulation)
- Phytoplankton chlorophyll concentrations
- Fish productivity (condition and recruitment of managed species, primary productivity)
- Trophic structure (relative biomass of feeding guilds, zooplankton)
- Estuarine and offshore habitat conditions (including extent of submerged aquatic vegetation in Chesapeake Bay)

The State of the Ecosystem reports also discuss the threats of proposed offshore wind energy development in the region, identifying overlaps between known fishery areas and proposed wind development sites and the implications for the marine ecosystem and fishery industry and ports (NOAA 2022a, 2022b). Links between climate change and managed species, including several Northeast RSGCN and Watchlist species, are also assessed in the State of the Ecosystem reports using monitoring indicators data.

5.3 STATE INVENTORY AND MONITORING PROGRAM EXAMPLES

The regional synthesis of the 2015 Northeast SWAPs identified shared monitoring approaches across the region (TCI and NEFWDTC 2017). One finding of this regional compilation was that Northeast SWAPs identified and used existing monitoring efforts and tools from state fish and wildlife agencies and their partners to assess the status of SGCN, the condition of key habitats, and relevant information on threats or existing program efforts. The following examples describe existing and new state inventory and monitoring programs that inform the SWAPs identification and use of existing monitoring efforts and tools from state fish and wildlife agencies and their partners to assess the status of species (Section 5.3.1), the condition of key habitats (Section 5.3.2), and relevant information on threats (Section 5.3.3) and existing program efforts (Section 5.3.4). A full list of survey and monitoring programs listed in the 2015 Northeast SWAPs is available as Appendix 5 in the SWAP Synthesis (TCI and NEFWDTC 2017).

5.3.1 EXAMPLES OF MONITORING SPECIES

Northeast states have incorporated several types of survey, inventory, monitoring, and assessment programs and projects into their SWAPs and conservation efforts. Several NEAFWA states have created and maintain fish and wildlife Atlases as inventories of species within the state for mammals (Pennsylvania, Vermont), fish (West Virginia), birds (Delaware, Rhode Island, Vermont), reptiles and amphibians (Maine, Maryland, New Jersey, Vermont), bees (Maine, Maryland, Vermont, Virginia), Lepidoptera (Connecticut, Maryland, Massachusetts, Virginia, West Virginia), freshwater mussels (Maine, New Jersey), Odonates (New Jersey, Rhode Island, Vermont), and tiger beetles (Maine). Most if not all states participate in national and international bird monitoring surveys every year. Some state conservation partners host or participate in BioBlitz events that target rapid species inventories at a specific location. An increasing number of states are harnessing the power of citizen scientists to survey, inventory, and monitor their fish and wildlife resources and habitat condition. The following list highlights state programs and projects addressing species, habitats, environmental conditions, and conservation actions.

VERMONT ATLAS OF LIFE

The **Vermont Atlas of Life** combined the results of multiple individual taxonomic Atlases into one comprehensive resource of the state's biodiversity[191]. This publicly available online Atlas of Life includes 14,328 species with more than 7.9 million records that is integrated with iNaturalist, eBird, eButterfly, and the Global Biodiversity Information Facility (GBIF) to capture observations from citizen scientists and the public.

REPORT WILDLIFE OBSERVATIONS - RHODE ISLAND

The Rhode Island Department of Environmental Management Division of Fish and Wildlife recruits citizen scientists in monitoring the distribution, abundance, and health of Rhode Island's wildlife[192]. A free mobile Survey123 app allows the public to submit observations to select multiple surveys. **Herp Observer** collects information on frogs, toads, salamanders, snakes, and turtles. The **Wild Turkey Brood Survey** and **Summer Deer Survey** report summer sightings of Wild Turkey (*Meleagris gallopavo*) and White-tailed Deer (*Odocoileus virginianus*) respectively. The **Songbird Mortality Report** collects observations of dead or dying wild birds. **Bee Observer** monitors bee distribution and status. General wildlife observations may also be submitted for Bobcat (*Lynx rufus*), Black Bear (*Ursus americanus*) and Coyote (*Canis latrans*). The Department collects the observation data for use in monitoring species and produces story maps of the results to share with the public.

OSPREY NATION - CONNECTICUT

The Connecticut Department of Energy and Environmental Protection (DEEP) has monitored populations of Osprey (*Pandion haliaetus*) in partnership with The Connecticut Audubon Society since 2014. **Osprey Nation** is a citizen science partnership collecting long-term data on arrival dates each spring, nest locations, nesting success, and departure dates[193]. Stewards monitor the condition of nesting sites and partner with Connecticut Audubon and the Connecticut DEEP to ensure the security and safety of the sites. Guidelines are provided to the stewards to standardize data collection. An interactive online map allows stewards, partners, and the public to view monitoring data and nest locations. The program also installs a remote camera to live stream an osprey nest. The Connecticut DEEP incorporates Osprey Nation monitoring data into the state's coastal permitting process to anticipate and plan for potential Osprey conflicts during the planning phase of proposed projects.

BIG NIGHT AMPHIBIAN MIGRATION MONITORING PROJECT - MAINE

The **Big Night Amphibian Migration Monitoring Project** in Maine invites citizen scientists and the public to participate in an annual spring survey of migrating amphibians and road crossing mortality levels across the state[194]. More than 2000 amphibians have been recorded since the project began in 2018. A volunteer scientist manual is provided to train observers. Through a partnership with the Center for Wildlife Studies the project expanded in 2021 with expanded coverage (300+ sites across all counties), additional equipment, and outreach to new audiences. The monitoring project is integrated with iNaturalist as a designated project to collect observations from the public.

NEW HAMPSHIRE WILDLIFE SIGHTINGS

The **New Hampshire Wildlife Sightings** resource is an online database collecting observations from citizen scientists and the public on wildlife occurrences in the state[195]. Sightings are reported via the online portal or a mobile devices app. Species of Interest are highlighted with species profiles, distribution maps, and links to additional information. Links are provided to the New Hampshire Fish and Game Nongame and Endangered Wildlife Program, New Hampshire Management Conservation Areas, and tips for wildlife watching in New Hampshire, facilitating education and outreach to the public.

CITIZEN SCIENCE - DISTRICT OF COLUMBIA

The District of Columbia offers several citizen science programs to engage the public in monitoring urban wildlife and their habitats[196]. The District supplements monitoring of bats through mist netting and acoustical surveys with a **Bat Spotters** volunteer

program and by soliciting reports of bat colonies living in buildings from the public[197]. The Bat Spotters program engages volunteers to adopt and monitor bat houses, which are available for purchase or can be built with building plans and instructions. Residents are encouraged to report to the Department of Energy and the Environment bat colonies of ten or more bats and offered the opportunity to monitor summer colonies by counting bats as they emerge from their roosts at sunset. Informational resources are provided online to educate the public on bat identification, threats to bats like White Nose Syndrome, and how to live with bats in urban areas.

The **Cottontails and Chipmunks! Oh My!** project recruits the District in monitoring populations of Eastern Cottontail Rabbits (*Sylvilagus floridanus*) and Eastern Chipmunks (*Tamias striatus*). An online form allows the public to submit sightings of these species. The District also provides a list of national citizen science projects and programs to encourage participation and representation of the District in those efforts, for bees, frogs, birds, and plants. Citizen scientists can also be trained in water quality monitoring, which monitors 22 locations across the District since 2018. Monitoring is conducted weekly from May to September and annual reports are prepared by the Department of Energy and the Environment.

LIGHT UP WEST VIRGINIA

In 2019-2020 the West Virginia Department of Natural Resources conducted a citizen science project to survey fireflies across the state[198]. More than 2000 observations were submitted with at least 24 confirmed species, including the rare and unique Synchronous Firefly (*Photinus carolinus*), which had not been documented in the state since the 1930s and is a Proposed RSGCN as of 2023. The resulting **Light Up West Virginia** storymap and online resource includes a heat map showing the density of firefly observations collected by the project, video of the synchronous flashing of *P. carolinus*, and a list of places where the public can see these evening displays[199]. Information on threats to fireflies and recommendations on how the public can help conserve and protect fireflies is included as well.

5.3.2 EXAMPLES OF MONITORING HABITATS

DELAWARE CENTER FOR THE INLAND BAYS

The **Delaware Center for the Inland Bays** is a partnership of the Department of Natural Resources and Environmental Control, Department of Agriculture, EPA, Delaware Senate, Delaware House of Representatives, Sussex County, and others with a mission to research, educate, and restore the habitats of Delaware's inland estuaries, excluding Delaware Bay[200]. The partnership monitors the inland bays' watershed, its

non-tidal wetlands, tidal wetlands, streams, and estuaries. **State of the Delaware Inland Bay** reports are prepared every five years, with 35 monitoring indicators that include habitat losses and shifting shorelines. Inventory projects to map the extent and distribution of seagrasses are conducted every year. Species surveys annually monitor Horseshoe Crab (*Limulus polyphemus*) spawning, Osprey (*Pandion haliaetus*) nests, diadromous fish passage, Blue Crab (*Callinectes sapidus*), Northern Diamondback Terrapin, and marine fish along the shoreline.

VERNAL POOLS – NEW HAMPSHIRE

The New Hampshire Department of Environmental Services conducts monitoring of vernal pools in the state[201]. Guidelines are available for standardized identification and documentation of vernal pool habitats, with designated **Northeast Vernal Pool Indicator Species**. A standardized documentation form is provided along with guidelines from the University of New Hampshire Cooperative Extension for the importance, vulnerabilities, wildlife, and stewardship of vernal pools. The public can report sightings of reptiles and amphibians in and near these wetland habitats through the New Hampshire Fish and Game **Reptile and Amphibian Reporting Program**[202]**,** the **New Hampshire Wildlife Sightings portal**[195], via email, or with a mail-in reporting form. A link to the US Army Corps of Engineers guidelines on avoiding and minimizing impacts to vernal pools and complying with wetland protection requirements also is provided.

NEW JERSEY LANDSCAPE PROJECT

The **New Jersey Landscape Project**, with version 3.3 released in 2017, offers a wildlife habitat mapping resource to assist community land-use planning and conservation[203]. Both terrestrial and aquatic habitats are included, as are potential sites for vernal pools. An online storymap illustrates and explains the methodology behind the habitat mapping project and each of its updates. The New Jersey Department of Environmental Protection maintains an online mapping application of the Landscape Project that allows an interactive selection of a particular location. Detailed habitat type and associated imperiled species are provided for the site selection. Technical appendices are available describing the protocol for accepting or rejecting species sighting reports, species occurrence area justifications, the land use / land cover categories, and the methods for identifying the patch and species labels on the maps. Habitat fragmentation by roads is included and riparian corridors identified. The Landscape Project is periodically updated with new land cover / land use datasets, allowing for long-term monitoring of landscape changes since 1986.

VIRGINIA CAVE BOARD

The **Virginia Cave Board**, established by the Virginia Cave Protection Act, maintains an inventory of the cave and karst systems in the state[204]. As of 2015, the inventory had documented 3805 caves of at least five feet in length in the state[205]. The Virginia Cave Board and Virginia Speleological Survey assess known caves and may designate Significant Caves, which are afforded natural heritage resource status and are subject to environmental project reviews. The Board participates in environmental reviews of projects in or near cave habitats and has developed guidelines and recommendations for private landowners on several topics.

5.3.3 EXAMPLES OF MONITORING ENVIRONMENTAL CONDITIONS

States monitor environmental conditions through multiple agencies and programs. Water quality monitoring of rivers, streams, and other water bodies, for example, is well established in state programs and can involve citizen scientists and non-governmental organizations. Point source pollution is monitored by regulatory agencies. Coastal erosion is monitored in coastal states by regulatory and non-regulatory agencies. This section highlights a few other environmental conditions or threats are monitored through state associated programs and projects.

ENVIRONMENTAL CONTAMINATION – NEW YORK

The Bureau of Ecosystem Health of the New York Department of Environmental Conservation, Division of Fish and Wildlife annually monitors environmental contaminants, resulting biotic disturbances to aquatic ecosystems, and the cleanup of contaminated sites[206]. Analyses of fish tissue samples collected during monitoring are used to issue health advisories for human consumption of sportfish and game. The Ecotoxicology and Standards Unit develops water quality and other standards to protect fish and wildlife and performs risk assessments for pesticides proposed for registration in New York state. Monitoring is conducted statewide and recent assessments include xenobiotic chemicals in fish across multiple watersheds, polychlorinated biphenyl (PCB) and organochlorine pesticide residues in Great Lakes fish, heavy metals and PCB residues in Blue Crab, chemical residues in fish and American Lobster (*Homarus americanus*) in Long Island Sound, and dioxins and furans in fish following remediation of a hazardous waste site.

SALT MARSH AND SEA LEVEL RISE – MARYLAND

The Maryland Department of Natural Resources monitors the elevation of salt marsh habitat within the Chesapeake Bay National Estuarine Research Reserve to track the impacts of climate change and sea level rise[207]. Changes in salt marsh elevation have been monitored since 2007 using two standardized techniques. The goal of this long-

term monitoring project is to determine if the marshes will be resilient to sea level rise, to share the data to inform management and protection efforts, and to promote the monitoring results for education and stewardship actions.

MARINE INVASIVE SPECIES PROGRAM – MASSACHUSETTS

The **Massachusetts Marine Invasive Species Program** monitors invasive species in the state[208]. Rapid Assessment Surveys are conducted at marinas every few years to collect and accurately identify new marine invasive species and to document the distribution of established species. The **Marine Invader Monitoring and Information Collaborative (MIMIC)** recruits volunteers to assist scientific experts to monitor marine invasive species. An online storymap provides photographs and descriptions of monitored species as well as maps of the distribution of each. Identification cards are available for 18 common marine invasive species monitored by the program. The MIMIC program is integrated with iNaturalist as a designated project.

WILDLIFE HEALTH – PENNSYLVANIA

The **Wildlife Futures Program** of PennVet at the University of Pennsylvania, in partnership with the Pennsylvania Game Commission, monitors wildlife health and provides several education, outreach, and guidance resources for the public, veterinarians, and wildlife rehabilitators[209]. The guidance resources include biosecurity recommendations, when to suspect diseases like Highly Pathogenic Avian Influenza, and summaries of state agency response programs to disease detection. Toll free hotlines are available to report abnormal, sick, injured, or dead birds and mammals to the Pennsylvania Game Commission. The Game Commission's **Wildlife Health Survey** also allows the public to easily report observations of wildlife health issues online[210]. The Wildlife Futures Program and the Pennsylvania Game Commission monitor new and recurring wildlife diseases, such as the avian morbidity and mortality event in the region in 2021, Highly Pathogenic Avian Influenza, Chronic Wasting Disease, White-Nose Syndrome, and West Nile Virus. A **Chronic Wasting Disease Data Visualization Dashboard** provides an interactive tool of monitoring data on the disease in Pennsylvania[211].

5.3.4 EXAMPLES OF MONITORING ACTIONS

Tracking SWAP Element 4 (Actions), remains a challenge at all scales, as it requires a robust monitoring effort that is seldom funded. Recent monitoring includes states' efforts to track their SWAP implementation.

CONSERVATION ACTION TRACKER – MAINE

The state of Maine developed a system to track actions identified in their State Wildlife Action Plan. **Maine's Conservation Action Tracker (CAT)** is an example of an

effort to capture both state and partner actions and of successful on-the-ground efforts to conserve their SGCN and habitats[212]. It allows users to document and showcase efforts to conserve Maine's most vulnerable species and habitats, learn about Wildlife Action Plan conservation projects statewide, search projects by the species or habitats they benefit, and make connections with other partners throughout the state.

5.4 SPECIES MONITORING

In addition to NEAFWA's Monitoring and Performance Reporting Framework (NEAFWA 2008) and the national framework for evaluating effectiveness of State Wildlife Grants funded projects (AFWA 2012), a number of taxa-specific surveys, inventory, or monitoring programs have been developed and implemented with NEAFWA's support and through other regional collaborations.

5.4.1 RCN PROJECTS

The NEAFWA Regional Conservation Needs (RCN) Grants program[213] strategically fills critical monitoring gaps and needs highlighted in SWAPs including surveys, assessments, and monitoring protocols on priority species. Directed RCN projects have been developed to address these needs for priority RSGCN species and their habitats. See *Chapter 4* and *Appendix 4A* for the full list of RCN projects with links to their final products. The following representative survey, monitoring, and assessment projects were completed within the last decade since the 2013 Regional Conservation Synthesis (TCI and NEFWDTC 2013).

FIVE-FACTOR ANALYSIS

An important RCN project was developed in 2015 to inform and expedite the federal workplan and listing process. Since 2010, the USFWS has received numerous listing petitions for potentially imperiled species. More than 25% of the species on the complete list occur in at least one state in the NEAFWA service region. Many of these species have been included as SGCN in one or more Wildlife Action Plan developed by NEAFWA state members.

A preliminary evaluation by state fish and wildlife agencies identified a number of these species for which the case for federal protection under the federal Endangered Species Act was thought to be unwarranted. The state NEAFWA partnership has found that needed actions may be taken sooner if relevant data are assembled for species of potentially lower conservation concern. The objective of this project was to facilitate state input and engagement in the USFWS listing process by synthesizing existing state

and regional information. It uses the "five-factor analysis" approach of the USFWS, applied to selected species on which substantial information is already available. The goals are to support on-going conservation action and reduce the likelihood of federal listing.

Five-factor status reviews were created for Little Brown Bat (*Myotis lucifugus*), Northern Red-bellied Cooter (*Pseudemys rubriventris*), Popeye Shiner (*Notropis ariommus*), and Chesapeake Logperch (*Percina bimaculata*). By providing this information in a form that can be readily used by the federal Endangered Species review team, the NEAFWA states can facilitate and/or potentially accelerate listing decisions for these four species of relatively low conservation concern and decrease the time needed for agency staff to respond to Service requests for information. Multiple benefits include the reduction of state and federal agency staff time needed for Section 7 compliance reviews for all WSFR funded grants.

EASTERN BLACK RAIL

Multiple RCN projects were developed to strategically address the need for more consistent and effective survey and monitoring protocols and procedures to be implemented regionally (for a full list see *Appendix 4A*). The Eastern Black Rail (*Laterallus jamaicensis jamaicensis*) is considered one of the most endangered birds in the Northeast region of the US and along the Atlantic Coast. Populations have declined by 85% in the Northeast since 1992, and this species now breeds in only a dozen (sometimes fewer) locations per state within its breeding range. Funds from an RCN grant were used to partially support the creation of a **Status and Distribution of the Eastern Black Rail along the Atlantic and Gulf Coasts of North America** (Watts 2016). Specifically, the funds supported collection of information from an established consortium of agencies, biologists, academic institutions, and land managers represented on the Eastern Black Rail Conservation and Management Working Group; a value-added synthesis of this information; and development of action items needed for a successful conservation campaign.

BIRD ASSESSMENT AND MONITORING STANDARD OPERATING PROCEDURES

The RCN program funded the **Development of Avian Indicators and Measures for Monitoring Threats and Effectiveness of Conservation Actions in the Northeast**[214]. Northeast regional monitoring procedures are now available for birds of grasslands, tidal marshes, and mountain forests - habitats that span the northeastern landscape, contain a high percentage of vulnerable species, and encompass the region's major management issues. These coordinated bird monitoring programs can measure region-level threats and management impacts on target birds and habitats identified by State Wildlife Action Plans as being of greatest conservation need. Products of this work

include peer-reviewed survey design, protocols, and standard operating procedures for each indicator group (grassland, tidal marsh, and mountain forest birds) along with a regional database for each of these groups. Support for the project accelerated implementation of **A Framework for Coordinated Bird Monitoring in the Northeast** (2007), **The Northeast Bird Monitoring Handbook** (2009), and essential components of The Northeast Monitoring and Performance Reporting Framework (NEAFWA 2008). The mountain bird survey data was gathered as part of the Vermont Center for Ecostudies' high-elevation bird monitoring program, **Mountain Birdwatch**[215]**.**

THE CONSERVATION OF TIDAL MARSH BIRDS: GUIDING ACTION AT THE INTERSECTION OF OUR CHANGING LAND AND SEASCAPES

The goal of this initiative was to provide the information necessary for all states along the New England and Mid-Atlantic Coast (Bird Conservation Region, BCR, 30) to protect regionally important habitats for tidal marsh birds (including direct actions for 26 SGCN). In the long-term, the project's goal is to provide a regionally consistent platform for tidal marsh monitoring in the face of anticipated sea-level rise and upland/watershed development.

This Competitive State Wildlife Grant supports work done in Maryland and Virginia that contributes to the Regional Conservation Needs grant awarded in 2010 **Identification of Tidal Marsh Bird Focal Areas in BCR 30.** This project conducted bird surveys using both passive and broadcast point count methods along tidal marshes in Maryland and Virginia, recording all bird species detected by sight and sound. In 2011, 398 points were surveyed spanning the Delmarva coastline of Maryland and Virginia and a few sites on Virginia's western Chesapeake Bay coastline. A total of 143 bird species in Maryland and 151 species in Virginia were observed from 273 points surveyed in April to June 2011-2012, spanning the Delmarva coastline of Maryland and Virginia. Spatial patterns of abundance were similar between years among 14 marsh bird species. Vegetation data were collected at 261 sample points according to the standardized protocol for the associated RCN project in 2011 and at 256 sample points in 2012. Vegetation data collected at each point included cover classes for plant communities present, presence of invasive species, percent cover of one to four dominant species, and percent cover of pannes/pools/creeks, open water, upland, and wrack. Dead snags were counted in each plot and the tide cycle during data collection was noted. All bird survey and vegetation plot data were submitted to the RCN grant cooperators for incorporation into the final regional analyses. Final regional maps, estimates of changes in distribution and abundance, and critical areas for long-term protection were determined.

BATS AND WHITE-NOSE SYNDROME

The RCN Grant Program supported two projects to address the ongoing White Nose Syndrome (WNS) crisis in Northeast bat populations (Reeder et al. 2011). The first studied the effects of the fungus that causes WNS on hibernating bats and demonstrated that bats infected by the fungus were aroused to normal body temperatures more frequently than uninfected bats. These arousals depleted the bats' fat stores and likely contributed to their subsequent mortality. The number of arousal events significantly predicted the bats' date of death; and the severity of fungal infection correlated with the number of arousal events.

The second project developed methodologies to combat WNS. Specific goals included: 1) testing potential treatments for efficacy against cultures of the fungal pathogen associated with WNS under laboratory conditions; 2) testing potential treatments for safety in healthy bats; and 3) testing potential treatments for efficacy against fungal infection in hibernating bats. The project tested formulations of terbinafine and other anti-fungal compounds.

A CSWG project supported this regional effort to address WNS through a multi-state coordination, investigation, and rapid response grant project. At the start of the 2008 grant, WNS was only known to be present in New York, Connecticut, Massachusetts, and Vermont. The hope was for the spread of the fungus to be limited to adjacent states the following year. Unfortunately, by the spring of 2009, it had swept south all the way to western Virginia. Although the sudden magnitude of the problem was unexpected, this grant was critical to preventing state agencies from being completely overwhelmed by the crisis. Eleven states participated in this grant: Pennsylvania, New Hampshire, Vermont, Connecticut, New Jersey, Delaware, Maryland, West Virginia, Virginia, Wisconsin, and New York. All of these states except for Wisconsin felt the impact of WNS on their bat populations during the grant period. Common goals of developing a public reporting system, improving public outreach, coordinating sample requests, and improving ability to monitor and track bat populations were developed and shared. The group cooperated in identifying and selecting research priorities that were most important to states already experiencing heavy mortalities associated with WNS.

ALLEGHENY WOODRAT RECOVERY

The objectives of this RCN project were to determine interactions between Allegheny Woodrat (*Neotoma magister*) populations and forest dynamics; to determine incidence of Raccoon Roundworm (*Baylisascaris procyonis*) parasite load in raccoon feces; to conduct population analysis based on previous mark/recapture data; and to compare the relative efficacy of live-trapping versus remote cameras for detecting presence of Allegheny Woodrats. The study estimated populations at the six long-term monitoring sites. Results suggest that woodrat populations exist at low densities, are continuing to

decline in western Maryland, and that certain sites represent critical habitat. These long-term monitoring sites are also considered to be some of the best strongholds for Allegheny Woodrat populations in western Maryland. But low population densities, continued declines in population, and the possible genetic consequences of interbreeding due to low populations put into question the species' long-term viability in the state.

BEST MANAGEMENT PRACTICES FOR RSGCN IN NORTHEAST FORESTS

This important RCN project provides BMPs to address the concerns about and impacts of biological resource use of forested habitats. Northeastern forests are considered key habitat for a large suite of wildlife, including several habitat specialists listed as SGCN in multiple states. Their vulnerability to various stressors has prompted the formation of several species--level conservation and research initiatives. This RCN project collaborated with several focused partnerships and with key forest stewards to integrate current ecological and biogeographic information into on the ground habitat enhancement. This collaboration produced spatially explicit management and conservation support for five regional SGCN: Bicknell's Thrush (*Catharus bicknelli*), Wood Thrush (*Hylocichla mustelina*), Canada Warbler (*Cardellina canadensis*), Rusty Blackbird (*Euphagus carolinus*), and American Marten (*Martes americana*). For each of these species, the report contains a species profile, conservation status, habitat landscape characteristics, desired habitat conditions, recommended practices and benefits with associated species, and ecosystem services and comprehensive planning. The project engaged both experts and end users to produce scientifically sound and practical guidelines for conserving these species and other SGCN in their guilds. Available occurrence data, distribution models, and stakeholder input delineated and prioritized areas with high management and conservation potential. Working directly with habitat stewards ensured that the recommended practices are implemented in management and conservation opportunity areas. Results include field guides and guidelines to managing habitat for RSGCN in the Northeast and Mid-Atlantic Forests (Lambert et al. 2017), a final report, and spatial prioritization for implementing these guidelines for RSGCN.

HELLBENDER POPULATION ASSESSMENT AND PROTOCOLS

The Hellbender (*Cryptobranchus alleganiensis*) is a Northeast RSGCN of High Concern Level. The Common Mudpuppy (*Necturus maculosus*) shares a significant portion of its habitat with the Hellbender. Both species have been identified as a Species of High Conservation Concern by the Northeast Partners in Amphibian and Reptile Conservation (NEPARC). Given the habitat overlap of these two species, efforts to detect Hellbenders concurrently generated data useful in monitoring Mudpuppy populations from 2014-2016. The objectives of this RCN project were: 1) to better document

Hellbender distribution in the northeast region; and 2) to develop standardized methodologies for monitoring Hellbender populations while collecting opportunistic information about Mudpuppy distribution. This was accomplished through stream surveys (including environmental DNA detection), improved communication among individuals working with Hellbenders or Mudpuppies, and the establishment of a regional stakeholder working group. Standardized protocols that ensure the consistency and efficiency of Hellbender/Mudpuppy surveys while minimizing disturbance of stream boulder habitat were developed. During the study, environmental DNA (eDNA) samples were collected from sites in New York, Pennsylvania, Maryland, West Virginia, and Virginia. Results of the project include: 1) a more comprehensive map of hellbender distribution in the northeast; 2) an eDNA archive (for detection of other stream-dwelling species); and 3) a protocol and communication framework to enable coordinated and efficient conservation of Hellbenders and Mudpuppies.

RANAVIRUS IN AMPHIBIAN POPULATIONS

In order to better understand the extent to which Ranavirus is impacting amphibian and reptile populations in the Northeast and to develop a sampling protocol for the region, this RCN project led by Maryland Department of Natural Resources staff with NEFWDTC and NEPARC participation, conducted a survey of amphibian larvae at randomly selected Wood Frog (*Lithobates sylvaticus*) breeding ponds in a study area encompassing parts of Delaware, Maryland, New Jersey, Pennsylvania, and Virginia. In 2013 and 2014, a total of 4,306 individual Wood Frog larvae were collected for quantitative PCR analysis by Montclair State University in New Jersey. Individuals representing seven amphibian species that are subject to active die-offs were collected for analysis by the USGS National Wildlife Health Center, representing both the largest geographic area and the greatest sample size ever screened for Ranavirus. A regional survey, diagnostic lab reports, and published scientific literature indicated that Ranavirus has been lab-confirmed in 33 herpetofauna species in at least 64 counties in the Northeast region. It was most found in Wood Frog larvae, Eastern Box Turtles (*Terrapene carolina*), and the larvae of Spotted Salamanders (*Ambystoma maculatum*), Green Frogs (*Lithobates clamitans*), and American Bullfrogs (*Lithobates catesbeianus*).

Scientists and conservation groups in the Northeast continue to address the challenge of how to best respond to the threat posed by Ranavirus, as the study indicated that state response capacity varied across the region. Most states (11 of 14) make use of the diagnostic services of the NWHC. The study developed and applied field protocols and recommended that disinfection protocols become standard operating procedure for all land management agencies as they work with groups like PARC to develop strategies to address the threat of emerging diseases.

PREVENTING BSAL IN AMPHIBIAN POPULATIONS

The 2015 SWAP Synthesis (TCI and NEFWDTC 2017) prioritized prevention and spread of the amphibian disease *Batrachochytrium salamandrivorans* (Bsal). In September 2016, the NEFWDTC and NEPARC reached out through the Northeast and Southeast Wildlife Disease Cooperatives to help protect wild populations of amphibians by preventing the introduction of *B. salamandrivorans* from imported amphibians. Collaborators, working with the Disease Cooperatives, developed methods for early detection that require swabbing individual animals and then testing the samples. Practical approaches to implementing these diagnostic tests are yet to be developed. Ideally, animals should be tested before leaving the country of origin. If imported, individuals would need to be held for a few days until results were returned or tracked and retrieved if testing positive. NEPARC provides information and resources and multiple protocols on preventing the introduction and spread of this disease in the Northeast[216]. A **North American Bsal Task Force** has been established and a **North American Strategic Plan to Prevent and Control Invasions of the Lethal Salamander Pathogen *Batrachochytrium salamandrivorans*** was developed in 2022.

TIMBER RATTLESNAKE POPULATION ASSESSMENT

The Timber Rattlesnake (*Crotalus horridus*) was once widespread throughout eastern North America but in the four New England states that were the focus of this RCN study, it now persists only in small, isolated populations. The goals of the study were to: 1) assess the viability of New England Timber Rattlesnake populations; 2), describe the population genetics structure of Timber Rattlesnakes in New England; 3) provide recommendations for genetic management and monitoring; and 4) develop a standardized protocol for monitoring Timber Rattlesnake populations informed by model-based estimates of occupancy and abundance.

Model-based estimates of population growth and Population Viability Assessment (PVA) results both suggest that populations in Vermont, New Hampshire, and Connecticut may be declining while the Berkshire Mountains metapopulation does not appear to be declining under current conditions. In all cases, population persistence was highly sensitive to survival suggesting that reducing anthropogenically-induced mortality is critically important. Available data strongly suggest that some Timber Rattlesnake populations in New England could benefit from genetic rescue. Recommendations suggest that managers consider the ecology and conservation status of each population, available resources, and potential impacts, and then assess the information provided by each method of monitoring in the development of any new project design.

CONSERVATION STRATEGY FOR THE NORTHERN DIAMONDBACK TERRAPIN

The Northern Diamondback Terrapin (*Malaclemys terrapin terrapin*) is found in eight states of the Northeast /Mid-Atlantic regions and is considered Threatened in Massachusetts, Endangered in Rhode Island, and of Special Concern in Connecticut. The species has been identified by the Northeast Partners in Amphibian and Reptile Conservation as a species of regional conservation concern in the Northeast. It is identified in more than three-quarters of the region's SWAPs; and more than 50% of the species' distribution is within the Northeast Region of North America (NEPARC 2010). Previous work in 1999 also suggested that the terrapin merits a federal listing assessment (Therres 1999).

This RCN project represented the first regional, comprehensive view of the status of the terrapin in the Northeast and Mid-Atlantic regions. The resulting regional Conservation Strategy can guide and coordinate multiple-state laws and policies to protect the terrapin and its habitat and may reduce the need for a federal listing assessment. The strategy includes a status and distribution assessment throughout the Northeast; gathering life history information; and identifying threats and conservation actions along with additional resources and needs. This project also conducted a Threat Assessment outlined by the Northeast Lexicon**Error! Bookmark not defined.**. Populations have d eclined due to multiple factors since the early 1900's. Bycatch in commercial fishing, loss of habitat, drowning in commercial and recreational crab pots, increased nest failure due to predation from raccoons and other subsidized predators, and road mortality have been the primary causes of population decline.

The project compiled state efforts and protocols to advance a **Regional Coordinated Survey including the Maryland Coastal Bays Terrapin Project**[217] for land and boat survey protocol and data sheets. The **Maryland Coastal Bays Program** created a database on local terrapin habitats to aid in conservation of the terrapin, using citizen scientists. The Program has also produced terrapin brochures, fact sheets, field guides, and other outreach information.

CONSERVATION PLAN FOR BLANDING'S TURTLE AND ASSOCIATED WETLAND-DEPENDENT SGCNS

Over the past decade, significant advancements have been made in addressing the information and conservation needs of RSGCN turtles. Multiple partners and grants (RCN and Competitive State Wildlife Grants) have resulted in robust conservation plans, protocols, and best management practices to be implemented regionally for these important RSGCN. They are summarized below with additional information available on https://www.northeastturtles.org.

Blanding's Turtle (*Emydoidea blandingii*) is a wide-ranging, semiaquatic species found in discontinuous areas from Nebraska to Nova Scotia. In the eastern United States, Blanding's Turtles occur in discrete areas of Maine, New Hampshire, Massachusetts, New York, and Pennsylvania, with the largest areas of occurrence in New England and northern New York and the largest known population in Massachusetts. Eastern populations are of conservation concern because of habitat alterations, adult roadkill, elevated nest and hatchling depredation, and other factors. In 2004, the **Northeast Blanding's Turtle Working Group** was formed as a partnership including representatives from four state wildlife agencies (ME, NH, MA, NY), universities, land managers, and researchers. Between 2004 and 2010, the group expanded to involve other key partners and the state of Pennsylvania. It published a status assessment (Compton 2007) summarizing the causes of regional population decline and calling for strategic, proactive conservation measures. In June 2014, the Northeast Blanding's Turtle Working Group completed the **Conservation Plan for Blanding's Turtle and Associated Wetland-Dependent Species of Greatest Conservation Need in the Northeastern United States**. This plan was updated in July 2021 after a second round of sampling and habitat management actions. Both efforts were multi-year collaborative projects funded by the USFWS through its Competitive State Wildlife Grant program (CSWG). The resulting website (https://www.northeastturtles.org) contains conservation and management plans for each of the four RSGCN species: Spotted (*Clemmys guttata*), Wood (*Glyptemys insculpta*), Blanding's, and Box (*Terrapene carolina*) Turtles. It also provides survey forms and protocols including the pit tag protocol.

IMPLEMENTATION OF THE BOG TURTLE CONSERVATION PLAN FOR THE NORTHERN POPULATION, WITH BENEFITS TO ASSOCIATED HEADWATER WETLAND SPECIES OF GREATEST CONSERVATION NEED

This RCN project supplemented efforts to perform habitat management, engage in landowner outreach, continue application of a multi-state database, continue implementation of standardized population and habitat monitoring protocols, survey potential and historic wetlands, perform health assessments, draft best management practices, expand upon and refine the recently developed conservation plan, and perform a genetic assessment to determine conservation units for the northern population of Bog Turtle (*Glyptemys muhlenbergii*).

Most recently, CSWG supported the continuation of the RCN project work with funding for the **Creating a Comprehensive Conservation and Management Plan for the Southern Lineage of the Bog Turtle and its Associated Habitats** project. The objective of this project is to fill critical information gaps by beginning to address the two most pressing threats for the southern lineage of the Bog Turtle. The project will

1) improve understanding of the current distribution of the southern lineage of Bog Turtles, 2) determine the status and viability of populations within the southern lineage of Bog Turtles, 3) conduct a large genetic study to identify metapopulations, management units, corridors, and current population genetic parameters, habitat management and nesting habitat creation for a subset of populations, and 4) perform outreach to landowners and law enforcement officials.

SPOTTED TURTLE CONSERVATION

The Spotted Turtle Working Group, a team of state and federal biologists and university and NGO partners, collaborated to quantify the Spotted Turtle (*Clemmys gutatta*) status and distribution from Maine to Virginia as well as the effects of climate change and habitat fragmentation on the species to prioritize both habitat conservation and management. As part of this RCN project, the sponsors conducted standardized population assessments at multiple spatial scales, with centralized data analysis, to: (1) establish population baselines; (2) inform a comprehensive adaptive management strategy; and (3) identify priority habitat and population management actions at the regional, state, and local levels. The resulting Status Assessment and 2022 Conservation Plan, the 2019 Monitoring Protocol, and field and data entry forms with instructions are available online[218].

A CSWG project supported expansion of this work on the Spotted Turtle through the **Conserving Vermont's Spotted Turtles: Using Novel Techniques to Detect a Cryptic Species and Identify Unknown Populations** project. This project will identify suitable Spotted Turtle habitats and will determine if those habitats are occupied. It will support the development of eDNA sampling protocols in lentic systems, which will be transferrable to other states with Spotted Turtle information gaps and to other SGCN freshwater turtle species. It will use standardized methods and protocols developed for the ongoing CSWG/RCN Spotted Turtle project to evaluate the species' presence at 25 sites and improve priority nesting habitat.

WOOD TURTLE CONSERVATION PLAN

The Conservation Plan for the Wood Turtle in the Northeastern United States is the product of a multi-year, proactive effort among Northeastern State Wildlife Agencies and their partners to articulate a strategic action plan for the protection of regionally significant populations of Wood Turtles (*Glyptemys insculpta*) in the northeastern United States. The fundamental objective of this Plan is to protect the evolutionary potential of the Wood Turtle by ensuring the persistence of functional, ecologically viable, and regionally significant populations throughout the Northeast Region. To accomplish this objective, and to effectively triage conservation efforts, the sponsors developed a spatially explicit, stratified **Wood Turtle Conservation Area Network** based on the best available population, landscape, and

genetic data. Ultimately—in order to achieve meaningful conservation of this unusual and iconic species--it will be necessary to stabilize, and reverse population declines both within this Conservation Area Network and elsewhere throughout the species' range. The plan includes a standardized survey protocol, field survey and turtle field forms, and a data entry template. Management guidelines, habitat management and poaching brochures, regulatory status, environmental review recommendations, and other helpful resources for Wood Turtles are available[219].

STATUS ASSESSMENT AND CONSERVATION PLAN FOR THE EASTERN BOX TURTLE

Although widespread and still relatively common throughout much of its range, the Eastern Box Turtle (*Terrapene carolina carolina*) has experienced dramatic declines in recent decades. This recent RCN project developed a status assessment and conservation plan for the Eastern Box Turtle in the Northeastern United States (West Virginia to Maine). Products include: (1) a standardized monitoring protocol; (2) a status assessment for the northeastern US; (3) a conservation area network representing conservation priorities for the species; and (4) a set of BMPs. Survey forms and multiple protocols, guides, partners, and other useful information for box turtle conservation are available[220]. NEPARC has developed habitat management guidelines, land use planning resources, and references for conservation of this species in the Northeast. Both the regional group (NEPARC) and its national affiliate (PARC) are dedicated to the conservation of herpetofauna and their habitats.

STATUS ASSESSMENT OF NORTHEAST LAND SNAILS

The Land Snails and Slugs of the Mid-Atlantic and Northeastern United States online database provides a wealth of information on invertebrate taxa status and distribution in the Northeast. NEAFWA's RCN program sponsored a 2016 Land Snail Assessment of the status and distribution of land snails in the Northeast as a first step to their conservation. Since then, almost 30 species of land snails have been identified as RSGCN or Watchlist species.

Land snails are an integral part of native habitats throughout the Northeast, playing important roles in cycling organic material and creating soil, moving energy and nutrients in food chains, and hosting major wildlife parasites. This project informed the important conservation needs and opportunities associated with 245 land snail species of the northeastern United States, many of which are listed as SGCN or Data Deficient by many of the 14 State Fish and Wildlife Agencies. This project assisted states in proactive participation in the USFWS Federal Prelisting Process and may potentially lead to preventing or minimizing additional listings under the Federal Endangered Species Act.

The project also expanded and upgraded the existing land snail and slug website of the Carnegie Museum of Natural History, using data compiled from other museum collections to produce a more comprehensive resource with regional maps[221]. There are at least 317 species profiles for the region, 311 with specimen records, and another six that may be reported in the future. Fifty of the species are non-native. The USFWS Science Applications program is providing additional funding to support expansion of this project and its online database.

CONSERVATION ASSESSMENT OF ODONATA IN THE NORTHEASTERN REGION

A similar assessment supported by the RCN program for the dragonflies and damselflies of the Northeast serves as the foundation for RSGCN data for these species. Odonata are well represented on imperiled species lists for the Northeast due to narrow distributions, low population abundance, documented threats, and declines of many species. At present, nearly 200 different species are listed as SGCN by at least one Northeastern SWAP.

The first Region-wide conservation assessment for the order Odonata (dragonflies and damselflies) was completed for more than 230 species that occupy a wide range of forested lentic and lotic habitats in the Northeast region. This assessment followed a procedure similar to those already conducted for certain vertebrate taxa in the Northeast (e.g., birds, reptiles and amphibians). It included measures of regional responsibility, conservation concern, and vulnerability in a matrix format that can be used to prioritize species and conservation actions. Odonata were well suited to an assessment because their distributions and habitat affinities are relatively well known and the number of species is manageable, especially as compared to other insect groups. The project compiled available status and distribution information for all Odonate species in the thirteen states that make up Region 5 of the USFWS. Regional responsibility was evaluated for all states within the Northeast and updated at the regional scale, supporting conservation decisions that benefit Odonates and their habitats. The resulting prioritization scheme directs limited state and regional resources toward effective conservation actions that benefit Odonata and their habitats and thereby guide implementation of SWAPs.

DISTRIBUTION AND CONSERVATION STATUS OF NEWLY DESCRIBED LEOPARD FROG SPECIES

Objectives of this study were to: 1) determine which leopard frog species occur presently and occurred historically in ten eastern US states; 2) refine the range of *Rana kauffeldi* relative to the two other leopard frog species; 3) map new, potentially reduced, ranges for the two congeners; 4) assess the species' conservation status, particularly in areas where *R. kauffeldi* is already known to be of concern; 5) contrast multi-level habitat

associations among the three species; and 6) improve upon the separation of species using acoustic and morphological field characters to facilitate future inventory, monitoring, and status assessments of the new species.

Significant changes in distribution of these species were documented but *R. kauffeldi* was confirmed in eight eastern US states: Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, and North Carolina. Eighty-nine percent of *R. kauffeldi* locations were within 20 kilometers of coastal waters. Differing habitat associations were also documented throughout its range. This multi-year, 10-state project demonstrated conclusively that *R. kauffeldi* is a habitat specialist with a small range centered in the most densely populated region of the United States. Making it more susceptible to stochastic events may exacerbate the impact of fungal pathogens and render it vulnerable to habitat fragmentation that in turn results in inhospitable dispersal. Another point of concern for *R. kauffeldi* is the coastal proximity of many populations. Coastal populations of wetland organisms may be threatened by rising sea levels and the increasing frequency and intensity of coastal storms, two threats associated climate change.

The study also found that *R. kauffeldi* has disappeared from a large part of its historical range in southern New York and Connecticut, including much of the Hudson Valley and all of Long Island. The study also reported disappearance of *R. pipiens* from much of the southern portion of its range from Pennsylvania east through northwestern New Jersey, southeastern New York, southern Connecticut, southern Rhode Island, and coastal Massachusetts. A new northern range limit was identified for *R. sphenocephala* in central New Jersey.

BEST MANAGEMENT PRACTICES FOR WETLAND BUTTERFLIES

This RCN project addressed the uncertain status and distribution of many wetland butterfly species in several Mid-Atlantic States, including SGCN and RSGCN species in the Northeast. Some species declines may be due in part to threats impacting groundwater wetlands, including outright destruction, habitat degradation, and the succession of open wetland habitats to forest or dense shrubland. Climate change and habitat fragmentation may further impact these species and leave them vulnerable to local extirpations. The primary objective of this effort was to enhance and expand populations of wetland butterfly SGCN through developing a greater understanding of the distribution and habitat requirements for these species, and by implementing habitat enhancement projects where needed. Project goals were to: (1) update distribution data for 14 butterfly SGCN in the region; (2) model species distribution and climate conditions for each species; (3) identify and prioritize wetlands that support one or more of these 14 species; (4) implement wetland enhancement and improvement

projects; and (5) develop best management practices (BMPs) for species distribution and climate modeling and for wetland enhancement projects.

Results should guide targeted survey work for these species as well as prioritize wetlands for enhancement projects. In the long-term, results may serve to improve habitats for these species, offering the potential to increase populations of butterfly SGCN and promote connectivity between populations through increased habitat availability. Fourteen species of wetland-inhabiting butterflies with SGCN status were surveyed in 2016 and 2017 at multiple sites across four states – Maryland, New Jersey, Pennsylvania, and West Virginia. Survey data was used to evaluate the status of each species in all states where they occurred as well as refine the distribution data for each species across the region. All data points were mapped in ArcGIS and used to model species distribution in terms of both habitat and climate. BMPs were developed, and habitat enhancement projects were initiated in Maryland and Pennsylvania. The report includes **Life History Guides** to the 14 species, the **Pennsylvania Habitat Management Guide for Pollinators**, **Wetland Butterfly Habitat Enhancement BMPs**, and additional resources including a model Wetland Restoration Report.

XERICS PROJECT BEE, MOTH, AND VEGETATION MONITORING

The Xeric Habitat for Pollinators RCN project developed monitoring protocols for bees, moths, and vegetation management of xeric habitats in the Northeast[222]. A protocol was developed to track native bee communities at survey sites. Bee identification by regional experts was critical to the effort, and the collection is now with the National Bee Inventory and Monitoring lab. The bee monitoring protocol outlines 5 sampling windows, monthly, from May to September. Transects are laid out in the target habitat with 24 small bowls of soapy water placed 5 meters apart and left through the daylight hours or overnight if possible. Observers also net bees for 30 minutes while visiting the site. Samples are submitted with a standardized label to the USGS Bee Inventory and Monitoring Laboratory.

The moth monitoring protocol developed by the project outlines five sampling monthly windows from April to October, adjusted as necessary for latitude. The primary goals were to develop more complete species lists and document relative abundances for nocturnal moths in xeric habitats in the Northeastern US and to link these results with habitat condition data and management strategies which are also being tracked and analyzed. Three 15W UV bucket traps are set at each site. In 2021, 715 macro moths and 354 micro moths were identified across 16 sites. This list includes nine Northeast RSGCN.

This Xerics Project focused on fire adapted habitats (Xeric Grassland, Barren, and Woodland) in the Northeast to improve the ability of Northeast states to implement

cost-effective habitat management for the benefit of native pollinators and other RSGCN that depend upon these priority habitat types. Templates for data collection and reporting were developed along with the vegetation monitoring project protocol, which seeks to provide data consistent with the long-standing monitoring programs at some of the more established sites. A key variable, the percent of vegetative cover, is expected to respond to treatments and to indicate habitat suitability for ground-nesting bees.

5.4.2 STANDARDIZED MONITORING PROTOCOLS

The Northeast Lexicon and AFWA Best Practices recommend the use of standardized monitoring protocols to facilitate data sharing and allow for regional assessments of species population status and trends (Crisfield and NEFWDTC 2022, AFWA 2012). The RCN Grant program has funded taxa surveys and assessments which have developed monitoring protocols for priority RSGCN reptiles and amphibians, birds, mammals, and several invertebrate taxa (see Section 5.4.1 above and *Appendix 4B*).

More than 120 species or groups of species that occur in the NEAFWA region have standardized monitoring protocols available, which are listed in *Supplemental Information 5*. The updated Northeast RSGCN Database includes information on the availability of standardized monitoring protocols for RSGCN and Watchlist species.

5.4.3 WATCHLIST [ASSESSMENT PRIORITY] SPECIES

The addition of a Watchlist [Assessment Priority] species list in 2023 alongside the identification of RSGCN allowed the taxonomic teams to prioritize species in need of survey, monitoring, or assessment in the Northeast. Two hundred twenty-nine (229) species were identified as RSGCN Watchlist [Assessment Priority] and 61 as Proposed RSGCN Watchlist [Assessment Priority] species that are not currently SGCN in any Northeast state (see *Chapter 1*)**.** The majority of RSGCN Watchlist [Assessment Priority] species (53%) and Proposed RSGCN Watchlist [Assessment Priority] species (87%) are invertebrates (Table 5.4.1).

This category, new to the Northeast region in 2023, incorporates RSGCN previously identified as Data Deficient in 2018 that remain priorities for regional surveying efforts. In some cases, regional differences in species status and trends were identified by the taxa teams. Other species were data deficient, but enough concern or known declines were noted to warrant inclusion as a Watchlist species. Current taxonomic uncertainties or reclassification were ongoing for other species which precluded taxa experts' ability to assess the status or distribution of these taxa. These species should be a priority for assessment efforts to collect additional data to document status, trends, and threats across the region.

The RSGCN Watchlist [Assessment Priority] and Proposed RSGCN Watchlist [Assessment Priority] species are associated with all 24 coarse habitat types associated with RSGCN (see *Chapter 2*). The highest numbers of Watchlist species are associated with interface, riverine, and palustrine habitat types:

1. Shorelines (131 species)
2. Riparian and Floodplains (131 species)
3. Beaches and Dunes (131 species)
4. Rivers and Streams (120 species)
5. Big Rivers (120 species)
6. Tidal Rivers and Streams (120 species)
7. Non-Tidal Wetlands (119 species)
8. Tidal Wetlands and Flats (119 species)

Table 5.4. 1 A total of 290 species were identified as priority species for additional survey, monitoring, and assessment on the 2023 RSGCN Watchlist.

Taxonomic Group	Number of Watchlist [Assessment Priority] Species	Number of Proposed Watchlist [Assessment Priority] Species
Amphibians	6	-
Bees	10	14
Birds	29	1
Caddisflies	7	2
Crayfish	3	14
Diadromous Fish	2	-
Fairy Shrimp	2	-
Fireflies	1	5
Freshwater Fish	31	3
Freshwater Mussels	2	-
Lepidoptera	39	5
Mammals	12	3
Marine Fish	11	1
Marine Invertebrates	9	-
Mayflies	9	11
Odonata	20	-

Reptiles	8	-
Stoneflies	2	-
Terrestrial Snails	22	2
Tiger Beetles	4	-
Total	**229**	**61**

Forested upland habitats (Forests and Woodlands, High Elevation Forests, and Agriculture: Plantations and Orchards; =108 species each) or open upland habitats (Alpine, Cliff and Talus, Grasslands, Shrublands, Agriculture: Croplands and Pasture, and Glades, Barrens and Savanna; n=100 each) also are associated with high numbers of these Watchlist species. Monitoring efforts could target these habitat types to survey or assess multiple Watchlist species concurrently.

5.5 OTHER DATABASES AND RESOURCES

Monitoring programs and databases for fish, wildlife, and plant species are available from numerous non-governmental, academic, and citizen science sources. These species data sources supplement governmental monitoring programs and offer an opportunity to address AFWA Best Practices recommendations to expand the capacity of state fish and wildlife agencies (AFWA 2012).

The **Xerces Society**, for example, offers numerous identification and monitoring guides for citizen scientists to monitor bees, Lepidoptera, dragonflies, freshwater mussels, aquatic macroinvertebrates, and pollinator plants[223]. Conservation biologists with the Xerces Society developed survey protocols and guidance for public agencies to facilitate monitoring of at-risk invertebrate species and their habitats on public lands; monitor the effectiveness of pollinator habitat restoration projects; and provide training to agency staff and citizen scientists on pollinator identification and monitoring[224].

The **Wildlife Monitoring Network of Long Island** collects observations of wildlife from citizen scientists and the public for Horseshoe Crabs, birds, crustaceans, fish, mammals, reptiles, and insects[225]. This network supports organized monitoring projects and educational workshops and offers field guides and wildlife rescue resources.

Table 5.5.1 lists species databases currently available from non-governmental, academic, and citizen science inventorying and monitoring programs and projects.

Table 5.5. 1 Numerous non-governmental and citizen science databases are publicly available online that contain inventory, monitoring, and status information on fish and wildlife resources of the Northeast.

Informational Database	Location and Description
Discover Life	https://www.discoverlife.org/ International database and encyclopedia of plant and animal species observations and profiles for more than 1.4 million species with 822,000+ known distribution maps.
FishBase	https://www.fishbase.se/search.php International database of 35,000+ fish species profiles with taxonomy, location, conservation status, habitat, biological use, protection status, trophic ecology, life history, identification keys, citations, and imagery.
Global Biodiversity Information Facility (GBIF)	https://www.gbif.us/ National species database for animals, plants, and fossils in the US and its Territories. More than 825 million observation records with taxonomy, occurrence status, location, date, issues and flags, source dataset, and publisher (e.g., USGS, NatureServe, NOAA). Previously known as the Biodiversity Information Serving Our Nation (BISON) database.
Global Invasive Species Database	http://www.iucngisd.org/gisd/ International database of invasive species with species profiles that include taxonomy, species description, native distribution, alien distribution, impacts, life cycle stages, reproduction, spread pathways, management techniques, references, and photographs.
iNaturalist	https://www.inaturalist.org/ Public observations of animal and plant species across the world, which are searchable by name or location with information on the seasonality, number, life stage, and sex of observations. Includes more than 411,000 species and 125 million observations contributed by 5.9 million people.

Informational Database	Location and Description
Invasive and Exotic Species of North America	https://invasive.org Database of invasive and exotic species profiles that include taxonomy, origin, life cycle, distribution, imagery, and invasive listing sources. Includes plants, insects, pathogens, and other species.
ITIS	https://www.itis.gov/ Integrated Taxonomic Information System (ITIS) is the authoritative taxonomic information source on animals, plants, fungi, and microbes of North America and the world and is the taxonomic reference standard for RSGCN and the national SGCN database maintained by the USGS.
IUCN Red List of Threatened Species	https://www.iucnredlist.org/ International Union for Conservation of Nature (IUCN) maintains a Red List of Threatened Species with comprehensive information on the global extinction risk status of animal, fungus, and plant species. Information on more than 153,000 species includes taxonomy, conservation status, status assessments, geographic range, population trends, habitat and ecology, threats, use and trade, and needed conservation actions.
NatureServe Explorer	https://www.natureserve.org/ NatureServe Explorer includes detailed information on the taxonomy, distribution, conservation status, ecology, life history, population, management and monitoring needs, threats, habitat, and biological research needs of more than 100,000 species of plants, animals, and ecosystems.

Informational Database	Location and Description
World Register of Marine Species (WoRMS)	https://www.marinespecies.org/ International authoritative classification and catalog of marine species names with more than 241,500 species recognized. Species profiles include taxonomy, distribution, attributes, images, conservation status, and associated datasets. Taxonomic reference standard for marine RSGCN.
Ocean Biodiversity Information System (OBIS)	https://obis.org/ International database of marine species observational records with more than 108 million records for nearly 180,000 species searchable by taxa, species, location, dataset, or data source. Species profiles include taxonomy, distribution, observation dates, number of observation records, environmental conditions of the observations, data quality, and associated datasets. Taxonomic reference standard for marine RSGCN.
SeaLifeBase	https://www.sealifebase.ca/ International database of 85,000 marine species searchable by species, location, taxonomic group, or ecosystem with information on life history, trophic ecology, data source, photographs, and more.
AmphibiaWeb	https://amphibiaweb.org/ AmphibiaWeb includes nearly 8600 amphibian species profiles from around the world that are searchable by species, location, taxa, or photograph. Species profiles in the database include taxonomy, distribution, reasons for decline, and conservation status.
Amphibian Disease Portal	https://amphibiandisease.org/ International database monitoring the distribution of amphibian pathogens *Batrachochytrium dendrobatidis* (Bd) and *B. salamandrivorans* (Bsal).

Informational Database	Location and Description
Birds of the World	https://birdsoftheworld.org/bow/home International database of birds across the world with comprehensive life history profiles searchable by species or family. Includes identification, taxonomy, systematics, distribution, habitat, movements and migration, diet and foraging, sounds and vocal behavior, behavior, breeding, demography and populations, conservation and management, priorities for future research, and photographs. Integrated with eBird database.
eBird	https://ebird.org Public observations of bird species across the world, which are searchable by species name or location in a database that includes species maps, photographs, and sounds.
Audubon Christmas Bird Count	https://www.audubon.org/conservation/science/christmas-bird-count Database of December bird observations across the US and Canada since 1900 with location, species counts, weather conditions, sponsoring organization, and participants.
Audubon Great Backyard Bird Count	https://birdcount.org Public global observation counts of birds conducted annually in February across four days since 1998, with data integrated into eBird since 2013.
Project FeederWatch	https://feederwatch.org/ Database and maps of public bird observations at bird feeders between November 1 and April 30 across the US and Canada since the mid-1970s.

Informational Database	Location and Description
Botanical Information and Ecology Network (BIEN)	https://bien.nceas.ucsb.edu/bien/ International database of georeferenced plant locations, plot inventories and surveys, species geographic distribution maps, plant traits, species-level phylogeny, and cross-continent, continent, and country-level species lists with more than 464,000 species.
BugGuide	https://bugguide.net/node/view/15740 Database of insects, spiders, and related species with identification keys, imagery, taxonomy, and species profiles with information on range, habitat, season, food, and citations.
Bumble Bee Watch	https://www.bumblebeewatch.org/ Database of 122,000+ observations of bumble bees and their nests across North America with verified identification of species, location, conservation status, observation date, and related information.
Butterflies and Moths of North America (BAMONA)	https://www.butterfliesandmoths.org/ International database of Lepidoptera observations across North America with regional species checklists, taxonomy, and species profiles for more than 7000 species with distribution maps, identification, life history, flight, caterpillar hosts, adult food, habitat, conservation status, management needs, verified sightings, and imagery.
eButterfly	https://www.e-butterfly.org/#/ Database of butterfly 491,000+ observations across North and Central America for 1,250+ species with species profiles including weekly frequency of observations, taxonomy, distribution, imagery, and citations.

Informational Database	Location and Description
North American Butterfly Association Butterfly Count	https://www.naba.org/butter_counts.html International database of butterfly observations since 1993 across 400+ 15-mile count circles in North America.
Land Snails and Slugs of the Mid-Atlantic and Northeastern US	https://www.carnegiemnh.org/science/mollusks/index.html Database of known terrestrial snails and slugs of the Northeast and Mid-Atlantic regions with imagery, taxonomy, and species profiles.
Atlas of Common Freshwater Macroinvertebrates of Eastern North America	https://www.macroinvertebrates.org/#/ Database of freshwater macroinvertebrate species for eastern North America with identification keys, diagnostic characteristics, high resolution imagery, genus overview, habitat, pollution tolerance, feeding habits, movements, and distribution. Integrated with the PocketMacros app.
Mayfly Central	https://www.entm.purdue.edu/mayfly/ Database of Ephemeroptera (mayfly) species across North America, including records for 573 species in the US organized by taxonomy.
Freshwater Mussel Host Database	https://mollusk.inhs.illinois.edu/57-2/ Database of more than 2700 known host interdependent relationships for freshwater mussels searchable by mussel or host species or family with location, data source, and natural or lab evidence for the relationship.
Nature's Notebook	https://www.usanpn.org/natures_notebook National database of 500,000+ phenology records for plants and animals tracking seasonal changes, with featured campaigns to track nectar sources for pollinators, the emergence of mayflies, flowers for bats, insect pests, and non-native invasive plants.

Informational Database	Location and Description
Odonata Central	https://www.odonatacentral.org/#/ Database of Odonata (dragonflies and damselflies) observations in the Western Hemisphere including species, location, date, level of confidence in identification, and imagery with more than 300,000 records.

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5.7 ENDNOTES

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