Chapter 3 - Table of Contents

Threats to Connecticut's GCN Species and Their Key Habitats

List of Figures

List of Tables

CHAPTER 3
THREATS TO CONNECTICUT'S GCN SPECIES AND THEIR KEY HABITATS

INTRODUCTION

Connecticut's greatest conservation need (GCN) species and their key habitats face numerous threats. Some threats are global or national in scale, while others are regional, statewide, or local. Identifying threats is a critical step in developing effective conservation actions. This chapter addresses Element 3, the threats affecting these important conservation targets.

State wildlife action plans are required to identify the problems that may adversely affect species of conservation need and their habitats. These include direct threats to species survival and habitat integrity, and challenges caused by deficiencies in data or resources. Threats affect a species by a direct action or through indirect impacts by limitation of a particular habitat condition. This WAP uses the IUCN categories of threats (Salafsky et al. 2008) as recommended by the Northeast Lexicon and Synthesis (Crisfield and NEFWDTC 2013; TCI and NEFWDTC 2013).

THREATS IN THE NORTHEAST REGION

There is no comprehensive assessment of threats to fish, wildlife, and their habitats across the northeastern region. However, threats have been identified by the northeastern states as part of their individual WAPs. After the completion of the 2005 WAPs for each northeastern state, a survey was conducted to identify common threats (AFWA 2011; Table 3.1). The 13 northeastern states and the District of Columbia identified 37 common, recurring threats to GCN species or their habitats (AFWA unpublished and 2011). Most frequently mentioned threats included invasive species (mentioned by 100% of northeastern states); industrial effluents (pollution); commercial and industrial areas; housing and urban development; and agricultural and forestry effluents, which can include water-born pollutants of nutrients or sediment, (all of these were mentioned by 83% of northeastern states). Other important challenges mentioned by the majority of northeastern states included: dams and water management; habitat shifting and alteration; recreational activities; roads and railroads; storms and flooding; temperature extremes; logging and wood harvesting; problematic native species; harvest or collection of animals; lack of information or data gaps; and droughts. In addition to the specific threats mentioned in the 2005 plans, recent work has emphasized the importance of additional, emerging threats such as climate change, exurban developments, new invasive species, and disease.

TABLE 3.1: KEY THREATS IDENTIFIED BY NORTHEASTERN STATES IN THEIR WILDLIFE ACTION PLANS IN DESCENDING ORDER OF LISTING RECURRENCES.

Key Threats	IUCN Category
Invasive non-native/alien species	Invasive & Other Problematic Species & Genes
Household sewage & urban waste water	Pollution
Industrial & military effluents	Pollution
Agricultural & forestry effluents (i.e. nutrient and sediment run-off)	Pollution
Housing & urban areas	Residential & Commercial Development
Commercial & industrial areas	Residential & Commercial Development
Recreational activities	Human Intrusions & Disturbance
Dams & water management/use	Natural System Modifications
Habitat shifting & alteration	Climate Change & Severe Weather
Storms & flooding	Climate Change & Severe Weather
Temperature extremes	Climate Change & Severe Weather
Lack of biological information/data gaps	Barriers/Needs
Droughts	Climate Change & Severe Weather
Roads & railroads	Transportation & Service Corridors
Harvesting/collecting terrestrial animals	Biological Resource Use
Logging & wood harvesting	Biological Resource Use
Other ecosystem modifications	Natural System Modifications
Problematic native species	Invasive & Other Problematic Species & Genes
Harvesting aquatic resources	Biological Resource Use
Air-borne pollutants	Pollution
Natural Resource Barriers: Low population levels, insufficient habitat requirements, etc.	Barriers/Needs
Garbage & solid waste	Pollution
Wood & pulp plantations	Agriculture & Aquaculture
Excess energy (i.e. light, thermal or noise pollution)	Pollution
Lack of capacity/funding for conservation actions	Barriers/Needs
Lack of education/outreach with public and other stakeholders	Barriers/Needs
Fire & fire suppression	Natural System Modifications
Non-timber crops (i.e. deforestation for farming)	Agriculture & Aquaculture
Tourism & recreation areas	Residential & Commercial Development
Lack of monitoring capacity/infrastructure	Barriers/Needs
Lack of capacity/infrastructure for data management	Barriers/Needs
Administrative/political barriers	Barriers/Needs
Shipping lanes	Transportation & Service Corridors
Gathering terrestrial plants	Biological Resource Use
Renewable energy (i.e. potential bird and bat mortality from wind farms)	Energy Production & Mining
Mining & quarrying	Energy Production & Mining

Identifying Threats In Connecticut

Threats affecting GCN species or their habitats in Connecticut were determined using the list developed in 2005 as a foundation, supplemented by a review of more than 120 existing conservation programs and plans (Appendix 1a). Threats were compiled from these sources as well as from stakeholders and partners through surveys and workshops. An iterative review process was used to refine and link the threats to conservation actions. Appendix 3 identifies these threats by GCN species and taxon. Appendix 3 also lists these compiled threats as they pertain to key habitats and their associated vegetative communities as identified by DEEP staff, ESSAC members, partners, stakeholders, and the public.

Threats were then evaluated by DEEP staff and other taxonomic and habitat experts. Finally, a survey of DEEP staff and a wide variety of stakeholders was conducted to capture their input on problems affecting wildlife species and key habitats. A complete list of threats for the 2015 WAP is located in Appendix 3.

The threats identified from the compilation of existing plans and programs described above were confirmed and validated iteratively by DEEP staff and stakeholder input throughout the development of this plan. After identification of threats, specific conservation actions were developed to address them (See Chapter 4).

Threat Classification

Two systems were used to classify and categorize threats: the International Union for Conservation of Nature (IUCN) and Tracking and Reporting Actions for Conservation of Species (TRACS). IUCN is a classification system used to categorize threats to species on the IUCN Red List and was recommended for use in WAPs by the Association of Fish and Wildlife Agencies' (AFWA) Best Practices Guidance document (AFWA 2012) and the Northeast Lexicon and Synthesis (Crisfield and NEFWDTC 2013, TCI and NEFWDTC 2013). TRACS is the tracking and reporting system for conservation and related actions funded by the U.S. Fish and Wildlife Service (USFWS), Wildlife and Sport Fish Restoration (WSFR) Program. TRACS is newly required for WAP revisions so that the USFWS is better able to report on outputs and outcomes of administered grants from the State Wildlife Grants (SWG) program. Wildlife TRACS replaces the previous reporting system used by the USFWS. Both IUCN and Wildlife TRACS use a three-tier, hierarchical system to classify threats. Level one is the broadest categorization with levels two and three increasing in specificity and detail.

International Union for Conservation of Nature

In 2008, IUCN and BirdLife International (BLI) published the first lexicon for threats and actions for conservation science. The lexicon was created by merging elements of previous classification systems into a single, unified language (IUCN 2008; Salafsky et al. 2008). The classification system was developed in a way that enables conservationists around the world to identify threats and possible actions, effectively allocate resources, and set conservation priorities, while also encouraging cross-project learning (IUCN 2008).

Northeast Lexicon

The Northeast Lexicon recommends the IUCN system for threat classifications, and incorporates classifications that are consistent with the TRACS system (a required federal reporting system for state fish and wildlife agencies). The northeastern states recognized a need to develop this comprehensive system by merging the IUCN and TRACS classification systems.

The *Northeast Lexicon: Terminology Conventions and Data Framework for State Wildlife Action Plans in the Northeast Region* describes the lexicon that was developed specifically for WAPs, and encourages regional collaboration and language unity while incorporating both classification systems (Crisfield and NEFWDTC 2013).

To rank threats by risk (level of impact considering severity and likelihood), the Northeast Lexicon provides definitions for the severity, reversibility, immediacy, spatial extent, certainty, and likelihood of threats (Table 3.2). These definitions may apply to single threats or the compounding impact of interacting threats (Crisfield and NEFWDTC 2013).

TABLE 3.2: NORTHEAST LEXICON THREAT RISK CHARACTERISTICS AND CATEGORICAL RATINGS (SOURCE: CRISFIELD AND NEFWDTC 2013)

Threat Characteristic	Low Impact	Moderate Impact	High Impact
Severity	**Slight Severity:** Degree of ecological change is minor	**Moderate Severity:** Degree of ecological change is substantial	**Severe:** Degree of ecological change is major
Reversibility Consider the likelihood of reversing the impacts within 10 years.	**Reversible:** Effects of the threat can be reversed by proven actions	**Reversible with difficulty:** Effects of the threat may be reversed but costs or logistics make action impractical	**Irreversible:** Effects of the threat are irreversible
Immediacy This characteristic assesses the time scale over which impacts of the threat will be observable.	**Long-term:** Effects of the threat are expected in 10-100 years given known ecosystem interactions or compounding threats	**Near-term:** Effects of the threat are expected within the next 1-10 years	**Immediate:** Effects of the threat are immediately observable (current or existing)
Spatial Extent Consider impact of threat within 10 years.	**Localized:** (<10%) A small portion of the habitat or population is negatively impacted by the threat.	**Dispersed or Patchy:** (10-50%)	**Pervasive:** (>50%) A large portion of the habitat or population is negatively impacted by the threat.
Certainty	**Low Certainty:** Threat is poorly understood, data are insufficient, or the response to threat is poorly understood	**Moderate Certainty:** Some information describing the threat and ecological responses to it is available, but many questions remain	**High Certainty:** Sufficient information about the threat and ecological responses to it is available
Likelihood Consider impact of the threat within 10 years. This characteristic is used to assess the certainty surrounding the threat and its impacts.	**Unlikely:** Effects of the threat are unlikely to occur (less than 30% chance)	**Likely:** Effects of threat are likely to occur (30-99% chance)	**Occurring:** Effects of the threat are already observable (100% chance)

THREATS TO CONNECTICUT'S FISH, WILDLIFE AND THEIR HABITATS

Key threats identified in this WAP are grouped categorically (Table 3.3). Some threats are specific to a single habitat or taxon; others impact groups of several closely related key habitats or taxa; others are applicable to most of the habitats found in Connecticut. A list of all threats identified in this revision process is presented in Appendix 3.

TABLE 3.3: KEY THREATS TO GCN SPECIES AND HABITATS USING IUCN AND NORTHEAST LEXICON CLASSIFICATIONS. (SOURCE: ADAPTED FROM SALAFSKY ET AL. 2008 AND CRISFIELD AND NEFWDTC 2013)

1. Residential and Commercial Development
• Loss, degradation, or fragmentation of habitats from development or changes in land use • Loss of coastal habitat due to development • Loss to development of buffers around streams, vernal pools, wetlands, and key habitats that provide migration corridors • Loss of large forest blocks (e.g., 2,000+ acres) with unbroken canopy due to fragmentation through development • Loss of cold water habitat and cold hilltop microclimate • Degradation of habitat due to impacts of new roads, impervious surfaces, and culverts • Loss of warm season grasslands • Loss of pollinator habitat
2. Administrative Challenges
• Insufficient staffing in fish and wildlife agencies to implement wildlife conservation • Insufficient staffing in fish and wildlife agencies for successional planning to ensure continuity of wildlife conservation • Public policy focused on goals and interests that adversely affect wildlife and natural resource conservation • Need for more effective policy to protect resources • Insufficient data exchange and coordination among the public, government, and scientific communities • Insufficient law enforcement
3. Education and Outreach Challenges
• Public indifference towards conservation • Promotion and persistence of inaccurate wildlife myths
4. Invasive and Other Problematic Species, Genes and Diseases
• Degradation of habitat from exotic and invasive species • Impacts to wildlife populations from emerging diseases • Depredation of wildlife and degradation of habitat by exotic, domestic, invasive or nuisance animals • Encroachment of invasive species on critical habitats • Degradation of habitat from over-browsing by deer
5. Natural Systems Modifications
• Loss of early successional habitat to natural succession • Loss and degradation of shoreline habitat due to modification (e.g., armoring, seawalls, riprap) • Lack of stand age diversity, structural diversity, and understory diversity among upland forests • Lack of fire needed to maintain certain habitats • Adverse effects of barriers to upstream habitats (e.g., dams, culverts, tide-gates) • Adverse effects of consumptive withdrawal of surface water or groundwater

- Loss of coldwater habitat due to warming from habitat modification such as wetland filling, impoundment, beaver dams, and removal of riparian vegetation
- Adverse effects of dredging, ditching, drawdowns, and other waterbody modifications
- Adverse effects to wildlife and habitats from excessive aquatic vegetation control

6. Resource Management Challenges

- Insufficient resources to maintain and enhance wildlife habitat
- Insufficient scientific knowledge regarding wildlife, fish, and their habitats
- Insufficient or inappropriate habitat management or modification on public and private lands
- Insufficient wildlife conservation and management at a regional level
- Delayed recovery of species with depressed populations due to limited reproductive potential, dispersal ability, or other factors

7. Pollution

- Effects of residual contaminants in sediments and water such as nutrients, herbicides, industrial contaminants, and pesticides on key habitats
- Loss of water quality and aquatic habitat due to farm field runoff
- Adverse effects of hypoxia and other water quality impairments due to eutrophication
- Adverse impacts from artificial light and reflective building surfaces
- Adverse effects from dumping of trash and yard waste in wildlife habitats
- Adverse impacts from mowing, power washing, and other property maintenance

8. Transportation and Utility Corridors

- Mortality of GCN species (especially amphibians and reptiles) on roads
- Habitat fragmentation from transportation and utility corridors
- Adverse effects from materials used for winter road treatment
- Degradation of water quality and modification of water flow due to roads

9. Human Intrusions and Disturbance

- Encroachment of humans, dogs, and cats in natural areas
- Degradation of habitats from off-road vehicles, boats, jet-skis, etc.
- Degradation of habitats from blazing of unauthorized trails
- Adverse impacts, such as direct disturbance, litter, injury, and habitat damage, caused by recreational activities.

10. Climate Change and Severe Weather

- Disruption of wildlife and plant life cycles due to changes in phenology of co-dependent species
- Degradation and loss of low-lying habitats due to sea level rise and salt water incursion
- Adverse effects on wildlife and habitats from severe weather events

11. Biological Resource Use

- Illegal collection and poaching of plant and animal species

12. Energy Production and Mining

- Adverse effects from construction of energy production and energy transport facilities (e.g., power plants, pipelines, windmills, transmission corridors)

13. Agriculture and Aquaculture

- Loss of water quantity due to agricultural use
- Degradation of agricultural open space due to loss of top soil
- Conventional farmland may not provide good wildlife habitat unless management practices are taken to increase wildlife diversity

RESIDENTIAL AND COMMERCIAL DEVELOPMENT

The primary threat to GCN species in New England and Connecticut is the conversion of land for housing, urban areas, and commercial, industrial, and recreational uses. Since its colonization, southern New England continues to be one of the most densely populated regions in the country. According to the most recent census figures, Connecticut's population is approximately 3,574,000 residents (U.S. Census 2010) making it the fourth most densely populated state with 743 residents per square mile. The 2010 census figure is about 4.9 percent higher than the population reported in the 2000 Census. That is the second highest rate of population growth among New England states, which averaged 3.8 percent region-wide (U.S. Census 2010).

Land cover changes from 1985 through 2010 have been determined through analysis of satellite-based remote sensing images by the UConn Center for Land Use Education and Research (CLEAR) program. This analysis shows that during this period the state has lost 18 acres per day to high-density development, which includes buildings, parking lots, and roads. The conversion of primarily forest land to development is illustrated by the loss of more than 115,000 acres of forest during this period (CLEAR 2014).

TABLE 3.4: LAND COVER CHANGES IN CONNECTICUT FOR THE PERIOD 1985 – 2010. (SOURCE: CLEAR 2014)

	1985			2010			Change		
	acres	sq. miles	%	acres	sq. miles	%	acres	sq. miles	%
Developed	509,996	796.9	16.0%	605,294	945.8	19.0%	95,299	148.9	3.0%
Turf & Grass	197,634	308.8	6.2%	245,551	383.7	7.7%	47,917	74.9	1.5%
Other Grass	41,761	65.3	1.3%	61,297	95.8	1.9%	19,536	30.5	0.6%
Ag. Field	272,107	425.2	8.6%	231,846	362.3	7.3%	-40,262	-62.9	-1.3%
Deciduous Forest	1,578,769	2,466.8	49.7%	1,473,716	2302.7	46.4%	-105,053	-164.1	-3.3%
Coniferous Forest	291,751	455.9	9.2%	281,546	439.9	8.9%	-10,205	-15.9	-0.3%
Water	110,432	172.5	3.5%	102,936	160.8	3.2%	-7,496	-11.7	-0.2%
Non-forested Wetlands	12,909	20.2	0.4%	13,219	20.7	0.4%	310	0.5	0.0%
Forested Wetlands	117,633	183.8	3.7%	111,546	174.3	3.5%	-6,088	-9.5	-0.2%
Tidal Wetlands	14,427	22.5	0.5%	14,593	22.8	0.5%	166	0.3	0.0%
Barren	20,571	32.1	0.6%	26,760	41.8	0.8%	6,189	9.7	0.2%
Utility ROW (Forest)	11,258	17.6	0.4%	10,928	17.1	0.3%	-330	-0.5	0.0%

See http://clear.uconn.edu/projects/landscapeLIS/galleryLC/index.html for a detailed, interactive map and information.

Despite the high percentage of forest cover in Connecticut, fragmentation resulting from development renders remaining habitats less suitable to the many species of wildlife that require large blocks of contiguous forest. The loss of 18 acres per day indicates that fragmentation of forest in Connecticut continues at a high rate. The Connecticut Statewide Forest Resource Plan (Flounders 2004) identifies forest fragmentation as one of the most detrimental factors affecting forest ecosystem health.

To analyze the degree of fragmentation of Connecticut's forests, and how fragmentation has progressed over time, CLEAR researchers developed a fragmentation model and applied it to the Center's multi-year land cover data (CLEAR 2009). Analysis of the 2006 land cover data revealed that almost 60 percent of the state was forested. However, tree cover alone is not a complete indicator of the functional health of forested ecosystems, which can be impacted by proximity to non-forested areas. Forested areas were classified into four main categories of increasing disturbance—core, perforated, edge, and patch—based on a key metric called edge width (Figure 3.1). The edge width indicates the distance within which other land covers (i.e., developed land) can degrade the forest. Based on available national research, an edge width of 300 feet was used.

The largest undisturbed or "core" patches are more than 500 acres. The next least-disturbed category, perforated, consists of the interior edges of small non-forested areas within a core forest, such as a house built within the woods. Edge makes up the exterior periphery of core forest tracts where they meet with non-forested areas. The most disturbed category, patch, refers to small fragments of forest completely surrounded by non-forested areas (CLEAR 2009).

During the study period of 1985 to 2006, Connecticut lost about 185 square miles of forest to development, or about 3.7 percent of the forest that existed in 1985. While a proportion of core forest was converted to non-forest (19.1%), most of the core forest was converted to perforated (36.6%) or edge (44.1%) forest by the encroachment of nearby development. This seems to reflect the prevalent patterns of development in Connecticut during this period, where "holes" of development—in the form of subdivisions—are punched into the landscape (CLEAR 2009).

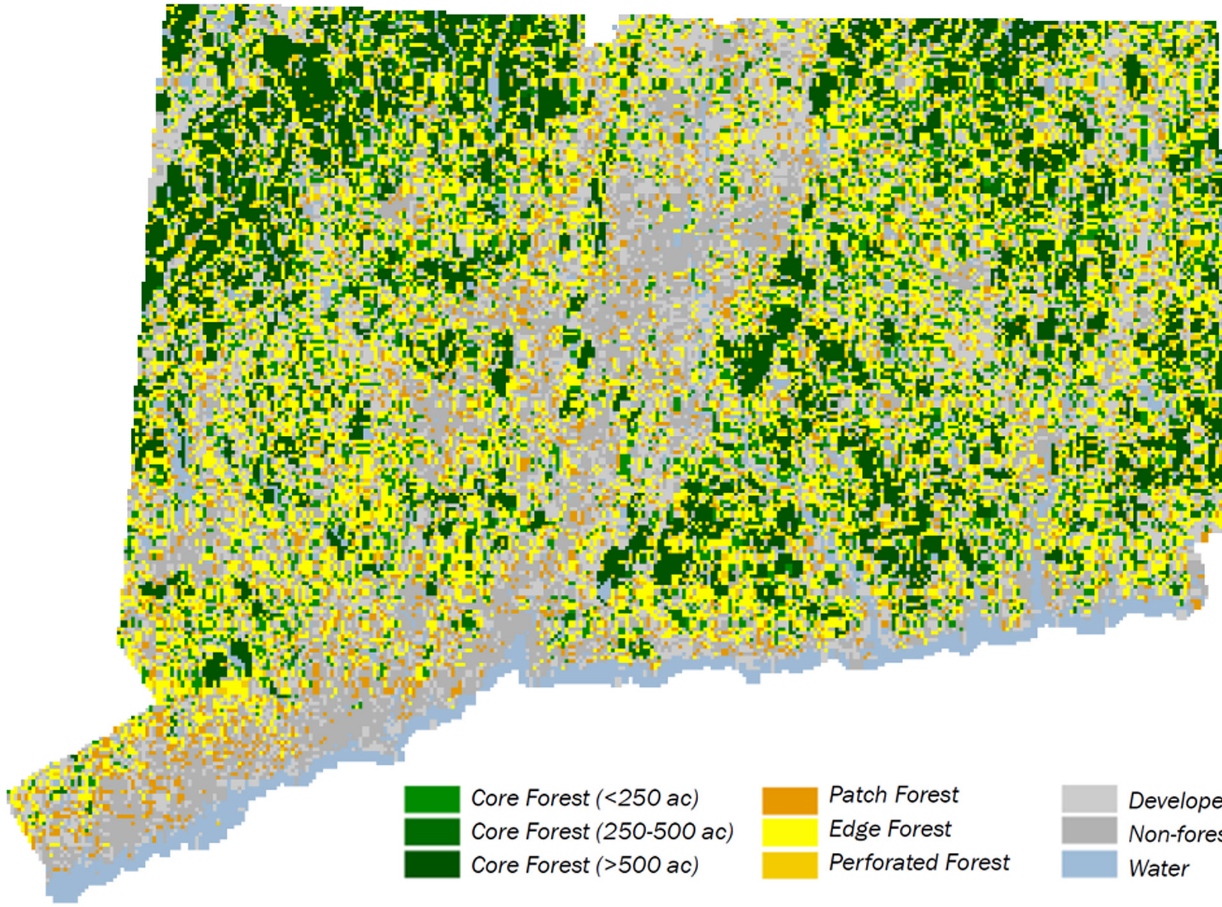

FIGURE 3.1: FOREST FRAGMENTATION IN CONNECTICUT. (SOURCE: CLEAR 2009)

Impacts to forest habitats pose a difficult challenge to wildlife managers because so much of Connecticut's forests are in private ownership. More than 102,000 individuals and private enterprises own 84 percent of Connecticut's forestland. State, federal, and other public owners hold only 16 percent. Private and public water utilities own some of the largest forested tracts; however, the number of owners with fewer than 50 acres of timberland has increased by 68 percent since 1975. Three-quarters of the private forest landowners have fewer than ten acres. These small tracts are primarily home sites (Flounders 2004). Therefore, participation by private forest landowners is critical for the success of land conservation in the future.

There are approximately 510,000 acres of freshwater wetlands and watercourses in Connecticut, or approximately 16 percent of the state's surface area. In 1972, recognizing that inland wetlands and watercourses are indispensable and irreplaceable fragile natural resources, and that such resources have been destroyed or are in danger of destruction because of unregulated use, Connecticut's legislature enacted the Inland Wetlands and Watercourses Act (IWWA - General Statutes of Connecticut Sections 22a-36 through 22a-45). The IWWA requires municipal regulation of activities that affect wetlands and watercourses. It provides an orderly process to balance the need for the economic growth and associated land use, with the need to protect Connecticut's environment and ecology. Included in this process is the requirement that the Commissioner of DEEP develop a reporting form on which Connecticut's municipal inland wetlands agencies can report on the permits they issue that may impact or affect inland wetlands and watercourses, as well as on enforcement actions and other proceedings these agencies undertake (CT DEEP 2013a).

The year 2010 marked the 21st year of standardized reporting of agency actions. During this period, reports were received from all but 17 of the 171 municipal Agencies. The average number of reporting forms received annually from 2000 through 2010 was 3,924. In 2005, DEEP received 4,488 reporting forms, and the number of reports received has been steadily declining since that time. In 2010, DEEP received 2,967 reporting forms. The pace of development in Connecticut is reflected in the volume of actions municipal agencies manage. The economic downturn experienced in the past few years seems to be reflected in the number of agency actions reported in 2010 (CT DEEP 2013a).

The majority of actions taken by municipal agencies involve the issuance of permits for activities likely to impact inland wetlands or watercourses. The permits issued, and their associated wetland and watercourse alterations, are for activities, either directly within a wetland or watercourse or in an upland area, that may impact nearby wetlands or watercourses. Of the 1,724 permits issued in 2010, 161 of these were for activities with a direct impact to wetlands and watercourses. Another 922 were for regulated activities solely in the upland. The three most common reported purposes were residential improvement by homeowner, new residential development for single family units, and commercial/industrial uses. However, these reasons do not account for the majority of acres of wetlands and watercourses impacted. In 2010, the three primary purposes for impacts to wetlands and watercourses were wetland creation/restoration, residential improvement by homeowner, and recreation/boating/navigation. (CT DEEP 2013a).

In addition to the loss of habitat, residential and commercial development can have other effects that are detrimental or even fatal to wildlife. For example, a recent assessment by Loss et al. (2014) estimates that between 365 and 988 million birds are killed every year by building collisions in the United States Roughly 56 percent of this mortality is associated with low-rise buildings; 44 percent with residences; and less than one percent with high-rises. Moreover, it appears that several species are disproportionately vulnerable to collisions at all building types, including Canada warbler, wood thrush, and worm-eating warbler. All three are GCN species in Connecticut (Loss et al. 2014).

It is estimated that free-ranging domestic cats are the single greatest source of anthropogenic mortality for birds and mammals in the United States Findings by Loss et al. (2013) indicate that 1.3 to 4.0 billion birds and 6.3 to 22.3 billion mammals are killed annually, mostly by feral cats. The conservation strategy for the New England cottontail (NEC) suggests that domestic cats may be important predators of this species, given the high human population and housing densities within much of the NEC range (Fuller and Tur 2012).

Administrative Challenges

The lack of stable funding creates challenges or obstacles that can be seen as threats to implementing conservation. The approach to wildlife management in the United States and Canada is known as the North American Model of Wildlife Conservation. In 1842, a U.S. Supreme Court ruling resulted in the Public Trust Doctrine that said that wildlife resources are owned by no individual, but instead are held in trust by government for the benefit of present and future generations. In short, most of the authority for managing wildlife rests with the states, and the public bears responsibility for providing funding (AFWA 2011). The lack of dedicated funding, especially for wildlife diversity, severely constrains the ability of state fish and wildlife agencies to plan, build capacity, conduct long-term monitoring, and manage at landscape scales, all of which are necessary to ensure successful management and conservation (AFWA 2011).

EDUCATION AND OUTREACH CHALLENGES

Public indifference toward fish and wildlife conservation can likewise pose an obstacle to implementing conservation. In 2006, DEEP launched an initiative known as *No Child Left Inside®*, described as "…a promise to introduce children to the wonder of nature–for their own health and well-being, for the future of environmental conservation, and for the preservation of the beauty, character and communities of the great State of Connecticut." (DEEP Website http://www.ct.gov/ncli/cwp/view.asp?a=4005&q=471154&ncliNav_GID=2004). DEEP recognized that children were not connecting with nature and thus may not be acquiring the skills and knowledge they need to become part of the next generation of environmental stewards. The Great Park Pursuit began nine years ago as a key component of DEEP's nationally recognized No Child Left Inside initiative, and its popularity has grown as families engage in healthy, fun, and awe-inspiring outdoor activities year after year. Although its primary target audience is children, adults with children may benefit as well. The success of these programs notwithstanding, an extreme and growing indifference to wildlife, conservation and environmental issues in general remains a major long-term threat.

INVASIVE AND OTHER PROBLEMATIC SPECIES, GENES, AND DISEASES

The spread of exotic invasive species poses one of the greatest threats to GCN species throughout the Northeast. With NEAFWA funding through the Regional Conservation Needs (RCN) Grant Program, Klopfer (2012) identified 238 invasive species from 12 groups with a potential to adversely affect GCN species, while at the same time acknowledging that this is not a complete list of invasive species for the Northeast. The majority of invasive species are plants (68%), and the majority of these (58%) occur in seven or more states. There were 71 (30%) invasive species common to all states in the Northeast. The habitat identified with the greatest number of invasive species is classified as "forest edge" with 115 species (48%), followed by pasture and grassland with 94 and 86 species respectively (39% and 36%).

Invasive species (both plant and animal), other problematic species, and diseases can cause serious ecological impacts by altering biodiversity and affecting population dynamics, size, and distribution of native species. It is important to identify and address these threats at early stages of invasion when control methods may be most successful. One avenue for identifying new sites of invasion is through early detection programs conducted primarily by volunteers.

The Connecticut Aquatic Nuisance Species Management Plan was developed by Connecticut Sea Grant, UConn College of Agriculture and Natural Resources, and DEEP, and was approved by the federal Aquatic Nuisance Species Task Force in 2007. The goal of the plan is to implement a coordinated approach to minimizing the ecological, socioeconomic, and public health impacts of aquatic nuisance species (plants and animals) in Connecticut. http://www.anstaskforce.gov/State%20Plans/CT_ANS_Plan.pdf

Invasive Plants

The Invasive Plant Atlas of New England (IPANE) maintains a comprehensive database of all invasive plant species in New England (IPANE 2014). Distribution maps, species data, and general information regarding invasive plants are provided on the website. For further information visit: http://www.eddmaps.org/ipane/index.html. Acutely invasive plants have also been tracked by other programs. For example the UConn Department of Plant Sciences and Landscape Architecture maintains a web site devoted to mile-a-minute vine. This plant was first detected in Connecticut in 2000, at one locality in the town of Greenwich. By 2014, this plant had been found in more than 40 municipalities (Figure 3.2).

Mile-a-minute vine can cause major ecological problems by overgrowing and out-competing other plants and forming dense mats that interfere with forest regeneration and seedling establishment. It grows up to 6 inches per day in ideal conditions. This species has been banned by the Connecticut Legislature (Sec. 22a-381d of the Connecticut General Statues makes it illegal to transport, cultivate, sell or distribute the species), but populations are continuing to spread through natural areas (UConn 2014).

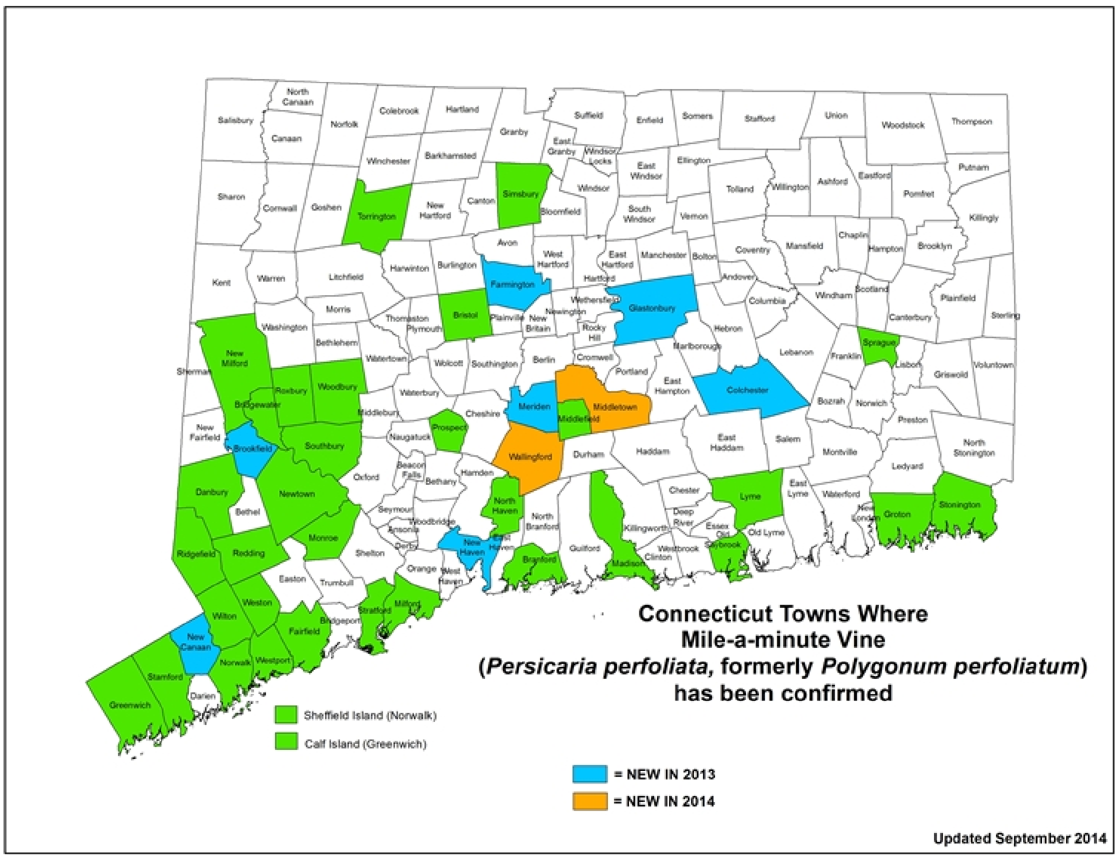

FIGURE 3.2: CONNECTICUT TOWNSHIP MAP DEPICTING THE RANGE EXPANSION OF MILE-A-MINUTE VINE.
(SOURCE: UCONN, DEPARTMENT OF PLANT SCIENCES AND LANDSCAPE ARCHITECTURE 2014)

The Connecticut Invasive Plant Working Group (CIPWG) (http://cipwg.uconn.edu/), established in 1997, comprises a diverse group of researchers, agency staff, and educators. Beginning in 2002, CIPWG has hosted biennial invasive plant symposia and other programs providing education about invasive species to a wider, public audience. CIPWG's mission is to "gather and convey information on the presence, distribution, ecological impacts, and management of invasive species; to promote uses of native or non-invasive ornamental alternatives throughout Connecticut; and to work cooperatively with researchers, conservation organizations, government agencies, green industries, and the general public to identify and manage invasive species pro-actively and effectively." (UConn 2014)

Revised in October 2013, the Connecticut Invasive Plant List includes 97 plants as determined by the Connecticut Invasive Plant Council in accordance with Connecticut General Statutes 22a-381a through 22a-381d. CIPWG has published multiple reports and fact sheets with information on preventing the spread of invasive species, proper disposal of invasive plants, and lists of potential native plant alternatives for natural resource managers and the general public. For a copy of the CT Invasive Plant List and other CIPWG publications visit: http://cipwg.uconn.edu/cipwg-publications/.

A guidebook on nuisance aquatic vegetation provides insight on the management of aquatic vegetation in lakes and ponds in Connecticut. This guidebook includes specific descriptions of aquatic plants, lists of algicides and herbicides and their effects, herbicide application recommendations, information on laws related to chemical use in ponds and lakes, and other general information (CT DEEP 2014a). The guide is available at: http://www.ct.gov/deep/lib/deep/pesticide_certification/Supervisor/aweeds.pdf.

The Invasive Aquatic Plant Program (IAPP) at the Connecticut Agricultural Experiment Station (CAES) was created in 2002, when scientists began surveying lakes and ponds for invasive aquatic species. The surveys track the spread of invasive plant species and their effects on native species. Baseline data to determine frequency and magnitude of invasions as it relates to water chemistry, sediment type, boat launches, watershed development, and climate change is also provided. Studies are also conducted to examine novel management options including effectiveness of herbicides, mechanical removal, water level manipulation, biological control, and integrated pest management (IPM) (CAES 2014). A list of publications from the IAPP is found at: http://www.ct.gov/caes/cwp/view.asp?a=2799&q=376996&caesNav=|&caesNav_GID=1805.

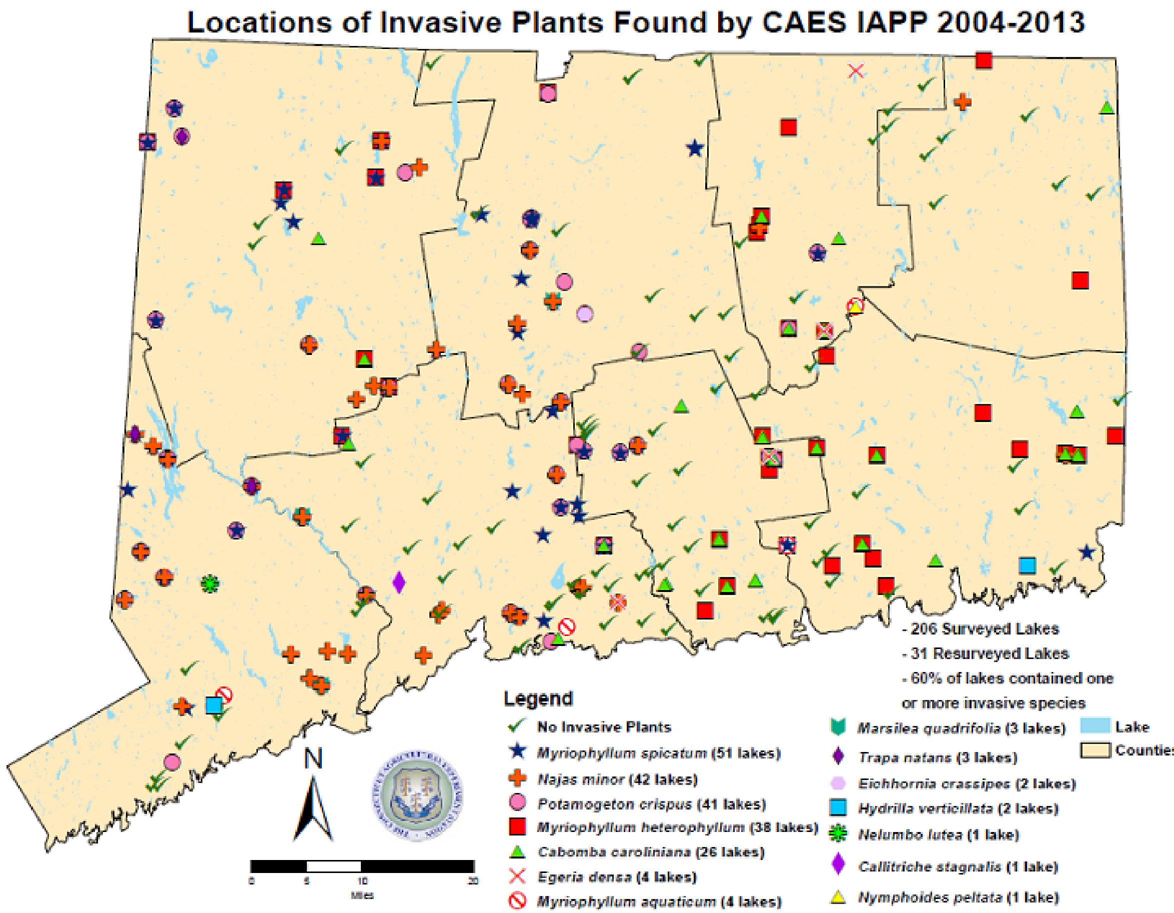

FIGURE 3.3: LOCATIONS OF AQUATIC INVASIVE PLANTS IN CONNECTICUT. (SOURCE: CAES 2014)

Invasive Insects

Among the many threats to trees in Connecticut, the threat from non-native insects is second only to catastrophic storm damage. Insects on this list include gypsy moth, Japanese beetle, hemlock woolly adelgid and European elm bark beetle. In addition, emerald ash borer (EAB) and Asian longhorned beetle pose imminent threats to Connecticut's forests.

The threat posed by EAB is especially significant because the state's ash populations have already been declining due to other diseases, such as ash yellows, making ash trees more susceptible to infestations. As of May 2015, EAB has been confirmed in all counties except Tolland and Windham, resulting in a statewide quarantine that regulates the movement of ash logs, ash materials, ash nursery stock, and hardwood firewood from within Connecticut to Rhode Island, portions of New York, northern New England and other states not known to be infested with EAB. Massachusetts is infested with EAB and therefore also has a statewide EAB quarantine. This allows transport of regulated articles from Connecticut to Massachusetts. To prevent the introduction of other wood boring insects such as Asian long-horned beetle, a permit from Connecticut Agricultural Experiment Station is required for any firewood coming into Connecticut from other states. The same is true of any wood intended for burning.

FIGURE 3.4: EMERALD ASH BORER. (SOURCE WWW.EMERALDASHBORER.INFO)

The Asian longhorned beetle has not yet been found in Connecticut, but has been found in the bordering states of New York and Massachusetts. The best strategy regarding this insect, if it is found in Connecticut, is to eradicate it before it can spread any further. Although this insect is easily recognizable, it can be difficult to find due to its affinity for tree tops in the initial stages of invasion. The damage caused to trees is also not easily diagnosed, which generally allows populations of Asian longhorned beetle to grow and infestations to spread over multiple years before being detected. Asian longhorned beetle has a broad range of hosts, which adds to the potential devastation in Connecticut's forests. Approximately 52 percent of the trees in Connecticut forests are considered susceptible to this insect pest, and 36 percent are considered to be highly susceptible (CT DEEP 2013b).

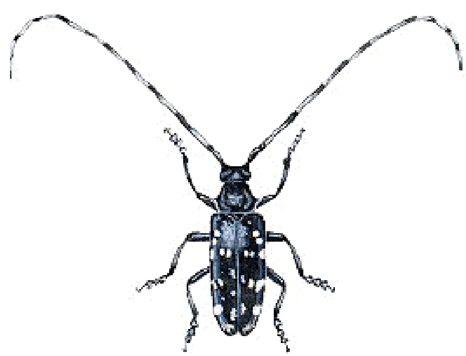

FIGURE 3.5: MALE ASIAN LONGHORNED BEETLE. (SOURCE: US FOREST SERVICE 2015)

The southern pine beetle (*Dendroctonus frontalis*) was found in 2015 attacking pitch pine in Wallingford (Wharton Brook S.P.) and North Haven. This beetle has caused significant pine mortality in the Pine Barrens of New Jersey and Long Island. It is difficult to know how destructive the beetle will be in the state, but its potential impact on the few remaining pitch pine habitats and associated rare and endangered species is considered a serious threat. A protocol that evaluates the degree of infestation and the tree's overall health should be performed before a pitch pine tree is cut down (M. Thomas, Connecticut Agricultural Experiment Station, pers. com., 2015).

Wildlife Diseases

Diseases have the potential to impact a broad range of wildlife. A disease that has received particular attention in the Northeast is white-nose syndrome (WNS), which has killed more than 5.7 million hibernating bats in the northeastern states. The RCN Grant Program has funded two projects to begin research and to address the threat of WNS. The disease is named for its causative agent, a white fungus (*Pseudogymnoascus destructans*) that invades the skin of hibernating or otherwise torpid bats. Research has demonstrated that bats affected by WNS arouse from hibernation more often than healthy bats, and the severity of cutaneous fungal infection correlates with the number of arousal episodes during hibernation. The increased frequency of arousal from torpor likely contributes to WNS-associated mortality, but the question of how fungal infection induces increased arousals remains unanswered. Other research on the development of methodologies to combat WNS in bats has involved testing potential treatments against cultured *P. destructans* under laboratory conditions, treatments for safety in healthy bats, and treatments for efficacy against *P. destructans* in hibernating bats.

Several species of bats found in Connecticut have been affected by WNS, including little brown, northern long-eared, tri-colored (formerly known as eastern pipistrelle), big brown, and Indiana bat (a federally endangered species). The Wildlife Division has been actively involved with investigating the impact of WNS since 2007. The fungus was first documented in Connecticut bats in 2008. Since then, precipitous declines have been documented at three primary hibernacula, which have been monitored since 1999. At one site, where more than 3,240 bats of three species were counted in 2007, only seven individuals were found in 2010. Surveys of that site were suspended to prevent disturbance to the surviving bats (CT DEEP 2014c), but elsewhere state biologists have been monitoring hibernating bats for signs of WNS, tracking maternity colonies, and encouraging state residents to report any bats found outdoors between the months of November through February (CT DEEP BNR 2011).

Snake Fungal Disease (SFD) is an emerging disease in certain populations of wild snakes in the eastern and midwestern United States While fungal infections were occasionally reported in wild snakes prior to 2006, the number of free-ranging snakes with fungal dermatitis submitted to the U.S. Geological Survey (USGS) National Wildlife Health Center (NWHC) and other diagnostic laboratories has increased recently. Laboratory analyses have demonstrated that the fungus *Chrysosporium ophiodiicola* is consistently associated with SFD, but often, additional fungi are isolated from affected snakes. At this time, definitive evidence that *C. ophiodiicola* causes SFD is inconclusive. As its name implies, SFD is only known to afflict snakes (USGS 2013).

Since 2009, timber rattlesnakes from separate populations in eastern, central and western Massachusetts have been found to have fungal dermatitis. With funding from the RCN Grant Program, researchers are actively trying to understand the spread of this disease and factors that contribute to its virulence in rattlesnake populations. For the latest updates go to: http://rcngrants.org/content/assessment-and-evaluation-prevalence-fungal-dermatitis-new-england-timber-rattlesnake.

In 2008, the Northeast Fisheries Administrators Association developed regional guidelines to coordinate the fish health management (fish disease management) efforts for the importation of fishes. These guidelines, for Connecticut and the region, set forth the essential requirements which include a fish health inspection system and references to the technical diagnostic

procedures for the prevention and control of fish pathogens.
http://www.maine.gov/ifw/fishing/pdfs/updated_northeastguidelines.pdf

Natural System Modifications

Natural system modifications to improve human welfare (e.g., fire and flood suppression) often degrade wildlife habitats (Salafsky et al. 2008) by eliminating processes essential to ecosystem maintenance.

The use of fire as a management tool was abandoned in the mid-1900s because of the threat posed to human settlements. Lack of fire in pitch pine barrens results in succession of these communities with an increase in hardwoods and a reduction in scrub oak understories that support the unique assemblage of plants and animals characteristic of barrens habitats. Recognition of this consequence of fire suppression has spurred conservation organizations and agencies throughout the Northeast to conduct controlled burns to manage pitch pine barrens and other fire-dependent habitats (Simmons 2006).

In Connecticut, the use of controlled burns to manage habitats can be problematic due to the relatively dense human population. Nevertheless, this management tool has continued to be used effectively in some portions of the state, for example at Stratford Point in 2012 when 20 acres of coastal grassland were burned (Connecticut Audubon Society 2012). Other successful management efforts using controlled burns include partnerships with private landowners for habitat restoration. Since 2004, Connecticut's Landowner Incentive Program (LIP) has been providing technical and cost share assistance to landowners for habitat management to protect, restore, enhance, and manage early successional habitat. Programs supported by the Wildlife Division, such as the Connecticut's Shrubland Habitat Enhancement Initiative, provide technical assistance to private landowners to develop habitat for the New England cottontail and other young forest-dependent species.

Another natural system modification identified as a threat to many aquatic and wetland habitats is water management, a broad category that includes dam construction, surface water diversion, withdrawals from surface and groundwater sources, and other operations that alter water flow patterns from their natural range of variation either deliberately or as a result of other activities. Of particular concern to fish and wildlife resources is the occurrence of dams on major rivers, preventing the migration of anadromous fish to inland spawning locations. In recent years, dam removal projects and fish ladders have restored riverine habitats in a number of locations. In 2012, a joint project of TNC's Connecticut Program and DEEP provided a fish ladder on the Mattabesset River (a tributary of the Connecticut River) that reopened 16.5 miles of riverine habitat. In 2013, the Connecticut River Watershed Council partnered with DEEP and the town of Old Lyme to install a fish ladder at the Rogers Lake dam, removing the last barrier to one of Connecticut's largest historic river herring runs.

Resource Management Challenges

Since 2005, information continues to be gathered and analyzed for a more comprehensive understanding of the state's priority species, especially those for which there is no baseline data. Lack of information on distribution, abundance, and life history variables is a detriment to developing actions to benefit the species in the state. Knowledge about invertebrate species is especially hampered by this deficiency. Past SWG projects have focused on specific taxa yet the need remains to collect additional data for many GCN species. Also, all new species information needs to be made more readily available to stakeholders, partners, and the public.

POLLUTION

Compared to other regions in the United States, the Northeast consists of some of the smallest states with the highest population densities. The combination of large metropolitan areas, bustling towns, and thriving industries generates significant amounts of waste in the form of household sewage, solid waste, and industrial effluents. Pollutants impair key riparian, aquatic, and terrestrial habitats throughout the region and pose serious threats to all northeastern aquatic systems.

There is a clear relationship between pollution and land use, which is explained by the degree of impervious cover associated with a given land cover category. Development increases the amount of impervious cover, which in turn increases the amount of runoff and decreases pollutant capture. Development also reduces the naturally occurring vegetation that serves as a buffer for pollutant delivery to surface water and groundwater. Generally, towns with higher percentages of urban land cover (and thus higher percentages of impervious surfaces) occur along the state's southwest coast (CT DEEP 2014d).

DEEP monitors and assesses the quality of the state's water bodies and reports on the condition of the state's waters every two years through the Integrated Water Quality Report (IWQR). In 2014, approximately 2,838 river miles were assessed, with 1,550 (55%) of those miles meeting the chemical and biological criteria to fully support aquatic life (Figure 3.6). This was an increase of 352 miles of healthy waters compared to the 2012 assessment. In addition, a recent assessment showed that 26,524 of 30,437 acres of lakes (87%) and 237 of 612 square miles of estuarine waters (39%) met the criteria to fully support aquatic life (CT DEEP 2014e).

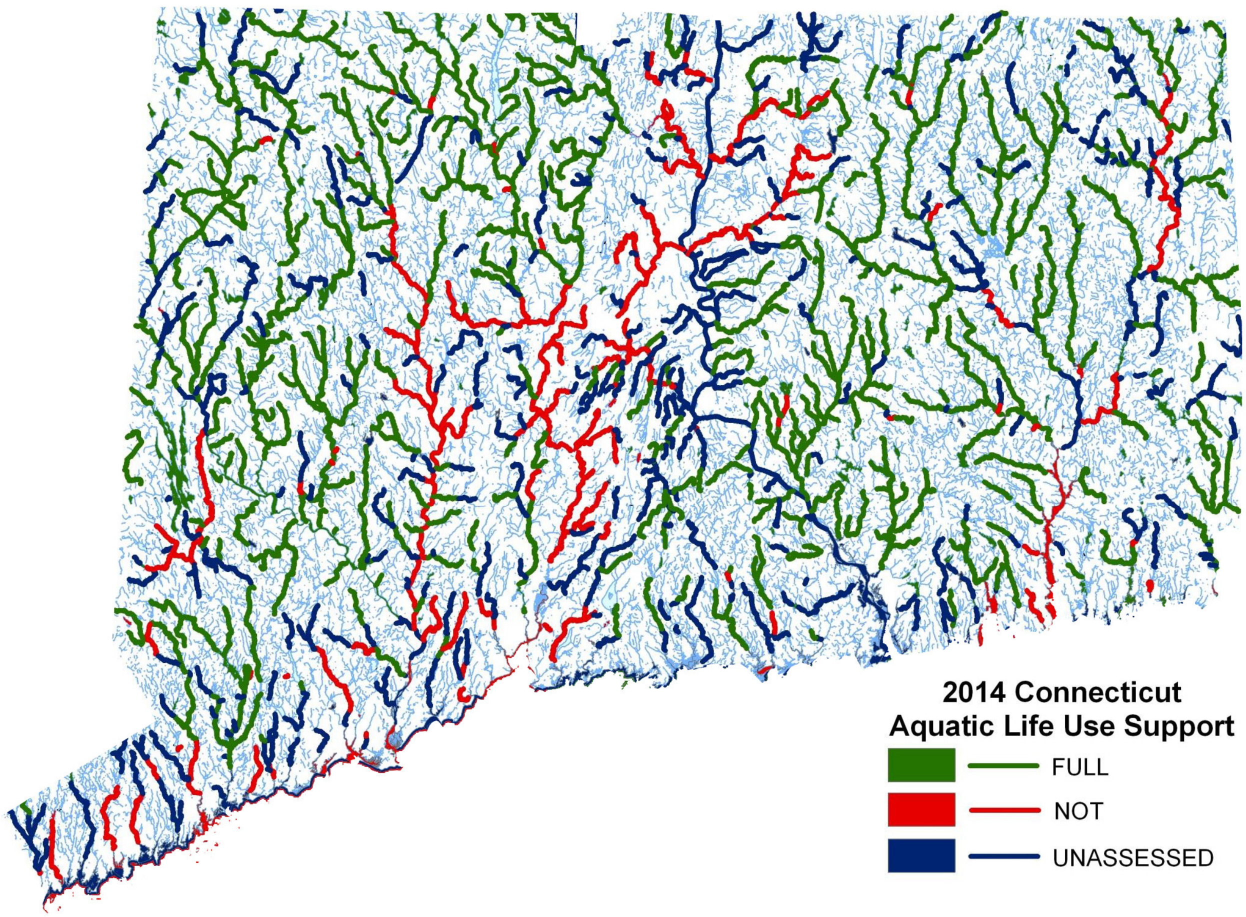

FIGURE 3.6: MAP OF CONNECTICUT WATER BODIES AS ASSESSED FOR SUPPORTING AQUATIC LIFE. (SOURCE: CT-DEEP 2014e)

The aquatic life of rivers and streams has been monitored through the cooperative efforts of the Inland Fisheries Division and Bureau of Water Management. Specifically, the Ephemeroptera, Plecoptera, Trichoptera Taxa Richness Index (EPT) and *Classifying the Health of Connecticut Streams Using Benthic Macroinvertebrates with Implications for Water Quality* (Bellucci et al 2013) are used as indicators of water quality, degraded aquatic conditions, and threats/stressors to the aquatic systems.

DEEP's Lake Water Quality Management Program strives to protect and restore the ecological integrity and recreational value of Connecticut's lakes and ponds by achieving and maintaining high water quality and natural habitat conditions through pollution prevention, pollution source abatement, and implementation of lake restoration technologies (CT DEEP 2014f). DEEP's Office of Long Island Sound Programs continues to work collaboratively at the local, state, and regional levels to monitor aquatic water quality in tidal waters (LISS 2014).

Connecticut revised its Water Quality Standards and Classification in 2013, and adopted new regulations for water quality standards in October, 2013. Municipal water quality classification maps, representing all inland water bodies in Connecticut, can be accessed online at:

http://www.ct.gov/deep/cwp/view.asp?a=2719&q=522518&deepNav_GID=1654

The U.S. Environmental Protection Agency (EPA) approved Connecticut's Nonpoint Source Management Program Plan in September, 2014. Connecticut's Coastal Nonpoint Source

Pollution Control Program is based on a comprehensive watershed approach that strives to restore and protect coastal water quality. Pollution control is focused on polluted runoff from a variety of areas such as agriculture facilities, marinas, and urban construction sites, including roads and highways (CT DEEP 2014d).

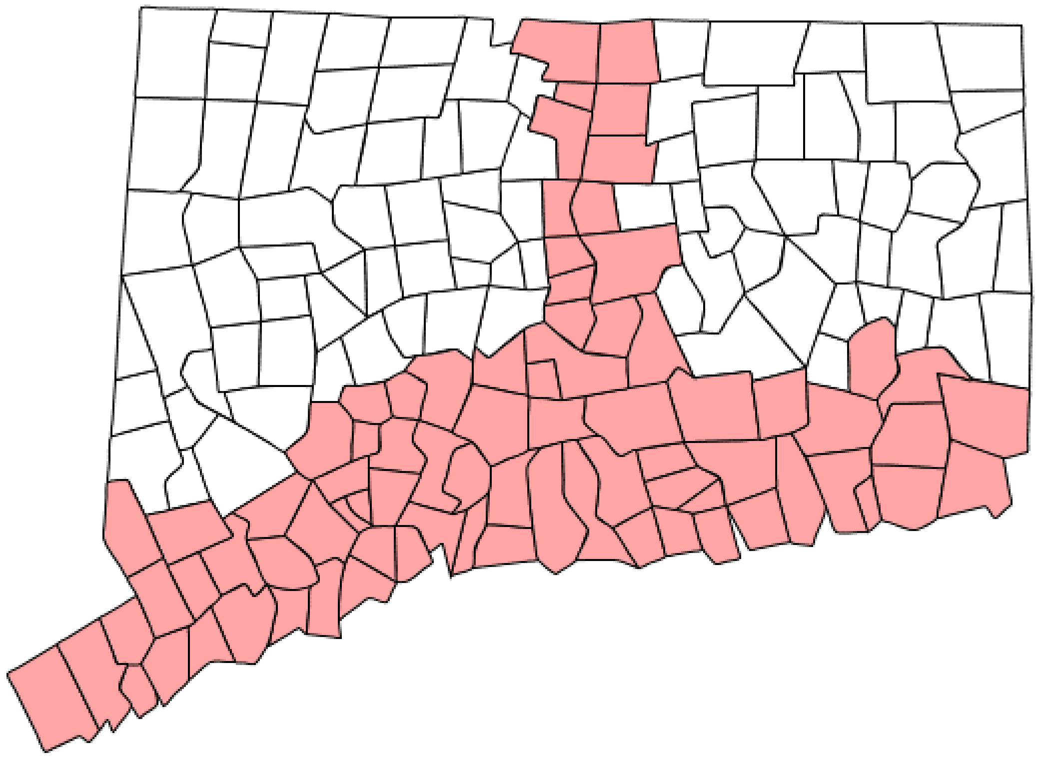

FIGURE 3.7: TOWNS LOCATED IN CONNECTICUT'S COASTAL NONPOINT SOURCE POLLUTION CONTROL PROGRAM MANAGEMENT AREA. (SOURCE: CT DEEP 2014d)

Agricultural nonpoint sources of pollution include nutrients (especially nitrogen and phosphorus), animal waste, pesticides, salts, and sediment. Chemical fertilizers and manure from animal facilities are the most common sources of excess nonpoint source nutrients in surface waters (CT DEEP 2014d).

Pesticides are substances designed to kill pest organisms, and as such can pose significant risks to humans and the environment. The EPA works to reduce those risks in several ways. The Office of Pesticide Program's (OPP) Conventional Reduced Risk Pesticide Program expedites the review and regulatory decision-making process of pesticides that pose less risk to human health and the environment than existing conventional alternatives. The goal of this program is to quickly register commercially viable alternatives to riskier conventional pesticides such as neurotoxins, carcinogens, reproductive and developmental toxicants, and groundwater contaminants.

EPA gives priority in its registration program for conventional chemical pesticides to pesticides that meet reduced risk criteria including low-impact on human health, low toxicity to non-target organisms (birds, fish, and plants), low potential for groundwater contamination, lower use rates, low pest resistance potential, and compatibility with Integrated Pest Management. Recently, a draft memorandum of understanding (MOU) was developed between the EPA OPP and the USFWS to protect migratory birds (EPA 2014). The purpose of this MOU is to promote the conservation of migratory bird populations through enhanced collaboration between EPA's OPP and USFWS on actions carried out by OPP. Migratory birds are an important component of biological diversity, and conserving them and their habitats supports ecological integrity, contributes to public conservation education, and enhances the growing interest in outdoor recreation opportunities (EPA 2014). For more information on this MOU between EPA and USFWS see: *http://www.epa.gov/oppfead1/cb/csb_page/updates/2014/birdtreaty.html*.

Use of chemical pesticides for agricultural purposes has been partially curtailed in recent years with the wider development of organic farms. Organic food is produced by farmers who emphasize the use of renewable resources and the conservation of soil and water to enhance environmental quality for future generations. Organic food is produced without using most conventional pesticides, fertilizers made with synthetic ingredients, or sewage sludge, bioengineering, or ionizing radiation. On organic farms, soil fertility is maintained with compost, cover crops, rock mineral powders and other natural fertilizers. Pests and diseases are controlled by crop rotation, biological control, and by applying non-synthetic materials. Weeds are managed by practices such as cultivation, mulches and flaming (NOFA 2014). Farms may be certified "organic" by agents accredited by the USDA.

Other sources of chemical pesticides and fertilizers come from lawn care practices that include the use of chemicals in maintaining residential and commercial lawns. DEEP offers several ideas for sustainable landscape practices that reduce pollution from stormwater runoff containing these substances. They include information and guidance on the benefits of rain gardens and standards for organic lawn care for homeowners and landscape and lawn care companies (CT DEEP 2014g)

Transportation and Utility Corridors

Transportation infrastructure that accompanies development compounds the fragmentation of habitats and interrupts wildlife travel corridors. From 1995 to 2012, there has been a 931 mile increase in Connecticut roadways (Table 3.5).

Table 3.5: Total miles of public roads in Connecticut. (Source: US DOT 2014)

Road Type	1995	2000	2012*
Urban	11,627	11,804	15,202
Rural	8,873	9,041	6,229
Total	20,500	20,845	21,431

*2012 figure for rural roads reflects a reclassification of previously designated "rural" areas to "urban" areas, rather than a decline in the number of rural road miles.

Human Intrusions and Disturbance

This category includes threats from human activities that are usually considered benign (e.g., hiking, biking), but may alter, destroy, and disturb habitats and species (Salafsky et al. 2008). In a state with a high population density, human disturbance is an important threat, and some species are particularly vulnerable to this threat.

Maritime beaches and the unique suite of species they support are one example. Beach-nesting birds, including piping plover and least tern, are particularly vulnerable because human disturbance often curtails breeding success. Foot and vehicular traffic can cause adults birds to abandon their nests, leaving eggs and chicks vulnerable to predation and overexposure to the sun. Even light human traffic on the beach can also directly cause mortality by crushing eggs and chicks. Interruption of feeding may also result from human disturbance, which can cause undue stress on juvenile birds during critical periods in their development. Dogs on the beach tend to harass the birds, while other predators associated with human developments (i.e., raccoons, skunks, foxes, as well as domestic and feral cats) are effective predators of ground nesting birds.

In Connecticut, nesting piping plovers are monitored and protected every spring by USFWS, DEEP, and volunteers working with the Connecticut Audubon Society, The Nature Conservancy, Audubon Connecticut, and local organizations such as the Milford Point/Stratford Great Meadows Friends Group. The protections afforded these plovers benefit other nesting species, including American oystercatchers and least terns, both of which are also threatened in Connecticut. Since protection and monitoring efforts began in 1984, nesting success has improved, resulting in more returning adults in subsequent years. In 2011, 52 pairs of piping plovers nested along the Connecticut coastline; nine more than in 2010. However, the number of young that fledged (reached flying stage) was 71; 11 less than the 82 plovers that fledged in 2010 (CT DEEP 2011) indicating a decline in nesting success.

Climate Change and Severe Weather

Climate change is now recognized as a potential major threat to fish and wildlife habitats, populations, and communities. There is evidence that climate change may already be affecting ecosystems as distributions of animals and plants change, ecological phenologies are disrupted, and community compositions and structures are altered. Species and populations likely to have greater sensitivities to climate change include those with highly specialized habitat requirements; native species already near temperature limits or having other narrow environmental tolerances; currently isolated, rare, or declining populations with poor dispersal abilities; and groups especially sensitive to pathogens. Species with these traits will be even more vulnerable if they have a small population, a low reproductive rate, long generation times, low genetic diversity, or are threatened by other factors (NFWPCAP 2012).

Climate modeling analyses for the northeastern region of the United States have projected major changes over the rest of this century, although the magnitudes of these changes are likely to vary spatially across the region. Using recent modeling studies, the Manomet Center for Conservation Sciences (MCCS) and the National Wildlife Federation (NWF) (MCCS and NWF 2013) have projected the following changes in the climate of the Northeast by 2070-2099:

- The annual average temperature across the region will increase by 2-5 °C (3.6- 9.0 °F) depending on the emissions scenario. The annual average temperature increase will have seasonal and geographical components, being greatest in the winter months and at higher latitudes.
- The number of extreme heat days per year (>50 °C, 90 °F) will increase from the current 10 to 20-40 days depending on the emissions scenario.

- The annual average precipitation across the region will increase by 7 to 15 percent, depending on the emissions scenario.
- The annual number of freeze days (days when temperature <0 °C, 32 °F) will decrease across region by 20 to 30 percent.
- The length of the plant growing season (days between last and first killing frosts) will extend by 30 to 50 days, depending on the emissions scenario, and the plant hardiness zones will advance north.
- The area of the region that is typically snow covered in winter will contract north to the northernmost parts of Vermont, New Hampshire and Maine.
- Soil moisture content (percent saturation) will decrease, particularly during the summer months by 1 to 2 percent.
- Evapotranspiration rates in the region will increase in the spring and summer by 1 to 2 percent depending on the emissions scenario.

Heavy rainfall events have already been observed with an increase of 240 percent in the Connecticut River Basin over the past 60 years (Parr and Wang 2014). Higher winter and spring peak steam flows have been recorded (Campbell et al. 2011). Additional weather predictions for the Northeast include: more frequent short-term droughts lasting one to three months, more intense hurricanes with more northerly tracks, slower storm drainage due to increased precipitation intensity, and higher sea level rise and water tables (Staudinger et al. 2015 in review). The combination of these conditions could result in a northeastern climate that bears little resemblance to that which currently prevails in the region, but is instead closer to the climate currently experienced farther south, for example in North or South Carolina (MCCS and NWF 2013).

Accelerating rising sea levels are another manifestation of the changing climate. With global temperatures rising, sea water is undergoing spatial expansion and ice caps and glaciers are melting and contributing to rising sea levels. Sea level rise poses significant threats to coastal ecosystems that may become inundated, resulting in habitat changes and losses, and adverse impacts to species or communities that depend on these habitats. Climate scientists generally agree that coastal ecological resources are likely to be among the most sensitive to the changing climate, and that the climate change impacts to ecosystems over the next few decades will be most marked in the coastal zones (Karl et al. 2009, Adaptation Subcommittee 2011).

Projections of sea level rise (Figure 3.8) have evolved over the last two decades. Earlier estimates were that over the course of this century the global mean sea level would rise between 10 cm and 60 cm. The most recent Intergovernmental Panel on Climate Change (IPCC) estimates were between 18 cm and 59 cm, depending on the greenhouse gas emissions scenario (IPCC 2007). However, other studies that include more recent measurements of Arctic and Antarctic ice melt have produced larger estimates of between 0.5 m and 2.0 m, depending on the emissions scenario. These estimates are based on a projected tripling of greenhouse gas concentrations in the atmosphere, a target that will likely be reached over the next 90 years (NWF and MCCS 2014).

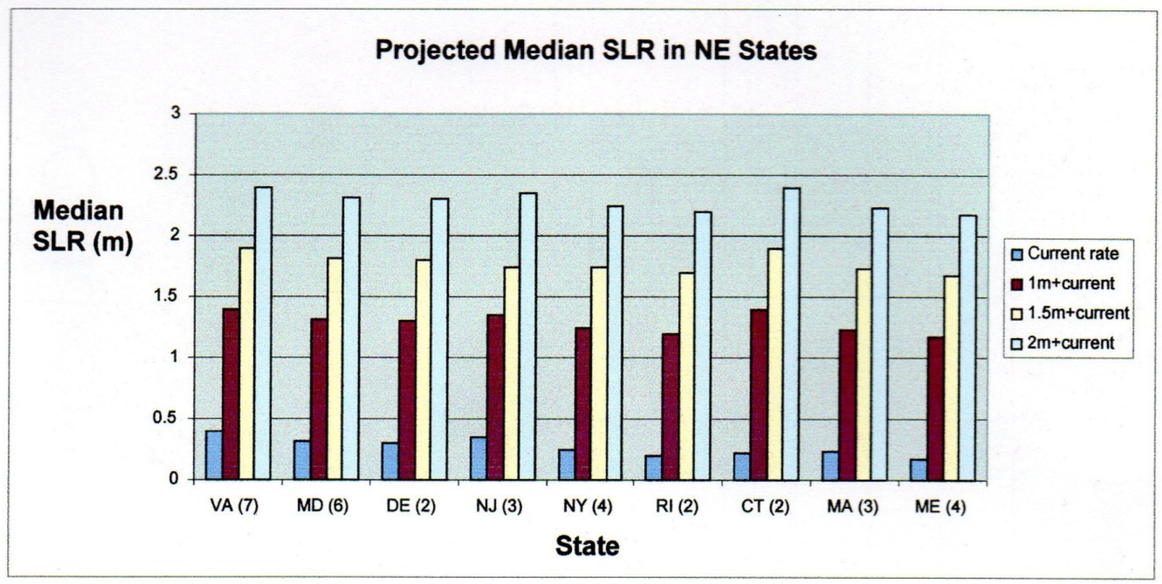

FIGURE 3.8: PROJECTED SEA LEVEL RISE (SLR) BY 2100 ACROSS VARYING POTENTIAL RATES IN SEA LEVEL RISE FOR NORTHEAST REGION STATES. (SOURCE: NWF AND MCCS 2014)

Sea level rise of 1 foot to 1.5 feet has already been reported in regions of the Northeast. The projected effects of climate change and sea level rise pose significant threats to GCN species and key habitats. Given many uncertainties, it can be difficult to determine how individual species will respond. However, it is anticipated that all of these climate changes will have a cascading effect on ecological systems. Species' distributions will shift at different times and paces. These shifts will be hindered by lack of connectivity or adaptation. Habitat specialists or species with low adaptive capacity are more likely to be negatively impacted by climate change than habitat generalists (Staudinger et al. 2015 in review). A variety of vulnerability assessments have been conducted to better understand the magnitude of these threats. All include some combination of specifying likely climate impacts, estimating exposure to these impacts, and accounting for non-climate stressors. Examples of non-climate stressors include invertebrate pests, over-abundant white-tailed deer, and invasive exotic plants that may already be threatening some communities. While climate change may increasingly exert adverse effects on these habitats, the current stressors will also continue to be important, conceivably even more important as these interactions may exacerbate the impacts of the changing climate. The most obvious examples concern the beneficial effects that climate change may have on the life cycles of pest species. There is already evidence that some forest pests are benefiting from a warming climate, for example hemlock wooly adelgid has already spread north and entered hemlock stands that were previously not vulnerable to this temperature-limited pest (NFWPCAP 2012).

Agriculture, an important land use in the Northeast, is predicted to change significantly because temperature and climate changes will dictate what crops are grown (Horton et al. 2014). Important crops such as cranberries and maple syrup will likely be replaced by production of other crops, while dairy production and fisheries will also suffer. Winter precipitation is projected to consist of less snow and more rain, and northern hardwood forests are projected to migrate north as temperatures and weather patterns change (EPA 2013).

Hurricanes Irene and Sandy illustrate the region's vulnerability to climate change. Inland impacts from Irene were more damaging than coastal effects, with intense flooding destroying bridges and roads. Seventeen municipal wastewater treatment plants were breached, and many towns and villages were isolated for extended periods of time. Hurricane Sandy resulted in many deaths, massive coastal damage from storm surges, subway flooding in New York City, and between 60 to 80 million dollars in damages (especially in New York, New Jersey, and Connecticut) (US GCRP 2014a).

The spread of vector-borne diseases due to climate change has also been noted as an increasing concern. The majority of occurrences of Lyme disease in the United States are in the Northeast, and more specifically in Connecticut. There are no definitive conclusions as to how climate change will influence the spread of Lyme disease; however, there are multiple studies that have begun to link tick activity and Lyme disease incidence to the climate (US GCRP 2014b). In Connecticut a one inch precipitation event increased the risk of contracting a stomach illness while swimming. Thus, another concern is that, more frequent heavy precipitation events could increase the incidence of waterborne disease in residents (US GCRP 2014b).

DEEP partnered with the EPA's Long Island Sound Study and the New England Interstate Water Pollution Control Commission to apply "sea level affecting marshes models" (SLAMM) to Connecticut's coast. While there are many uncertainties and the data is limited, this study concludes that 50 to 97 percent of high marsh or irregularly flooded marsh will be lost by 2100. Many factors may change before that time, but models like this can be useful to help direct habitat and species conservation.

Vulnerability of Connecticut Habitats to Climate Change

Understanding ecological vulnerabilities provides valuable information that may be used to inform decision-making processes and may suggest policies or actions to reduce future impacts. In 2010, the Adaptation Subcommittee of the Connecticut Governor's Steering Committee on Climate Change released *The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health,* which provided details and summaries of climate change projections, overall risk assessments, key scientific findings, and recommended actions (Adaptation Subcommittee 2010). Experts completed a risk assessment survey to identify primary climate drivers, the likely severity, time horizons for impacts, and urgency for action. Vulnerability rankings were calculated based on average survey scores, and included narrative comments; however, data on uncertainty was not elicited. A statewide online survey collected additional expert opinions and rankings data on wildlife.

The Subcommittee's Natural Resources Working Group reported that certain habitat types within the state are at increased risk from projected changes in climate. Habitats at highest risk are cold water streams, tidal marsh, open water marine, beaches and dunes, freshwater wetlands, offshore islands, major rivers, and forested swamps. These habitat types are broadly distributed from Long Island Sound and the coast to the upper watersheds and forests across the state. The degree of impact will vary, but likely changes include conversion of rare habitat types (e.g., cold water to warm water streams, tidal marsh and offshore islands to submerged lands), loss and/or replacement of critical species dependent on select habitats, and the increased susceptibility of habitats to other threats (e.g., fragmentation, degradation and loss due to irresponsible land use management, establishment of invasive species). The additional stress of climate change will certainly have implications for a range of ecosystems, including those supported and maintained by the high risk habitats mentioned above as well as other habitats and species within the state (Adaptation Subcommittee 2010).

Several other habitats with low risk scores were considered worthy of further consideration because of their limited distribution and unique contributions to Connecticut's biodiversity. These include: rocky outcrops and summits, bogs and fens, and sand barrens and warm season grasslands. These habitats are restricted in distribution by the availability of suitable geologic formations at elevation, specific hydrologic conditions, and select glacial deposits. As with many unique or spatially limited habitats, the principal option is to assume these habitats will accommodate the projected changes in temperature, precipitation, and sea level rise, or be converted to other habitats. This is currently occurring along the Connecticut coast where sea level fens are converting to brackish wetlands. The Natural Resources Working Group determined that all the primary climate drivers are likely to impact Connecticut's natural resources. The three dominant climate drivers are considered to be temperature, precipitation, and sea level rise. Extreme events such as more intense and frequent storms and extensive droughts will also play a critical role in defining impacts to natural resources.

Temperature was identified as a dominate driver among a variety of terrestrial and aquatic habitat types ranging from upland forest complexes and talus slopes to cold water streams, lakes, ponds, impoundments, and shorelines. The dominant driver for the open water marine systems in Long Island Sound was increased water temperature. Alterations in precipitation will drive changes not only in aquatic habitats such as freshwater wetlands, major rivers, warm water streams, and bogs and fens, but in terrestrial habitats like rocky outcrops and summits and early successional shrublands and forests. For coastal habitats such as tidal marshes, beaches and dunes, offshore islands, and intertidal flats and shores, the dominant driver is sea level rise. Several habitats were identified as likely to be influenced by both expected precipitation and temperature changes: forested swamps, sand barrens, and warm season grasslands.

Habitat types are assigned to urgency-for-action categories, by decade, based on the pace at which change is expected to occur (i.e., 2020, 2050, or 2080). The habitats with the highest risk are, in most cases, assigned to the most urgent action category of 2020, meaning that the necessary action is required during this and the next decade. Cold water streams, tidal marshes, beaches and dunes, and freshwater wetlands fall in this category. Habitats with high risk scores in the 2050 category include major rivers, forested swamps, subtidal aquatic beds, and warm water streams. The majority of the remaining habitats were in the 2080 category. Note that these assignments are intended to provide an initial assessment and are not prescriptive or authoritative. Tangible manifestations of changes in climate may in fact be realized much sooner or later than suggested by these responses.

Select Habitats at Risk

The following assessments of select habitats at risk in Connecticut were provided by the Natural Resources Working Group (Adaptation Subcommittee 2010).

Cold Water Streams and Associated Riparian Zones: The limited distribution and quantity of this habitat in Connecticut makes it particularly fragile and susceptible to projected changes in climate. As air temperatures increase, the suitability of cold water streams for critical species such as brook trout and burbot will decline. In many locations the critical water temperature threshold is already being exceeded, particularly in shallow reaches during the late summer months. This has important ramifications not only for the abundance of top predators like brook trout and brown trout, but also for many other, equally important aquatic organisms that support a dynamic food web within the streams and the adjoining terrestrial ecosystems. The continued viability of this habitat is an important consideration, especially in light of the recreational opportunities and associated economic benefits it creates.

Tidal Marsh: Tidal marshes along the coast have been and will continue to be impacted by both sea level rise and storm events. The pace of sea level rise will likely outpace accretion and inundate existing coastal marshes, resulting in rapid loss and conversion (from high to low marsh to mudflat) with concurrent impacts on dependent plant and wildlife species. In addition, the supportive nursery function of these coastal marshes, especially for ecologically and recreationally important finfish, will be impaired by changes in the condition and availability of this habitat. Further upstream on major rivers like the Connecticut River, freshwater tidal marshes will be lost or converted. This will result from increases in salinity as the estuaries move upstream, a lack of suitable adjoining areas to accommodate upland migration, lower summer flows, and alteration in the amplitude and timing of the annual spring freshets. The reduction in extent and complexity of these highly productive interfaces between land and water will have impacts on ecological function (storm buffering, flood storage, fish nurseries, water filtering) and biodiversity within the state.

Open Water Marine: Changes have already been observed in the open water marine habitat in Long Island Sound. The projected changes in water temperature will result in an increase in the occurrence of warm-water species from the south and a retreat of coldwater species to northern marine systems. Rebuilding commercially harvested species like American lobster and winter flounder through fishery management actions will be more difficult and alterations of migratory patterns and timing in anadromous fish species are likely. The potential alteration of plankton dynamics from temperature and salinity gradient shifts, coupled with continued nutrient loading, may result in sustained changes to the entire food web of Long Island Sound.

Beaches and Dunes: The beaches and dunes habitat is highly susceptible to impacts from sea level rise and storm events, given the limited distribution and position of this habitat along the coastal fringe. The on-going erosion and transport of sediment along the coast will likely increase, resulting in further loss of this habitat and conversion of supportive dunes to beaches. Important beach-and-dune dependent species such as horseshoe crab, piping plover, and other migratory shorebirds will be impacted with the loss of this critical habitat. In addition, a decline in recreational opportunities and property values will occur in the absence of substantial investment to mitigate these projected losses.

Herbaceous Freshwater Wetlands: These habitats represent a diversity of ecosystems that are highly dependent on, and susceptible to, alterations in hydrology, both in surface water runoff and groundwater discharge. Relatively small changes in the timing and amount of annual precipitation will influence the suitability and distribution of wetlands systems, particularly vernal pools and wet meadows, for many wetland-dependent amphibians, birds, and plant species. These changes will mean that wetland-dependent species must either relocate via available corridors to other wetland systems or perish. Extended droughts that occur earlier in the breeding season along with elevated temperatures and lower groundwater tables may reduce the distribution and condition of wetlands statewide.

Additional information on the vulnerability of Connecticut's key habitats can be found in recent assessments of the likely impacts of climate change on Northeast habitats conducted through a collaborative effort of the NEAFWA, MCCS, and the NWF. These reports include: The Vulnerabilities of Northeastern Fish and Wildlife Habitats to Climate Change (MCCS and NWF 2013); The Vulnerabilities of Northeastern Fish and Wildlife Habitats to Sea Level Rise (NWF and MCCS 2014); and, Climate Change and Riverine Cold Water Fish Habitat in the Northeast: A Vulnerability Assessment Review (MCCS and NWF 2013). Copies of these reports are available online at: http://rcngrants.org/content/assessing-likely-impacts-climate-change-northeastern-fish-and-wildlife-habitats-and-species.

BIOLOGICAL RESOURCE USE

This category includes threats from the consumptive use of biological resources including deliberate and unintentional harvesting, as well as the control of certain species (Salafsky et al. 2008). This threat has been identified as an issue for 46 percent of GCN reptile and amphibian species, primarily due to the collection of these animals for the pet trade.

Several GCN bird and mammal species are game species and may be harvested during regulated hunting seasons. For instance, cottontail rabbits are considered small game animals and are legally hunted in four of the six states inhabited by New England cottontail (NEC). Stronghold states for this species, including Massachusetts, Connecticut, and New York, permit taking both species during regulated hunting seasons. The impact on the NEC population is believed to be minimal because hunting pressure is low relative to the overall abundance of cottontails, and not considered significant compared to other mortality factors (Fuller and Tur 2012).

The Long Island Sound Trawl Survey (LISTS) is a vital tool used by Marine Fisheries Division staff to measure the abundance and distribution of finfish, squid and other macro-invertebrates (lobster, crabs, horseshoe crabs, whelks) in Long Island Sound, independent of commercial or recreational fishing. By comparing Trawl Survey data with current fishery data (e.g., landings, catch/effort, and seasonal patterns) each species' harvest can be weighed against its abundance, providing a gauge to determine whether harvest limit targets are being met. The Trawl Survey also provides a measure of recruitment (i.e., abundance of young fish entering the population each year), as well as detailed characterization of the size and age composition of several species entering the sound. Results of the most recent LISTS for 2013 is available online at:
http://www.ct.gov/deep/lib/deep/fishing/fisheries_management/trawl_survey_2013_with_cover_web.pdf

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