Appendix B: Habitat Profiles

Alpine

Photo by Ben Kimball

Acres in NH:	4158
Percent of NH Area:	<1
Acres Protected:	4158
Percent Protected:	100

Habitat Distribution Map

Habitat Description

In New Hampshire, alpine habitat occurs above treeline (trees taller than 6 ft.) at approximately 4,900 ft., primarily within the Franconia and Presidential Ranges of the White Mountains. This region endures high winds, precipitation, cloud cover, and fog, resulting in low annual temperatures and a short growing season (Bliss 1963, Sperduto and Cogbill 1999). The interaction between severe climate and geologic features—such as bedrock, exposure, and aspect—determine the distribution and structure of alpine systems (Antevs 1932, Bliss 1963, Harries 1966, Sperduto and Cogbill 1999). Alpine habitat is comprised of low, treeless tundra communities embedded in a matrix of bedrock, stone, talus, or gravel, with or without thin organic soil layers, and interspersed with krummholz. Soils are well drained, highly acidic, nutrient poor, and weakly developed (Sperduto and Cogbill 1999).

Alpine vegetation is grouped into four natural community systems by NHNHB (Sperduto 2011): the alpine tundra, alpine ravine/snowbank, subalpine heath - krummholz/rocky bald, and alpine/subalpine bog systems. The alpine tundra is the primary system in the alpine zone, and occupies most of the summits, ridges, and slopes above treeline. The system is named for its resemblance to the tundra of the arctic zone, and is dominated by mat-forming shrubs like diapensia (*Diapensia lapponica*), alpine blueberry (*Vaccinium uliginosum*), bearberry willow (*Salix uvaursi*), and alpine-azalea (*Kalmia procumbens*), and graminoids such as Bigelow's sedge (*Carex bigelowii*) and highland rush (*Juncus trifidus*).

The alpine ravine/snowbank system is restricted to high-elevation ravines, particularly those with distinct cirque headwalls. This system occupies these settings where snow accumulates to significant depths and is late to melt in the spring. These conditions produce diverse vegetative communities with a mix of alpine and lowland species. The subalpine heath - krummholz/rocky bald system is found at elevations below the “true alpine” zone, primarily from 3,000 to 4,900 ft. “Krummholz” refers to wind-dwarfed thickets of trees, primarily black spruce (*Picea mariana*) or balsam fir (*Abies balsamea*). In heath – krummholz communities, patches of these stunted trees are mixed with various low shrubs, including Labrador-tea *(Rhododendron groenlandicum*), sheep laurel (*Kalmia angustifolia*), and crowberries (*Empetrum spp*.).

Alpine/subalpine bog systems are actually a type of peatland (see Peatland Habitat Profile), but are included in this profile because they are only found as small patches embedded within larger alpine or subalpine ecosystems. They are small (less than an acre to around five acres) and occur in concavities on ridges, and on moderate to steep slopes over bedrock where some combination of limited drainage, the damp subalpine climate, late melting snowpacks, and self-maintaining *Sphagnum* (peat moss) mats contribute to peat accumulation. Alpine/subalpine bogs are dominated primarily by lowland bog plants found in poor level fen/bog systems, but are distinguished from them by the presence of alpine and subalpine species.

Justification (Reason for Concern in NH)

Alpine habitat is a rare community throughout the Northeast, occurring mostly as isolated “islands” on high peaks. Unique alpine plant communities, extreme climatic conditions, and isolation lead to rare and endemic insect communities. White Mountain fritillary and artic butterflies are known to occur only on the Presidential Range, and their host plants may be sensitive to disturbance and climate change. Human impacts exist in almost every alpine zone, with the highest concentration occurring on ridges and summits (Harvey 2003). The impacts of human presence on alpine birds and mammals are not known. Alpine vegetation and soils are not well adapted to heavy recreational traffic.

Over the past 20 years, climate change has often been presumed to be the greatest threat to alpine habitats in New Hampshire, with the climatic treeline increasing in elevation with rising temperatures, displacing alpine-adapted vegetation (Halloy and Mark 2003, Lesica and McCune 2004). However, recent research suggests that alpine areas in the White Mountains may not be as vulnerable to climate change as originally believed, because encroachment by woody vegetation is controlled by mechanical degradation from wind and ice—phenomena that are unlikely to change significantly under climate change scenarios as they are currently understood (Seidel et al. 2009). Despite these revised predictions, alpine vegetation may still be vulnerable to atmospheric pollutants such as nitrogen and ozone.

Protection and Regulatory Status

The majority of New Hampshire alpine habitat is within the boundaries of the WMNF. The WMNF is part of the National Wilderness Preservation System (16 U.S.C. 1131-1136, 78 Stat. 890). This system is comprised of federally owned areas designated by Congress as “Wilderness Areas.” Three Wilderness Areas in the WMNF (Great Gulf, Presidential-Dry River, Pemigewasset) contain alpine habitat.

Distribution and Research

In New Hampshire, alpine habitat occupies 0.13% (7,717 acres) of the state, with the highest concentration occurring in the Presidential Range. The Presidential Range distribution includes Alpine Garden (5,175 to 5,575 ft.), Bigelow's Lawn (5,500 ft.), Great Gulf (4,228 to 5,828 ft.), Huntington Ravine (4,075 to 5,475 ft.), Tuckerman's Ravine (4,525 to 5,125 ft.), Monroe Flats (5,075 ft.), Oakes Gulf (4,400 to 5,000 ft.), Washington Summit (6,288 ft.), and Lakes of the Clouds (5,012 ft.) on Mt. Washington; Edmunds Col (4,938 to 5,100 ft.) on Mt. Madison (5,367 ft.); Bumpus Brook (5,799 ft.) on Mt. Adams; Monticello Lawn (5,390 ft.); Mt. Clay (5,533 ft.); King's Ravine (3,825-5,000 ft.) on Mt. Jefferson; Mt. Franklin (5,001 ft.); Mt. Monroe (5,384 ft.); and Mt. Eisenhower (4,760 ft.) (Harvey 2003). The remaining New Hampshire alpine habitat includes: North Baldface, South Baldface, Mt. Davis (3,819 ft.), Mt. Bond (4,690 ft.), Mt. Bondcliff (4,265 ft.), Mt.Guyot (4,580 ft.), South Twin (4,902 ft.), Mt. Lafayette (5,260 ft.), Mt Lincoln (5,089 ft.), and Mt Moosilauke (4,802 ft.) (Harvey 2003).

Current distribution, historic distribution, and status of alpine habitat is synthesized from expert review and consultation, management plans, technical field reports, scientific journals, and plant and community records in the New Hampshire Heritage Biological and Conservation Data System (BCD). Habitat maps were generated utilizing Hale and Rock (2003) landcover analysis for the WMNF, AMC alpine habitat polygons for the Presidential Range and Franconia Ridge, and NHNHB exemplary alpine natural communities. Alpine invertebrate distributions need study.

Relative Health of Populations

New Hampshire's largest expanse of alpine habitat occurs in the Presidential Range (6,931 ac), followed by Franconia Ridge (379 ac) and Baldface (247 ac). The remaining alpine habitat units comprise 160 ac.

Habitat Condition

Biological Condition:
Species richness of rare animals within their dispersal distances from the polygon
Species richness of rare animals within polygon
Species richness of rare plants in polygon
Richness of rare and exemplary natural communities in polygon

Landscape Condition:
Area (hectares) Landscape Complexity
Local Connectedness

Human Condition:
Index of Ecological Integrity scaled to State
Density of hiking trails in the unit (km/km^2)

Habitat Management Status:

The Wilderness Areas in the WMNF containing alpine habitat (Pemigewasset, Presidential-Dry River, and Great Gulf Wilderness Areas) are managed according to the guidelines and standards delineated in the Land and Resource Management Plan for the White Mountain National Forest. Natural processes are allowed to continue with minimal impediment, effects and impacts of human use will be minimized, primitive recreation opportunities will be provided, appreciation of the qualities of wilderness landscapes will be fostered, and utilization for educational and scientific purpose will be continued (USDA Forest Service 2004).

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation from ozone (Threat Rank: Medium)

Nitrogen oxides (Nox) and volatile organic compounds (VOC) are emissions produced in the burning of fossils fuels in power plants and gasoline engines. Ozone is a secondary pollutant produced by photochemical reactions between Nox and VOC. These reactions are fueled by UV radiation, resulting in higher ozone production in summer and at higher elevations (Finco et al. 2013).

Ozone is a highly phytotoxic pollutant, interfering with both photosynthesis and cellular metabolism. These impacts are reflected in a decrease in the numbers of flowers and fruits a plant will produce, as well as impaired water use efficiency and other functions. Plants weakened by ozone may be more susceptible to pests, disease, and drought (Allen 2002).

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Habitat degradation from mercury deposition (Threat Rank: Medium)

Exposure of wildlife to mercury may result in mortality, developmental effects, and reduced reproductive success.

Studies have documented significant concentrations of mercury in the blood of songbirds, particularly high-elevation species such as Bicknell's thrush (Rimmer et al. 2005). While the toxic effects of bioaccumulation in animals have been documented, plants do not appear to be sensitive to mercury (Lovett et al. 2009).

Habitat degradation from acid deposition (Threat Rank: Medium)

Acid deposition may result in plant mortality, alteration of soil/water chemistry, and loss of nutrients.

Acid deposition has declined significantly as a result of decreased emissions from fossil fuel-burning power plants (Burns et al. 2011). However, it is unlikely that sensitive habitats that have already experienced significant acidification will recover without further reductions in acid deposition.

Habitat degradation from contamination around railway tracks (Cog railway) (Threat Rank: Medium)

The engines from the cog railway have historically caused contamination of the area surrounding the tracks, as a result of the coal-fired engines. Additionally, the installation of buried cable and fiber-optic lines adjacent to the tracks disturbed alpine vegetation and created an unvegetated zone several meters wide.

Four years after the installation of the buried cable lines along the cog railway, recovery of alpine vegetation has been extremely slow (Capers & Taylor 2014). This same study observed frequent cinders produced by coal-fired trains throughout the study area, although their effects on vegetation are unknown. The cog railway has replaced most of their coal-fired engines with biodiesel engines, eliminating the generation of new cinders, although other chemical contamination may still occur.

List of Lower Ranking Threats:

Habitat degradation from snow compaction related to recreational activity

Habitat degradation from recreation infrastructure that concentrates visitor impacts around facilities (AMC huts and Mt. Washington summit buildings)

Habitat degradation from hikers that trample vegetation and cause soil erosion

Mortality from the collection of individuals from the wild

Habitat conversion and impacts from roads

Habitat conversion and degradation from wind tower and turbine development or communication towers, potential for ongoing wildlife impacts through direct mortality and disturbance to behavior.

Habitat degradation from changes in temperature or weather patterns that can change species composition

Actions to benefit this Habitat in NH

Monitor vegetation to assess habitat changes across space and time

Primary Threat Addressed: Habitat degradation from changes in temperature or weather patterns that can change species composition

Specific Threat (IUCN Threat Levels): Climate change & severe weather

Objective:

To assess changes in habitat resulting from various aspects of climate change and atmospheric pollution.

General Strategy:

The Appalachian Mountain Club and Mount Washington Observatory have been conducting long-term monitoring on alpine vegetation to document changes in species composition and structure resulting from the effects of atmospheric pollution and climate change. NHFG should provide support to these ongoing efforts.

Political Location:	**Watershed Location:**
Coos County	Androscoggin-Saco Watershed

Advise land managers on mitigating trail impacts.

Primary Threat Addressed: Habitat degradation from hikers that trample vegetation and cause soil erosion

Specific Threat (IUCN Threat Levels): Human intrusions & disturbance

Objective:

Eliminate the co-occurrence of trail impacts with delineated S1-ranked natural communities and rare alpine lepidopteran habitats.

General Strategy:

NHFG will delineate sensitive areas and provide trail advisories to all managing agencies to mitigate trail impacts to wildlife and wildlife habitats. NHFG will become a recognized participant of the Appalachian Trail Conference (ATC) Cooperative Management System. Participants include AMC, DOC, NHDES, and WMNF formalized through a series of Cooperative Agreements at both the state-level and local level (New Hampshire is one of the only states that does not have a wildlife agency as a partner). NHFG will be involved in the development, review, and approval of the Appalachian Trail Local Management Plan. NHFG will enter a MOA with DRED to maintain and manage trails in accordance with the health of wildlife and wildlife habitats.

Political Location:	Watershed Location:
Coos County	

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Appalachian Oak Pine Forest

Photo by Pete Bowman

Habitat Distribution Map

Acres in NH:	688,106
Percent of NH Area:	12
Acres Protected:	116,978
Percent Protected:	17

Habitat Description

The Appalachian oak - pine forest system is found mostly below 900 ft elevation in southern New Hampshire, south of and at lower elevations than the hemlock-hardwood-pine forest system (Sperduto 2011). In these forests, the climate is warmer and drier, elevations are lower, the growing season is longer, and fire was historically more frequent than in the forests to the north. These forests are characterized by tree species with a distribution centered in the central Appalachian states further to the south, which are largely absent from other New Hampshire forests. These include several oak species such as white oak (*Quercus alba*), black oak (*Quercus velutina*), scarlet oak (*Quercus coccinea*), and chestnut oak (*Quercus montana*), as well as hickories (*Carya spp*.), sassafras (*Sassafras albidum*), pitch pine (*Pinus rigida*), and mountain laurel (*Kalmia latifolia*).

Substrates in these forests include nutrient-poor, dry to mesic sandy glacial tills, and some large areas of sand plain or shallow-to-bedrock tills, particularly in the seacoast and lower Merrimack and Connecticut River valleys. Sand plains in these areas that have a frequent fire history tend toward pine barren habitat; those with a less frequent fire regime (i.e., more than 50 to 100 years) are more likely to support hemlock - hardwood - pine forests. More isolated patches of Appalachian oak - pine forest can be found to the north in central New Hampshire, on dry rocky ridges or sand plains with a historic fire regime.

Justification (Reason for Concern in NH)

Appalachian oak - pine forest currently has a limited distribution in New Hampshire, covering approximately 12% of the state's land area. Available data indicate that approximately 12% of the state's potential Appalachian oak pine forest is on permanently protected lands. This forest type supports 104 vertebrate species in New Hampshire, including 8 amphibians, 12 reptiles, 67 birds, and 17 mammals. Threatened and endangered wildlife species occurring in this forest type include timber rattlesnake and eastern hognose snake. In New Hampshire, intense development has dramatically reduced the area of this forest type that is influenced by natural disturbance regimes, resulting in a preponderance of the forest currently in older age classes. A full range of age classes well distributed on the landscape is important to support the diversity of wildlife species that depend on this forest type.

Protection and Regulatory Status

Most of New Hampshire's Appalachian oak - pine forest occurs on small, privately owned parcels. Forestry on state lands is covered by RSAs 216, 217, and 218. RSA 227 stipulates requirements for residual basal area in riparian areas. The manual "Good Forestry in the Granite State" (Bennett 2010) provides recommended management practices for sustainable forestry in New Hampshire.

Distribution and Research

Appalachian oak pine forest occurs primarily in southern New Hampshire, with more than 40% by area in Rockingham County and approximately 20%, 15%, and 10% in Hillsborough Strafford, and Cheshire counties, respectively. Additional fieldwork is needed to evaluate correlations between soil series and forest type as outlined in Homer (2005). County soil surveys outline soils suitable for forestry from an economic perspective. However, little has been done to evaluate soils from an ecological perspective (e.g., if left unmanaged, an area with a particular soil would eventually succeed to Appalachian oak pine forest). Fieldwork is also needed to ground truth the Appalachian oak pine map. Research is needed to identify human-created disturbance regimes that can maintain and regenerate Appalachian oak pine forest.

Relative Health of Populations

An approximately 5% decrease in forest area occurred between 1992 and 1993 and 2001 in the 4-county area where approximately 90% of New Hampshire's potential Appalachian oak pine forest occurs.

Habitat Condition

Biological Condition:

Species richness of rare animals within their dispersal distances from the polygon
Species richness of rare plants by landform and elevation zone
Richness of rare and exemplary natural communities in polygon
Vertebrate species richness (VT/NH GAP Analysis)

Landscape Condition:

Landscape Complexity
Local Connectedness

Similarity of habitat
Size of unfragmented block within which matrix forest is located

Human Condition:
Index of Ecological Integrity

Habitat Management Status:

Approximately 25% of the 4-county area in which approximately 90% of potential Appalachian oak pine forest area occurs is in certified Tree Farms (calculated from TNC data and data in Thorne and Sundquist 2001).

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat conversion and degradation from development (Threat Rank: High)

Development reduces matrix forest habitat by converting natural forest to landscaped lawns and impermeable surfaces (e.g., buildings, roads). Development also contributes to forest fragmentation by directly reducing habitat, increasing traffic on existing roads, and requiring construction of new transportation infrastructure.

A study of 10 New Hampshire communities found that their populations increased by an average of 70.9% (range 9.7 to 189.7%) between 1974 and 1992, while developed land increased by an average of 137.2%. In the community with 9.7% population growth, developed land increased by 15.9% (New Hampshire Office of State Planning (NHOSP) 2000).

Habitat degradation from warming conditions that allow cold-limited forest pests to move north (Threat Rank: Medium)

New Hampshire forests are currently at risk from a variety of insect pests (emerald ash borer, balsam wooly adelgid, gypsy moth, etc.). The current ranges of some of these pests, such as hemlock wooly adelgid, are believed to be limited by cold winter temperatures (NHDFL 2015). Under a warming climate scenario, the ranges of some of these species could expand, and new insect species could move into the state.

Climate change is expected to result in the movement of forest pests (Dukes et al. 2009), but these impacts are primarily speculative at present.

Habitat degradation and mortality from insect pests (gypsy moth, Asian longhorn beetle, introduced insects) (Threat Rank: Medium)

There are a number of non-native insect pests that have the potential significantly impact forest habitats, including gypsy moth, hemlock wooly adelgid, emerald ash borer, and Asian longhorned beetle. The relatively low concentrations of hemlock and ash trees in Appalachian oak – pine forests mean that hemlock wooly adelgid and emerald ash borer are not significant pests in this habitat.

However, gypsy moth and Asian longhorned beetle both have the potential for devastating impacts in these forests.

Gypsy moth outbreaks have resulted in significant damage to New Hampshire's forests in the past (UNH Cooperative Extension 2003). Current population levels are fairly low and typically controlled by a variety of parasites and predators. However, given the proper combination of population dynamics and suitable weather conditions, there is the potential for catastrophic outbreaks in the future.

Habitat degradation from introduced or invasive plants (Threat Rank: Medium)

Invasive species are regarded as one of the leading threats to at-risk species nationwide, behind only habitat destruction (Stein and Flack 1996). In particular, invasive plants may decrease plant species diversity, produce allelopathic chemicals that retard other species, modify disturbance regimes, and significantly modify the species' composition and structure of vegetation (Silander and Klepeis 2001).

Different habitat types have varying levels of vulnerability to invasion by exotic plants. Typically occurring on dry sites with acidic, nutrient-poor soils, Appalachian oak – pine forests are less susceptible to threat of invasive plants than some other habitats. Nevertheless, there are several woody understory species that are frequently observed in this habitat, particularly glossy buckthorn (Frangula alnus), Japanese barberry (Berberis thunbergii), and burning bush (Euonymus alatus). These plants are much more likely to be observed where the habitat is heavily fragmented by residential and commercial development.

Habitat degradation from the creation and presence of roads (Threat Rank: Medium)

Transportation infrastructure fragments forest blocks, creating edge effects from light penetration and exposure to wind and pollutants such as road salt and hydrocarbons.

Large carnivores may be unable to maintain sustainable populations in landscapes with road densities exceeding 1 mi/ mi2 (Forman and Alexander 1998). Roads affect forest and habitat conditions well beyond the actual edge of the forest (Ranney et al. 1981). Roads can negatively affect landscape permeability for black bears, bobcats, and lynx (Forman et al. 2003).

Habitat conversion due to sand and gravel extraction (Threat Rank: Medium)

Appalachian oak - pine forests typically occur on dry, well-drained sites. These sites are often well-drained because they occur on deposits of sand and gravel, often along large rivers. Large sand and gravel deposits are frequently targeted for surface mining. When a site is mined for these materials, any habitats that occurred there are destroyed, and the wildlife that utilized them are displaced.

DES maintains a database of sand and gravel mining operations that have applied for a permit with the agency. Within the approximate range of Appalachian oak - pine habitat in NH, there are over 50 known sand or gravel mines. The majority of those do not have their boundaries delineated in a GIS layer, but the ones that do impact over 2500 acres. It is unknown how many of these locations previously supported Appalachian oak - pine forest, but presumably many of them did, particularly on sand deposits in the Merrimack River valley and near the seacoast.

Habitat conversion resulting from decisions on land use and management (Threat Rank: Medium)

In New Hampshire, land use decisions are made at the municipal scale by volunteer planning boards with little or no training in natural resource issues. In cities and some of the larger towns, professional planning staff evaluate proposed developments and provide input to the planning board, but this is the exception rather than the rule. Most professional planners lack training in ecology or natural resources. Decisions are typically based on engineering and aesthetic considerations, with no recognition of direct or cumulative impacts on the underlying ecological functions of the affected lands or on impacts to wildlife habitat.

A Growth Management Advisory Committee convened by the New Hampshire Office of State Planning in 1999 concluded that:

- Impacts of growth and development are cumulative over decades
- Development in New Hampshire has occurred incrementally, resulting in fragmentation and loss of important and environmentally sensitive areas, including forestlands and wildlife habitat
- Communities seldom evaluate the potential impacts of their zoning ordinance or land use regulations (NHOSP 2000)

List of Lower Ranking Threats:

Habitat degradation from increased risk of fire due to summer droughts

Habitat degradation from increased ice and wind storms that cause damage to trees resulting in acceleration of species composition changes

Habitat and species impacts from salvage logging that occurs after storms and pest invasions resulting in species composition changes

Species and habitat impacts from species composition changes related to climate change

Habitat degradation from mercury deposition

Habitat degradation from acid deposition

Habitat degradation from groundwater and surface withdrawals

Habitat degradation from a lack of fire that leads to loss of constituent plant species

Disturbance and habitat degradation from hiking and biking trails

Habitat degradation and mortality from legal and illegal OHRV and snowmobile activity

Habitat impacts and conversion from the reduction in forest-based economy and infrastructure

Mortality of wildlife species from the creation and presence of roads

Habitat conversion and impacts to wildlife from fragmentation

Habitat degradation from drought stress that leads to increased fire

Actions to benefit this Habitat in NH

Incorporate habitat conservation into local land use planning

Primary Threat Addressed: Habitat conversion and degradation from development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:

Enhance protection of Appalachian oak - pine forests by incorporating conservation goals into planning documents, such as municipal and regional master plans, zoning ordinances, and subdivision regulations.

General Strategy:

The critical gap that NHFG can address is the scientific basis for implementing land use policies and regulations that protect the ecological function and health of wildlife populations and their habitats. This technical assistance needs to be combined with an integrated approach to land use decisions among local decision-makers. NHFG should work with UNH Cooperative Extension and New Hampshire Office of Energy and Planning, key outreach partners to facilitate training for NHFG biologists on the integration of wildlife habitat information into local land use planning and regulation. Likewise, Cooperative Extension can facilitate training for town planners, planning boards, regional planners, and others involved in writing master plans and local ordinances, on how to integrate wildlife considerations into local planning.

Political Location:	**Watershed Location:**
Statewide	Merrimack Waterhsed

Location Description:

Within the range of Appalachian oak - pine forest, primarily in southern NH, particularly in the southeast.

Prioritize locations and mitigation strategies to reduce direct mortality of wildlife on existing roads and promote connectivity among fragmented habitat

Primary Threat Addressed: Mortality of wildlife species from the creation and presence of roads

Specific Threat (IUCN Threat Levels): Transportation & service corridors

Objective:

The objective is to identify important locations and appropriate strategies for mitigating the effects of roads on mortality of wildlife species and connectivity among populations in habitat patches fragmented by roads.

General Strategy:

This action will have the following components: (1) identify high priority locations for implementing road-mitigation strategies. These priority locations may be based on individual species of concern, high mortality of multiple species, concerns regarding wildlife-vehicle collisions and public safety, and/or regional connectivity analyses such as the Staying Connected Initiative. Approaches used for identifying priority locations may include spatial models and direct observation of live and dead animals on roads (Clevenger et al. 2002, Beaudry et al. 2008, Langen et al. 2009, Patrick et al. 2012); (2) Identify appropriate mitigation strategies such as signage and crossing structures based on biophysical setting and the ecology of target (Jackson 2003, Patrick et al. 2010); (3) Support enabling conditions for implementing road mitigation strategies including increased public funding and appropriate policies and procedures for transportation management agencies that ensure that reengineering of existing structures such as curbs, culverts and underpasses promotes wildlife passage. Priority species will include timber rattlesnake, eastern hog-nosed snake, bobcat, and black bear.

Political Location:	**Watershed Location:**

Continue monitoring program to identify new pests and pathogens that threaten forest health.

Primary Threat Addressed: Habitat degradation from warming conditions that allow cold-limited forest pests to move north

Specific Threat (IUCN Threat Levels): Climate change & severe weather

Objective:
The objective is to protect forest habitats from new forest pests arriving in New Hampshire as a result of movement by people or natural dispersal.

General Strategy:
The Division of Forests and Lands Forest Health Program currently conducts regular monitoring of forest health issues, and undertakes activities specifically designed to document the arrival of new pests and pathogens. One example is the program using swimming pool filters to try and document occurrences of Asian longhorned beetle.

Political Location:	**Watershed Location:**
Statewide	

Protect unfragmented blocks and other key wildlife habitats.

Primary Threat Addressed: Habitat conversion and degradation from development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
The objective is to protect the largest and highest quality occurrences of Appalachian oak - pine forest habitat, with an emphasis on developing and maintaining corridors for wildlife movement and species dispersal.

General Strategy:

Political Location:	**Watershed Location:**
Statewide	Merrimack Watershed

Minimize the effect of new road construction on wildlife mortality and habitat fragmentation

Primary Threat Addressed: Mortality of wildlife species from the creation and presence of roads

Specific Threat (IUCN Threat Levels): Transportation & service corridors

Objective:
The objective is to ensure that new roads are designed and located with the goal of minimizing effects on wildlife mortality and habitat fragmentation

General Strategy:
New roads should be avoided where possible. When road construction is justified, roads should be located to avoid bisecting wetlands, wetland/upland interfaces, large blocks of contiguous habitat, and other habitat types that organisms traverse during their life-history cycle (for example, adjacent to known snake hibernacula). Where new roads will cross known or likely wildlife movement paths or

fragment previously contiguous habitat, an evaluation of the most appropriate mitigation strategies should be conducted based on the threat status of the species, the biophysical setting and corresponding nature of the wildlife crossing (for example organisms concentrated in a narrow corridor of suitable habitat or spread along a long road segment), and traffic volume. On high traffic volume roads, a combination of regularly maintained barrier fences and suitable crossing structures should be used. On low traffic volume roads, ensuring that curbs and other barriers do not prevent crossing may be the most appropriate strategy (i.e. facilitating the passage of organisms over the roadway). Signage as a strategy for reducing mortality should be used with consideration due to concerns that this approach is not effective. Reducing vehicle speed through road-design elements can be an effective tool for reducing wildlife-vehicle collision. This strategy requires information regarding appropriate road location and design being readily available in an appropriate format for use by decision-makers. The efficacy of this strategy will be greatly increased by ensuring that best management practices are embedded in policies and procedures of transportation management agencies, state agencies, and local municipalities.

Political Location: **Watershed Location:**

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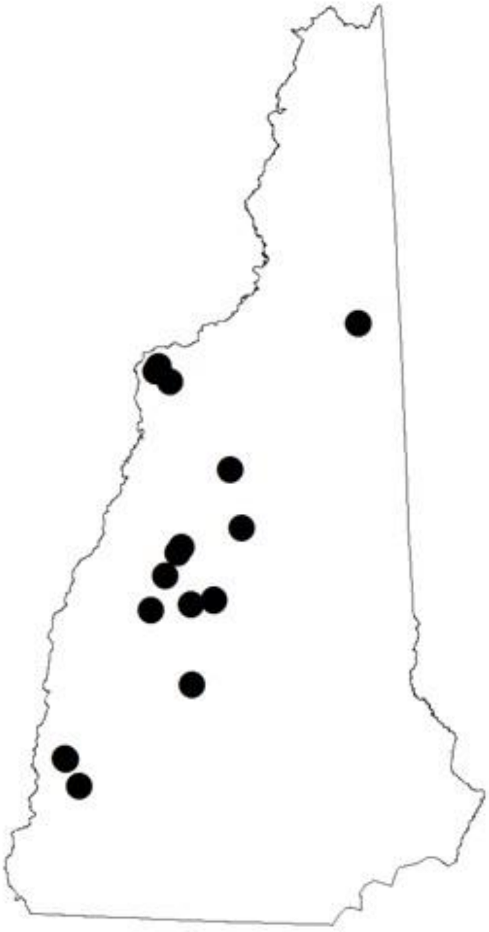
Caves and Mines

Photo by Emily Preston

Acres in NH: not available
Percent of NH Area:
Acres Protected:
Percent Protected:



Habitat Distribution Map

Habitat Description

Caves and mines are distinguished from all other New Hampshire habitats by being located below ground. Cave and mine habitat does not represent an ecosystem, but rather an abiotic habitat type. Prior to the 1800s, no underground cave or mine habitat existed in New Hampshire other than the small fracture “caves” located in tourist areas such as Lost River and The Polar Caves; such structures are not true caves. Abandoned lead, graphite and mica mines exist in many towns around the state, and were mostly created in the late 1800's and early 1900s. These mines serve as hibernating habitat for bats.

Justification (Reason for Concern in NH)

Five of New Hampshire’s 8 bat species overwinter in the state, hibernating in thermally stable underground caves or mines. A small number of mines in New Hampshire are known to provide habitat for hibernating bats, although historic mining data suggest that there could be additional mines that provide suitable winter habitat. For conservation, it is necessary to maintain mines with attributes (e.g., temperature, airflow, low disturbance) that are required by hibernating bats. Managers need better knowledge of hibernacula sites to conserve overwintering animals.

Protection and Regulatory Status

The Bureau of Land Management and Office of Surface Mining provide no data regarding use of abandoned mines. They may provide public service announcements indicating the danger of entering abandoned mines, but no specific federal law appears to regulate non-commercial use of mines.
At the state level, under the Revised Statutes Annotated (RSA), Title I (the State and its Government), Chapter 12-E regulates mining and reclamation activities in New Hampshire. Section 12-4:V discusses the requirements of post-mining reclamation, and states "post-mining uses may include agricultural, recreational, residential, commercial, industrial, forestry or open space land use." This post-mining reclamation appears to relate to the habitat surrounding the mine, but not the mine itself. Chapter 12-E does not provide regulations pertaining to use of the mine after commercial mining activities have ceased.
Most mines used by bats for hibernating occur on private land. One is on state land and two are protected by conservation easements. Only one of those is gated.

Regulatory Protections: Federal Endangered Species Act, Endangered Species Conservation Act (RSA 212-A)

Regulatory Comments: Historic preservation regulations may come into play for some mines.

Management Guidelines

Caves and mines that harbor bats should be protected from human entry during the hibernation period. This can be accomplished through proper gating of the mine entrances using bat-friendly gates, or by signage and landowner cooperation.

Distribution and Research

Coos, Grafton, Merrimack

There are 7 known abandoned mines that serve as winter hibernacula in New Hampshire. Within the Northeast region, approximately 198 hibernacula have been documented by 2005 (approximate numbers per state are: Connecticut = 2, Maine = 3, Massachusetts = 16, New York = 150, Rhode Island = 0, and Vermont = 27), with just 55 in New England.

New Hampshire's hibernacula are concentrated in Grafton County (6 of 9 sites), Coos County (2 sites) and Merrimack County (1 site). Additionally, potential hibernacula are located in Grafton County (6 mines), Sullivan County (2 mines), and Cheshire County (1 mine). Mean minimum distance between nearest neighbor mine sites was 20.7 km (range 1.7 – 61.8 km).

New Hampshire's hibernacula are concentrated in Grafton County (5 of 7 sites), with one site located in each of Coos and Merrimack Counties. Additionally, potential hibernacula are located in Grafton County (6 mines), Sullivan County (2 mines), and Cheshire County (1 mine). Mean minimum distance between nearest neighbor mine sites was 20.7 km (range 1.7 – 61.8 km).
It is important to survey all known mines for use by bats. Sites should be described in terms of microclimate and disturbance regimes; this will allow managers to determine the potential of a mine to serve as a hibernaculum.

Habitat Condition

Biological Condition:
To be updated at a later date

Landscape Condition:
To be updated at a later date

Human Condition:
To be updated at a later date

Habitat Management Status:

The only ongoing habitat management action occurring in New Hampshire is the maintenance of a bat gate at Mascot Lead Mine. Bat gates have been installed at hibernacula for the last 35 years to reduce or eliminate disturbance (Tuttle 1976). These gates are steel-welded structures installed at the entrance to a mine or cave that restrict human access while producing minimal impact on air flow and flight behavior of bats. Because many caves and mines are found in remote locations, bat gates have been described as “the only means available for protecting these [colonies]” (Pierson et al. 1991). Some states, such as Pennsylvania, have installed bat gates hibernacula that contain Indiana bats (Butchkoski 2003)

Despite the increased use of gates as a conservation tool, there has been little attempt to quantify the effectiveness of gating (Currie 2002). In fact, there are several instances of mines and caves experiencing population declines or complete abandonment following construction of bat gates (Tuttle 1976, Johnson et al. 2002).

Two bat gates were installed at the Mascot Lead Mine in 1992—one on the lower adit (Level 1) and another on the upper adit (Level 2). Prior to installation, a census of bats in the mine estimated a hibernating population of 874 bats representing five species. A 1993 survey (1,504 bats representing five species) strongly suggests that the bat gate has not negatively impacted the microclimate of Mascot Lead Mine nor has it impeded the flight behavior or hibernacula preferences of the bats. Given the design of the gate and the security of the access door, it is reasonable to assume these bat gates have been highly effective at minimizing human disturbance. The gates were repaired in 2006. Since 2010 NRCS has offered the installation of bat-friendly gates as a practice for EQIP cost share funding.

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a “medium” or “high” score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Mortality of wildlife species from humans entering mines during hibernation period for recreation (Threat Rank: Medium)

Active cavers and casual cave explorers disturb bats when they enter occupied caves and mines. Noise, light, changes in temperature and airflow, and physical contact can all disturb bats (Thomas 1995). In winter during hibernation, these disturbances can cause bats to arouse from hibernation and thus use up precious stored energy. Bats susceptible to white-nose syndrome are especially vulnerable to disturbance, as the disease already causes increased numbers of arousals and depletion of stored fat.

Caving is a well-known recreational activity and the effects of disturbances to bats are well documented. See bat species profiles.

List of Lower Ranking Threats:

Habitat conversion from the re-opening of mines used as hibernacula for mineral extraction

Mortality of wildlife species from humans entering mines during hibernation period for research

Habitat degradation and conversion from the modification of mine entrance by landowner to avoid litigation

Habitat degradation and conversion from the modification of mine entrance due to weathering

Habitat conversion from mine collapse due to weathering

Habitat conversion due to the backfilling of mine by natural processes

Habitat conversion due to backfilling of mine by landowner to avoid litigation

Actions to benefit this Habitat in NH

Prevent loss of mine habitat due to landowner alteration of mine entrances and interiors.

Primary Threat Addressed: Habitat degradation and conversion from the modification of mine entrance by landowner to avoid litigation

Specific Threat (IUCN Threat Levels): Energy production & mining

Objective:
Work with landowners to provide solutions to issues they may have with their mines to prevent alteration of the mine entrance or interior.

General Strategy:
Provide information on bat-friendly gates and other means to address issues that landowners may have with their mines. Keep in regular contact with mine owners.

Political Location: **Watershed Location:**

Prevent disturbances to hibernating bats

Primary Threat Addressed: Mortality of wildlife species from humans entering mines during hibernation period for recreation

Specific Threat (IUCN Threat Levels): Human intrusions & disturbance

Objective:
Prevent recreational use of known bat hibernacula during the hibernation period

General Strategy:
Through education, bat-friendly gates and other means prevent people from entering hibernacula during the hibernation period.

Political Location: Statewide

Watershed Location:

References and Authors

2015 Authors:

Emily Preston, NHFG

2005 Authors:

Jacques Veilleux, Frankin Pierce University; Scott Reynolds, St. Paul's School

Literature:

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Grasslands

Photo by Ben Kimball

Acres in NH:	255,980
Percent of NH Area:	4
Acres Protected:	30,718
Percent Protected:	12

Habitat Distribution Map

Habitat Description

Extensive grasslands are defined as areas greater than 10 ha that are dominated by grasses, forbs, and sedges with little shrub or tree cover (generally less than 10%) (Vickery and Dunwiddie 1997, DeGraaf and Yamasaki 2001). Grasslands include hayfields and pastures, fallow fields, cropland (cornfields and other row crops), airports, military installations, landfills, forb, and sedge-dominated meadows, heathlands, and similar non-alpine areas (Vickery and Dunwiddie 1997, Mitchell et al. 2000). Native plant species typical of northeastern grassland include goldenrod (*Solidago spp.*), aster (*Symphyotrichum spp*.), big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and meadowsweet (*Spirea alba*) (Mehrhoff 1997). Rare plant species found in New England grassland include wild lupine (*Lupinus perennis*), butterfly weed (*Asclepias tuberosa*), and northern blazing star (*Liatris scariosa var. novae-angliae*) (Mehrhoff 1997).

Justification (Reason for Concern in NH)

Historically, grasslands were relatively rare in New England (Motzkin and Foster 2002). These included a mix of native grassy heaths (e.g., blueberry barrens, coastal grasslands, openings in pine barrens), beaver meadows, and areas maintained by Native Americans (Askins et al. 2007). Following European settlement, extensive areas of forest were cleared for agriculture, timber, and growing settlements, and by the mid-1800s much of New England was 50% forested or less (Litvaitis 1993, Hall et al. 2002).

Prior to this time, wildlife species specialized on grassland habitats (primarily birds) were rare or absent from much of the region, but had begun to colonize by the late 1800s (Askins 1997). By the early 1900s, these newly created agricultural lands were being abandoned as settlers moved west. As forests reclaimed the land, grassland specialists began to decline, to the point that many formerly common species are now rare and local in much of New England, and often still declining (Sauer et al. 2014).

There has been much discussion about the relative importance of both historic and recent grasslands in New England. One perspective holds that these habitats were originally rare, and thus that the species they support were never important components of the New England fauna. Under this view, conservation directed toward grasslands should be a lower priority, and best implemented in areas where significant grasslands – and their associated species – are still an important part of the landscape. The other perspective acknowledges that many of these species were historically rare, but considers them just as valid a component of the regional fauna as species in other habitats, and thus worthy of conservation. The latter approach also considers that many of these species are declining across their ranges (including the native grasslands in the Midwest and West), and that even efforts in peripheral areas may be of value.

In New Hampshire, grasslands serve as primary breeding and nesting grounds for several bird species of conservation concern including the state-endangered Northern Harrier (*Circus cyaneus*) and Upland Sandpiper (*Bartramia longicauda*), state-threatened Grasshopper Sparrow (*Ammodramus savannarum*), Horned Lark (*Eremophila alpestris*), Vesper Sparrow (*Pooecetes gramineus*), Bobolink (*Dolichonyx oryzivorus*), and Eastern Meadowlark (*Sturnella magna*). Most of these species are declining across large portions of their continental ranges (Sauer et al 2014). Many grassland birds are area sensitive, meaning that they require large areas (often larger than a single territory) for nesting. Minimums vary by species, ranging from 2 ha for Bobolink to 40 to 80 ha for Upland Sandpipers (Jones and Vickery 1997).

Other species of conservation concern that would benefit from the conservation of grasslands include Black Racer, Smooth Green Snake, Northern Leopard Frog, Wood Turtle, and others. Grassland invertebrates include a host of grasshoppers, butterflies, moths, and spiders (Vickery and Dunwiddie 1997). The value of some grassland habitats, especially fallow fields and grassland edges, is increasingly recognized for pollinators like the Monarch butterfly and bumble bees. Agricultural lands in general, while not always important for SGCN, provide important foraging habitat to a wide range of wildlife, particularly in the non-breeding season. These areas can also serve as valuable green spaces that connect other habitats and allow for wildlife movement that would not be possible in developed landscapes.

Protection and Regulatory Status

Grasslands have no special regulatory status. Grasslands that are habitat for endangered or threatened species are protected under RSA 212 if modifying the habitat would result in those species' inability to use the habitat.

A number of programs exist that protect critical grasslands and farmland from development. LCHIP provides fee simple or conservation easement grants to communities, land trusts, and others to help protect priority lands. Since 1979, the State Department of Agriculture has administered an Agricultural Land Preservation Program, which was created under RSA 432:18-31a for the sole purpose of protecting prime farmland through conservation easements. In addition, the program works with land trusts, conservation organizations, and municipalities to protect important farm resources. The state, through the Current Use Advisory Board within the Department of Revenue Administration, administers the Current Use Taxation program, which was created via RSA 79-A to encourage, among other things, the protection of agriculture and wildlife resources. The program reduces state property taxes by 20 percent for lands of at least 4 ha that are open year-round to public recreational use.

At the federal level, the NRCS administers the Agricultural Conservation Easement Program through the USDA. The Agricultural Conservation Easement Program provides funds to help purchase development rights to keep farmland in agriculture. The program provides up to 50 percent of the fair market easement value (NRCS 2015a).

At the local level, many municipalities have passed open space bonds to help protect natural resources of local and statewide importance. Since 2000, municipalities have invested over $125 million in land protection (SPNHF 2005). It is unknown how many hectares of grassland or farmland have been protected through these investments.

Distribution and Research

Grasslands in New Hampshire are largely restricted to hay fields, cropland, airports, capped landfills, and military installations. According to the grassland habitat mapping completed by NHFG, there are 94,578 ha of grassland complexes at least 10 ha in size. Most of these grasslands occur in Grafton county (18,937 ha: 20%) followed by Merrimack and Coos counties [12,139 (13%) and 11,635 (12%) ha, respectively]. Cheshire, Hillsborough, Rockingham, Strafford, and Sullivan counties contain 7,300 to 9,600 ha of extensive grassland each, whereas Carroll and Belknap counties contain the least amount of grassland at approximately 4,700 ha each.

Research is needed to clarify the complex relationships between land use, natural disturbance, and biogeography of rare wildlife. Historically, many Native American and European land uses imitated natural disturbance regimes capable of maintaining grasslands. These land uses included firewood and timber harvesting, controlled burning, and clearing for year-round or seasonal settlements and agriculture. Some of the natural disturbances these land uses may imitate include fire, extreme weather, herbivory, extensive colonial nesting (passenger pigeons), and sand plain terracing resulting from alluvial denudation and deposition.

Native grasslands and heathlands are recognized as fine-scale, fire-driven structural features of pitch pine and scrub oak woodlands (NHNHB). However, more inclusive land use and biogeographic data suggest a broader historic extent of native grasslands and heathlands. Other research should determine causes of grassland wildlife declines, explore the relationship between invertebrates and grassland, and improve techniques for grassland mapping.

Relative Health of Populations

Because all grasslands in New Hampshire are currently of anthropogenic origin, consideration of the “original” extent of this habitat in the state (see Justification) is somewhat moot, and discussion of current habitat condition by necessity must focus on areas that are actively managed. This management generally takes one of two forms: agriculture or “maintenance mowing” (e.g., airports and capped landfills). Within the agricultural sector, grasslands can be further divided into row crops, pastures, or hayfields, all of which vary significantly in their value for grassland wildlife.

Agricultural grasslands have been in decline in New Hampshire since the late-1800s, when there were over a million hectares of farmland in the state (Harper 1918 in Litvaitis 1993). Following extensive farmland abandonment in the early 1900s, the total amount of land in agriculture declined significantly. Of interest, however, was an increase of 7000 hectares from 2001 to 2010, largely a result of timber harvest (NOAA 2014). Corn or other row crops are of limited value for the majority of grassland wildlife (although such areas may be heavily used by multiple species during the non-breeding season, including waterfowl, raptors, sparrows, and blackbirds). The breakdown of remaining agricultural grasslands between pastures and hayfields is unknown, but hayfields clearly predominate. These are generally better habitat for grassland birds, although also subject to greater threats, particularly frequent mowing. In a study in the Upper Valley region of New Hampshire and Vermont, Sydoriak (2014) found that 45% of farmers were mowing earlier and more often than they were 20 years ago, with concomitant impacts to grassland birds. This study and another in Vermont's Champlain Valley (Troy et al. 2005) found significant variability in farmers' ability or willingness to alter management in a way that would improve habitat for grassland birds.

Airports make up the majority of non-agricultural grasslands in the state, and are often the primary (if not only) sites for the rarer grassland birds. For safety reasons, the grass along runways and taxiways is kept short by regular mowing, the frequency of which varies with site conditions (weather, grass types, airport capacity). Just as in hayfields, frequent mowing is detrimental to grassland birds and other wildlife, and airports with more intensive management regimes are likely to be of lower quality from the perspective of conserving these species. Although limited in extent, capped landfills need not be mowed regularly, as long as woody vegetation in discouraged, and thus provide grassland habitat without the attendant risk of mowing-related mortality.

Habitat Condition

Biological Condition:
Species richness of rare animals within polygon
Species richness of rare animals within their dispersal distances from the polygon
Species richness of rare plants in polygon
Richness of rare and exemplary natural communities in polygon

Landscape Condition:
Area (hectares) Similarity (amount of
grassland within 1km)

Human Condition:
Index of Ecological Integrity
Eastern Meadowlark landscape capability model

Habitat Management Status:

Grasslands are subject to a wide array of management practices, although most are heavily managed for agricultural outputs rather than wildlife. There are programs for agricultural lands that compensate farmers for implementing management that benefits wildlife, and some smaller grassland parcels are specifically managed for conservation purposes (e.g., on state WMAs). Non-agricultural grasslands (mostly airports) are generally managed for safety reasons (including suppression of woody plants on capped landfills), and in some cases practices at these sites can accommodate the needs of wildlife.

Financial & Technical Assistance Programs:
Several programs provide financial and technical assistance to farmers for managing and preserving agriculture fields for wildlife. These include the USDA's Agricultural Conservation Easement Program, and Environmental Quality Incentive Program (EQIP), as well as the USFWS's Partners for Fish & Wildlife Program (Partners Program), and the NHFG Small Grants Program. University of New Hampshire Cooperative Extension Wildlife Specialists also provide technical assistance to farmers and other landowners on wildlife habitat management issues.

1. The Environmental Quality Incentives Program (EQIP) offers financial and technical assistance to help agricultural producers install or implement structural and management practices on eligible agricultural land. An EQIP Technical Committee in each state sets eligible habitat improvement practices, of which there are nearly 70 in New Hampshire. These include such things as nutrient management, installation of manure storage facilities, and restoration of declining habitats. Eligible EQIP practices that would benefit grasslands include brush management, pasture and hay planting, prescribed grazing, restoration and management of declining habitats (New Hampshire NRCS 2005a). Statistics are currently unavailable to determine how many ha have been treated with each of these practices. In 2014, New Hampshire received nearly $4.5 million for EQIP.

2. Since 1990, the USFWS's Partners for Fish & Wildlife Program in New Hampshire has provided technical and financial assistance to landowners, state agencies, many organizations and individuals to restore fish and wildlife habitat such as coastal wetlands, riparian habitats, and grasslands.

Management on State Lands
The NHFG owns in fee-simple nearly 300 hectares of fields (NHFG unpublished data). Two hundred twenty eight hectares are maintained in active agriculture (either hay or cropland). The remainder is maintained via brush hog mower with mowing occurring every 1-3 years after the bird nesting season.

Few of the NHFG fields are greater than 10 ha. The Osborne Wildlife Management Area (WMA) in Belknap County is an easement owned property with a complex of fields totaling 64 ha. The property owner actively farms these fields. The Lime Pond conservation easement in Coos County has an 11 ha field that is currently hayed. The Fort Hill WMA in Coos County has the largest complex of fields on NHFG property, totaling 153 ha. Forty-two ha are owned under a conservation easement and are actively farmed by the property owner, a dairy farmer. An additional 74 ha of fields are owned in fee simple status by the department and leased to the same dairy farmer. Thirty-seven ha are owned in fee simple status, but the previous landowner retained the agriculture rights and is also currently farmed.

The Department of Resources and Economic Development (DRED) owns in fee-simple or under conservation easement approximately 543 ha of fields and other early-successional openings (DRED unpublished data). Forty ha are maintained in active agriculture (either hay or cropland). One-hundred-and-thirty-seven ha are maintained via mowing by State Parks or NHFG. The remainder is not maintained on a regular basis.

Like NHFG, DRED owns or manages few fields greater than 10 ha. Specifically, 9 properties may provide opportunities for grassland. These, along with the NHFG owned or managed fields, should be evaluated for their potential to provide grassland habitat.

Management on Other Lands
All others grassland complexes greater than 10 ha occur on private land and, to a much lesser extent,

on land of private land trusts, municipalities, and other conservation organizations/agencies. It is not known to what extent grasslands on other conservation lands are maintained. Grasslands on private lands are typically owned by farmers and are therefore maintained as cropland or pastureland.

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat impacts and mortality from insecticide use (Threat Rank: Medium)

Depending on the type of insecticide used, non-target arthropods (e.g., pollinators) can be killed by pesticide applications. In a recent broad-scale analysis of population trends, Mineau and Whiteside (2013) propose that lethal effects of pesticides are at least as important as drivers of grassland bird declines as other aspects of agricultural intensification. In addition, use of insecticides may suppress prey populations and have indirect effects on grassland dependent wildlife. More study is needed on specific effects and prevalence of this threat in New Hampshire.

Habitat and species impacts from agricultural pesticide use (Threat Rank: Medium)

In addition to the threats associated with insecticides (see appropriate threat), use of herbicides may have detrimental effects in grassland systems by altering plant species composition. This effect may be greatest where agriculture is most intensive, and efforts are made to minimize unwanted "weedy" species at the edges of or within crop fields. Although the crop fields themselves are rarely important habitat for wildlife, these herbicide effects can spread to adjacent areas that may be more valuable.

Habitat impacts from introduced or invasive plants (Threat Rank: Medium)

Although many of the grasses already present in New England grasslands are not native, there is a suite of new species invading the region which have potential impacts on forage quality (e.g., in hayfields) and habitat structure (e.g., Scheiman et al. 2003). At present there are limited data on the effects of these plants on grassland birds, and studies that have been conducted have found variable results (e.g., Scheiman et al. 2003).

Habitat degradation from a lack of field maintenance and associated succession (Threat Rank: Medium)

In the absence of periodic mowing, grassland sites revert to shrublands and eventually to forest, rendering them unsuitable for grassland specialist wildlife.

Habitat degradation and disturbance from airport runway maintenance (Threat Rank: Medium)

This threat is separate from both mowing and construction, and pertains to human activity associated with existing infrastructure. Such activity includes paving, light installation, and other things that might result in vehicles and other equipment being parked off-runway in potential grassland bird habitat.

Habitat conversion to cropland or sod (excluding hay) (Threat Rank: Medium)

Many of the best existing grasslands in New Hampshire are in river valleys, where they are subject to agricultural conversion from hayfields, which are suitable for a wide range of wildlife species, to row crops or sod, which generally are not. However, current economic forces appear to be maintaining the current balance between hay and crop (predominately corn)

Mortality and nest disturbance resulting from frequency and timing of mowing (Threat Rank: Medium)

Mowing is generally considered the greatest threat to grassland birds because it either destroys nests outright or exposes them to greater predation risk. Other wildlife that use these habitats, such as turtles, may experience direct mortality. Frequency of mowing varies with location and land use. Airports are required to mow areas adjacent to runways and taxiways for safety reasons, while in active hayfields mowing is an economic activity. To maximize both quality and quantity of hay, farmers may harvest as many as 3-4 times a season, a frequency which generally does not allow for successful reproduction by grassland birds (Bollinger et al. 2000). Mowing at airports may be less detrimental since smaller areas are generally mowed, although mowing usually occurs more frequently.

Habitat conversion and impacts from airport construction (Threat Rank: Medium)

Expansion of runways or addition of new infrastructure (e.g., hangers) has the potential to remove suitable grassland habitat at some of the more important sites for grassland birds in the state, particularly Upland Sandpiper, Horned Lark, Grasshopper Sparrow, and Eastern Meadowlark.

Habitat conversion due to development and impacts from fragmentation (Threat Rank: Medium)

Because many grassland birds are area sensitive (not nesting or nesting in lower densities in smaller habitat patches; Heckert 1994, Vickery et al. 1994, Jones and Vickery 1997, Helzner and Jelinski 1999), fragmentation within previously extensive areas of habitat may result in population losses disproportionately larger than the actual acreages affected by development.

List of Lower Ranking Threats:

Habitat and species impacts from pesticide use

Habitat impacts and mortality from insecticide use

Habitat degradation and disturbance from OHRV and associated trails

Disturbance and mortality from walking and training dogs (Emphasis on off-leash dogs)

Habitat degradation and species disturbance from overgrazing of grassland habitat

Actions to benefit this Habitat in NH

Periodically assess the health and conditions of grassland habitats.

Primary Threat Addressed: Habitat degradation from a lack of field maintenance and associated succession

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:

General Strategy:
Assess the availability of higher resolution satellite imagery to use to better map grass-land complexes and their condition. Assess in more detail the rate of loss of open space to development and the attendant effects on grasslands. Assess effectiveness of Farm Bill programs by implementing monitoring programs on lands where Farm Bill monies have been applied.

Political Location: **Watershed Location:**
Statewide

Work with airports to implement conservation measures where needed and appropriate.

Primary Threat Addressed: Habitat degradation and disturbance from airport runway maintenance

Specific Threat (IUCN Threat Levels): Transportation & service corridors

Objective:

General Strategy:
Airports are often the primary sites for many grassland bird populations in New Hampshire. Potential actions could include: 1) modify mowing regimes (location and timing) as allowable under FAA guidelines and 2) install flushing bars on mowing equipment. Conduct systematic surveys of grassland birds in these areas.

Political Location: **Watershed Location:**
Statewide

Work with private and public landowners to implement conservation measures where needed and appropriate.

Primary Threat Addressed: Mortality and nest disturbance resulting from frequency and timing of mowing

Specific Threat (IUCN Threat Levels): Agriculture & aquaculture

Objective:

General Strategy:
Provide landowners of important grasslands information on practices that benefit wildlife in this habitat. Specific actions include outreach about appropriate management practices (delayed mowing, etc.), cost-share programs, and other options for land protection and/or management. In a study conducted in the Connecticut River Valley of New Hampshire and Vermont, 64% of farmers and 92% of other grassland landowners were unaware of the financial assistance available for managing grassland habitats (Sydoriak 2014).

Political Location: **Watershed Location:**
Statewide

Conserve significant parcels of agricultural land

Primary Threat Addressed: Habitat conversion due to development and impacts from fragmentation

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:

General Strategy:
To prevent development – work with NRCS, Municipalities. LCHIP etc. to complete this action

Political Location:

Watershed Location:

Identify key grassland parcels for implementation of conservation measures

Primary Threat Addressed: Habitat conversion due to development and impacts from fragmentation

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:

General Strategy:
Use a combination of GIS data, habitat condition, local knowledge, and information on populations of grassland wildlife to prioritize grassland areas for future conservation or management. This action includes provision of this prioritized list to NRCS, state and federal agencies, conservation commissions, and land trusts.

Political Location:
Statewide

Watershed Location:

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Hemlock Hardwood Pine Forest

Photo by Ben Kimball

Habitat Distribution Map

Acres in NH:	2,039,406
Percent of NH Area:	34
Acres Protected:	387,487
Percent Protected:	19

Habitat Description

The hemlock-hardwood-pine forest is a transitional forest region in New Hampshire (Sperduto 2011). This forest occurs between the northern hardwood - conifer forest to the north and at higher elevations (mostly above 1,400 ft.) and the Appalachian oak - pine forests to the south and at lower elevations (mostly below 900 ft.). This transitional forest lacks most boreal species and central hardwood species that characterize these other forests, but has many Alleghanian species such as white pine (*Pinus strobus*) and hemlock (*Tsuga canadensis*). Many of the other species of this system are common throughout the eastern United States. Hemlock - hardwood - pine forests are found throughout the state from the White Mountains south below about 1,500 ft. Dry-mesic to mesic glacial till soils are most abundant, but this system also occupies river terraces, sand plains, and stabilized talus areas covered by a forest canopy. It includes dry, sandy soils with red oak and white pine that have not been burned enough to support pitch pine sand plains system. These areas are likely to succeed to hemlock and/or beech over the long term without the return of fire.

The main matrix forest community that defines this system is hemlock - beech - oak - pine forest. Hemlock and American beech (*Fagus grandifolia*) are the primary late-successional trees in this community, with maximum ages of about 600 and 300 years, respectively. Red oak (*Quercus rubra*) and white pine are also typically abundant, in contrast to their absence or low abundance in northern hardwood - conifer forests. Most of the old-field white pine stands in central New Hampshire are successional examples of this system. Sugar maple (*Acer saccharum*) and yellow birch (*Betula alleghaniensis*) are occasional but of less importance than in northern hardwood - conifer forests. They are most frequent in mesic areas such as concavities and along drainages where white ash

(*Fraxinus americana*) is frequent, or locally abundant in patches of semi-rich mesic sugar maple forest. Red spruce (*Picea rubens*) and balsam fir (*Abies balsamea*) are generally sparse or absent, but are occasional on the lower slopes of some mountains south of the White Mountains (i.e., Ossipee Mountains, Mt. Monadnock). Central hardwood/ Appalachian species are essentially absent, including hickories (*Carya spp*.), and oaks (*Quercus spp*.) other than red oak, (see Appalachian oak - pine forest description).

Variation in soils or landscape position within this system explains much of the variation in community composition. Hemlock forests often occur in ravines or extremely rocky sites; beech forests occur on coarse washed till soils; semi-rich mesic sugar maple forests occur in colluvial landscape positions or are associated with bedrock or till with greater base-cation contributions to the soil; hemlock - oak - northern hardwood forest occurs in more mesic settings or at higher elevations near the transition to northern hardwood - conifer forests; dry red oak - white pine forests occur on sandy or rocky soils that may perpetuate oak and pine dominance locally with repeated disturbance.

Justification (Reason for Concern in NH)

Hemlock - hardwood - pine forest is the most widely distributed forest type in New Hampshire, covering approximately 34% of the state’s land area. Available data indicate that roughly 19% of the state’s potential hemlock - hardwood - pine forest is on permanently protected lands. This forest type supports 140 vertebrate species in the state, including 15 amphibians, 13 reptiles, 73 birds, and 39 mammals. Threatened and endangered wildlife species occurring in this forest type include osprey, timber rattlesnake, and eastern hognose snake.

Protection and Regulatory Status

Approximately 19% of New Hampshire’s hemlock-hardwood-pine forest occurs on conservation lands.

Forestry on state lands is covered by RSAs 216, 217, and 218. RSA 227 stipulates requirements for residual basal area in riparian areas. The manuals “Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire” (NHDFL 2004) and “Good Forestry in the Granite State” (Bennett 2010) provide recommended management practices for sustainable forestry in New Hampshire.

Distribution and Research

Hemlock - hardwood - pine forest is widely distributed in New Hampshire with every county except Coos supporting between 5% and 20% of the total area of this forest type.

Additional fieldwork is needed to evaluate correlations between soil series and forest type as outlined in Homer (2005). County soil surveys outline soils suitable for forestry from an economic perspective. However, little has been done to evaluate soils from an ecological perspective (e.g., if left unmanaged, an area with a particular soil would eventually succeed to hemlock - hardwood - pine forest). Fieldwork is also needed to ground truth the hemlock - hardwood - pine map.

Relative Health of Populations

An approximately 3% decrease in forest area occurred between 1992 and 1993 and 2001 in the 9-county area where nearly 100% of New Hampshire’s potential hemlock - hardwood - pine forest is found.

Habitat Condition

Biological Condition:
Species richness of rare animals within their dispersal distances from the polygon
Species richness of rare plants in polygon
Richness of rare and exemplary natural communities in polygon
Vertebrate species richness (VT/NH GAP Analysis)

Landscape Condition:
Landscape Complexity
Local Connectedness
Similarity of habitat within 5km
Size of unfragmented block within which matrix forest is located

Human Condition:
Index of Ecological Integrity

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation and mortality from insect pests (hemlock wooly adelgid and others) (Threat Rank: High)

The hemlock wooly adelgid (*Adelges tsugae*), a small, sap-sucking insect native to Japan and China, became established in the Pacific Northwest in 1924 (na.fs.fed.us/fhp/hwa,). This insect became established in Virginia in the early 1950s and has since been spreading in the northeastern United States. As of 2015, infestations have been identified in 82 towns in eight counties in the state (NHDFL 2015). This species can be spread through the transportation of infected nursery stock as well as by wind, birds, and mammals. Eastern hemlock (*Tsuga canadensis*) has demonstrated little or no resistance to adelgid damage and mortality (McClure et al. 2001).

Based on FIA plot data, hemlock is the second most abundant tree species in New Hampshire (Morin & Pugh 2014), with the greatest concentration in the hemlock - hardwood - pine forest habitat. The hemlock wooly adelgid sucks sap from young hemlock twigs, resulting in needle drop, twig die-back, growth reduction, and tree mortality over the course of several years (Havill et al. 2014). It is difficult to overestimate both the ecological and economic impacts if hemlock wooly adelgid causes high mortality throughout New Hampshire.

Habitat degradation and impacts (fragmentation) from increased demand for wind power and associated transmission lines (Threat Rank: Medium)

In response to the threats associated with climate change, there is a strong incentive to develop renewable wind energy facilities. These "wind farms" are typically located on long ridgetops to maximize exposure to sustained winds. The habitats that occupy the footprints of wind turbines and transmission corridors are lost, and the remaining adjacent habitat is fragmented. There is an increased risk of migratory bird and bat mortality in areas with towers and turbines.

Kerlinger (2000) prepared an extensive literature review for the USFWS Office of Migratory Bird Management on avian mortality at towers and turbines. Birds that migrate along ridgelines at night are at greatest risk for tower collision by becoming disorientated when encountering lighted towers (Partners in Flight, unpublished data). Current estimates of the numbers of birds killed annually by communication towers range between 4 and 10 million (www.towerkill.com). A study at a West Virginia wind energy facility identified significant mortality of bats from collisions with wind turbines (Hein et al. 2013).

Habitat impacts from an increase in invasive plants moving north (Threat Rank: Medium)

Many invasive plants are currently limited by temperature, and are likely to expand northward into New Hampshire as a result of climate change. These species can displace or outcompete native plants and alter the composition and structure of habitats.

Invasive species can have a variety of negative impacts on natural communities and habitats (Stein and Flack 1996). In some cases, they can alter the chemistry of forest soils, leading to permanent changes in species composition (Ehrenfeld et al. 2001). A warming climate can enhance the spread of invasive plants through multiple pathways (Hellman et al. 2008).

Habitat degradation from warming conditions that allow cold-limited forest pests to move north (Threat Rank: Medium)

New Hampshire forests are currently at risk from a variety of insect pests (emerald ash borer, balsam wooly adelgid, gypsy moth, etc.). The current ranges of some of these pests, such as hemlock wooly adelgid, are believed to be limited by cold winter temperatures (NHDFL 2015). Under a warming climate scenario, the ranges of some of these species could expand, and new insect species could move into the state.

Hemlock woolly adelgid has significantly impacted stands of hemlock in the southern and central Appalachians, but has only spread slowly in northern New England due to its inability to tolerate cold winter temperatures (Paradis et al. 2007). However, under warming climatic conditions, it could expand its range northward, with the potential for widespread mortality of hemlock in New Hampshire.

Habitat degradation from succession to mature age structure (Threat Rank: Medium)

Early successional areas and young forest are critical habitats for a variety of wildlife species (DeGraaf et al. 2006). As forests mature, they lose many of the attributes that support these early-successional species, with potentially significant impacts on wildlife populations.

Since 1960, the acreage of forest characterized by large-diameter trees has been increasing (Morin & Pugh 2014). Prior to 1983, the acreage of young forests (1-5” diameter) had been declining, and has since been stable. However, this young forest is not evenly distributed among forest types, and the amount of early successional habitat in areas of hemlock – hardwood – pine forest is well until 10% of the total acreage of the type.

Habitat conversion and impacts to wildlife from fragmentation (Threat Rank: Medium)

Within the past 10 years, there have been 3 large scale wind energy facilities constructed in New Hampshire. These "wind farms" are typically located on long ridgetops to maximize exposure to sustained winds, and include turbines that are approximately 400 feet tall, which can pose a significant threat to birds and bats. Birds that migrate along ridgelines at night are at greatest risk for tower collision by becoming disoriented when encountering lighted towers (Partners in Flight, unpublished data). The habitats that occupy the footprints of wind turbines and transmission corridors are lost, and the remaining adjacent habitat is fragmented.

There were 78 known towers sited in New Hampshire as of 2010 (www.towerkill.com) and 475 towers currently mapped by NHFG. Kerlinger (2000) prepared an extensive literature review for the USFWS Office of Migratory Bird Management on avian mortality at towers and turbines. Current estimates of the numbers of birds killed annually by communication towers range between 4 and 10 million (www.towerkill.com). Bats are also vulnerable to impacts from wind energy facilities. Based on field data collection in a study of bat mortality at a wind energy facility in West Virginia, Hein et al. (2013) estimated a mortality rate of roughly 100 bats per turbine per year.

Habitat conversion due to development (Threat Rank: Medium)

Development reduces matrix forest habitat by converting natural forest to landscaped lawns and impermeable surfaces (e.g., buildings, roads). Development also contributes to forest fragmentation by directly reducing habitat, increasing traffic on existing roads, and requiring construction of new transportation infrastructure.

A study of 10 New Hampshire communities found that their populations increased by an average of 70.9% (range 9.7 to 189.7%) between 1974 and 1992, while developed land increased by an average of 137.2%. In the community with 9.7% population growth, developed land increased by 15.9% (New Hampshire Office of State Planning (NHOSP) 2000).

Habitat conversion resulting from decisions on land use and management (Threat Rank: Medium)

In New Hampshire, land use decisions are made at the municipal scale by volunteer planning boards with little or no training in natural resource issues. In cities and some of the larger towns, professional planning staff evaluate proposed developments and provide input to the planning board, but this is the exception rather than the rule. Most professional planners lack training in ecology or natural resources. Decisions are typically based on engineering and aesthetic considerations, with no recognition of direct or cumulative impacts on the underlying ecological functions of the affected lands or on impacts to wildlife habitat.

A Growth Management Advisory Committee convened by the New HOSP in 1999 concluded that:
- Impacts of growth and development are cumulative over decades
- Development in New Hampshire has occurred incrementally, resulting in fragmentation and loss of important and environmentally sensitive areas, including forestlands and wildlife habitat
- Communities seldom evaluate the potential impacts of their zoning ordinance or land use regulations (NHOSP 2000)

List of Lower Ranking Threats:

Mortality from pesticides used to control insect outbreaks

Habitat degradation from increased storm intensity and frequency

Mortality and habitat degradation from the creation and presence of roads

Mortality and habitat degradation from road fragmentation

Habitat impacts and conversion from the reduction in forest-based economy and infrastructure

Disturbance and habitat degradation from hiking and biking trails

Habitat degradation and mortality from legal and illegal OHRV and snowmobile activity

Habitat conversion and degradation of forest to permanent openings and infrastructure, fragmentation, and disturbance to wildlife by visitor activity

Habitat degradation from increased storm intensity and frequency

Mortality from pesticides used to control insect outbreaks

Habitat and species impacts from salvage logging that occurs after storms and pest invasions resulting in species composition changes

Mortality from pesticides used to control insect outbreaks

Habitat degradation from acid deposition

Habitat degradation from mercury deposition

Habitat degradation from increased ice and wind storms that cause damage to trees resulting in acceleration of species composition changes

Species and habitat impacts from species composition changes related to climate change

Habitat degradation from drought that changes soil composition and reduced seedling recruitment

Habitat degradation and impacts from increased and unsustainable harvest due to demand for biomass fuel

Habitat degradation from groundwater and surface withdrawals

Actions to benefit this Habitat in NH

Protect unfragmented blocks and other key wildlife habitats.

Primary Threat Addressed: Habitat conversion due to development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
The objective is to protect the largest and highest quality occurrences of hemlock – hardwood - pine forest habitat, with an emphasis on developing and maintaining corridors for wildlife movement and species dispersal.

General Strategy:
NHFG should use maps of prioritized unfragmented blocks and other key habitat information to review and identify land protection projects. These maps should also be distributed to the conservation community. Virtually all wildlife and habitats will directly or indirectly benefit from habitat protection, and the land protection strategy should be viewed as one of the most important ways to ensure long-term wildlife protection.

Political Location:	**Watershed Location:**
Statewide	Merrimack Watershed

Support the Division of Forests and Lands in the implementation of the hemlock woolly adelgid action plan.

Primary Threat Addressed: Habitat degradation and mortality from insect pests (hemlock wooly adelgid and others)

Specific Threat (IUCN Threat Levels): Invasive & other problematic species, genes & diseases

Objective:
The objective is to minimize the impact of hemlock woolly adelgid on NH forests and control its spread in the state.

General Strategy:
The "Action Plan to Restrict the Spread and Manage Hemlock Woolly Adelgid within the State of New Hampshire" is designed to guide the appropriate agencies and personnel in the management of hemlock woolly adelgid. The action plan was developed by the NH Division of Forests and Lands and recommended by the state's Forest Pest Advisory Group which is comprised of pest specialists representing the NH Division of Forests and Lands, USDA Forest Service, NH Department of Agriculture Markets and Foods, UNH Cooperative Extension, The Society for the Protection of New Hampshire's Forests, The Nature Conservancy, the Granite State Society of American Foresters, and the USDA Animal and Plant Health Inspection Service. These organizations are brought together by the State Forester to provide oversight in the management of major forest pest outbreaks.

Political Location: **Watershed Location:**

Continue monitoring program to identify new pests and pathogens that threaten forest health.

Primary Threat Addressed: Habitat degradation from warming conditions that allow cold-limited forest pests to move north

Specific Threat (IUCN Threat Levels): Climate change & severe weather

Objective:
The objective is to protect forest habitats from new forest pests arriving in New Hampshire as a result of movement by people or natural dispersal.

General Strategy:
The Division of Forests and Lands Forest Health Program currently conducts regular monitoring of forest health issues, and undertakes activities specifically designed to document the arrival of new pests and pathogens. One example is the program using swimming pool filters to try and document occurrences of Asian longhorned beetle.

Political Location: **Watershed Location:**
Statewide

Protect unfragmented blocks and other key wildlife habitats.

Primary Threat Addressed: Habitat conversion due to development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
The objective is to protect the largest and highest quality occurrences of hemlock – hardwood - pine forest habitat, with an emphasis on developing and maintaining corridors for wildlife movement and species dispersal.

General Strategy:
NHFG should use maps of prioritized unfragmented blocks and other key habitat information to review and identify land protection projects. These maps should also be distributed to the conservation community. Virtually all wildlife and habitats will directly or indirectly benefit from habitat protection, and the land protection strategy should be viewed as one of the most important ways to ensure long-term wildlife protection.

Political Location:	**Watershed Location:**
Merrimack County	Merrimack Watershed

Incorporate habitat conservation into local land use planning.

Primary Threat Addressed: Habitat conversion due to development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
Enhance protection of hemlock - hardwood - pine forests by incorporating conservation goals into planning documents, such as municipal and regional master plans, zoning ordinances, and subdivision regulations.

General Strategy:
The critical gap that NHFG can address is the scientific basis for implementing land use policies and regulations that protect the ecological function and health of wildlife populations and their habitats. This technical assistance needs to be combined with an integrated approach to land use decisions among local decision-makers. NHFG should work with UNH Cooperative Extension and New Hampshire Office of Energy and Planning, key outreach partners to facilitate training for NHFG biologists on the integration of wildlife habitat information into local land use planning and regulation. Likewise, Cooperative Extension can facilitate training for town planners, planning boards, regional planners, and others involved in writing master plans and local ordinances, on how to integrate wildlife considerations into local planning.

Political Location:	**Watershed Location:**
Statewide	Merrimack Watershed

Location Description:
Hemlock - hardwood - pine forests are found throughout southern and central NH.

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Peter Bowman, NHNHB

2005 Authors:
Carol R. Foss, NHA

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High Elevation Spruce-Fir Forest

Photo by Ben Kimball

Habitat Distribution Map

Acres in NH:	351,537
Percent of NH Area:	6
Acres Protected:	312,868
Percent Protected:	89

Habitat Description

Harsh climatic extremes and highly erosive soils play a significant role in determining the structure and species composition of high elevation spruce - fir forests found in New Hampshire. Increased rainfall (more than 6 inches per 1,000 ft. in elevation), snow cover (increase in weeks of snow cover per year), relative humidity (resulting in prolonged cloud cover) and wind movement (up to 25% more at 3,800 ft.), coupled with decreased mean air temperature (decrease in number of frost free days) and shallow, nutrient poor soils result in stands predominated by coniferous tree species. The coniferous stands found at high elevations experience drastically slowed and limited growth due to the truncated growing season and harsh climatic extremes (Vogelmann et al. 1969). As defined by NHNHB (Sperduto 2011), the high-elevation spruce - fir forest system includes two dominant natural communities—high-elevation spruce - fir and high-elevation balsam fir forests—and one peripheral community—northern hardwood - spruce - fir forest.

At the upper end of the elevation range for this habitat (between 3,500 and 4,500 ft.) is the high-elevation balsam fir forest (Sperduto & Nichols 2011). In this community, balsam fir (*Abies balsamea*) and heart-leaved paper birch (Betula cordifolia) are the dominant tree species. Above 4,500 ft., the forest transitions to subalpine krummholz vegetation, where black spruce (*Picea mariana*) becomes an important component of the community. A distinctive form of natural disturbance within the balsam fir forest is a pattern of wind-induced mortality known as “fir-waves.” Fir waves are linear patches of blown-down or standing dead trees oriented perpendicular to the prevailing wind, and arranged in a progression of waves of different ages of resulting regeneration adjacent to one another.

Decreasing in elevation, high-elevation spruce - fir forests are generally found between 2,500 and 3,500 ft. on upper mountain slopes and ridge tops, but may be higher or lower depending on local site conditions. The characteristic tree species in this community are red spruce (*Picea rubens*) and balsam fir, along with heart-leaved paper birch, paper birch (*Betula papyrifera*), and yellow birch (*B.alleghaniensis*).

At elevations between 2,100 and 2,800 ft. is the northern hardwood - spruce - fir forest, a transitional community between the high-elevation spruce - fir forest above and the sugar maple - beech - yellow birch forest below. This forest type is characterized by a variable mixture of red spruce, balsam fir, yellow birch, American beech (*Fagus grandifolia*), and sugar maple (*Acer saccharum*). While the boundary between high elevation spruce – fir forest and northern hardwood – conifer forest habitats can be ambiguous, examples of this community that are likely to maintain a mixed composition over the long term are probably most closely aligned with the hardwood forests below, because the northern hardwoods have not been excluded by the climatic and poorer soil conditions closely associated with their disappearance at higher elevations in the high-elevation spruce - fir forest.

Habitats that may be embedded in high elevation spruce - fir forests include alpine communities, rocky ridges, cliffs, talus slopes and landslides, and high elevation wetlands. See associated profiles.

Justification (Reason for Concern in NH)

High elevation spruce - fir forest has a very limited distribution in New Hampshire, covering between 4 and 6% of the state's land area (Publicover et al. 2015). This forest type supports 66 vertebrate species in the state, including 2 amphibians, 2 reptiles, 38 birds, and 24 mammals. Threatened and endangered wildlife using this forest type include Canada lynx and American marten. Blackpoll warblers and Bicknell's thrush breed exclusively in high elevation spruce - fir habitats. Other species that use high elevation habitat and may be less common at lower elevations include spruce grouse, boreal chickadee, white-winged crossbill, and American three-toed woodpecker. Common species that use the spruce - fir cover at high elevations include moose, deer, bear, fisher, and common raven. Moose tend to winter at higher elevations where they browse on fir, mountain ash, and yellow birch. Black bears will use these stands for escape, denning, or even resting cover. High elevation ridgelines also serve as important migratory routes for songbirds, raptors, and bats.

High elevation spruce - fir provides some of the last areas relatively free of human disturbance. Furthermore, due to conservation efforts and poor accessibility, the high elevation areas represent some of the last large, remote, contiguous blocks of spruce - fir habitat. Silviculture practices resulting from budworm harvests and the historic high value of spruce - fir and/or mill demands that have been placed on spruce - fir have dramatically affected spruce - fir distribution at lower elevations, thus making high elevation habitat that much more important (Staats 1996).

Lastly, soil cover at these higher elevations is much more fragile (i.e., soil compaction can dramatically reduce the ability of the soil absorb extra moisture) than that found at lower elevations. Soils above 2,700 ft. are usually very acidic, resulting in reduced nutrient availability to plants. Increased rainfall, snowfall, and moisture absorption capabilities of high elevation soils (due to the higher organic components) also make them a prime area for water filtration and water supply.

Protection and Regulatory Status

Approximately 89% of New Hampshire's high elevation spruce - fir forest occurs on conservation lands. Current protection for high elevation spruce - fir includes a no-cut zone above 2,700 ft on state lands and Forest Service property and private conservation lands (Bunnell Tract and The Nature Conservancy), zoning ordinances (PD6 zones) in unincorporated towns, the cooperative High Elevation MOU for large landowners developed by NHFG and DRED, a conservation easement (held by DRED), and finally an MOU between the WMNF and NHFG pertaining to the management of wildlife habitats.

Distribution and Research

High elevation spruce - fir habitat occurs in the White Mountain, Mahoosuc-Rangeley, and Connecticut Lake ecological subsections. High elevation spruce - fir can also occur locally at higher elevations of the Vermont Uplands subsection in central/south-central New Hampshire. The majority of this forest type is found within the White Mountain subsection.
Distribution research should concentrate on the area of high elevation spruce - fir forest that has experienced harvesting within the past 20 years, the long-term impacts of harvesting on forest structure and species composition, the overall effectiveness of the High Elevation MOU, and the effects of acid deposition and global warming on the distribution and abundance of high elevation spruce - fir.

Relative Health of Populations

Historically, extensive alteration and harvesting occurred throughout the distribution of high elevation spruce - fir. Current habitat under federal or state ownership is protected from further harvesting, while parcels that remain under private ownership exhibit extensive impacts from recent harvesting.

Habitat Condition

Biological Condition:
Species richness of rare animals within their dispersal distances from the polygon
Species richness of rare plants in polygon
Richness of rare and exemplary natural communities in polygon
Vertebrate species richness (VT/NH GAP Analysis)

Landscape Condition:
Landscape Complexity
Local Connectedness
Similarity of habitat within 5km
Size of unfragmented block within which matrix forest is located

Human Condition:
Index of Ecological Integrity

Habitat Management Status:

Habitat management and restoration policy in the WMNF and virtually all state and conservation land is to allow natural succession to regenerate as much of the historical spruce - fir area as possible. Timber harvesting is still proposed under private land ownerships, with little to no effort to maximize spruce - fir regeneration after harvesting.

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation from insect pests (Balsam wooly adelgid, spruce budworm) (Threat Rank: High)

There are a number of native and non-native insect pests that have the potential significantly impact high elevation spruce fir forests including spruce budworm and balsam woolly adelgid. Both forest pests could drastically reduce the amount of fir on the landscape, especially at lower elevations. Spruce budworm is projected to increase over the next ten years and we are already seeing impacts from small infestations of balsam woolly adelgid on the landscape in northern New Hampshire. Some are projecting that the spruce budworm will have a greater impact on higher elevation fir as a result of prolonged warmer temperatures, allowing the insect to complete its lifecycle at higher elevations than the previous outbreak. Similarly, balsam wooly adelgid is often controlled due to prolonged periods of cold temperatures in the winter, which have been reduced as a result of climate change.

The impacts of balsam woolly adelgid and spruce budworm are well documented (Ragenovich and Mitchell 2006; Kucera and Orr 1981).

Habitat impacts and conversion due to unfavorable conditions for spruce-fir to move into the alpine zone which allows replacement by hardwoods (Threat Rank: Medium)

Habitat degradation and impacts (fragmentation) from increased demand for wind power and associated transmission lines (Threat Rank: Medium)

Habitat conversion and degradation of forest to permanent openings and infrastructure, fragmentation, and disturbance to wildlife by visitor activity (Threat Rank: Medium)

Development such as roads, ski slopes, and energy and communication infrastructure reduce the matrix forest habitat by converting forests to permanent openings. Development also contributes to forest fragmentation and shifting wildlife community composition, especially during winter months. Roads and compacted surfaces exposed to wind and weather events allow competing species and predator access to historically isolated habitats resulting in overlap in distribution and home ranges that were historically partitioned.

While development in this habitat is limited, a variety of facilities have been documented, including roads, ski areas, wind power facilities and transmission lines, communication towers, and other recreational facilities (hiking huts) (Publicover and Kimball 2011).

Habitat conversion and impacts to wildlife from fragmentation associated with renewable energy development (Threat Rank: Medium)

High elevation spruce-fir forests are often regenerated through natural processes such as fir waves, wind throw and natural gap dynamics. When development occurs that can exacerbate the effects of the natural system dynamics it can create an imbalance of habitat structure over time. For example, fragmenting a large patch of high elevation spruce - fir with a wide road can impact the natural movement of a fir wave across a slope. This can also cause additional blow down which then creates a

much larger gap within the forest than would typically occur with a natural disturbance.
Within the past 10 years, there have been 3 large scale wind energy facilities constructed in New Hampshire. These facilities include wind turbines that are approximately 400 feet tall, which can pose a significant threat to birds and bats. Birds that migrate along ridgelines at night are at greatest risk for tower collision by becoming disoriented when encountering lighted towers (Partners in Flight, unpublished data).

There were 78 known towers sited in New Hampshire as of 2010 (www.towerkill.com) and 475 towers currently mapped by NHFG. Kerlinger (2000) prepared an extensive literature review for the USFWS Office of Migratory Bird Management on avian mortality at towers and turbines. Current estimates of the numbers of birds killed annually by communication towers range between 4 and 10 million (www.towerkill.com). Bats are also vulnerable to impacts from wind energy facilities. Based on field data collection in a study of bat mortality at a wind energy facility in West Virginia, Hein et al. (2013) estimated a mortality rate of roughly 100 bats per turbine per year.

Habitat conversion due to development (Threat Rank: Medium)

Potential impacts of hiking and biking trails include soil compaction and loss, reduced soil moisture, loss of organic litter, loss of ground cover vegetation, loss of native plant species, introduction of weeds and pathogens, and change in vegetation composition (Pickering et al. 2010).

Even low-impact, dispersed recreation has the potential to have serious effects on wildlife (Reed & Merenlender 2008). Mountain biking has become a popular recreation activity in New Hampshire. The New England Mountain Biking Association has over 5,000 members and 5 local chapters in New Hampshire (http://www.nemba.org/about). While anecdotal evidence suggests that the intensity of mountain biking activity has increased in New Hampshire in recent years, there is currently no documentation of impacts to wildlife or habitat.

List of Lower Ranking Threats:

Species and habitat impacts from species composition changes related to climate change

Habiat impacts from increased temperatures that reduce seed production in some species (balsam fir)

Habitat degradation from mercury deposition

Habitat degradation from acid deposition

Habitat degradation from introduced or invasive plants

Habitat degradation and mortality from legal and illegal OHRV and snowmobile activity

Disturbance and habitat degradation from hiking and biking trails

Habitat degradation from forestry practices that cause a loss of natural age structure, soil compaction and erosion

Habitat degradation from temperature stress

Habitat conversion resulting from decisions on land use and management

Actions to benefit this Habitat in NH

Advise Site Evaluation Committee on wind energy facilities

Primary Threat Addressed: Habitat conversion and impacts to wildlife from fragmentation associated with renewable energy development

Specific Threat (IUCN Threat Levels): Energy production & mining

Objective:
No net loss or impact on high elevation spruce-fir.

General Strategy:
Examining potential long and short-term implications of wind farm development and maintenance will aid in making decisions and recommendations dealing with wind farm proposals at local, state, regional and a national level.

Political Location:	**Watershed Location:**
Coos County	Androscoggin-Saco Watershed

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Lowland Spruce-Fir Forest

Photo by Ben Kimball

Acres in NH:	219,054
Percent of NH Area:	4
Acres Protected:	81,050
Percent Protected:	37

Habitat Distribution Map

Habitat Description

This habitat consists of conifer forests that occupy valley bottoms, lowland flats, and lake basins. It is well developed and most common north of the White Mountains from 1,000–2,500 ft., less common in the White Mountains, and infrequent in higher valley bottoms south of the mountains. This habitat occurs primarily as a mosaic of lowland spruce - fir forest and red spruce swamp communities on sites with mineral soils, which can range from well or moderately well drained upland forests to poorly or very poorly drained swamps. Somewhat poorly drained soils have intermediate drainage and very common.

In the lowland spruce - fir forest community, red spruce (*Picea rubens*), balsam fir (*Abies balsamea*), mosses, and lichens are abundant, and a variety of herbs and shrubs may be present. The red spruce swamp has a canopy dominated by spruce, with cinnamon fern (*Osmundastrum cinnamomeum*) and carpets of *Sphagnum* moss forming a lush understory beneath a moderate tall shrub layer and a sparse dwarf heath layer.

In addition to the two communities described above, a third natural community type—the montane black spruce - red spruce forest—is also found in valley bottoms between 2,000 and 3,000 ft. elevation. This is a rare forest type only described from the upper Pemigewasset Valley in the White Mountains, but could be expected to occur at other locations in the North Country.

Justification (Reason for Concern in NH)

Lowland spruce - fir forest covers only 4% of New Hampshire. This forest type supports 101 vertebrate species in the state, including 9 amphibians, 2 reptiles, 53 birds, and 37 mammals. Of the bird species, 15 are essentially restricted to or heavily dependent on spruce - fir forest, and 7 require mature age classes. Threatened and endangered wildlife species occurring in this forest type include Canada lynx, eastern small-footed bat, American marten, peregrine falcon, bald eagle, and American three-toed woodpecker. Extensive heavy cutting in recent decades has substantially reduced the distribution of mature spruce - fir forest in New Hampshire. Forest inventory data from 2005 (Miles 2005) suggest that 71% of live spruce and fir trees were in the 2-inch diameter class and less than 1.5% were in diameter classes of 10 inches and above. However, Morin and Pugh (2014) identified a significant increase in volume for both red spruce and balsam fir between 2008 and 2013. Soil and other environmental conditions over extensive acreage in northern New Hampshire create the potential to support either spruce - fir or northern hardwood - conifer forest. Past harvesting in some of these areas have resulted in conversion of former spruce - fir sites to northern hardwood - conifer forest.

Protection and Regulatory Status

Much of New Hampshire's lowland spruce - fir occurs on private industrial land; approximately 37% of this forest type occurs on conservation lands. Areas of public ownership include the White Mountain National Forest, Nash Stream Forest, Lake Umbagog National Wildlife Refuge, Pondicherry Refuge, and Randolph Community Forest.

Forestry on state lands is covered by RSAs 216, 217, and 218. RSA 227 stipulates requirements for residual basal area in riparian areas. The manuals "Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire" (NHDFL 2004) and "Good Forestry in the Granite State" (Bennett 2010) provide recommended management practices for sustainable forestry in New Hampshire.

Distribution and Research

Lowland spruce - fir forest occurs primarily in northern New Hampshire, with approximately 45% by area in Coos County and approximately 20% in Grafton County.

Fieldwork is needed to evaluate correlations between soil series and forest type as outlined in Homer (2005). County soil surveys outline soils suitable for forestry from an economic perspective. However, little has been done to evaluate soils from an ecological perspective (e.g., if left unmanaged, an area with a particular soil would eventually succeed to lowland spruce - fir forest). Fieldwork is also needed to ground truth the lowland spruce - fir map to assist with refining it.

Relative Health of Populations

The maps produced as part of the 2005 Wildlife Action Plan delineated roughly 10% of New Hampshire as lowland spruce - fir forest, using models that identified which forest type was most likely to occur given local variables of elevation, soil type, slope, and aspect. The maps produced for the 2015 plan use the Northeast Terrestrial Habitat Classification, which delineates habitat types based on current condition. Following these models, lowland spruce - fir forest occupies only 4% of the state. This dramatic reduction in area demonstrates the difference between potential and actual conditions, and likely reflects the impacts that timber management has had on the distribution of forest types in northern New Hampshire.

Habitat Condition

Biological Condition:
Species richness of rare animals within their dispersal distances from the polygon
Species richness of rare plants in polygon
Richness of rare and exemplary natural communities in polygon
Vertebrate species richness (VT/NH GAP Analysis)

Landscape Condition:
Landscape Complexity
Local Connectedness
Similarity of habitat within 5km
Size of unfragmented block within which matrix forest is located

Human Condition:
Index of Ecological Integrity

Habitat Management Status:

Certified Tree Farms cover approximately 55% of the two-county area in which approximately 80% of New Hampshire's potential lowland spruce - fir forest area occurs (calculated from data in Thorne and Sundquist 2001 and TNC data).

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation and mortality from insect pests (inlcuding spruce budworm and BWA) (Threat Rank: High)

There are a number of native and non-native insect pests that have the potential to significantly impact lowland spruce-fir forests including spruce bud worm and the balsam woolly adelgid. Both forest pests could drastically reduce the amount of fir on the landscape, especially at lower elevations. Spruce budworm is projected to increase over the next ten years and we are already seeing impacts from small infestations of balsam woolly adelgid on the landscape in northern New Hampshire.

The impacts of balsam woolly adelgid and spruce budworm are well documented (Ragenovich and Mitchell 2006; Kucera and Orr 1981).

Habitat degradation and impacts from harvesting practices that prevent much of forest from reaching later successional stages (Threat Rank: High)

Extensive, heavy cutting in recent decades has substantially reduced the distribution of mature spruce - fir forest in New Hampshire. Soils and other environmental conditions over extensive acreage in northern New Hampshire create the potential to support either spruce-fir or northern hardwood - conifer forest.

Recent forest inventory data (NHDFL 2010) suggest that harvesting of spruce and fir is exceeding growth of these species. Historical harvesting practices in some areas have resulted in conversion of former spruce - fir sites to northern hardwood - conifer forest. Mahaffey (2014) reports that softwoods are being harvested far in excess of growth in the Androscoggin Valley-Mahoosuc Region of northern NH, which is further evidence of the imbalance of softwood age classes on private ownerships in NH. Currently the USFS and the White Mountain National Forest is providing the highest percentage of mature spruce - fir. This likely has impacts on wildlife species that require older age classes and landscape connectivity to persist on the landscape.

Habitat degradation from harvest practices resulting in stand conversion (Threat Rank: High)

Habitat degradation and impacts (fragmentation) from increased demand for wind power and associated transmission lines (Threat Rank: Medium)

Pressure to develop and distribute alternative energy sources (especially the associated transmission lines) could fragment spruce - fir forest in the lowlands of Coos County or along ridgelines in western New Hampshire. Associated shifts in government policy may open currently protected areas to such development.

There are currently several renewable energy projects that have affected or could affect lowland spruce - fir forests in New Hampshire. Transmission lines that would be used to distribute the electricity produced by these facilities could fragment habitat across the region.

Habitat degradation and mortality from legal and illegal OHRV and snowmobile activity (Threat Rank: Medium)

Negative effects to wildlife resulting from OHRVs can include the physical alteration of habitat, the removal of vegetation or replacement of native species by disturbance-tolerant exotics and/or noxious weeds, increased noise disturbance, a reduction in habitat security, and (in some instances) direct injury or mortality (USFS 2004).

Off-road vehicle use is increasing rapidly in the Northeast. In 2013, there were over 65,000 registered off-road vehicles in New Hampshire, including over 17,000 ATVs. The total number of registered off-road vehicles is predicted to reach 37,000 by the year 2008, an increase of 42% (New Hampshire Trails Bureau 2003). Unregulated, these vehicles can have devastating impacts on ecosystems (Taylor no date).

Habitat conversion due to management and associated impacts from fragmentation (Threat Rank: Medium)

List of Lower Ranking Threats:

Habitat degradation and impacts from increased and unsustainable harvest due to demand for biomass fuel

Species and habitat impacts from species composition changes related to climate change

Habitat impacts from drought that allows invasion of drought-tolerant species

Habitat degradation from increased risk of fire due to summer droughts

Habitat degradation from drought that changes soil composition and accelerates organic decomposition that can lead to invasion by hardwoods

Habitat impacts from increased temperatures that reduce seed production in some species (balsam

fir) Habitat degradation from mercury deposition

Habitat degradation from the use of herbicides for hardwood control

Habitat degradation from acid deposition

Habitat degradation from groundwater and surface withdrawals

Disturbance and habitat degradation from hiking and biking trails

Habitat impacts and conversion from the reduction in forest-based economy and infrastructure

Mortality and habitat degradation from road fragmentation

Mortality and habitat degradation from the creation and presence of roads

Habitat degradation from changes in tree species and decomposition of organic soils

Actions to benefit this Habitat in NH

Conduct research on the condition of lowland spruce – fir forests.

Objective:

To gain a better understanding of age distribution and forest structure in lowland spruce – fir forests.

General Strategy:

The majority of lowland spruce – fir forests in New Hampshire occur in privately-owned industrial forest lands, and have experienced heavy harvesting pressure in recent decades. Forest inventory data from 2005 (Miles 2005) suggest that 71% of live spruce and fir trees were in the 2-inch diameter class and less than 1.5% were in diameter classes of 10 inches and above. However, Morin and Pugh (2014) identified a significant increase in volume for both red spruce and balsam fir between 2008 and 2013. Research should combine remote sensing with field inventories to improve knowledge about the condition of these forests, and identify areas for protection of older stands.

Political Location:

Coos County

Conduct research on habitat connectivity in lowland spruce – fir forest.

Objective:
To gain a better understanding of wildlife movement between patches of lowland spruce – fir forest.

General Strategy:

Lowland spruce – fir forest is a critical habitat type for a number of threatened and endangered wildlife species, include Canada lynx, American marten, and American three-toed woodpecker. In order for populations of these species to persist, individual animals need to be able to move between patches of suitable habitat relatively safely. NHFG and partners should conduct research to delineate travel corridors that connect patches of lowland spruce – fir forest. Research could combine remote sensing with field wildlife surveys to identify corridors that receive the greatest use.

Political Location:

Coos County

Conduct research on habitat conversion of potential lowland spruce – fir forests.

Objective:

To identify areas that have likely been converted from lowland spruce – fir forest to northern hardwood forest.

General Strategy:

The maps produced as part of the 2005 Wildlife Action Plan delineated roughly 10% of New Hampshire as lowland spruce - fir forest, using models that identified which forest type was most likely to occur given local variables of elevation, soil type, slope, and aspect. The maps produced for the 2015 plan use the Northeast Terrestrial Habitat Classification, which delineates habitat types based on current condition. Following these models, lowland spruce - fir forest occupies only 4% of the state. This dramatic reduction in area demonstrates the difference between potential and actual conditions, and likely reflects the impacts that timber management has had on the distribution of forest types in northern New Hampshire. Research should be conducted to determine where these differences most likely represent a conversion of forest type, and thus present opportunities for restoration.

Political Location:

Coos County

Provide technical assistance on lowland spruce – fir forest management to private landowners.

Primary Threat Addressed: Habitat degradation and impacts from harvesting practices that prevent much of forest from reaching later successional stages

Specific Threat: Natural system modifications

Objective:

Provide technical assistance to landowners on improving lowland spruce – fir forest habitat on private lands.

General Strategy:

Recent forest inventory data (NHDFL 2010) suggest that harvesting of spruce and fir is exceeding growth of these species. Historical harvesting practices in some areas have resulted in conversion of former spruce - fir sites to northern hardwood - conifer forest. NHFG and UNH Cooperative Extension should work with landowners to identify management practices for restoring lowland spruce – fir forests on sites that have been converted to hardwoods, and for enhancing the condition of existing lowland spruce – fir stands.

Political Location:

Coos County

Grafton County

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2015 Authors:
Peter Bowman, NHNHB

2005 Authors:
Carol R. Foss, NHA

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Northern Hardwood-Conifer Forest

Photo by Ben Kimball

Habitat Distribution Map

Acres in NH:	1263512
Percent of NH Area:	21
Acres Protected:	694932
Percent Protected:	55

Habitat Description

Northern hardwood – conifer forests are found generally between 1,400 and 2,500 ft. in elevation in northern and central New Hampshire. In latitude and elevation, this matrix forest is positioned between the high-elevation spruce - fir and hemlock - hardwood - pine forests. The primary natural community of this system is the sugar maple - beech - yellow birch forest, which is characterized by American beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), and yellow birch (*Betula alleghaniensis*). This community forms a matrix containing patches of several other communities. Hemlock - oak - northern hardwood forests occur at lower elevations (800 to 1,500 ft.) and are differentiated from the matrix community by a substantial presence of hemlock (*Tsuga canadensis*), with red oak (*Quercus rubra*) and white pine (*Pinus strobus*) also frequent. This community occurs in valley bottoms and lower slopes of the White Mountains, and at middle to higher elevations of hills and low mountains in western New Hampshire. Hemlock - spruce - northern hardwood forests are also found at elevations below 2,000 ft. This is a conifer or mixed hardwood – conifer forest with considerable hemlock and red spruce (*Picea rubens*) mixing with variable amounts of birches, other northern hardwoods, balsam fir (*Abies balsamea*), and sometimes white pine. It occurs primarily on river terraces, stream ravines, and compact till settings in the mountains, where it transitions to more typical northern hardwoods on richer soils (e.g., fine tills). Semi-rich mesic sugar maple forests are a common but relatively small part of this system, found where there is slightly enriched till or fine river terrace sediments. Both beech forest and hemlock forest types are occasional in this and hemlock -

hardwood - pine forest habitats, but generally form small patches.

Northern hardwood - spruce - fir forests mark the transition to the high-elevation spruce - fir forest habitat, but in most cases are considered part of the northern hardwood - conifer forest system because the hardwood trees that disappear in high-elevation spruce - fir (due to climate and/or soil conditions) are still present. Some spruce - fir or mixed forests that have been cut or heavily disturbed may currently support a hardwood or mixed forest canopy, and may or may not succeed to greater spruce - fir prominence.

Justification (Reason for Concern in NH)

Northern hardwood - conifer forest covers approximately 20% of New Hampshire. Available data indicate that approximately 55% of the state's northern hardwood - conifer forest is on permanently protected lands. This forest type supports 137 vertebrate species in the state, including 42 mammals, 73 birds, 8 reptiles, and 14 amphibians. Threatened and endangered wildlife species occurring in this forest type include peregrine falcon and bald eagle. Development pressure is heavy within some parts of the range of northern hardwood - conifer forest in New Hampshire, particularly in the Lakes Region and the perimeter of the WMNF.

Protection and Regulatory Status

Much of New Hampshire's northern hardwood - conifer forest is under private management for production of pulp, veneer, and lumber. Approximately 55% of this forest type occurs on conservation lands. Public ownerships include the WMNF, Lake Umbagog National Wildlife Refuge, various state lands, and town forests and conservation lands. Extensive areas of northern hardwood - conifer forests occur on the Connecticut Lakes Headwaters property, which are protected by a conservation easement held by DRED. Several non-governmental conservation organizations also hold northern hardwood - conifer forest lands in fee or easement.

Forestry on state lands is covered by RSAs 216, 217, and 218. RSA 227 stipulates requirements for residual basal area in riparian areas. The manuals "Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire" (NHDFL 2004) and "Good Forestry in the Granite State" (Bennett 2010) provide recommended management practices for sustainable forestry in New Hampshire.

Distribution and Research

Northern Hardwood-Conifer forest occurs primarily in northern New Hampshire, with approximately 45% by area in Coos County and approximately 30% in Grafton County. Carroll and Sullivan counties support 5 to 10%, and Belknap, Cheshire, and Hillsborough counties support less than 5%.

Additional fieldwork is needed to evaluate correlations between soil series and forest type as outlined in Homer (2005). County soil surveys outline soils suitable for forestry from an economic perspective. However, little has been done to evaluate soils from an ecological perspective (e.g., if left unmanaged, an area with a particular soil would eventually succeed to northern hardwood-conifer forest).

Relative Health of Populations

Relative Health of Populations: The acreage of northern hardwood - conifer forest on conservation lands increased significantly as a result of several large land protection projects in the past 15 years, including the Connecticut Lakes Headwaters, expansion of Lake Umbagog NWR, and the Androscoggin Headwaters Forest Legacy Easement.

Habitat Condition

A set of GIS data was used to assess ecological condition of each habitat type. Chapter 3 describes the methodology. The data used for this habitat is described below.

Biological Condition:
Species richness of rare animals within their dispersal distances from the polygon
Species richness of rare plants in polygon
Richness of rare and exemplary natural communities in polygon
Vertebrate species richness (VT/NH GAP Analysis)

Landscape Condition:
Landscape Complexity
Local Connectedness
Similarity of habitat within 5km
Size of unfragmented block within which matrix forest is located

Human Condition:
Index of Ecological Integrity

Habitat Management Status:

Certified Tree Farms cover approximately 55% of the two-county area in which approximately 80% of New Hampshire's potential northern hardwood - conifer forest area occurs (calculated from TNC data and data in Thorne and Sundquist 2001).

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation and mortality from insect pests (Threat Rank: High)

There are a number of non-native insect pests that have the potential significantly impact forest habitats, including gypsy moth, hemlock wooly adelgid, emerald ash borer, and Asian longhorned beetle. In northern hardwood – conifer forests, where white ash is a frequent canopy tree, emerald ash borer (EAB) currently presents the greatest threat, with the potential to virtually eliminate this species from New Hampshire forests.

There are 3 species of ash (*Fraxinus* spp.) native to New Hampshire, all of which are vulnerable to attack from emerald ash borer. The most common, white ash, is widespread in upland forests, and is a frequent, if rarely dominant, component of northern hardwood – conifer forests (Morin & Pugh 2014). EAB is a non-native beetle from Asia that became established in Michigan in 2002, where larval infestations began attacking native ash species. Since then it has spread throughout the midwest and northeastern U.S., resulting in the mortality of tens of millions of ash trees (USFS 2008). While biological control methods are in development, the spread of EAB has been unchecked to date. EAB was first discovered in NH in 2013 in Concord. Since then it has been documented in 10 towns in the southern part of the state.

Habitat impacts from an increase in invasive plants moving north (Threat Rank: Medium)

Many invasive plants are currently limited by temperature, and are likely to expand northward into New Hampshire as a result of climate change. These species can displace or outcompete native plants and alter the composition and structure of habitats.

Invasive species can have a variety of negative impacts on natural communities and habitats (Stein and Flack 1996). In some cases, they can alter the chemistry of forest soils, leading to permanent changes in species composition (Ehrenfeld et al. 2001). A warming climate can enhance the spread of invasive plants through multiple pathways (Hellman et al. 2008).

Habitat degradation and impacts (fragmentation) from increased demand for wind power and associated transmission lines (Threat Rank: Medium)

Within the past 10 years, there have been 3 large scale wind energy facilities constructed in New Hampshire. These "wind farms" are typically located on long ridgetops to maximize exposure to sustained winds, and include turbines that are approximately 400 feet tall, which can pose a significant threat to birds and bats. Birds that migrate along ridgelines at night are at greatest risk for tower collision by becoming disoriented when encountering lighted towers (Partners in Flight, unpublished data). The habitats that occupy the footprints of wind turbines and transmission corridors are lost, and the remaining adjacent habitat is fragmented.

Kerlinger (2000) prepared an extensive literature review for the USFWS Office of Migratory Bird Management on avian mortality at towers and turbines. Birds that migrate along ridgelines at night are at greatest risk for tower collision by becoming disorientated when encountering lighted towers (Partners in Flight, unpublished data). Current estimates of the numbers of birds killed annually by communication towers range between 4 and 10 million (www.towerkill.com). A study at a West Virginia wind energy facility identified significant mortality of bats from collisions with wind turbines (Hein et al. 2013).

Habitat degradation from warming conditions that allow cold-limited forest pests to move north (Threat Rank: Medium)

New Hampshire forests are currently at risk from a variety of insect pests (emerald ash borer, balsam wooly adelgid, gypsy moth, etc.). The current ranges of some of these pests, such as hemlock wooly adelgid, are believed to be limited by cold winter temperatures (NHDFL 2015). Under a warming climate scenario, the ranges of some of these species could expand, and new insect species could move into the state.

Hemlock woolly adelgid has significantly impacted stands of hemlock in the southern and central Appalachians, but has only spread slowly in northern New England due to its inability to tolerate cold winter temperatures (Paradis et al. 2007). However, under warming climatic conditions, it could expand its range northward, with the potential for widespread mortality of hemlock in New Hampshire.

Habitat degradation from increased ice and wind storms that cause damage to trees resulting in acceleration of species composition changes (Threat Rank: Medium)

More frequent disturbance events (e.g., hurricanes, ice storms, tornadoes) will likely favor shade-intolerant, early successional species (paper birch and aspen) over shade tolerant, late successional species (beech and hemlock). Higher rates of disturbance would also alter the relative proportions of different seral stages of forest.

Many climate change scenarios predict that intense storms with high winds and heavy rainfall will become more frequent (Hayhoe et al. 2008). In general, hardwood tree species tend to be more vulnerable to damage from ice storms than softwood species (Miller-Weeks et al. 1999). These storms could cause widespread impacts to forests through windthrow and damage to tree canopies, leading early successional species to become more abundant, but evidence to support these predictions is speculative.

Habitat conversion and impacts to wildlife from fragmentation (Threat Rank: Medium)

Within the past 10 years, there have been 3 large scale wind energy facilities constructed in New Hampshire. These facilities include wind turbines that are approximately 400 feet tall, which can pose a significant threat to birds and bats. Birds that migrate along ridgelines at night are at greatest risk for tower collision by becoming disoriented when encountering lighted towers (Partners in Flight, unpublished data).

There were 78 known towers sited in New Hampshire as of 2010 (www.towerkill.com) and 475 towers currently mapped by NHFG. Kerlinger (2000) prepared an extensive literature review for the USFWS Office of Migratory Bird Management on avian mortality at towers and turbines. Current estimates of the numbers of birds killed annually by communication towers range between 4 and 10 million (www.towerkill.com). Bats are also vulnerable to impacts from wind energy facilities. Based on field data collection in a study of bat mortality at a wind energy facility in West Virginia, Hein et al. (2013) estimated a mortality rate of roughly 100 bats per turbine per year.

Habitat conversion due to development (Threat Rank: Medium)

Development reduces matrix forest habitat by converting natural forest to landscaped lawns and impermeable surfaces (e.g., buildings, roads). Development also contributes to forest fragmentation by directly reducing habitat, increasing traffic on existing roads, and requiring construction of new transportation infrastructure.

A study of 10 New Hampshire communities found that their populations increased by an average of 70.9% (range 9.7 to 189.7%) between 1974 and 1992, while developed land increased by an average of 137.2%. In the community with 9.7% population growth, developed land increased by 15.9% (New Hampshire Office of State Planning (NHOSP) 2000).

Habitat conversion resulting from decisions on land use and management (Threat Rank: Medium)

In New Hampshire, land use decisions are made at the municipal scale by volunteer planning boards with little or no training in natural resource issues. In cities and some of the larger towns, professional planning staff evaluate proposed developments and provide input to the planning board, but this is the exception rather than the rule. Most professional planners lack training in ecology or natural resources. Decisions are typically based on engineering and aesthetic considerations, with no recognition of direct or cumulative impacts on the underlying ecological functions of the affected lands or on impacts to wildlife habitat.

A Growth Management Advisory Committee convened by the New HOSP in 1999 concluded that:
- Impacts of growth and development are cumulative over decades
- Development in New Hampshire has occurred incrementally, resulting in fragmentation and loss of important and environmentally sensitive areas, including forestlands and wildlife habitat
- Communities seldom evaluate the potential impacts of their zoning ordinance or land use regulations (NHOSP 2000)

List of Lower Ranking Threats:

Habitat and species impacts from salvage logging that occurs after storms and pest invasions resulting in species composition changes

Species and habitat impacts from species composition changes related to climate change

Habitat degradation from mercury deposition

Habitat degradation from acid deposition

Habitat conversion and degradation of forest to permanent openings and infrastructure, fragmentation, and disturbance to wildlife by visitor activity

Habitat degradation and mortality from legal and illegal OHRV and snowmobile activity

Disturbance and habitat degradation from hiking and biking trails

Habitat impacts and conversion from the reduction in forest-based economy and infrastructure

Mortality and habitat degradation from road fragmentation

Mortality and habitat degradation from the creation and presence of roads

Habitat degradation from increased storm intensity and frequency

Actions to benefit this Habitat in NH

Incorporate habitat conservation into local land use planning

Primary Threat Addressed: Habitat conversion resulting from decisions on land use and management

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
Enhance protection of northern hardwood - conifer forests by incorporating conservation goals into planning documents, such as municipal and regional master plans, zoning ordinances, and subdivision regulations.

General Strategy:
The critical gap that NHFG can address is the scientific basis for implementing land use policies and regulations that protect the ecological function and health of wildlife populations and their habitats. This technical assistance needs to be combined with an integrated approach to land use decisions among local decision-makers. NHFG should work with UNH Cooperative Extension and New Hampshire Office of Energy and Planning, key outreach partners to facilitate training for NHFG biologists on the integration of wildlife habitat information into local land use planning and regulation. Likewise, Cooperative Extension can facilitate training for town planners, planning boards,

regional planners, and others involved in writing master plans and local ordinances, on how to integrate wildlife considerations into local planning.

Political Location:	**Watershed Location:**
Statewide	Pemi-Winni Watershed

Location Description:
Northern hardwood - conifer forests occur statewide, but are most prevalent in central and northern NH.

Continue monitoring program to identify new pests and pathogens that threaten forest health.

Primary Threat Addressed: Habitat impacts from an increase in invasive plants moving north

Specific Threat (IUCN Threat Levels): Climate change & severe weather

Objective:
The objective is to protect forest habitats from new forest pests arriving in New Hampshire as a result of movement by people or natural dispersal.

General Strategy:
The Division of Forests and Lands Forest Health Program currently conducts regular monitoring of forest health issues, and undertakes activities specifically designed to document the arrival of new pests and pathogens. One example is the program using swimming pool filters to try and document occurrences of Asian longhorned beetle.

Political Location:	**Watershed Location:**
Statewide	

Protect unfragmented blocks and other key wildlife habitats.

Primary Threat Addressed: Habitat conversion due to development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
The objective is to protect the largest and highest quality occurrences of northern hardwood - conifer forest habitat, with an emphasis on developing and maintaining corridors for wildlife movement and species dispersal.

General Strategy:
NHFG should use maps of prioritized unfragmented blocks and other key habitat information to review and identify land protection projects. These maps should also be distributed to the conservation community. Virtually all wildlife and habitats will directly or indirectly benefit from habitat protection, and the land protection strategy should be viewed as one of the most important ways to ensure long-term wildlife protection.

Political Location:	**Watershed Location:**
Statewide	Pemi-Winni Watershed

Location Description:
Northern hardwood - conifer forests occur statewide, but are most prevalent in central and northern NH.

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Pine Barrens

Photo by Pete Bowman

Acres in NH:	8099
Percent of NH Area:	<1
Acres Protected:	3240
Percent Protected:	40

Habitat Distribution Map

Habitat Description

Pine barrens are early-successional habitats occurring on northeastern coastal sand plains or on sandy, glacial outwash deposits of major river valleys (Howard et al 2005). Soils are acidic, droughty, nutrient-poor, and excessively well-drained. In New Hampshire, pine barrens are dominated by pitch pine (*Pinus rigida*) and scrub oak (*Quercus ilicifolia*) and form a matrix of dense scrub oak thickets and heath barrens interspersed with pockets of pitch pine forest and grassy openings (Sperduto and Nichols 2011). This structural and compositional heterogeneity is in constant flux, a process maintained by frequent disturbances such as wildfire. Fires occur naturally and regularly in pine barrens, with lightning serving as the primary ignition source (Howard et al 2005). These fires are able to spread rapidly across the community's flat expanse of dry, fire-prone vegetation (Howard et al 2005). Lee sides of habitat features, such as eskers, rivers, and slopes act as natural firebreaks, creating variation in species composition as well as vegetational age distributions (Howard et al 2005).

The two variants of the pitch pine-scrub oak woodland community occurring in New Hampshire are the Merrimack Valley variant and the Ossipee variant (Sperduto and Nichols 2011). The Merrimack Valley variant occurs in the Concord pine barrens and occupies Windsor sandy loams and Hinckley cobbly sandy loams (VanLuven 1994), both deposits of the post-glacial Lake Merrimack (Sperduto and

Nichols 2011). This variant is characterized by a high diversity of both common and rare vascular plants, including wild lupine (*Lupinus perennis*), clasping milkweed (*Asclepias amplexicaulis*), and New Jersey redroot (*Ceanothus americanus*) (Sperduto and Nichols 2011). The Ossipee variant occurs in the Ossipee pine barrens, occupying deep outwash deposits between Ossipee and Silver Lake (Sperduto and Nichols 2011). Less diverse than the southern variant, the Ossipee variant is instead associated with more northern plant species such as red bearberry (*Arctostaphylos uva-ursi*), three-toothed cinquefoil (*Sibbaldiopsis tridentata*), and blue ground-cedar (*Diphasiastrum tristachyum*) (Sperduto and Nichols 2011).

Justification (Reason for Concern in NH)

Pine barrens are among the most imperiled communities in the world (Raleigh et al 2003). Throughout the thousands of years of their existence, pitch pine-scrub oak woodlands have significantly contributed to the biological diversity of the northeast (Howard et al 2005). These communities support a suite of species that are regionally and globally rare (Howard et al 2005). Of the rare fauna occurring within them, the largest assemblage is Lepidoptera, as demonstrated in New Hampshire (VanLuven 1994). Of the 726 Lepidoptera species collected in the Concord pine barrens, 4 are globally imperiled and 37 are rare to the state, including the federally and state endangered Karner blue butterfly (*Lycaeides melissa samuelis*) as well as the state endangered frosted elfin (*Callophyrus* [*Incisalia*] *irus*) and persius duskywing skipper (*Erynnis persius persius*) (VanLuven 1994, Chandler 2001, Sperduto and Nichols 2011). A large proportion of these Lepidopteran fauna are exclusively dependent on blue lupine and other plants restricted to pine barrens (Sperduto and Nichols 2011). The Ossipee pine barrens lacks the level of Lepidopteran diversity found in its southern counterpart, although it does support the only New England occurrences of the pine pinion moth (*Lithophane lepida lepida*), and the Acadian swordgrass moth (*Xylena thoracica*) (Sperduto and Nichols 2011).

Pine barren communities also serve a role in the life histories of a number of vertebrates, a relationship based on edaphic and structural features, rather than host plant specificity (Howard et al 2005). These species include approximately 50% of northeastern birds, almost 60% of northeastern mammals, and a number of reptiles and amphibians (Howard et al 2005).
Historically, pine barrens provided the array of distinctive habitat features required by their associated fauna (Howard et al 2005). However, with increased fire suppression during the last half-century, this habitat's natural course of succession has been severely disrupted (Howard 2003). Reduced intensity and frequency of natural disturbance caused the pitch pine-scrub oak woodland to advance into a closed pitch pine-scrub oak forest, eliminating structural elements critical to the long-term viability of indigenous species populations (Raleigh et al 2003, Howard et al 2005). Moreover, urban development has added to the effects of fire suppression, further reducing the extent of pitch pine-scrub oak woodland communities (Howard et al 2005). The result has been significant habitat loss and fragmentation in systems that were historically large and contiguous (Howard et al 2005).

Protection and Regulatory Status

Federal

National Plant Protection Act: promotes the preservation of wild lupine, clasping milkweed, and golden heather (Hudsonia ericoides) on state lands, but provides no protection on private property (VanLuven 1994)

State

New Hampshire Native Plant Protection Act of 1987.

Local

Concord Municipal Airport Development and Conservation Management Agreement: restricts development within designated conservation zones, authorizes the New Hampshire Fish and Game Department, the Department of Resources and Economic Development, the New Hampshire Army National Guard, and the United States Fish and Wildlife Service to undertake management actions to provide and enhance essential habitat for federally and state listed threatened and endangered species of Lepidoptera.

Distribution and Research

Pine barrens are predominantly restricted to New Jersey, though regionally rare examples occur in Maine, New Hampshire, Massachusetts, Pennsylvania, and New York (Howard 2003). In New Hampshire, this habitat is limited to the Sebago-Ossipee and Gulf of Maine Coastal Plain ecoregion subsections (Sperduto and Nichols 2011). The Ossipee pine barrens is located within the towns of Ossipee, Tamworth, Freedom, Madison, and Effingham, at an elevation range of 137-152m (Howard 2003). Its estimated historic extent encompassed over 2,833 ha (7,000 ac), which has since been reduced to about 1,214 ha (3,000 ac) (Howard 2003). The Concord pine barrens occurs within the city of Concord at an elevation of 105m. Its distribution once covered approximately 1,821 ha (4,500 ac) along the Merrimack River from Concord south to Nashua, of which only 227 ha (563 ac) re-main today (VanLuven 1994).

Areas requiring further research include historical distribution, geologic and ecological processes contributing to the formation of pitch pine-scrub oak woodland communities, distribution and condition of populations of pine barrens-dependent fauna, and the role of land-use history in maintaining and/or promoting the establishment of pitch pine-scrub oak woodland habitat.

Relative Health of Populations

Good examples of pitch pine-scrub oak woodlands in New Hampshire occur in the Concord pine barrens (Concord) and the Ossipee pine barrens, (Freedom, Madison, Ossipee, and Tamworth), with the Ossipee pine barrens being considered the largest and most pristine pitch pine-scrub oak woodland community in the state (Howard 2003, Sperduto and Nichols 2004). A small, heavily managed population of Karner blue butterflies exists in the Concord pine barrens, and populations of other lepidopteran species associated with this habitat are found in both the Concord and Ossipee pine barrens. The Ossipee pine barrens support the largest concentration of Eastern Whip-poor-wills in the state, as well as significant populations of several other species of shrubland-dependant birds (Hunt 2013).

Habitat Condition

A set of GIS data was used to assess ecological condition of each habitat type. Chapter 3 describes the methodology. The data used for this habitat is described below.

Biological Condition:
Species richness of rare animals within their dispersal distances
Richness of rare and exemplary natural communities
Species richness of rare plants by landform and elevation zone
Vertebrate species richness (VT/NH GAP Analysis)

Landscape Condition:
Landscape Complexity

Local Connectedness
Similarity of habitat within 5km
Size of unfragmented block within which matrix forest is located

Human Condition:
Index of Ecological Integrity

Habitat Management Status:

Current habitat management and restoration techniques used in the Concord pine barrens include native plant propagation, vegetation management using specialized mowers and feller bunchers, and prescribed fire. Habitat monitoring is completed before and after management implementation. The goal is to create a shifting mix of native grassland, shrubland, and woodland features (Fuller et al. 2003).

The Nature Conservancy has been actively managing the Ossipee pine barrens since 2007 including mechanical treatments to create firebreaks and remove unwanted vegetation, and prescribed burning. The intent is to maintain, enhance, and restore ecological processes vital to the overall function of the pitch pine-scrub oak woodland community (Raleigh et al 2003).

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation from catastrophic fire (Threat Rank: Medium)

Without a regular fire regime, fuels have accumulated, increasing the risk of high intensity wildfires inappropriate to pine barrens regeneration. Changing climate may also modify the existing rate and severity of disturbance events such as fire.

Refugia are needed within the landscape to protect Lepidoptera populations (Swengel and Swengel 2007). Refuges have three main functions in relation to fire: they enhance immediate survival during a fire event, facilitate the persistence of individuals and populations after fire and assist with re-establishment of populations in the longer term (Robinson et al. 2013).

Habitat degradation and mortality from a lack of fire that leads to loss of constituent plant species (Threat Rank: Medium)

Due to the xeric soil, flammable pine litter, and flat terrain on which they occur, pine barrens have been subject to frequent wildfires (Howard 2003). The absence of such disturbance, combined with the natural processes associated with succession, have caused the community composition of pitch pine-scrub oak woodlands to shift into a closed-canopy forest dominated by fire intolerant hardwoods (Howard et al 2005).

In the northeast, pitch pine-scrub oak woodland communities require periodic fire to persist (Wagner et al 2003). Fire suppression has been a major factor contributing to the decline of disturbance-dependent habitats throughout the northeast (Raleigh 2003). In the last half-century, natural fire disturbance has been eliminated from both the Concord and Ossipee pine barrens systems, leading to a significant shift in community composition and structure (VanLuven 1994, Howard 2003). In Concord, the distinguishing mosaic of grassy openings, heath barrens, scrub oak thickets, and pitch pine woodlands no longer exists, as it has been replaced by medium-fire tolerant white pine and fire intolerant hardwoods (VanLuven 1994). Similarly, white pine and fire-intolerant hardwoods have substantially increased over the last 50 years in the Ossipee pine barrens and are predicted to soon be the dominant canopy species (Howard et al 2005).

Habitat impacts from inappropriate timber management (Threat Rank: Medium)

Selective cutting has been the dominant method for timber management over the past few decades. In a fire adapted forest such as pine barrens, this method may be inappropriate for maintaining a typical species composition resulting in a more hardwood dominated forest.

Cut unit size is the most important factor influencing landscape pattern in pine barrens due to the importance of large openings in the fire adapted system (Radeloff et al. 2006).

Habitat conversion from infrastructure development (Threat Rank: Medium)

It has been asserted that one of the major threats to pine barrens is habitat loss, primarily as a result of development (Howard et al 2005). Habitat features associated with these communities, such as level terrain, sandy soils, high stability, high permeability, and low compaction, make them optimal for commercial and residential development. Some species of vertebrates that use pine barrens can travel significant distances, requiring large blocks of contiguous habitat. A half-century of constant growth has resulted in a severe loss of habitat in communities that were historically large and contiguous (Howard et al 2005).

Throughout the northeast, nearly half of all known pitch pine-scrub oak woodland communities have been lost as a result of development and fire suppression (Jordan et al 2003). New Hampshire had at one time supported 4 such communities, including the Nashua, Manchester, Concord, and Ossipee pine barrens (The Nature Conservancy 2004). As in the remainder of the region, increased development and urban sprawl throughout the state drastically reduced the extent of these communities. Both the Nashua and Manchester pine barrens have been entirely altered, while a mere 10% of the historic Concord Pine Barrens and 30% of the Ossipee remain today (Helmbolt and Amaral 1994, The Nature Conservancy 2004).

Species impacts from fragmentation (Threat Rank: Medium)

As more patches are created isolation prevents dispersal of moth species eventually losing them at certain locations over time. Size of fragment affects the species that survive based on life history charactersitics.

Affinity of a species to forest habitat or less dtermines the size of fragment they will use ranging from hedgerow, small to large patches (Slade et al. 2013). Declines in species related to severity of fragementation also releated to the functional group - tree, shrub or grass forb feeding species (Schmidt and Roland 2006).

List of Lower Ranking Threats:

Habitat impacts from herbivory (deer browsing)

Habitat degradation and species impacts from introduced or invasive plants

Habitat degradation and species impacts from introduced or invasive plants

Species impacts and mortality from introduced animal species

Habitat degradation and species impacts from change of structure

Mortality (accidental) of species from recreational activity

Mortality of lepidoptera species from recreational activity

Mortality from the collection of individuals from the wild

Mortality from collecting lepidoptera species

Habitat degradation from the selective removal of species through mowing

Habitat impacts from shifts and changes in species composition

Habitat impacts from the fragmentation of remaining populations

Mortality related to development

Actions to benefit this Habitat in NH

Habitat Conservation

Primary Threat Addressed: Habitat conversion from infrastructure development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:

General Strategy:
Identify remaining patches of pine barrens and potential pine barrens sites in Ossipee and Concord for future protection. Protection plan should also include the intent to manage the parcel as needed to restore or maintain pine barrens on site.

Political Location:

Watershed Location:

Habitat Mangament and Restoration

Primary Threat Addressed: Habitat degradation from a lack of fire that leads to loss of constituent plant species

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:

General Strategy:
Habitat management will increase the distribution and abundance of pine barrens within their existing and historical range by restoring closed-canopy stands to an early-successional structure. Standard habitat management techniques including forestry, fire, and herbicide application have well-documented efficacy in reducing the cover of canopy-forming, shade-tolerant, and fire-sensitive species. Early-successional plant species abundance increases in response to a broad range of

vegetation management techniques (Smallidge et al. 1996). Management simulates natural and anthropogenic disturbance, creating areas of open or semi-open habitat interspersed with closed woodlands. In addition to maintaining open habitat structure, fire management releases scarce nutrients, exposes bare mineral soil, and stimulates flowering, germination, and seedling establishment of fire-adapted species, while serving to promote and maintain connectivity across the landscape (Wagner et al 2003). This continually changing heterogeneous landscape satisfies the microhabitat needs of a suite of indigenous species.

Political Location: **Watershed Location:**

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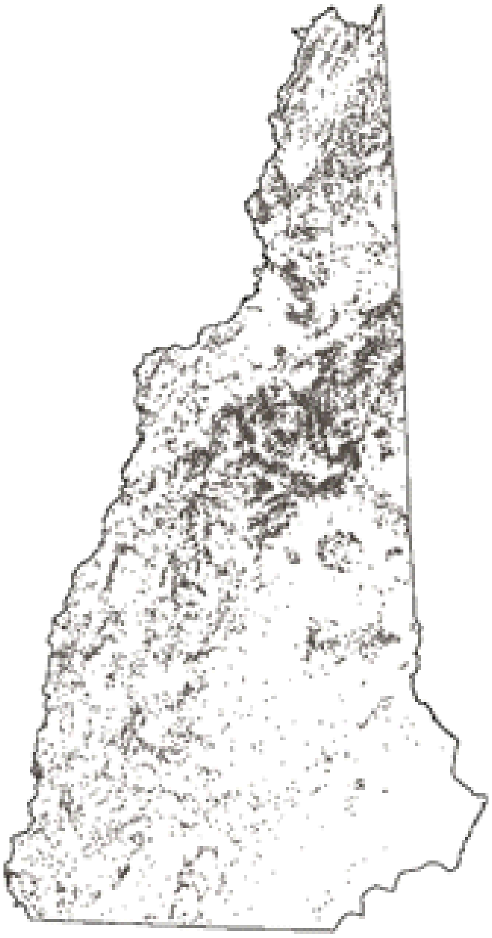
Rocky Ridge, Cliff, and Talus

Photo by Dan Sperdutot

Acres in NH:	100863
Percent of NH Area:	2
Acres Protected:	68587
Percent Protected:	68



Habitat Distribution Map

Habitat Description

This profile covers three related but distinct habitats: rocky ridges, cliffs, and talus slopes. In the 2005 Wildlife Action Plan, rocky ridges and talus slopes were discussed in one habitat profile, while cliffs were addressed in a separate profile. However, these habitats are associated with features that often occur in close proximity to one another on the landscape and are often the result of related geologic processes, and it was considered opportune to lump them together for the purposes of habitat modeling and mapping. Despite this lumping, cliff and talus habitats are still delineated separately from rocky ridges on habitat maps, and these habitats will be discussed separately in this profile where appropriate.

The combination of habitats discussed in this profile corresponds to six natural community system types as described by NHNHB (Sperduto 2011). These systems can be divided into two major groups primarily by elevation and geographic distribution. The first of these groups includes the montane rocky ridge, montane - subalpine cliff, and montane talus slope systems. These are montane systems, generally occurring above 2,200 ft. in elevation, and found primarily in the White Mountains and the highlands of west-central New Hampshire. The second group are temperate (<2,200 ft.) systems found primarily in central and southern New Hampshire. These are the temperate ridge - cliff - talus, rich temperate rocky woods, and rich Appalachian oak rocky woods systems.

Cliffs are steep rocky outcrops greater than 65 degrees in slope and over 3 meters in height. Both montane - subalpine and temperate cliffs are exposed to the elements, do not accumulate significant amounts of snow pack, and may be protected from runoff by overhangs. Vegetation is sparse and is usually restricted to cracks and crevices where soil accumulates. Although cliffs are generally dry, seeps do occur and may influence vegetation, pH, and nutrients.

Montane rocky ridges occur on outcrops and shallow-to-bedrock ridges and summits at mid-elevations in New Hampshire. They are dominated by some combination of red spruce (*Picea rubens*), red pine (*Pinus resinosa*), and red oak. Outcrops include cliff slabs, which are steep bedrock exposures of < 65 degree slope. This system includes nearly all the rocky ridges in the White Mountain region and other rocky exposure between 1,300–3,000 ft. in elevation elsewhere in the state. These rocky ridges, summits, and slabs have a woodland to sparse woodland canopy structure (ranging from completely open patches to forest cover < 60%) and extensive open bedrock.

Talus slopes commonly occur below steep mountain slopes and cliffs, usually as a result of mass wasting of the cliff above. The boulders and other component rock material can be stabilized or loose. Montane talus slopes are found at mid to high elevations in the White Mountains and are characterized by spruce, fir, and various other northern species. This system tends to have an open woodland character, with frequent canopy gaps and lichen-dominated talus barren openings. Soil development is variable on these slopes, and moisture conditions range from dry to mesic. Larger examples can have giant talus blocks at their base with late-melting ice that produces a cold, moist microclimate supporting alpine plants well below treeline. This system mostly occurs above 2,200 ft. in elevation, but occasionally down to about 1,500 ft.

In the temperate group, the temperate ridge - cliff - talus system combines the three habitats in a single system, because individual rocky ridge, cliff or talus landscape settings at lower elevations rarely occur at system-level scales that support more than 1 or 2 natural community types. However, system-level complexes of communities are found where ridge, cliff, and talus formations co-occur at single sites (or at least two out of three). In these circumstances, each setting may only contain one or two communities, but collectively form repeating assemblages of 3-6 communities. In the mountains, the montane rocky ridge, montane - subalpine cliff, and montane talus slope systems remain separate, as they tend to occur at larger scales and with a greater diversity of communities, meriting their system status.

The temperate ridge - cliff - talus system is typically expressed as a complex mosaic of rocky woodlands, rock outcrops, cliffs, and talus slopes with an abundance of oaks, pitch or white pines, and other temperate species. Rocky ridge communities usually occupy ridgetops and upper slopes and have a woodland or sparse woodland structure with extensive bedrock exposure. These bedrock outcrops include slabs with less than 65 degree slopes. Slabs with slopes greater than 65 degrees are classified as temperate acidic cliffs. Where fracturing of cliffs and slabs produces accumulations of large boulders, talus communities are formed. These include temperate lichen talus barrens, which are lichen-dominated boulder fields with little vascular plant cover, and wooded talus communities such as red oak - black birch wooded talus, which generally have an open woodland structure. Wooded talus communities have variable and patchy understories of tall shrubs, vines, flowering herbs, and ferns such as rock polypody (*Polypodium virginianum*) .

The other two systems within the temperate group are the rich temperate rocky woods and rich Appalachian oak rocky woods systems. Structurally, these two systems are quite similar, occurring primarily as closed-canopy forests on slopes with significant amounts of exposed bedrock and/or loose boulders. They both have plant species compositions that reflect enriched soil conditions. The rich Appalachian oak rocky woods system has a more southerly distribution in NH, occurring within 30 miles of the coast or the Massachusetts border, and is characterized by the dominance of Appalachian species such as white oak (*Quercus alba*), hickories (*Carya* spp.), and flowering dogwood (*Benthamidia florida*). While both of these systems occupy rocky slopes, many occurrences lack the large accumulation of talus boulders that provide habitat structure favored by many wildlife species.

Justification (Reason for Concern in NH)

Talus Slopes And Rocky Ridges:
Talus slope and rocky ridge habitat is uncommon throughout the Northeast, occurring mostly in isolated patches near cliffs and on the tops of low mountains and hills. Due to their scenic views, rocky ridges are recreational destinations, and thus the potential for recreational impacts to the habitat is high. As in alpine habitat, soil depth is shallow and therefore the vegetation is highly susceptible to trampling (D. D. Sperduto, NHNHB, personal communication). Multiple instances of damage and threats to rare plant populations and exemplary natural community occurrences in rocky ridge settings have been documented (NHNHB 2005). Rock outcrops in intensively managed forests have been shown to serve as important biodiversity refugia for some bryophyte species (Pykala 2004), and therefore presumably for related invertebrates and other
wildlife species that use this habitat. Rocky ridges may also be targeted for wind energy development. Due to the inaccessible nature of talus slopes, human impacts exist primarily on the rocky ridge portion of this habitat, though some bootleg trails and other impacts are found on talus. For example, rock-climbing activity, in particular, has been found to decrease plant diversity and gastropod species richness, density, and diversity on the talus at the base of cliffs with climbing routes (McMillan and Larson 2002, McMillan et. al. 2003). Talus slopes have a distinct habitat compared to cliffs (Kubesova and Chytry 2005) and therefore should be treated separately in conservation plans. Talus slopes and rocky ridges provide crucial habitat for several rare wildlife species in New Hampshire, including timber rattlesnake and bobcat.

Cliffs:
Cliffs are primary nesting sites for the state threatened American peregrine falcon (*Falco peregrinus anatum*). Cliffs are used by many other species as well, including the state endangered golden eagle (*Aquila chrysaetos*), common raven (*Corvus corax*), state endangered timber rattlesnake (*Crotalus horridus*), long-tailed shrew (*Sorex dispar*), rock vole (*Microtus chrotorrhinus*), state endangered eastern small-footed bat, (*Myotis leibii*), gray fox (*Urocyon cinereoargenteus*), and
bobcat (*Lynx rufus*) (DeGraff et al. 2006). The extreme range in chemical and physical factors (e.g., pH, temperature, moisture) found on cliffs may be important to endemic invertebrates and plants. Although often viewed as isolated or inaccessible, the popularity of cliffs and cliff tops as recreational destinations is rapidly increasing.

Protection and Regulatory Status

Very little of New Hampshire's rocky ridge, cliff, or talus habitat is protected by laws, rules, or regulations. A notable exception, however, is within the boundaries of the WMNF where many of New Hampshire's larger examples or groupings of these habitats occur and where several forms of protection apply. In the 2004 revised management plan (draft) for the WMNF, special protection is afforded specifically to "the rarest exemplary natural communities," including all exemplary cliff and talus slope communities (US Forest Service 2004). The WMNF is part of the National Wilderness Preservation System (16 U.S.C. 1131-1136, 78 Stat. 890). Some of these habitat areas occur within federally owned areas designated by Congress as "Wilderness Areas." There are currently 4 Wilderness Areas in the WMNF (Great Gulf, Presidential-Dry River, Pemigewasset, and Sandwich) containing talus slope and rocky ridge habitat. Management practices and recreational impacts are tightly restricted in these areas.

Cliffs: Areas occupied by state endangered and threatened plants and animals are protected under RSA 217-A and RSA 212-A respectively. Under the 1979 Peregrine Falcon recovery plan, the United States Fish and Wildlife Service (USFWS) protects peregrine falcon nests. Areas within 20 m of peregrine falcon nests are closed to hikers and climbers during the nesting season, typically April to August (United States Forest Service (USFS) 2004).

The White Mountain National Forest (WMNF) prohibits rock defacement, including “chipping to create foot and hand holds, gluing to stabilize features, and attaching permanent artificial handholds. Route cleaning is prohibited where federal-listed threatened, endangered, and sensitive species occur. Removing, altering, or manipulating vegetation, soils, or other natural features at the cliff edge, talus slope, or cliff base is prohibited. To protect natural features, the use of mechanical or motorized devices, explosives, or chemicals for cleaning or developing climbing routes is prohibited” (WMNF Proposed Land and Resource Management Plan 2004). The Department of Resources and Economic Development (DRED) has no regulations for rock climbing on state lands, with the exception that hikers must register before climbing any routes on Cannon Cliff (Webster 1996). The USFWS (1979) established a landowner agreement to protect peregrine nesting sites.

Distribution and Research

In New Hampshire, rocky ridge, cliff, and talus slope habitat occupies approximately 2% of the state. There is no particular locus of concentration, with isolated polygons and clusters of polygons occurring throughout the state. However, this habitat by definition does occur more frequently in the mountains and regions with steep hilly slopes, such as the White Mountains, hilly ridges in the central and western parts of the state, and discreet mountain areas such as Pawtuckaway State Park and the Ossipee Mountain Range.

CLIFFS: Cliffs occur throughout the mountainous and lowland regions of New Hampshire. Montane acidic cliffs are found in northern areas at elevations of 360 to 1,000 m (1,200 to 3,500 ft). Montane circumneutral cliffs are found in the northern White Mountains at elevations of 275 to 1,000 m (900 to 3,500 ft). Temperate acidic and circumneutral cliffs are found south of the White Mountains below elevations of 300 m (1,000 ft). Calcareous cliffs are restricted to western New Hampshire along the Connecticut River (Sperduto and Nichols 2011). Seeps can occur in any of these cliff types.

Research is needed to relate the patterns of plant and animal diversity to the chemical and physical at-tributes of cliffs. Surveys and long-term monitoring may be needed to determine species composition, trends, and conservation targets. Surveys should be designed to include all taxa, including invertebrates.

Relative Health of Populations

There are over 100,000 acres of rocky ridge, cliff, and talus habitats in New Hampshire, and of this, roughly 68% occurs on conservation lands.

Habitat Condition

A set of GIS data was used to assess ecological condition of each habitat type. Chapter 3 describes the methodology. The data used for this habitat is described below.

Biological Condition:
Species richness of rare animals within polygon
Species richness of rare animals within their dispersal distances from the polygon

Species richness of rare plants in polygon
Richness of rare and exemplary natural communities in polygon

Landscape Condition:
Contiguous area of adjacent ridge/talus/cliff habitat combined (hectares)
Local Connectedness

Human Condition:
Index of Ecological Integrity scaled to State
Climbed (identified per 2005 WAP Cliffs data, and newer WMNF rock climbing trail areas)
Distance to nearest hiking trail (meters)
Distance to nearest road (meters)

Habitat Management Status:

The 4 Wilderness Areas in the WMNF containing talus slope and rocky ridge habitat (Pemigewasset, Presidential-Dry River, Sandwich Range, and Great Gulf Wilderness Areas) are managed according to the guidelines and standards delineated in the Land and Resource Management Plan for the WMNF, such that natural processes are allowed to continue with minimal impediment, effects and impacts of human use will be minimized, primitive recreation opportunities will be provided, appreciation of the qualities of wilderness landscapes will be fostered, and utilization for educational and scientific purpose will be continued (USFS 2004). National scenic trails bisecting talus slope and rocky ridge habitat will be administered in accordance with the Wilderness Act (1981) and are under the management authority of the Cooperative Management System (1984 MOU between the USFS and the Appalachian Trail Conference), composed of the Appalachian Mountain Club, Dartmouth Outing Club (DOC), NHDES, and WMNF. In addition, an MOU between NHFG, USFWS, and the USFS was established in 1996 delegating authority to develop, maintain, and manage all of the fish, wildlife, and rare plant resources and their habitats within the WMNF to NHFG.

CLIFFS: The 1996 MOU between the NHFG, USFWS, and USFS gives NHFG authority to develop, maintain, and manage all of the fish, wildlife, and rare plant resources within the WMNF. The 1993 memorandum of understanding (MOU) between DRED and NHFG directs land management practices that offer opportunities to combine agency resources for the improvement of wildlife habitat, forest recreation, and forestry operations for public use and benefit. In areas where cliffs occur in the WMNF, habitat improvement is forbidden because habitat should only be a result of natural processes (USFS 2004).

Cliff habitat improvement is not known to be occurring anywhere else in New Hampshire, although some cliff-dwelling species are being managed. Climbing routes that are less than 20 m from known peregrine falcon nesting sites are closed during the breeding and nesting seasons. ASNH posts cliff closure signs to protect peregrine falcons, WMNF has at least one falcon-related display on the Kancamagus Highway, and the Appalachian Trail Conference (ATC) and National Park Service (NPS) created an interpretive sign about cliff ecology that has been installed at Holts Ledge in Lyme, New Hampshire.

Informal agreements exist with Appalachian Mountain Club (AMC), EMS, and IME (1986) regarding posting cliff closure signs (for rare bird nesting) in stores and clubhouses to steer hikers away from Franconia Notch, Willard, and Frankenstein. Under an MOA between Rumney Climbers Association and WMNF, “The Rumney Climber’s Association has the sole responsibility for overseeing fixed anchors, erosion control, new route activity, trail maintenance, posting peregrine falcon closures, and monitoring the status of rare plants at this popular New Hampshire climbing area."

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Disturbance and habitat degradation from hiking and biking trails (Threat Rank: Medium)

Recreational use of rocky ridge habitat is high (much less so for talus slopes). Human disturbance, primarily trampling and off-road vehicle use, is the greatest threat to rocky ridge habitat (USFS 2004, D. D. Sperduto, NHNHB, personal communication). Structures, designated trails, undesignated trails, climbing routes, popular ski areas, and viewpoints co-occur with the some of the most sensitive rocky ridge communities, such as those at Mount Cardigan in Orange, Mount Pawtuckaway in Nottingham, and Humphreys Ledge in Bartlett (NHNHB 2005). The disturbance incurred at such sites from trampling in summer and snow compaction in winter (both from foot traffic and snowmobiles) may result in vegetative stress, mortality, and erosion, thereby reducing recolonization within these sensitive communities.

Magnitude of response is strongly correlated with trampling intensity (Cole 1995, USFS 2004). Like alpine communities, rocky ridge communities and their soils have been shown to have low tolerances for trampling (Sperduto and Cogbill 1999, D. D. Sperduto, NHNHB, personal communication). Substantial reductions in vegetation cover and height, as well as soil erosion, can result from trampling (Cole 1995, Cole and Monz 2002). Despite varying tolerances of trampling resistance and resiliency among natural communities within this habitat, they all have a threshold beyond which impacts become irreversible (D. D. Sperduto, NHNHB, personal communication).

Habitat degradation from mining activities (Threat Rank: Medium)

Cliff or rocky ridge habitats could be mined, essentially destroying the habitat.

Quarrying of dimension stone (RSA 155-e) is permitted by the state through the Department of Resources and Economic Development. In the past 13 years, there has been one permit application for a new stone quarry in New Hampshire (W. Carpenter, pers. comm.). While there are currently some quarries operating without permits, their extent is limited.

Habitat conversion and degradation from wind tower and turbine development or communication towers, potential for ongoing wildlife impacts through direct mortality and disturbance to behavior. (Threat Rank: Medium)

Construction of cell towers or wind turbines could directly impact rocky ridges and indirectly affect cliff faces via increased erosion. There is an increased risk of migratory bird mortality in areas with towers and turbines (Kerlinger 2000).

There were 78 known towers sited in New Hampshire as of 2010 (www.towerkill.com) and 475 towers currently mapped by NHFG. Kerlinger (2000) prepared an extensive literature review for the USFWS

Office of Migratory Bird Management on avian mortality at towers and turbines. Birds that migrate along ridgelines at night are at greatest risk for tower collision by becoming disoriented when encountering lighted towers (Partners in Flight, unpublished data). Current estimates of the numbers of birds killed annually by communication towers range between 4 and 10 million (www.towerkill.com). Bats are also vulnerable to impacts from wind energy facilities. Based on field data collection in a study of bat mortality at a wind energy facility in West Virginia, Hein et al. (2013) estimated a mortality rate of roughly 100 bats per turbine per year.

Habitat conversion due to development (Threat Rank: Medium)

Rocky ridges may be impacted by the construction of vacation homes. Clifftop development could impact cliffs through erosion.

There is little evidence to suggest that rocky ridges, cliffs and talus slopes are experiencing significant development pressure.

List of Lower Ranking Threats:

Habitat degradation and disturbance from climbers

Habitat degradation and conversion due to clifftop development

Habitat degradation from drought stress and associated mortality of vegetation

Habitat impacts from drought stress and associated mortality of vegetation

Habitat degradation from energy development, including direct impact to clifftop and indirect impact to cliff face

Mortality and habitat impacts (fragmentation) from roads

Disturbance to cliff-nesting species from timber harvesting occurring near cliffs

Habitat degradation and conversion due to clifftop development Mortality

from the commercial collection of individuals from the wild Habitat

degradation and species impacts from mercury deposition Disurbance to

nesting species from motorized recreation near cliff face Habitat

degradation from snow compaction related to recreational activity Habitat

degradation from fire suppression that causes vegetation changes Habitat

degradation from fire suppression that causes vegetation changes Habitat

degradation and species impacts from acid deposition

Habitat degradation from acid deposition

Mortality and disturbance related to intentional or unintentional shooting and trapping

Actions to benefit this Habitat in NH

Advise trail managers on mitigation for habitat impacts, regulation, and policy

Primary Threat Addressed: Disturbance and habitat degradation from hiking and biking trails

Specific Threat (IUCN Threat Levels): Human intrusions & disturbance

Objective:
Reduce impacts of recreation on rare plant populations and exemplary occurrences of rare natural community types associated with rocky ridge habitats.

General Strategy:
NHFG will delineate sensitive areas and provide trail advisories to all managing agencies to mitigate trail impacts to wildlife and wildlife habitats. NHFG will become a recognized participant of the Appalachian Trail Conference (ATC) Cooperative Management System. Participants include AMC, DOC, NHDES, and WMNF formalized through a series of cooperative agreements at both the state-level and trail section-by-trail section level (New Hampshire is one of the only states that do not have a wildlife agency as a partner). The NHFG will be involved in the development, review, and approval of the Appalachian Trail Local Management Plan. The NHFG will enter a Memorandum of Agreement with the Department of Resources and Economic Development to maintain and manage trails in accordance with the health of wildlife and wildlife habitats. The NHFG will review the 1996 Memorandum of Understanding between the Department, USFWS, and the USFS.

Political Location: **Watershed Location:**

Conduct research on impacts of recreational climbing on cliff habitats and rare plant and animal species.

Primary Threat Addressed: Habitat degradation and disturbance from climbers

Specific Threat (IUCN Threat Levels): Human intrusions & disturbance

Objective:
The objective is to identify where recreational climbing is having an impact on cliff vegetation and rare plant species.

General Strategy:
Site-specific information on the impacts of climbers in NH is generally lacking, and is necessary if management of recreational activities is going to be successful. WMNF is currently in the midst of a study on the impacts of recreational climbing, but follow-up visits have not been conducted, and these results may have to be supplemented by further research.

Political Location: **Watershed Location:**
Statewide

Advise Site Evaluation Committee on wind energy facilities

Primary Threat Addressed: Habitat conversion and degradation from wind tower and turbine development or communication towers, potential for ongoing wildlife impacts through direct mortality and disturbance to behavior.

Specific Threat (IUCN Threat Levels): Energy production & mining

Objective:
To minimize impacts on rocky ridge habitats.

General Strategy:
Examining potential long and short-term implications of wind farm development and maintenance will aid in making decisions and recommendations dealing with wind farm proposals at local, state, regional and a national level.

Political Location:
Statewide

Watershed Location:

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Shrublands

Photo by NHFG

Habitat Distribution Map

Acres in NH: not available
Percent of NH Area: Acres
Protected: Percent
Protected:

Habitat Description

Shrublands are habitats dominated by shrubs or young trees, sometimes interspersed with mature trees (see also pine barrens) or open bare or grassy areas. Typical examples in New Hampshire include regenerating timber harvests, power line rights-of-way, shrubby old fields and edges, and reverting gravel pits. From a wildlife perspective, such habitats can be subdivided into those dominated by shrubs vs. dominated by saplings (Oehler et al. 2006). The former – sometimes referred to as "scrub-shrub" – is more typical of abandoned old fields and utility rights-of-way. Such habitats can often persist for relatively long periods without the need for additional management. Saplings, on the other hand, are typical of areas subject to timber harvest, and rarely retain early successional characteristics beyond 15-20 years. These are also regularly referred to as "young forest," and are also considered under the several forest habitat profiles in the 2015 Wildlife Action Plan. Both sub-types will be referred to as "shrubland" habitat throughout this profile unless otherwise noted.

Justification (Reason for Concern in NH)

Shrubland and other woody-dominated early-successional habitats are in decline in New Hampshire and throughout the northeast region (Trani et al. 2001, Brooks 2003). As such, the wildlife species associated with shrubland habitats are also in decline (Hunter et al. 2001, Litvaitis 2001, Dettmers 2003, Wagner et al. 2003). In New Hampshire, birds typical of early successional habitats are declining more than any other habitat group (22 of 28 species, Hunt 2009). In addition, Partners in Flight (PIF), a cooperative bird conservation organization seeking to maintain populations of North American landbirds, has identified the northeast region as being particularly important for maintaining source populations of shrubland birds and many are PIF priority species for the ecoregion that comprise New Hampshire (Dettmers 2003). Since 1960, the distribution and abundance of New England cottontail has declined substantially throughout New England (Johnston 1972, Jackson 1973, Litvaitis 1993). They have declined to such an extent that in 2006 they were designated as a “candidate” for federal listing under the Endangered Species Act. Additionally, 139 species of reptiles, amphibians, birds, and mammals either prefer (17 species) or utilize (122 species) shrub and old-field habitats (Scanlon 1992).

Protection and Regulatory Status

Shrubland habitats in general have no special regulatory status. Shrublands inhabited by state endangered or threatened species are protected under RSA 212 if habitat modification would affect the species.

Few natural resource protection programs focus on shrubland habitats.

Distribution and Research

The amount of early-successional habitat increased dramatically after European settlement. Much land was cleared for farmland in the 18th and 19th centuries (Cronon 1983, Whitney 1994). However, cleared lands were abandoned in the mid 1800s for more productive farms in the midwestern United States and the industrialized cities of the northeast. Many tracts of land that were cleared for agriculture reverted to second-growth forests and species associated with early-successional habitats abounded (Irland 1982, DeGraaf and Miller 1996, Foster et al. 2002, Litvaitis et al. 2005). Most of the abandoned farmlands matured into closed-canopy forests by 1960 and species dependent on these habitats quickly declined (Litvaitis 1993).

Today, given the lack of fires and the reduction in areas potentially impacted by beavers, coupled with the extent and effect of habitat fragmentation caused by development, especially in the southeastern part of the state, the future health of shrubland wildlife is dependent on active management to reclaim and maintain a suitable network of habitat patches on the landscape. Doing so is especially important for species like New England cottontails, which are threatened with extirpation in New Hampshire.

Relative Health of Populations

One reasonable indicator of shrubland habitat health in New Hampshire is the trend in the amount of forestland dominated by seedlings and saplings. From 1973 to 2002, the amount of area in seedling/sapling forest declined 63% from nearly 449,000 hectares to just over 167,000 hectares. Seven counties experienced a 70 – 100% decline. Grafton County experienced a 55% decline. Coos County, where much of New Hampshire’s industrial forests are located, experienced only a 12% decline. More recently, increases in timber harvesting resulted in a net gain of roughly 30,000 ha of some sort of early successional habitat between 2001 and 2010 (NOAA 2014).

It is difficult to ascertain the extent of shrubland habitats in New Hampshire historically or currently. A number of mechanisms are theorized to have created and maintained shrubland habitats prior to European colonization. These include Native American use of fire and beaver activity.

Habitat Condition

A set of GIS data was used to assess ecological condition of each habitat type. Chapter 3 describes the methodology. The data used for this habitat is described below.

Biological Condition:
To be updated at a later date

Landscape Condition:
To be updated at a later date

Human Condition:
To be updated at a later date

Habitat Management Status:

Creation and management of shrublands and young forest in the Northeast have been identified as a priority by conservation partners (citations). Several large scale initiatives have been working within New Hampshire to improve the amount of this habitat available on the landscape including: The Young Forest Initiative (www.youngforest.org), The New England Cottontail Initiative (www.newenglandcottontail.org), and The Woodcock Initiative (www.timberdoodle.org). The American Woodcock and Ruffed Grouse Conservation Plans call for the creation of over 600,000 acres of early-successional habitat annually in the Northeast to restore populations of these popular game birds. There are numerous songbirds of conservation concern listed in state Wildlife Action Plans that require early-successional habitat including shrublands and Partners in Flight Plans call for the generation of millions of acres of shrubland and young forest habitats across the region to maintain or reverse declines of these species including golden-winged warblers and whip-poor-will. Similarly State and Federal agencies have been identifying and implementing management acres on lands under their control contributing to the presence of this habitat type across the landscape.

Financial & Technical Assistance Programs

There are a number of programs that provide financial and technical assistance to landowners to manage and reclaim shrubland habitats for wildlife. These include the United States Department of Agriculture's Environmental Quality Incentive Program (EQIP), as well as the United States Fish & Wildlife Service's Partners for Fish & Wildlife Program (Partners Program), and the New Hampshire Fish & Game (NHFG) Department's Small Grants Program. University of New Hampshire Cooperative Extension specialists and county-based educators in the Forestry and Wildlife Program, and NHFG Regional biologists also provide technical assistance to landowners on wildlife habitat management issues.

The Environmental Quality Incentives Program offers financial and technical help to assist agricultural producers install or implement structural and management practices on eligible agricultural land. An EQIP Technical Committee in each state sets eligible habitat improvement practices. There are nearly 70 eligible practices in New Hampshire. These include such things as nutrient management and the installation of manure storage facilities to restoration of declining habitats. Eligible EQIP practices that would benefit shrubland habitat include brush management, hedgrerow planting, prescribed grazing, restoration and management of declining habitats, and tree/shrub establishment, among others. Statistics are currently unavailable to determine how many hectares have been treated with each of these practices.

Since 1990, the U.S. Fish & Wildlife Service's Partners for Fish & Wildlife Program in New Hampshire has provided technical and financial assistance to landowners, state agencies, many organizations and individuals to restore fish and wildlife habitat such as coastal wetlands, riparian habitats, and grasslands (USFWS 2001).

Since its inception in 2001, the NHFG Small Grants Program has funded 165 acres of alder/aspen regeneration projects, and nearly 2,400 acres of old field maintenance. NHFG Regional staff provide technical assistance on the planning of these projects.

Management on State Lands

The NHFG owns in fee-simple nearly 300 hectares of fields (NHFG unpublished data). Two hundred twenty eight hectares are maintained in active agriculture (either hay or cropland). The remainder is maintained via brush hog mower with mowing occurring every 1-3 years after the bird nesting season. Field management is reviewed periodically to determine if any should be converted to shrubland habitat. Because of the great need for shrubland habitat in the southeastern part of the state, several hectares of field land on WMAs are in the process of being coverted to shrubland including nearly 15 hectares on the Lamprey River WMA in Durham, and another approximately 15 hectares on the Bellamy WMA in Dover.

The Department of Resources and Economic Development (DRED) owns in fee-simple or under conservation easement approximately 543 hectares of fields and shrubland openings (DRED unpublished data). Forty hectares are maintained in active agriculture (either hay or cropland). One hundred thirty seven hectares are maintained via mowing by State Parks or NHFG personnel. The remainder is not maintained on a regular basis. The NHFG State Lands Biologist will be working with DRED to evaluate the fields under DRED management to determine which ones would be more suited for shrubland habitat management and to develop a strategy for maintaining them.

Management on Other Lands

All other shrubland habitats occur on federal lands (e.g., White Mountain National Forest, Umbagog National Wildlife Refuge, Great Bay National Wildlife Refuge, Pondicherry National Wildlife Refugue, and others), private land, and to a much lesser extent land of private landtrusts, municipalities, and other conservation organizations/agencies. It is not known to what extent shrubland habitats are maintained on these lands.

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation due to natural succession or lack of active management (Threat Rank: High)

Shrubland and young forest may revert to a closed canopy forest with little to no understory in the absence of disturbance reducing the available habitat for a suite of species. As more open land is converted to development there is less overall space for shrubland-dependent species to shift into when natural forest succession or lack of active management makes their current habitat patch unsuitable.

With the decline of native shrublands (e.g, pitch pine-scrub oak barrens, dune thickets) from development and degradation, human created shrublands (e.g., old fields, reverting gravel pits, rights-of-way) have increased in importance to shrubland-dependent wildlife. These human created shrublands are ephemeral and require natural or human disturbance to retain their shrubby structural characteristics (Brooks 2003).

Habitat conversion due to development and impacts from fragmentation (Threat Rank: High)

Direct loss of shrubland habitat occurs through the conversion to residential, industrial, and commercial development resulting in fragmentation of remaining habitat patches.

In eastern North America over the last 60 years, open habitats (grasslands, savanna, barrens, and shrublands) have declined by 98%, with shrubland communities comprising 24% of this decline (Tefft 2006). New Hampshire's population grew by 17.2% from 1990 to 2004--the fastest growing state in the northeast for the past four decades.

Mortality from subsidized or introduced predators (Threat Rank: Medium)

As a landscape becomes fragmented by development and agriculture, patches of suitable shrubland habitat shrink in size, while predator populations increase in number due to expanded food availability (crops, garbage, bird feed, pet food left unsecure, etc.). This makes it much more likely that predators will penetrate and prey on wildlife attempting to utilize those small shrubland patches.

Populations of generalist predators including foxes, raccoons, skunks, and crows often thrive in developed landscapes because of their ability to take advantage of resources associated with humans (Barbour and Litvaitis 1993, Oehler and Litvaitis 1996). Large populations of these predators result in predation rates that can reduce or even eliminate small populations of prey species like New England cottontails and some songbirds.

Habitat and species impacts from introduced or invasive plants (Threat Rank: Medium)

Many of the high risk invasive plants in New Hampshire are woody shrubs that thrive from disturbance. These invaders rapidly colonize sunny openings outcompeting native seedlings, in some cases forming dense monocultures. The impact of these invaders on wildlife differs greatly usually due to a change in structure or availability of food resources generated from them (berries, host specific caterpillars).

American robin experiences higher levels of predation when nesting in common buckthorn as compared to nesting in native species (Schmidt and Whelan 1999). Nutritional analysis of fruits from common native and invasive shrubs in New York showed that native shrubs have the highest fat content and energy densities (Smith et al. 2013). Monocultures of glossy buckthorn reduce diversity of woody species regeneration following canopy removal, reducing habitat quality for species such as New England cottontail which require a more varied stem structure to provide cover during winter (NHFG observation).

Habitat impacts resulting from a lack of public support for creation and maintenance of shrublands and young forest (Threat Rank: Medium)

Opposition to even age timber management ("clear cutting") has resulted in selective removal of tree species which does not result in dense shurbland and young forest.

The public support for large timber harvests (clear cuts) has generally declined in the past 50 years. A survey conducted for NHFG by Responsive Management in 2004 indicates 51% of respondents moderately or strongly oppose clearcuts <5 acres while 72% moderately or strongly oppose clearcuts >5 acres. Additionally, biologists cite lack of support by the public, landowners, and even some resource professionals to the types of management that would lead to the development or maintenance of shrublands, and a lack of funding and staff to attain habitat management goals on public land or to provide sufficient technical and financial assistance to private landowners (Oehler 2008).

Habitat impacts from aspects of right-of-way management (Threat Rank: Medium)

Utility corridors are maintained on average 3-4 year cycle across the state by mowing all woody vegetation in the boundaries. The regeneration of the woody vegetation is beneficial to wildlife in between maintenance cycles, but may become a sink habitat resulting in losses during the year of vegetation removal.

Several species of early successional birds regularly use right-of-way, and many reach their highest densities in these habitats (Hunt 2013). Habitat along utility corridors facilitate dispersal of New England cottontail among patches (Fenderson et al. 2014).

List of Lower Ranking Threats:

Disturbance and mortality from walking and training dogs (Emphasis on off-leash

dogs) Habitat and species impacts from hiking, biking, and horse back riding

Habitat degradation and disturbance from legal and illegal OHRV activity

Habitat degradation from active sand and gravel mining and reclamation practices that make habitat unsuitable

Actions to benefit this Habitat in NH

Develop and implement a statewide invasive species management plan.

Primary Threat Addressed: Habitat and species impacts from introduced or invasive plants

Specific Threat (IUCN Threat Levels): Invasive & other problematic species, genes & diseases

Objective:

General Strategy:
Work with the state Invasive Species Council to develop a plan prioritizing resources for invasive species management. This is especially important when creating or maintaining shrublands and young forest habitat because it is very susceptible to invasion.

Political Location: **Watershed Location:**

Habitat Management and Restoration

Primary Threat Addressed: Habitat degradation due to natural succession or lack of active management

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:

General Strategy:

Since shrubland habitats are relatively short lived, 20 to 25 years in most cases, periodic management is needed to maintain the dense habitat structure. The frequency of vegetation management necessary to maintain shrubland conditions depends on site conditions. Relatively stable shrublands require monitoring and occasional selective cutting, mowing, or herbiciding of small trees that invade the area (e.g., every 5 years). Reclamation of old fields, pastures, or gravel pits that have succeeded to second growth forest will initially require aggressive clearing using a hydroaxe, Brontosaurus, or tree shear to remove larger unwanted trees. Once shrublands become well established they may require only periodic mowing or cutting, every 5 to 10 years or more (Tefft 2006).

Political Location: **Watershed Location:**

Work with public utility companies to develop and implement ROW management strategies that will promote shrublands

Primary Threat Addressed: Habitat impacts from aspects of right-of-way management

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:

General Strategy:

Coordinate with utility companies to develop integrated management plans that will promote shrub species and maintain cover within rights-of-way instead of clear cutting all vegetation every 3-4 years with the boundaries.

Political Location: **Watershed Location:**

Habitat Protection

Primary Threat Addressed: Habitat conversion due to development and impacts from fragmentation

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:

General Strategy:

Permanently protecting the most important shrublands that have known populations of SGCN (e.g., New England cottontail) through fee simple acquisitions or conservation easements will ensure that these habitats are maintained in perpetuity for priority wildlife species and other plants and animals. Land conservation measures will also provide a more consistent opportunity to manage shrubland conditions that are ephemeral without human or natural disturbance.

Political Location: **Watershed Location:**

Statewide

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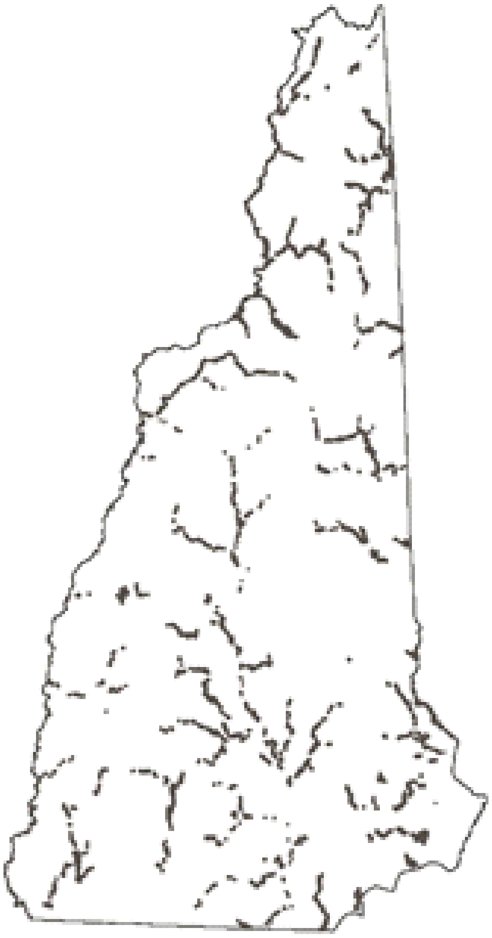
Floodplain Habitats

Photo by Ben Kimball



Habitat Distribution Map

Acres in NH:	23,201
Percent of NH Area:	>1
Acres Protected:	7656
Percent Protected:	33

Habitat Description

Floodplains occur in river valleys adjacent to river channels and are prone to periodic flooding. Floodplains are often comprised of forests, oxbows, meadows, and thickets. The habitats, vegetation, and hydrologic regime of floodplains are strongly influenced by watershed size, gradient, and channel morphometry. Most open or partially wooded floodplain communities occur on low floodplains. Sloughs, oxbows, vernal pools, and other depressions in the floodplain tend to be inundated for longer periods than low floodplains (Sperduto 2011). Floodplain soils range from well-drained coarse sand on levees to poorly drained silts and mucks in depressions, and tend to be moderately to strongly minerotrophic (Sperduto 2011).

Montane/near-boreal floodplains are found primarily along rivers in the White Mountains or northern New Hampshire, and have relatively high gradients and flashy flood regimes compared to other floodplain systems. Sugar maple (*Acer saccharum*) and balsam fir (*Abies balsamea*) are dominant trees, and riparian wetlands such as oxbows and sloughs are uncommon in these high-gradient floodplains.

Major river silver maple floodplains occur primarily along the Connecticut and Merrimack Rivers, and occasionally on lower reaches of major tributaries. These floodplains are often interspersed with oxbow marshes and shrub communities. The forested areas are characterized by a canopy of silver maple (*Acer saccharinum*) over a lush herbaceous layer, with a sparse shrub layer.

Temperate minor river floodplains are found along large streams and small rivers in central and southern New Hampshire. These ecosystems are usually comprised of a mosaic of red maple forests, oxbows, vernal pools, and shrub thickets. Minor river floodplains generally have reduced flood intensity and duration compared to large river floodplains. In addition to red maple, sycamore and swamp white oak floodplain forests occur less commonly (Sperduto and Nichols 2011).

Justification (Reason for Concern in NH)

Riparian forests support diverse natural communities, protect and enhance water quality (they filter and sequester pollution), and control erosion and sediment (NHOSP 1989, Welsch 1991, Dahl 2000). Tockner and Stanford (2002) estimate that in Europe and North America, up to 90% of flood plains are under cultivation and are functionally extinct.

Riparian forests support a variety of wildlife resources. They provide breeding habitat for a number of bird species, including the red-shouldered hawk (*Buteo lineatus*), veery (*Catharus fuscescens*), cerulean warbler (*Dendroica cerulea*), American redstart (*Setophaga ruticilla*), warbling vireo (*Vireo gilvus*), and Baltimore oriole (*Icterus galbula*) (Foss et al. 2000a, Hunt 2005). They also provide habitat for migratory and upland breeding birds (Foss et al. 2000b). Mammals associated with rivers and streams, particularly beaver (*Castor canadensis*), mink (*Mustela vison*), and river otter (*Lutra canadensis*), rely on riparian forests. Floodplain wetlands, such as vernal pools and oxbow marshes, are important breeding areas for a number of amphibians, including Jefferson salamander (*Ambystoma jeffersonianum*) and northern leopard frog (*Lithobates pipiens*). These wetlands also provide habitat for reptiles, such as wood turtle (*Glyptemys insculpta*), Blanding's turtle (*Emydoidea blandingi*), and spotted turtle (*Clemmys guttata*).

Protection and Regulatory Status

- Any laws that deal with regulation of freshwater wetlands would apply in portions of the floodplain considered jurisdictional wetlands (RSA 482-A).
- FEMA administers the National Flood Insurance Program, which works with local jurisdictions to regulate development in floodplains, with the primary purpose of minimizing future flood damage (FEMA 2005).
- The Shoreland Protection Act (NHDES, RSA 483-B) requires that farmers follow BMPs as established by the New Hampshire Department of Agriculture. Most of these BMPs pertain to the storage and/or application of fertilizers and pesticides near waterways for maintaining water quality and do not address floodplain habitats. The Shoreland Protection Act also limits the amount of tree removal and other activities within 250 ft. of rivers and requires a primary structure setback of at least 50 ft.

Distribution and Research

Floodplain forests are found along rivers throughout New Hampshire. The montane/near-boreal floodplain system is found primarily in the White Mountains and North Country, although there are some examples in the Sebago-Ossipee region and along the Pemigewasset River south of the White Mountains. Major river silver maple floodplains are found along the main stems of large rivers, such as the Merrimack, Connecticut, Pemigewasset, and Androscoggin Rivers, and the lower stretches of major tributaries. Temperate minor river floodplains occur on rivers and large streams throughout central and southern New Hampshire (Sperduto 2011).

Surveys should verify predicted floodplain forests, particularly for rare communities within the temperate minor river floodplain system, such as swamp white oak floodplain forest (S1) and sycamore floodplain forest (S1). Rare wildlife should be incorporated into habitat-based inventories.

Relative Health of Populations

The temperate minor river floodplain system comprises approximately half of all mapped floodplain hectares in the state. The remaining floodplains are divided roughly evenly between the major river silver maple floodplain and the montane/near-boreal floodplain. This imbalance is due in part to the number of small rivers in southern New Hampshire, and in part to the amount of major river silver maple floodplain that has been converted to agriculture. The greatest area for the montane/near-boreal floodplain is in the Upper Ammonoosuc River drainage, while the Middle Androscoggin River watershed has the largest amount of major river silver maple floodplain. Both of these watersheds are in northern New Hampshire. The largest area of temperate minor river floodplain is in the Lamprey River watershed, in the seacoast region.

Habitat Condition

Biological Condition:
Species richness of rare animals within polygon
Species richness of rare animals within their dispersal distances from the polygon
Species richness of rare plants in polygon
Richness of rare and exemplary natural communities in polygon

Landscape Condition:
Area of largest floodplain forest patch in the Complex
Number of floodplain forest patches in the Complex
Local Connectedness
Landscape Complexity

Human Condition:
Index of Ecological Integrity
Road density within 250 meters of the Complex
Percent of floodplain forest drainage area that is impounded
Distance to nearest dam (meters)
Distance to nearest road (meters)

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a “medium” or “high” score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation from dams that impound rivers and alter hydrology of floodplains (Threat Rank: High)

Floodplain forests are periodically flooded, and this regular disturbance creates and maintains these communities (Bornette and Amoros 1996). There are over 5000 dams in New Hampshire and a large percentage of New Hampshire’s floodplain forests occur along stretches of river that have had their flow and flood regimes modified by dams.

Dams significantly alter natural flood regimes. Higher floodplain terraces that may have naturally flooded every 20-100 years may never receive flooding after a dam is built to regulate flow (Nislow and Magilligan 2000). Water storage dams often have different effects on floodplains than “run-of-river” dams that allow for normal river flow outside periods of high water. Water storage dams often permanently alter the species composition and structural diversity of downstream floodplains, whereas such effects are much less severe below run-of-river dams (Nilsson et al. 1997). On a heavily dammed river, Kingsford and Thomas (2004) found dramatic declines in all bird groups that used floodplain wetlands. Both storage dams (NHNHB 1998, NHNHB 1999, NHNHB 2000) and run-of-river dams (NHNHB 1996, NHNHB 1997) have been built in New Hampshire. The changes in vegetation resulting from these impoundments can also impact the wildlife that use these habitats.

Habitat conversion of floodplains to residential or commercial developments (Threat Rank: High)

Floodplain habitats are restricted to relatively narrow bands that occur discontinuously along rivers, and are naturally fragmented by changes in topography or underlying geology along a river’s course. However, fragmentation by human activities can be a serious threat to wildlife that use these floodplains. Agricultural fields, roads, and residential and commercial development all contribute to the fragmentation of floodplain forests, with agriculture having the greatest impact.

The effects of habitat fragmentation on many types of wildlife are well documented. Open upland habitats (agricultural and old fields) present a significant barrier to amphibian dispersal (Gibbs 1998, Rothermel and Semlitsch 2002). Literature regarding the effects of fragmentation on forest birds is even more extensive (Blake and Carr 1987, Darveau et al. 1995, Hobson and Bayne 2000).

Species impacts from insecticide use (mosquito treatment) (Threat Rank: Medium)

New Hampshire permits the control of mosquitoes using larvicides (bacteria and insect growth regulators) and adulticides (pyrethroid synthetic pesticides) (NH DHHS 2008). Many of these pesticides can affect a broad spectrum of insect and other invertebrate species.

Larvicides are applied specifically to wetlands. Insect growth regulators like methoprene are broadly toxic to invertebrates, particularly crustaceans. Bacterial controls like *Bacillus thuringiensis var. israelensis* (BTI) are toxic to non-biting midges, which are an important food source in wetlands for a variety of wildlife species, including invertebrates, fish, amphibians, and birds. Pyrethroid adulticides are highly toxic to many aquatic organisms and are specifically prohibited from being applied to wetlands and water bodies. However, these chemicals can enter wetlands through drift from aerial spraying (Mazzacano & Black 2013).

Habitat degradation from non-point and point contaminants (Threat Rank: Medium)

There are a variety of pollutants that can enter wetlands as a result of runoff from roads and other developed areas. These include hydrocarbons from oil and gasoline, metals such as lead, zinc, and copper, and road salt.

Metals and hydrocarbons can have toxic effects on wildlife that vary depending on species and type of contaminant. Salt runoff can have significant impacts to freshwater and terrestrial plant species, causing dieback or failure to germinate (Wright et al. 2006).

Habitat degradation from introduced or invasive plants (Threat Rank: Medium)

Invasive plant species are a serious threat to natural systems (Stein et al. 2000). Invasive alien plants threaten natural communities by out-competing native plants for light, nutrients and space, altering the physical structure of the vegetation, and altering nutrient cycles. Many native plants support host-specific invertebrates, which could be impacted by competition from invasives. Floodplain habitats are particularly vulnerable to invasive plants because the frequent disturbances from flooding give aliens opportunities to establish, and because these species tend to thrive in the nutrient rich soils characteristic of floodplains.

In New Hampshire, there are several exotic plants that are particularly problematic in floodplain habitats, including Asian bittersweet *(Celastrus orbiculatus*), Japanese knotweed (*Fallopia japonica*) and black swallowwort (*Cynanchum louiseae*) (Cygan 2011). Although research into specific effects of invasive plants on wildlife has been limited, at least one study has shown that Japanese knotweed can have measurable negative impacts on amphibians (Maerz and Blossey 2002). Additionally, climate change may exacerbate the invasive species threat. Increased stress, new deposits of mineral soil, eroded surfaces and edge habitat may lead to increases in invasive species which specialize in disturbed edge habitats. More intense flooding events may also disperse invasive species into new areas.

Mortality and habitat degradation from road fragmentation (Threat Rank: Medium)

Transportation infrastructure fragments forest blocks, creating edge effects from light penetration and exposure to wind and pollutants such as road salt and hydrocarbons. Transportation infrastructure and its use by vehicles also create dispersal barriers, edge effects, and increased mortality for floodplain wildlife (Forman et al. 2003).

Habitat fragmentation can influence many species including those with limited mobility (Mader 1984, Reh and Seitz 1990, Herrmann et al. 2005). Floodplain and other wetland taxa are more likely to disperse through forested uplands than non-forested uplands (deMaynadier and Hunter 1999, Nekola et al. 2002), so habitat fragmentation could alter the upland to the extent that individuals are no longer able to migrate. Floodplains are patchy-linear habitats within an upland landscape and the wildlife that depend on them often exhibit little migration between patches (Gibbs 2000). With this limited migration and limited genetic exchange, any further hindrance to migration between habitats could render local populations vulnerable to extinction.

Habitat degradation from roads that alter hydrology in floodplains (Threat Rank: Medium)

In floodplains, the presence of roads and railroads can cause hydrologic alterations, impeding the movement of floodwaters downstream and isolating backwaters and side channels.

Floodplains and valley bottoms have been preferred locations for transportation infrastructure (both roads and railroads) for centuries (Blanton & Marcus 2009). A study of two river basins in Washington State found that 44 to 58 percent of the total floodplain area in the three study basins is disconnected by these roads and railroads (Blanton & Marcus 2014).

Habitat conversion to agriculture (Threat Rank: Medium)

Because of their rich, productive alluvial soils, floodplains in New Hampshire have a long history of being cleared for agricultural use. Clearing for agriculture destroys floodplain forest habitat and displaces wildlife that rely on it.

Although agricultural fields (primarily corn) are common on floodplains in New Hampshire, there is little new clearing occurring.

List of Lower Ranking Threats:

Habitat degradation from acid deposition

Habitat degradation from increased sedimentation

Habitat degradation from fertilizer that increases eutrophication

Habitat degradation from mercury deposition

Habitat degradation from dumping trash

Habitat degradation from groundwater and surface withdrawals

Mortality and habitat degradation from OHRV activity

Disturbance and habitat degradation from hiking and biking

trails Mortality from the collection of plants (ostrich fern)

Habitat conversion from forestry occurring in a floodplain which removes the forested component of the habitat

Habitat degradation from changes in precipitation patterns that can change species composition

Actions to benefit this Habitat in NH

Prioritize locations and mitigation strategies to reduce direct mortality of wildlife on existing roads and promote connectivity among fragmented habitat

Primary Threat Addressed: Mortality and habitat degradation from road fragmentation

Specific Threat (IUCN Threat Levels): Transportation & service corridors

Objective:
The objective is to identify important locations and appropriate strategies for mitigating the effects of roads on mortality of wildlife species and connectivity among populations in habitat patches fragmented by roads.

General Strategy:
This action will have the following components: (1) identify high priority locations for implementing road-mitigation strategies. These priority locations may be based on individual species of concern, high mortality of multiple species, concerns regarding wildlife-vehicle collisions and public safety, and/or regional connectivity analyses such as the Staying Connected Initiative. Approaches used for identifying priority locations may include spatial models and direct observation of live and dead animals on roads (Clevenger et al. 2002, Beaudry et al. 2008, Langen et al. 2009, Patrick et al. 2012); (2) Identify appropriate mitigation strategies such as signage and crossing structures based on biophysical setting and the ecology of target (Jackson 2003, Patrick et al. 2010); (3) Support enabling conditions for implementing road mitigation strategies including increased public funding and appropriate policies and procedures for transportation management agencies that ensure that reengineering of existing structures such as curbs, culverts and underpasses promotes wildlife passage. Priority species will include wood turtle and northern leopard frog.

Political Location: **Watershed Location:**

Minimize the effect of new road construction on wildlife mortality and habitat fragmentation

Primary Threat Addressed: Mortality and habitat degradation from road fragmentation

Specific Threat (IUCN Threat Levels): Transportation & service corridors

Objective:
The objective is to ensure that new roads are designed and located with the goal of minimizing effects on wildlife mortality and habitat fragmentation.

General Strategy:
New roads should be avoided where possible. When road construction is justified, roads should be located to avoid bisecting wetlands, wetland/upland interfaces, large blocks of contiguous habitat, and other habitat types that organisms traverse during their life-history cycle (for example, adjacent to known snake hibernacula). Where new roads will cross known or likely wildlife movement paths or fragment previously contiguous habitat, an evaluation of the most appropriate mitigation strategies should be conducted based on the threat status of the species, the biophysical setting and corresponding nature of the wildlife crossing (for example organisms concentrated in a narrow corridor of suitable habitat or spread along a long road segment), and traffic volume. On high traffic volume roads, a combination of regularly maintained barrier fences and suitable crossing structures should be used. On low traffic volume roads, ensuring that curbs and other barriers do not prevent crossing may be the most appropriate strategy (i.e. facilitating the passage of organisms over the roadway). Signage as a strategy for reducing mortality should be used with consideration due to concerns that this approach is not effective. Reducing vehicle speed through road-design elements can be an effective tool for reducing wildlife-vehicle collision. This strategy requires information regarding appropriate road location and design being readily available in an appropriate format for use by decision-makers. The efficacy of this strategy will be greatly increased by ensuring that best management practices are embedded in policies and procedures of transportation management agencies, state agencies, and local municipalities.

Political Location: **Watershed Location:**

Develop and implement a comprehensive management approach for high priority invasive species that threaten floodplain forests.

Primary Threat Addressed: Habitat degradation from introduced or invasive plants

Specific Threat (IUCN Threat Levels): Invasive & other problematic species, genes & diseases

Objective:
The objective is to mitigate the threat posed by invasive plant species by reducing the abundance, and controlling the spread, of high priority species.

General Strategy:
This action will have the following components: identifying high priority floodplain forests for targeted invasive species control; developing a list of species, including early detection species, to focus control efforts on (glossy buckthorn (Rhamus frangula), Japanese knotweed (Fallopia japonica), and Oriental bittersweet (Celastrus orbiculatus) are known problem species in floodplain forests; promoting an early detection and rapid response (EDRR) approach to invasive species control in floodplain forests; connecting ongoing small and large scale invasive species management programs, like the Upper CT River Cooperative Invasive Species Management Area (CISMA) and the Invasive

Species Plant Atlas of New England (IPANE), to promote coordinated actions within priority floodplain forest areas. Priority species will include Glossy buckthorn, Japanese knotweed, and bittersweet.

Political Location: **Watershed Location:**

Promote the creation of local ordinances restricting development in floodplains as presented in "Innovative Land Use Planning Techniques."

Primary Threat Addressed: Habitat conversion of floodplains to residential or commercial developments

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
The objective is no further loss of floodplain habitat to residential or commercial development.

General Strategy:
"Innovative Land Use Planning Techniques" is a document developed by the Department of Environmental Services to present ideas on land use planning to New Hampshire municipalities. Included among these ideas are suggestions for reducing the impacts of flooding on communities, focusing on local ordinances restricting development activities in mapped floodplains. NHFG should work with the NH Association of Conservation Commissions to emphasize the value of such protections to wildlife resources.

Political Location: **Watershed Location:**

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Peter Bowman, NHNHB

2005 Authors:

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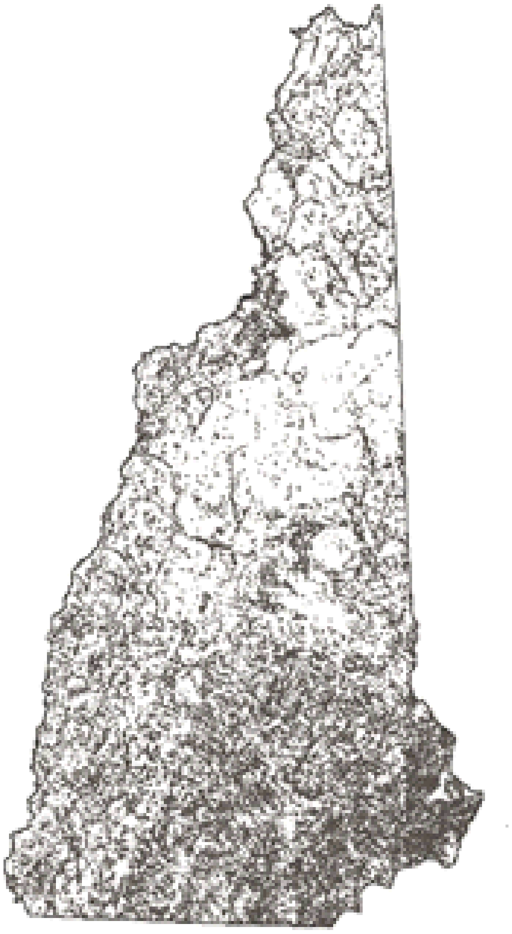
Marsh and Shrub Wetlands

Photo by Pete Bowman



Habitat Distribution Map

Acres in NH:	154,340
Percent of NH Area:	3
Acres Protected:	41,672
Percent Protected:	27

Habitat Description

The marsh and shrub wetland habitat described here corresponds to the drainage marsh - shrub swamp and sand plain basin marsh systems described by NHNHB (Sperduto 2011). Drainage marsh-shrub swamp systems have a broad flood regime gradient that is often affected by the presence or abandonment of beaver (*Castor canadensis*) activity (Sperduto 2011). Generally, the trophic regime of these systems is moderately to strongly minerotrophic, with soils consisting of poorly drained decomposed muck and mineral with a pH between 5 and 6 (Sperduto 2011).

The drainage marsh - shrub swamp system is often grouped into three broad habitat categories: meadow marshes (wet meadows), emergent marshes, and scrub-shrub wetlands. Meadow marshes are often dominated by herbaceous vegetation (especially sedges) often less than 1 m in height and saturated for long periods during the growing season, but seldom flooded (Pedevillano 1995, NHDES Wt 101.91). Because meadow marshes are a subset of an overall herbaceous emergent vegetation category, they will be discussed in this profile along with marshes unless stated otherwise. NHNHB terminology will be used to describe different meadow marsh communities (Sperduto 2011, Sperduto and Nichols 2011). Examples of ‘wet meadow’ natural communities in New Hampshire may include tall graminoid meadow marsh, sedge meadow marsh, and short graminoid - forb meadow marsh/mudflat (Sperduto and Nichols 2011). Representative wildlife that use wet meadows include ribbon snake (*Thamnophis sauritus sauritus*), northern harrier (*Circus cyaneus*), northern leopard frog (*Lithobates pipiens*), and spotted turtle (*Clemmys guttata*; Benyus 1989).

Emergent marshes are dominated by emergent herbaceous vegetation and have a water table that is generally at or above the surface throughout the year, but can fluctuate seasonally (Pedevillano 1995, NHDES Wt101.51). Examples of marsh natural communities in New Hampshire include cattail marshes and emergent marshes (Sperduto and Nichols 2012). Wildlife associated with emergent marshes include Blanding's turtle (*Emydoidea blandingii*), spotted turtle (*Clemmys guttata*), pied-billed grebe (*Podilymbus podiceps*), American black duck (*Anas rubripes*), northern harrier (*Circus cyaneus*), American bittern (*Botaurus lentiginosus*), Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), least bittern (*Ixobrychus exilis*), common gallinule (*Callinula chloropus*), great-blue heron (*Ardea herodias*), red-winged blackbird (*Agelaius phoeniceus*), muskrat (*Ondatra zibethica*), mink (*Mustela vison*), and spring peeper (*Pseudacris crucifer*) (Benyus 1989, Pedevillano 1995).

Woody vegetation, predominantly saplings and shrubs, dominates shrub swamps. They frequently flood in the spring or contain pockets of standing water (Pedevillano 1995). Examples of natural communities in New Hampshire include: highbush blueberry - winterberry shrub thicket, buttonbush shrubland, and alder - dogwood - arrowwood alluvial thicket. Wildlife associated with shrub swamps includes Blanding's turtle (*Emydoidea blandingii*), spotted turtle (*Clemmys guttata*), New England cottontail (*Sylvilagus transitionalis*), Canada warbler (*Wilsonia canadensis*), American woodcock (*Philohela minor*), gray catbird (*Dumetella carolinensis*), moose (*Alces alces*), and many breeding amphibians (Benyus 1989, Pedevillano 1995).

Although no invertebrate species are discussed here specifically, numerous groups of invertebrates use marsh and shrub wetlands for one or all life stages including but not limited to worms (e.g., leaches, flatworms, earthworms), mollusks (snails, clams, and mussels), crustaceans (e.g., scuds, decapods), mayflies, caddisflies, dragonflies and damselflies, and water beetles.

Justification (Reason for Concern in NH)

Eighteen species of conservation concern addressed in the New Hampshire Comprehensive Wildlife Strategy depend on this habitat and a number of other species use this habitat for foraging, nesting, breeding, and cover. Also, several state or federally rare natural communities are associated with this habitat (Taylor et al. 1996).

Wetlands are habitats that provide a number of critical functions such as flood control, pollutant filters, shoreline stabilization, sediment retention and erosion control, food web productivity, wildlife habitat, recreation, and education (Tiner 1984, North American Waterfowl Management Plan 1986, New Hampshire Office of State Planning 1989). Expenditures related to waterfowl alone generate several billion dollars annually in North America (North American Waterfowl Management Plan 1986). Although the number of wetlands filled in New Hampshire has been small compared to the overall amount of wetlands available in the landscape, impacts to 'non-impacted' wetlands from surrounding land use is of great concern, especially in southern New Hampshire. Protecting landscapes with relatively undisturbed freshwater wetlands will be critical for maintaining biodiversity and ecological functions in the Northeast (Sundquist and Stevens 1999, Hunt 2005).

Protection and Regulatory Status

The following rules, regulations, and acts represent those that are most likely to affect freshwater marshes and shrub wetlands in New Hampshire. This is not intended to be a complete list of all possible regulations.

Appendix B: Habitats

International

North American Wetlands Conservation Act (1989): enacted to support the goals of the North American Waterfowl Management Plan of 1986.

Federal

- Clean Water Act-Section 404; administered by the USACE and USEPA: regulates discharge of dredge or fill material into "waters of the United States" including wetlands.
- Migratory Bird Conservation Act (1929): authorizes federal acquisition of land for migratory waterfowl refuges.
- Emergency Wetlands Resources Act (1986): requires the Secretary of Interior (through USFWS) to produce updated reports every ten years on the status and trends of wetlands and deepwater habitats in the conterminous United States (Dahl and Johnson 1991); Section 303- requires inclusion of wetlands in statewide comprehensive outdoor recreation plans (SCORP).

State

- Fill and Dredge in Wetlands; NHDES (NHDES, RSA 482-A)- requires applicant to obtain a permit to fill or dredge jurisdictional wetland habitats. The NHDES has placed emphasis on preserving bogs and marshes based upon rarity and difficulty in restoration of value and functions (NHDES Wt 302.01). For all major (> 1,800 m^2) and minor (270- 1,800 m^2) impact projects, the applicant must assess impacts to plants, fish, and wildlife including rare, special concern species, state and federally listed threatened and endangered species, species at the extremities of their ranges, migratory fish and wildlife, and exemplary Natural communities identified by the NHNHB (NHDES Wt 302.04). The NHDES Wetlands Bureau does not require construction setbacks from non-tidal freshwater wetlands (except under RSA 485-A).
- Water Pollution and Waste Disposal Statute (RSA 485-A)- subsurface wastewater disposal systems must be greater than 15 m (50 ft) from poorly drained (hydric B) soils and 23 m (75 ft) from very poorly drained (hydric A) soils.
- Exotic Aquatic Weeds (RSA 487:16-a), NHDES - the sale, distribution, importation, purchase, propagation, transportation, or introduction of exotic aquatic weeds into the state is prohibited.
- New Hampshire Endangered Species Conservation Act (RSA 212-A)
- Nongame Species Management Act (1988) (RSA 212-B)—the NHFG Nongame and Endangered Species Program has responsibility and authority to conduct research, management, and education related to those species not hunted, fished, or trapped.
- Waterfowl Conservation Program (RSA 214:1-d) - funds from the NHFG Waterfowl Conservation account may be used for the development, management, preservation, conservation, restoration, acquisition, and maintenance of migratory waterfowl habitat.
- Native Plant Protection Act (RSA 217-A);
  NHNHB

- ***Local***
- Designation of Prime Wetlands (RSA 482:a-15): towns may designate individual wetlands as 'prime' based on NHDES protocol (NHDES Wt 700). Projects located in or adjacent to designated prime wetlands under RSA 482-A:15 are considered major impact projects and require a full application to NHDES.
- Local wetland regulations and zoning vary considerably. Recommended buffer distances are summarized in Chase et al. (1995).

Distribution and Research

Drainage marsh - shrub swamp systems are widespread throughout New Hampshire (Sperduto 2011), although the White Mountain region likely has a lower density than other areas. Sand plain basin marsh systems occur mostly east-central and southern New Hampshire but may occasionally occur further north (Sperduto 2011). For the distribution of natural communities in each Ecoregion subsection, see Sperduto and Nichols (2011).

Field-verify the prediction of mapped wetlands, especially for high priority sites and where rare natural communities may occur. Rare and at-risk wildlife should be incorporated into habitat-based inventories.

The Marsh and Shrub Wetland mapping could be potentially improved as new and updated GIS layers become available. Periodic updating and refining of this layer will be necessary to ensure appropriate conservation actions are being taken for the highest priority wetlands and update changes to wetland communities due to natural (e.g., succession) or anthropogenic (e.g., wetland filling) causes.

Relative Health of Populations

Marsh area (ha) was greatest in the Gulf of Maine Coastal Plain and least abundant in the Vermont Piedmont, White Mountains, and Northern Connecticut River Valley ecoregion subsections.

Between 2004 and 2015, NH DES documented approximately 950 acres of wetlands lost in New Hampshire through development activities (Crystal, pers. Comm).

Habitat Condition

A set of GIS data was used to assess ecological condition of each habitat type. Chapter 3 describes the methodology. The data used for this habitat is described below.

Biological Condition:
Species richness of rare animals within polygon
Species richness of rare animals within their dispersal distances from the polygon
Species richness of rare plants in polygon
Richness of rare and exemplary natural communities in polygon

Landscape Condition:
Area of largest marsh in the Complex
Number of dominant NWI vegetation classes (FO, EM, SS, PUB, AB) in the Complex
Number of marsh polygons in the Complex
Local Connectedness
Landscape Complexity

Human Condition:
Index of Ecological Integrity
Road density is within 250 meters of the Complex
NHDES Landscape Level Wetlands Assessment score for Water Quality degradation
NHDES Landscape Level Wetlands Assessment score for Human Activity within 500 feet

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Mortality and habitat impacts (fragmentation) from roads (Threat Rank: High)

Depending on the extent of fragmentation and loss or degradation of upland habitat, wildlife may be affected differently. Most species associated with wetlands use a portion of surrounding uplands for foraging, dispersing, reproduction, egg laying, resting, cover, and overwintering (Semlitsch and Bodie 2003). Extent and area of upland use can vary widely among species. Impacts to upland habitats from development can result in direct mortality of individuals, create barriers to dispersal, fragment species populations, eliminate or reduce the quality of nesting or forage habitat, and increase predation of nests or young as a result of generalist predators benefiting from an abundance of forage.

Habitat fragmentation can influence many species including those with limited mobility (Mader 1984, Reh and Seitz 1990, Herrmann et al. 2005). Marsh and other wetland taxa are more likely to disperse through forested uplands than non-forested uplands (deMaynadier and Hunter 1999, Nekola et al. 2002), so habitat fragmentation could alter the upland to the extent that individuals are no longer able to migrate. Marshes and other wetlands are patchy habitats within an upland landscape, and the wildlife that depend on them often exhibit little migration between patches (Gibbs 2000). With this limited migration and limited genetic exchange, any further hindrance to migration between habitats could render local populations vulnerable to extinction.

Species impacts from insecticide use (mosquito treatment) (Threat Rank: Medium)

New Hampshire permits the control of mosquitoes using larvicides (bacteria and insect growth regulators) and adulticides (pyrethroid synthetic pesticides) (NH DHHS 2008). Many of these pesticides can affect a broad spectrum of insect and other invertebrate species.

Larvicides are applied specifically to wetlands. Insect growth regulators like methoprene are broadly toxic to invertebrates, particularly crustaceans. Bacterial controls like *Bacillus thuringiensis var. israelensis* (BTI) are toxic to non-biting midges, which are an important food source in wetlands for a variety of wildlife species, including invertebrates, fish, amphibians, and birds. Pyrethroid adulticides are highly toxic to many aquatic organisms and are specifically prohibited from being applied to wetlands and water bodies. However, these chemicals can enter wetlands through drift from aerial spraying (Mazzacano & Black 2013).

Habitat degradation from sedimentation (Threat Rank: Medium)

Elevated levels of sediments entering wetlands arrive through runoff from roads, construction sites, and agricultural fields. Sediment deposition in wetlands can lead to decreased plant species diversity and favorable conditions for the spread of invasive plants (Wright et al. 2006).

Sediment deposition in wetlands can influence the ability of seeds to germinate and grow by altering light availability, temperature, and oxygen levels in the soil (Wardrop & Brooks 1998). Sediment deposition can also reduce microtopographic variation and surface area in the wetland that contributes to native species diversity. Relatedly, higher sediment deposition rates favored invasive species tolerant of sediment such as reed canary grass (Werner & Zedler 2002).

Habitat degradation from non-point and point contaminants (Threat Rank: Medium)

There are a variety of pollutants that can enter wetlands as a result of runoff from roads and other developed areas. These include hydrocarbons from oil and gasoline, metals such as lead, zinc, and copper, and road salt.

Metals and hydrocarbons can have toxic effects on wildlife that vary depending on species and type of contaminant. Salt runoff can have significant impacts to freshwater and terrestrial plant species, causing dieback or failure to germinate (Wright et al. 2006).

Habitat degradation from fertilizer that increases eutrophication (Threat Rank: Medium)

Runoff of fertilizers from agricultural fields and lawns into wetlands can result in algal blooms. The decomposition of the organic matter produced during these algal blooms results in depleted levels of dissolved oxygen, which can impact wetland wildlife and plant species.

Algal blooms resulting from fertilizer runoff reduces dissolved oxygen concentrations enough to kill or displace fish and invertebrates (Carpenter et al. 1998). Elevated nutrient levels in wetlands also favors the growth and spread of invasive plants (Wright et al. 2006).

Habitat impacts and conversion due to development of surrounding uplands (Threat Rank: Medium)

Depending on the extent of fragmentation and loss or degradation of upland habitat, wildlife may be affected differently. Most species associated with wetlands use a portion of surrounding uplands for foraging, dispersing, reproduction, egg laying, resting, cover, and overwintering (Semlitsch and Bodie 2003). Extent and area of upland use can vary widely among species. Impacts to upland habitats from development can result in direct mortality of individuals, create barriers to dispersal, fragment species populations, eliminate or reduce the quality of nesting or forage habitat, and increase predation of nests or young as a result of generalist predators benefiting from an abundance of forage.

Wildlife that uses a landscape of wetland and upland mosaics are not protected adequately by existing state regulations. Although wetlands are given special attention through state permitting and this activity is warranted, most upland habitats are given little consideration. Alteration of terrain permits are required when more than 9,290 m2 (100,000 ft2) of terrain are affected, and these are reviewed for wildlife impacts, including rare or endangered species. However, projects that affect smaller upland areas, even if they are adjacent to wetlands, are not reviewed. Maintaining undisturbed terrestrial buffers around wetland habitats is critical to protecting water resources and maintaining population viability for many species (Semlitsch and Bodie 2003). For example, loss of nesting cover has contributed to long-term declines of some duck species (e.g., American black duck, North American Waterfowl Management Plan 1986). The NHFG requires at least a 91 m (300 ft.) undeveloped upland buffer in areas protected for nesting waterfowl. In an analysis of appropriate buffer distances for protecting water resources in New Hampshire, Chase et al. (1995) determined that a 30 m (100 ft.) vegetated buffer around wetlands is likely to protect many water resources and habitat for some wildlife species. However, many reptiles and amphibians require much larger buffers (e.g., 127-290 m) to prevent population declines (Semlitsch and Bodie 2003). Some species (e.g., Blanding’s turtle) may travel several kilometers from occupied wetlands. Therefore, a landscape-level planning effort will be required to maintain the biodiversity of New Hampshire’s landscape.

List of Lower Ranking Threats:

Habitat degradation from altering wetland hydrology

Habitat degradation from changes in precipitation patterns that change duration and seasonality of flooding

Habitat degradation from increased temperatures that make habitat more vulnerable to invasive species

Habitat degradation and mortality from forestry activities near wetland

Mortality and habitat degradation due lead from ammunition and tackle

Habitat degradation and mortality from legal and illegal OHRV and snowmobile activity

Habitat conversion from the direct filling of wetlands for development

Habitat conversion and mortality from the removal of beaver and human-made dams

Habitat degradation from mercury deposition

Habitat degradation from groundwater and surface withdrawals

Mortality from lake and pond drawdowns

Habitat degradation from dredging ponds and removal or management of vegetation

Habitat degradation and species impacts from introduced or invasive plants

Species impacts from introduced or invasive animals

Disturbance from acid deposition

Mortality from hiking and biking trails

Actions to benefit this Habitat in NH

Prioritize locations and mitigation strategies to reduce direct mortality of wildlife on existing roads and promote connectivity among fragmented habitat

Primary Threat Addressed: Mortality and habitat impacts (fragmentation) from roads

Specific Threat (IUCN Threat Levels): Transportation & service corridors

Objective:
The objective is to identify important locations and appropriate strategies for mitigating the effects of roads on mortality of wildlife species and connectivity among populations in habitat patches fragmented by roads.

General Strategy:
This action will have the following components: (1) identify high priority locations for implementing road-mitigation strategies. These priority locations may be based on individual species of concern, high mortality of multiple species, concerns regarding wildlife-vehicle collisions and public safety, and/or regional connectivity analyses such as the Staying Connected Initiative. Approaches used for identifying priority locations may include spatial models and direct observation of live and dead

animals on roads (Clevenger et al. 2002, Beaudry et al. 2008, Langen et al. 2009, Patrick et al. 2012); (2) Identify appropriate mitigation strategies such as signage and crossing structures based on biophysical setting and the ecology of target (Jackson 2003, Patrick et al. 2010); (3) Support enabling conditions for implementing road mitigation strategies including increased public funding and appropriate policies and procedures for transportation management agencies that ensure that reengineering of existing structures such as curbs, culverts and underpasses promotes wildlife passage. Priority species will include Blanding's turtle, spotted turtle, and New England cottontail.

Political Location: **Watershed Location:**

Promote measures to protect wetlands as described in "Innovative Land Use Planning Techniques."

Primary Threat Addressed: Habitat impacts and conversion due to development of surrounding uplands

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
The objective is reduce impacts to wetlands from other land uses, including development, transportation, and agriculture.

General Strategy:
"Innovative Land Use Planning Techniques" is a document developed by the Department of Environmental Services to present ideas on land use planning to New Hampshire municipalities. Included among these ideas are suggestions for protecting wetlands from various forms of human disturbance, focusing on the creation of local ordinances to establish buffers around wetlands and watercourses. NHFG should work with the NH Association of Conservation Commissions to emphasize the value of such protections to wildlife resources.

Political Location: **Watershed Location:**

Minimize the effect of new road construction on wildlife mortality and habitat fragmentation

Primary Threat Addressed: Mortality and habitat impacts (fragmentation) from roads

Specific Threat (IUCN Threat Levels): Transportation & service corridors

Objective:
The objective is to ensure that new roads are designed and located with the goal of minimizing effects on wildlife mortality and habitat fragmentation

General Strategy:
New roads should be avoided where possible. When road construction is justified, roads should be located to avoid bisecting wetlands, wetland/upland interfaces, large blocks of contiguous habitat, and other habitat types that organisms traverse during their life-history cycle (for example, adjacent to known snake hibernacula). Where new roads will cross known or likely wildlife movement paths or fragment previously contiguous habitat, an evaluation of the most appropriate mitigation strategies should be conducted based on the threat status of the species, the biophysical setting and corresponding nature of the wildlife crossing (for example organisms concentrated in a narrow

corridor of suitable habitat or spread along a long road segment), and traffic volume. On high traffic volume roads, a combination of regularly maintained barrier fences and suitable crossing structures should be used. On low traffic volume roads, ensuring that curbs and other barriers do not prevent crossing may be the most appropriate strategy (i.e. facilitating the passage of organisms over the roadway). Signage as a strategy for reducing mortality should be used with consideration due to concerns that this approach is not effective. Reducing vehicle speed through road-design elements can be an effective tool for reducing wildlife-vehicle collision. This strategy requires information regarding appropriate road location and design being readily available in an appropriate format for use by decision-makers. The efficacy of this strategy will be greatly increased by ensuring that best management practices are embedded in policies and procedures of transportation management agencies, state agencies, and local municipalities.

Political Location: **Watershed Location:**

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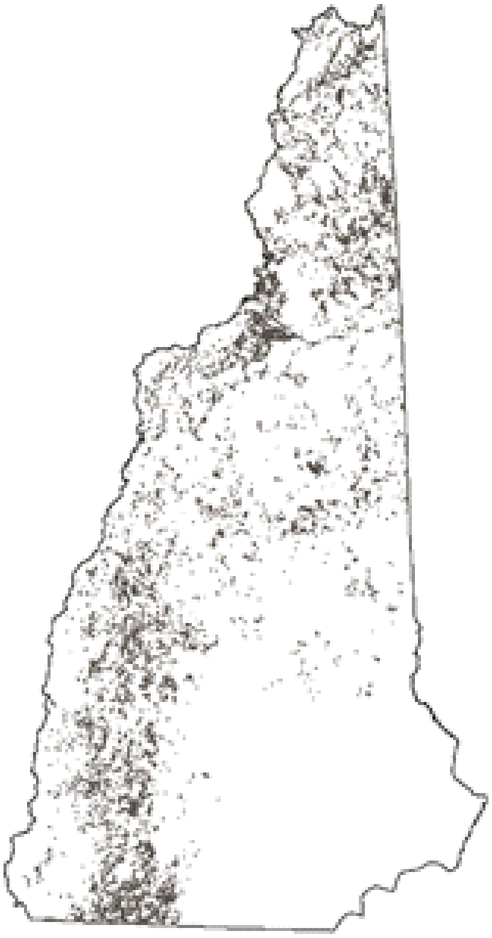
Northern Swamps

Photo by Ben Kimball

Acres in NH:	36143
Percent of NH Area:	1
Acres Protected:	12289
Percent Protected:	34



Habitat Distribution Map

Habitat Description

This habitat consists of forested wetlands found mainly in the northern half of the state, with an extension south in the highlands of southwest New Hampshire. This type corresponds primarily to the black spruce peat swamp and montane/near-boreal minerotrophic peat swamp systems described by NHNHB (Sperduto 2011). This habitat can also include larger occurrences of the forest seep/seepage forest system in the northern half of the state. In the 2005 Wildlife Action Plan, the black spruce peat swamp and montane/near-boreal minerotrophic peat swamp systems were included as a subset of peatlands, but their structure and associated species differ substantially from open peatlands such as bogs and fens, and here are addressed as a separate habitat. The wetlands of the forest seep/seepage forest system are found throughout the state and are typically quite small (<0.25 ac), but larger occurrences (5-10 acres) can be found in northern New Hampshire.

Black spruce peat swamps are largely found in central and northern New Hampshire, typically in closed or stagnant basins with limited drainage. They have deep organic soils that are acidic and nutrient-poor. These swamps have a forest or woodland structure, but often surround open peatlands. Boreal conifers dominate, particularly black spruce (*Picea mariana*), and to a lesser extent American larch (*Larix laricina*), red spruce (*Picea rubens*), or balsam fir (*Abies balsamea*). Tall shrub thickets can also occur in this system, with mountain holly (*Ilex mucronata*) being the most frequent species. Smaller, more mixed-canopy examples infrequently occur in the southern part of the state, supporting some species with more temperate distributions, such as highbush blueberry (*Vaccinium corymbosum*) and maleberry (*Lyonia ligustrina*).

Like black spruce swamps, montane/near-boreal minerotrophic peat swamps are also primarily found in central and northern parts of the state. Unlike black spruce swamps however, they are strongly influenced by mineral-enriched groundwater seepage, with soils that are considerably less acidic. Northern white cedar (*Thuja occidentalis*) and black ash (*Fraxinus nigra*) are characteristic trees in this habitat, but these swamps support a very high diversity of vascular plant and bryophyte (moss and liverwort) species that thrive in the nutrient-rich conditions.

From a wildlife habitat perspective, forest seeps are unusual in that they are typically very small (<0.25) features embedded within the forested landscape. Seeps occur where groundwater emerges at the soil surface and begins flowing into a stream. Despite their small size, they support a distinctive suite of plant species, and have value as wildlife habitat for some amphibians. Due to their size, they are not generally identified on maps. However, on certain soil types in northern New Hampshire, groundwater seepage can occur over extensive areas, and in these locations can support seepage forest communities and forest seep/seepage forest systems.

Justification (Reason for Concern in NH)

Wetlands are habitats that provide a number of critical functions such as flood control, pollutant filters, shoreline stabilization, sediment retention and erosion control, food web productivity, wildlife habitat, recreation, and education (Tiner 1984, North American Waterfowl Management Plan 1986, New Hampshire Office of State Planning 1989).

Protection and Regulatory Status

Federal

- Clean Water Act-Section 404; administered by the USACE and USEPA: regulates discharge of dredge or fill material into “waters of the United States” including wetlands.
- Emergency Wetlands Resources Act (1986): requires the Secretary of Interior (through USFWS) to produce updated reports every ten years on the status and trends of wetlands and deepwater habitats in the conterminous United States (Dahl and Johnson 1991); Section 303- requires inclusion of wetlands in statewide comprehensive outdoor recreation plans (SCORP).

State

- Fill and Dredge in Wetlands; NHDES (NHDES, RSA 482-A)- requires applicant to obtain a permit to fill or dredge jurisdictional wetland habitats. The NHDES has placed emphasis on preserving bogs and marshes based upon rarity and difficulty in restoration of value and functions (NHDES Wt 302.01). For all major (> 1,800 m2) and minor (270-1,800 m2) impact projects, the applicant must assess impacts to plants, fish, and wildlife including rare, special concern species, state and federally listed threatened and endangered species, species at the extremities of their ranges, migratory fish and wildlife, and exemplary Natural communities identified by the NHNHB (NHDES Wt 302.04). The NHDES Wetlands Bureau does not require construction setbacks from non-tidal freshwater wetlands (except under RSA 485-A).
- Water Pollution and Waste Disposal Statute (RSA 485-A)- subsurface wastewater disposal systems must be greater than 15 m (50 ft) from poorly drained (hydric B) soils and 23 m (75 ft) from very poorly drained (hydric A) soils.
- New Hampshire Endangered Species Conservation Act (RSA 212-A)
- Nongame Species Management Act (1988) (RSA 212-B)—the NHFG Nongame and Endangered

- Species Program has responsibility and authority to conduct research, management, and education related to those species not hunted, fished, or trapped.
- Native Plant Protection Act (RSA 217-A); HNHB

Local
- Designation of Prime Wetlands (RSA 482:a-15): towns may designate individual wetlands as ‘prime’ based on NHDES protocol (NHDES Wt 700). Projects located in or adjacent to designated prime wetlands under RSA 482-A:15 are considered major impact projects and require a full application to NHDES.
- Local wetland regulations and zoning vary considerably. Recommended buffer distances are summarized in Chase et al. (1995).

Distribution and Research

Northern swamps are found primarily in the White Mountains and North Country, although they are also frequent in the southwestern highlands of the state. They are rare in southeastern New Hampshire. Research is needed to better understand the distribution, composition, and classification of the black spruce peat swamp system in southeastern New Hampshire.

There are a few forested wetlands in Coos County that have been mapped as temperate swamps, but additional research should determine whether these are more properly classified as northern swamps.

Relative Health of Populations

At around 36,000 acres, northern swamps account for just under 1% of the state's land area. Of that, approximately 34% occurs on conservation lands.

Between 2004 and 2015, NH DES documented approximately 950 acres of wetlands lost in New Hampshire through development activities (Crystal, pers. comm).

Habitat Condition

A set of GIS data was used to assess ecological condition of each habitat type. Chapter 3 describes the methodology. The data used for this habitat is described below.

Biological Condition:
Species richness of rare animals within polygon
Species richness of rare animals within their dispersal distances from the polygon
Species richness of rare plants in polygon
Richness of rare and exemplary natural communities in polygon

Landscape Condition:
Area of largest swamp in the Complex
Number of dominant NWI vegetation classes (FO, EM, SS, PUB, AB) in the Complex
Number of swamp polygons in the Complex
Local Connectedness
Landscape Complexity

Human Condition:
Index of Ecological Integrity

Road density within 250 meters of the Complex Distance to nearest road (meters)

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat conversion from forestry practices that alter species composition (Threat Rank: Medium)

Timber harvesting in forested wetlands changes the vegetation structure and the amount of decaying woody debris in the wetland. It can cause rutting and can increase compaction of the soil, leading to increased runoff and nutrient inputs.

In New Hampshire, any activity that involves dredging material from or adding material to a wetland requires a permit (NHDES 2015). However, forestry activities can occur in wetlands under frozen conditions, since neither dredge nor fill occurs under such circumstances. Forested wetlands are not always properly delineated, particularly on NWI maps (Tiner 2007), so attempts to avoid wetlands during timber harvesting may not be successful. Although northern swamp species such as black spruce, northern white cedar, and eastern larch are harvested in much lower volumes than are most other species in New Hampshire (Frieswyk and Widmann 2000), harvesting may still occur, particularly near the edges of swamps. Forestry activities can also compact soil, particularly organic soils such as peat (Bennett 2010), leading to increased runoff. Decomposition of slash left near the edge of a peat swamp can alter the structure and density, and thus the water transport abilities, of the peat (Damman and French 1987).

Habitat degradation from increased temperature causes changes in species composition, and the eventual conversion to a different habitat type. (Threat Rank: Medium)

Northern swamps frequently have organic soils, which are likely to decompose more rapidly under a warmer climate. The degradation of these organic soils could lead to significant changes in overall species composition, and the eventual conversion to a different habitat type.

Northern swamps appear to have similar vulnerabilities as open peatlands, especially if they occur on organic soils (e.g., black spruce and northern white cedar swamps) (Gignac and Vitt 1994). It is likely that some of these swamps will convert over time to a composition more like that of temperate swamps, or possibly even marshes, if temperate woody species do not become established. Gradual conversion to upland forest habitat (e.g., lowland spruce-fir) could be accelerated under drying scenarios (Hayhoe et al. 2008).

List of Lower Ranking Threats:

Habitat degradation from increased sedimentation

Habitat degradation from non-point and point contaminants

Species impacts from insecticide use (mosquito treatment)

Habitat degradation from fertilizer that increases eutrophication

Habitat degradation from mercury deposition

Disturbance from acid deposition

Habitat degradation from introduced or invasive plants

Habitat degradation from groundwater and surface withdrawals

Mortality from legal and illegal OHRV activity

Mortality from hiking and biking trails

Mortality and habitat impacts (fragmenation) from roads

Habitat conversion from the direct filling of wetlands for development

Habitat conversion from development of surrounding uplands

Actions to benefit this Habitat in NH

Delineate forested swamps in northern New Hampshire and notify large landowners

Primary Threat Addressed: Habitat conversion from forestry practices that alter species composition

Specific Threat (IUCN Threat Levels): Biological resource use

Objective:
Eliminate changes to wetland structure, vegetation, and ecological processes due to cutting.

General Strategy:
Through aerial photo interpretation supplemented by field surveys, the predicted northern swamp map will be refined in areas north of the White Mountains, to create a detailed map of northern swamps by community or system. Portions of the northern swamp map corresponding to different ownerships will be distributed to the landowners of commercial timberland. For this distribution process, a GIS layer of ownerships may need to be created if landowners cannot provide shapefiles of their holdings or digital tax maps are not available. The entire map will be given to the NHDES Wetlands Bureau for use in the environmental review process.

Political Location:	**Watershed Location:**
Coos County	Androscoggin-Saco Watershed

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2015 Authors:
Peter Bowman, NHNHB

2005 Authors:

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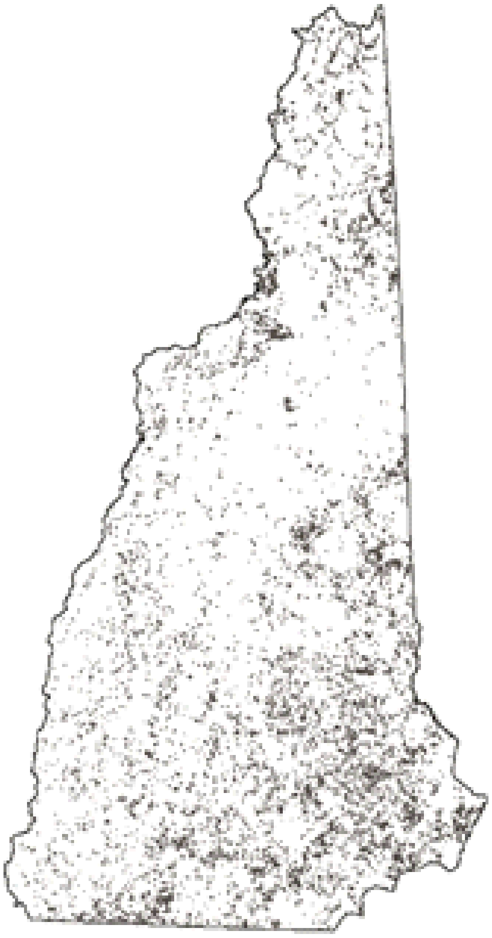
Peatlands

Photo by Ben Kimball

Acres in NH:	55889
Percent of NH Area:	1
Acres Protected:	20120
Percent Protected:	36



Habitat Distribution Map

Habitat Description

Peatlands as described here are open wetlands characterized by organic (peat) soils derived from incompletely decomposed plant matter. This habitat corresponds to 7 different natural community systems as described by NHNHB (Sperduto 2011), and only includes open wetlands dominated by shrubs, herbs, and mosses. Forested wetlands with peat soils are included in either the Temperate Swamp or Northern Swamp habitats. Peatlands develop in saturated areas where the growth rate of plants exceeds the decomposition rate of their remains. Over time, this imbalance results in the build-up of thick deposits of peat. In kettle hole bogs and poor level fen/bogs, the conditions are highly acidic, nutrient poor, and oxygen deprived. Medium level fens are less acidic, more oxygen-rich, and have higher concentrations of mineral nutrients. Both rich and poor peatlands have numerous plant species adapted to the growing conditions in these habitats.

Peatland natural community systems are differentiated primarily by their landscape position and the source and mineral content of water. Kettle hole bog systems are found primarily in central and southern New Hampshire and form where large blocks of glacial ice detached from the retreating ice sheet and melted, forming holes that held water and subsequently filled in from the edges with peat. These bogs generally do not have inlet or outlet streams and receive most of their water from precipitation, augmented by some surface runoff from their small watersheds. As a result, kettle hole bogs are typically the most acidic and nutrient poor of peatland systems. A typical vegetation sequence from the upland border to the center of the kettle hole is a marshy moat, a tall shrub fen or black spruce swamp, within which is an open boggy area of black spruce (*Picea mariana*) and leatherleaf (*Chamaedaphne calyculata*), then a floating moss carpet with extremely dwarfed shrubs, and patches of *Sphagnum* in open pools.

Poor level fen/bog systems are open, very acidic peatlands that receive very limited inputs of mineral nutrients from the surrounding uplands, and have very little or no groundwater or lake and stream influence. They occur in a variety of landscape settings, ranging from nearly closed-basins to broad drainageways with sluggish, meandering streams, and adjacent to lakes but away from the influence of the lake-water. Floristically, poor fens tend to have a species composition very similar to that of kettle hole bogs, but poor fens may lack some of the natural communities characteristic of the centers of kettle hole bogs.

Medium level fen systems are open, acidic peatlands with greater inputs of mineral nutrients than poor level fen/bogs due to the effects of upland runoff, exposure to lake and stream water, or limited groundwater seepage. They have higher pH values than poor fens or bogs. They occur in a variety of landscape settings, but mostly along stream and lake borders where the nutrient levels and seasonal fluctuations of water levels are greater than in poor level fens, but less than in emergent marshes (thus allowing peat to accumulate over the long term). These systems are a mosaic of open, sedge-dominated fens, dwarf to medium-height shrublands, and open moss lawns, carpets, and pools. A typical natural community sequence from the upland border towards the center of the basin, channel, or water-margin is as follows: a moat; a tall shrub fen zone; a dense medium-height shrub zone with sweet gale (*Myrica gale*); sedge fen; and open moss carpet areas closest to the water's edge. Moss carpets or lawns are typically not present or well developed in fens along streams, but are more common in lake border or floating mat settings. Medium level fens are found statewide, and are more common than kettle hole bog and poor level fen/bog systems.

In addition to the systems discussed above, NHB has described four other peatland natural community systems: montane sloping fen system, calcareous sloping fen system, patterned fen system, and alpine/subalpine bog system. All four of these systems are quite rare in New Hampshire, and occurrences tend to be small (<5 acres). The alpine/subalpine bog system occurs only in the alpine zone of the White Mountains, and is included in the Alpine Habitat Profile.

Justification (Reason for Concern in NH)

Conservation of peatlands is vital to the continued existence of many rare species in New Hampshire. Changes in nutrients, water quality, or hydrologic inputs to peatlands can convert them to non-peatland wetlands that may not be suitable for original flora and fauna. Southern New Hampshire peatlands are susceptible to development, while northern peatlands require protection from potentially damaging forestry practices.

Peatlands play a vital role in carbon and nitrogen cycling (Moore 2002). However, peatlands across the globe may be at risk due to climate change, which may push these communities further north. The current range of many peatland communities barely extend southward into northern New Hampshire, making them, and the wildlife that depend on them, particularly vulnerable in this state. Many rare peatland plants are restricted to the northern or southern part of the state, or to higher elevations. Likewise, several wildlife species such as the ringed boghaunter, rusty blackbird (*Euphagus carolinus*), and northern bog lemming are restricted to only those peatlands in either the northern or southern part of the state.

Protection and Regulatory Status

Federal

- Clean Water Act Sections 401 (USEPA 2005a), 402 (USEPA 2005b), 404 (USEPA 2005c): Requires a permit for discharge of pollutants, dredge, or fill material into navigable waters, such that the discharge will comply with water quality standards.

State

- RSA 482-A, Fill and Dredge in Wetlands (New Hampshire General Court 2004): Requires a permit for any project involving dredge or fill impacts to wetlands.
- Wt 303.02, Wetlands Bureau rules (NHDES 2004): Projects involving bogs, designated Prime Wetlands, rare or exemplary natural communities in wetlands, or endangered or threatened wildlife in wetlands are considered major impact projects.
- RSA 485-A, Water Pollution and Waste Disposal (New Hampshire General Court 2004): subsurface wastewater disposal systems must be greater than 15 m from poorly drained (hydric B) soils and 23 m from very poorly drained (hydric A) soils.
- RSA 217-A, Native Plant Protection Act (New Hampshire General Court 2004): Removing threatened, endangered or special concern plants from public land or land owned by another party is prohibited.

Distribution and Research

Peatlands are broadly distributed throughout the northeastern United States and Canada. However, many peatland types have a restricted distribution. New Hampshire is in a transition zone where peatlands typical of southern regions and northern boreal regions can be found. Medium level fens and poor level fens and bogs are widespread in New Hampshire. Kettlehole bogs and coastal conifer peat swamps reach their northern extent in southern and central New Hampshire. Patterned fens and calcareous sloping fens are restricted to northern New Hampshire, and alpine/subalpine bogs and montane sloping fens are restricted to high elevations of the White Mountains and northern New Hampshire. Peatlands are sparse in mountainous regions.

Surveys should be conducted for peatland species that are found in adjacent states and provinces, and to confirm and update New Hampshire’s rare species records. Targeted species could include northern bog lemming and bog elfin (*Callophrys lanoraieensis*).

Relative Health of Populations

At just under 56,000 acres, total peatland area is less than 1% of New Hampshire’s total land area. The majority of known peatland area falls within 5 ecoregions (Figure 1): the two coastal ecoregions, the two northernmost ecoregions, and one central ecoregion (Sebago-Ossipee Hills and Plain).

Between 2004 and 2015, NH DES documented approximately 950 acres of wetlands lost in New Hampshire through development activities (Crystal, pers. comm).

Habitat Condition

A set of GIS data was used to assess ecological condition of each habitat type. Chapter 3 describes the methodology. The data used for this habitat is described below.

Biological Condition:

Species richness of rare animals within polygon
Species richness of rare animals within their dispersal distances from the polygon
Species richness of rare plants in polygon
Richness of rare and exemplary natural communities in polygon

Landscape Condition:
Area of largest peatland in the Complex
Number of dominant NWI vegetation classes (FO, EM, SS, PUB, AB) in the Complex
Number of peatland polygons in the Complex
Local Connectedness
Landscape Complexity

Human Condition:
Index of Ecological Integrity
Road density within 250 meters of the Complex
NHDES Landscape Level Wetlands Assessment score for Water Quality degradation
NHDES Landscape Level Wetlands Assessment score for Human Activity within 500 feet

Habitat Management Status:

Habitat management of peatlands is generally limited to land protection (see Protection and Regulatory Status). Restoration of peatlands is difficult and more commonly practiced in areas where peat is frequently mined or where forestry activities regularly occur on peatlands. These activities are not known to occur in New Hampshire at a large scale. Consequently, there is little active management of peatlands and there are few management strategies more effective than simply protecting land and allowing natural processes to occur. Several peatlands occur on lands managed for wildlife (i.e., Umbagog National Wildlife Refuge) where the primary management goals are for other habitats or wildlife and may involve water level management that is not conducive to peatlands. These areas may provide opportunities to study whether current management strategies could be improved for peatland habitats.

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Species impacts from insecticide use (mosquito treatment) (Threat Rank: Medium)

New Hampshire permits the control of mosquitoes using larvicides (bacteria and insect growth regulators) and adulticides (pyrethroid synthetic pesticides) (NH DHHS 2008). Many of these pesticides can affect a broad spectrum of insects and other invertebrate species.

Larvicides are applied specifically to wetlands. Insect growth regulators like methoprene are broadly toxic to invertebrates, particularly crustaceans. Bacterial controls *like Bacillus thuringiensis var. israelensis* (BTI) are toxic to non-biting midges, which are an important food source in wetlands for a variety of wildlife species, including invertebrates, fish, amphibians, and birds. Pyrethroid adulticides are highly toxic to many aquatic organisms and are specifically prohibited from being applied to wetlands and water bodies. However, these chemicals can enter wetlands through drift from aerial spraying (Mazzacano & Black 2013).

Habitat degradation from non-point and point contaminants from run-off (Threat Rank: Medium)

There are a variety of pollutants that can enter wetlands as a result of runoff from roads and other developed areas. These include hydrocarbons from oil and gasoline, metals such as lead, zinc, and copper, and road salt.

Metals and hydrocarbons can have toxic effects on wildlife that vary depending on species and type of contaminant. Salt runoff can have significant impacts to freshwater and terrestrial plant species, causing dieback or failure to germinate (Wright et al. 2006).

Habitat degradation from groundwater and surface withdrawals (Threat Rank: Medium)

Extraction of groundwater and surface water for municipal water supplies or commercial uses could result in a local lowering of the water table, potentially impacting wetlands that lose contact with groundwater.

There have been several studies that examine the potential for groundwater withdrawals to impact wetlands and water bodies (Laidig et al. 2010; Mortellaro et al. 1995). Peatlands are particularly vulnerable to these impacts because drying of peat can cause decomposition of organic soils and and subsequent subsidence. A recent case in Massachusetts saw the state place limits on groundwater withdrawals from municipal wells due to observable impacts to a nearby Atlantic White Cedar Swamp, including drying of organic soils and changes in plant species composition (MA Water Resources Commission 2013).

Habitat degradation from extended periods of drought (Threat Rank: Medium)

Increased temperatures as a result of climate change already have the potential to increase decomposition rates, causing peat mats to decay more rapidly. Extended periods of drought may further promote increased decomposition.

Climate change models suggest that summers will see more extended period of drought (Hayhoe et al. 2008) Changes in peatland hydrology have the potential to increase decomposition rates for peat. The combination of increased temperatures and reduced precipitation (at least seasonally) will result in increased evapotranspiration, which in turn could lower surface water levels (Gorham 1991) and expose peat to air and wind. In addition, lowered water levels may foster colonization by trees that are otherwise unable to survive on saturated peatlands (Gignac and Vitt 1994).

Habitat degradation and mortality from increased temperatures (Threat Rank: Medium)

Increased temperature may result in increased decomposition rates, causing peat mats to decay more rapidly, and resulting in a loss of peatland habitat, and possible conversion to marsh.

In a typical climate change scenario, higher temperatures and a longer growing season will result in an increased decomposition rate for peatlands. As this rate increases, organic matter accumulation will not be able to keep pace with decomposition, and peat soils will begin to break down (Gorham 1991, Gignac and Vitt 1994). Without this organic matrix, many plants restricted to peatlands will disappear, and likely be replaced with those more typical of marsh or open water habitats.

Habitat conversion from the direct filling of wetlands for development (Threat Rank: Medium)

Most wetlands are filled for residential and commercial developments, road development or maintenance, agriculture and recreation (e.g., athletic fields). Direct filling has catastrophic and immediate impacts to the wetland habitat and the species that use it. Wetland alterations that do not result in complete filling also may have substantial impacts to wetlands and associated fauna, but effects may not be detected immediately.

The loss and degradation of wetland habitats is a major threat to most groups of wildlife including waterfowl (North American Waterfowl Management Plan 1986, 2000) and other birds (Hunt 2005), and reptiles and amphibians (Mitchell 2003). Between 2004 and 2014, 957 wetland acres were impacted in New Hampshire, with a high of 197 acres in 2006 and a low of 41 acres in 2012 (S. Crystall NHDES, pers. comm). Wetland types were not described in impact totals and impacts to wildlife resulting from loss of uplands were not considered. Under NHDES regulations, marshes receive some priority for protection and large marshes are not likely to be filled. However, driveway and road crossing placement in wetlands in order to gain access to developable uplands occurs frequently (M. N. Marchand, NHFG, personal observation).

Habitat impacts and conversion due to development of surrounding uplands (Threat Rank: Medium)

Construction near peatlands, which may involve dredging and filling, reduces available habitat for peatland-dependent species. Wildlife using peatlands, such as turtles, may also use uplands for part of their life cycle or for migration. Species that are restricted to peatlands may require connectivity between patches for occasional genetic exchange and maintenance of genetic diversity. Loss of upland habitat isolates peatlands and makes travel between them difficult for wildlife. Thus, fragmentation results in a loss of both genetic exchange and functional upland habitat.

Peatlands take a long time to develop due to the slow accumulation of peat; thus, lost peatlands are not easily restored (Rochefort et al. 2003). Peatlands can only develop within certain topographic and hydrologic settings (Crum 2000, Damman and French 1987), so artificial creation of new peatlands is generally not possible.

Habitat fragmentation can influence many species including those with limited mobility (Mader 1984, Reh and Seitz 1990, Herrmann et al. 2005). Peatland and other wetland taxa are more likely to disperse through forested uplands than non-forested uplands (deMaynadier and Hunter 1999, Nekola et al. 2002), so habitat fragmentation could alter the upland to the extent that individuals are no longer able to migrate. Peatlands and other wetlands are patchy habitats within an upland landscape, and the wildlife that depend on them often exhibit little migration between patches (Gibbs 2000). With this limited migration and limited genetic exchange, any further hindrance to migration between habitats could render local populations vulnerable to extinction.

List of Lower Ranking Threats:

Habitat degradation from increased sedimentation

Habitat degradation from mercury deposition

Disturbance from acid deposition

Habitat degradation from fertilizer that increases eutrophication

Species impacts from introduced or invasive plants

Habitat degradation from altering wetland hydrology

Mortality and degradation from legal and illegal OHRV activity

Disturbance and habitat degradation from hiking and biking trails

Mortality from the collection of rare plants

Habitat degradation and mortality from forestry activities near wetland

Habitat conversion from the mining of peat

Actions to benefit this Habitat in NH

Prioritize locations and mitigation strategies to reduce direct mortality of wildlife on existing roads and promote connectivity among fragmented habitat

Primary Threat Addressed: Habitat impacts and conversion due to development of surrounding uplands

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
The objective is to identify important locations and appropriate strategies for mitigating the effects of roads on mortality of wildlife species and connectivity among populations in habitat patches fragmented by roads.

General Strategy:
This action will have the following components: (1) identify high priority locations for implementing road-mitigation strategies. These priority locations may be based on individual species of concern, high mortality of multiple species, concerns regarding wildlife-vehicle collisions and public safety, and/or regional connectivity analyses such as the Staying Connected Initiative. Approaches used for identifying priority locations may include spatial models and direct observation of live and dead animals on roads (Clevenger et al. 2002, Beaudry et al. 2008, Langen et al. 2009, Patrick et al. 2012); (2) Identify appropriate mitigation strategies such as signage and crossing structures based on biophysical setting and the ecology of target (Jackson 2003, Patrick et al. 2010); (3) Support enabling conditions for implementing road mitigation strategies including increased public funding and appropriate policies and procedures for transportation management agencies that ensure that reengineering of existing structures such as curbs, culverts and underpasses promotes wildlife passage. Priority species will include mink frog and northern bog lemming.

Political Location: **Watershed Location:**

Minimize the effect of new road construction on wildlife mortality and habitat fragmentation

Primary Threat Addressed: Habitat impacts and conversion due to development of surrounding uplands

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
The objective is to ensure that new roads are designed and located with the goal of minimizing effects

on wildlife mortality and habitat fragmentation

General Strategy:

New roads should be avoided where possible. When road construction is justified, roads should be located to avoid bisecting wetlands, wetland/upland interfaces, large blocks of contiguous habitat, and other habitat types that organisms traverse during their life-history cycle (for example, adjacent to known snake hibernacula). Where new roads will cross known or likely wildlife movement paths or fragment previously contiguous habitat, an evaluation of the most appropriate mitigation strategies should be conducted based on the threat status of the species, the biophysical setting and corresponding nature of the wildlife crossing (for example organisms concentrated in a narrow corridor of suitable habitat or spread along a long road segment), and traffic volume. On high traffic volume roads, a combination of regularly maintained barrier fences and suitable crossing structures should be used. On low traffic volume roads, ensuring that curbs and other barriers do not prevent crossing may be the most appropriate strategy (i.e. facilitating the passage of organisms over the roadway). Signage as a strategy for reducing mortality should be used with consideration due to concerns that this approach is not effective. Reducing vehicle speed through road-design elements can be an effective tool for reducing wildlife-vehicle collision. This strategy requires information regarding appropriate road location and design being readily available in an appropriate format for use by decision-makers. The efficacy of this strategy will be greatly increased by ensuring that best management practices are embedded in policies and procedures of transportation management agencies, state agencies, and local municipalities.

Political Location: **Watershed Location:**

Promote measures to protect wetlands as described in “Innovative Land Use Planning Techniques.”

Primary Threat Addressed: Habitat degradation from non-point and point contaminants from run-off

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:

The objective is reduce impacts to wetlands from other land uses, including development, transportation, and agriculture.

General Strategy:

“Innovative Land Use Planning Techniques” is a document developed by the Department of Environmental Services to present ideas on land use planning to New Hampshire municipalities. Included among these ideas are suggestions for protecting wetlands from various forms of human disturbance, focusing on the creation of local ordinances to establish buffers around wetlands and watercourses. NHFG should work with the NH Association of Conservation Commissions to emphasize the value of such protections to wildlife resources.

Political Location: **Watershed Location:**

Promote enforcement of the Groundwater Protection Act

Primary Threat Addressed: Habitat degradation from groundwater and surface withdrawals

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:

The objective is to ensure the protection of wetland habitats from impacts of groundwater withdrawals.

General Strategy:

The Groundwater Protection Act was established to protect groundwater and surface water resources from the impacts of groundwater withdrawals. NHFG and NHB should work with DES to document any potential impacts to peatland and other wetland resources and identify methods of mitigating these affects.

Political Location:

Statewide

Watershed Location:

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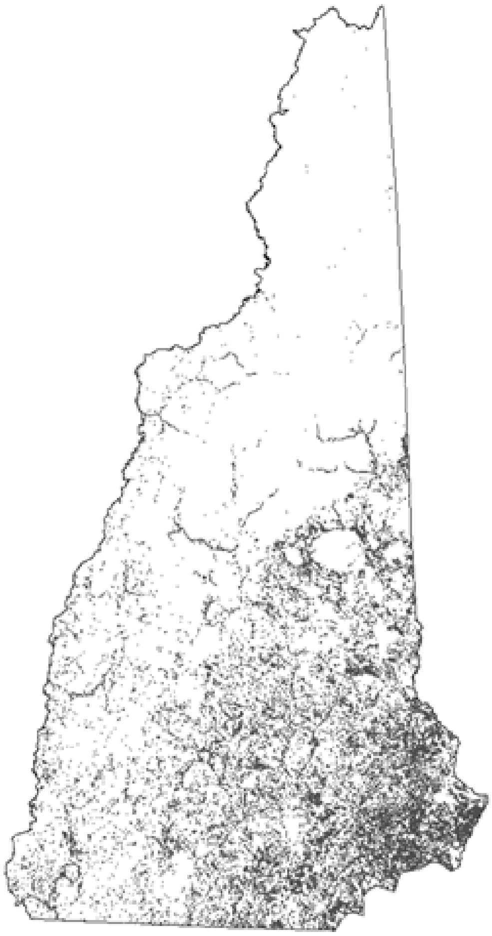
Temperate Swamps

Photo by Ben Kimball

Acres in NH:	92333
Percent of NH Area:	2
Acres Protected:	20313
Percent Protected:	22



Habitat Distribution Map

Habitat Description

This habitat consists of forested wetlands found primarily in central and southern New Hampshire, and corresponds to the temperate peat swamp, coastal conifer peat swamp, and temperate minerotrophic swamp systems described by NHNHB (Sperduto 2011). In the 2005 Wildlife Action Plan, the temperate peat swamp and coastal conifer peat swamp systems were included as a subset of peatlands, but their structure and associated species differ substantially from open peatlands such as bogs and fens, and here are addressed as a separate habitat. The wetlands of the temperate minerotrophic swamp system were essentially unrepresented in the original WAP. They are distinct from peat swamps in terms of hydrology, water chemistry, and species composition, but have a generally similar structure as forested wetlands.

Temperate peat swamps are found throughout southern and central New Hampshire, typically in isolated or stagnant basins with saturated, organic soils. These swamps are most frequently dominated by red maple (*Acer rubrum*), with an understory characterized by the tall shrubs highbush blueberry (*Vaccinium corymbosum*) and winterberry (*Ilex verticillata*). In many examples in southeastern New Hampshire, black gum (*Nyssa sylvatica*) is a significant component of the canopy. Most occurrences of the coastal conifer peat swamp system are defined by the dominance of Atlantic white cedar (*Chamaecyparis thyoides*). There are four Atlantic white cedar communities described for New Hampshire, all of which are rare in the state. This system also includes the pitch pine - heath swamp, a rare community usually associated with the pine barrens landscape. Most coastal conifer peat swamps occur within 30 miles of the Atlantic coast, although a few examples of an inland type of Atlantic white cedar swamp occur at a greater distance from the ocean.

Like temperate peat swamps, temperate minerotrophic swamps are typically dominated by red maple. However, unlike peat swamps, minerotrophic swamps primarily have mineral soils that are less acidic. The hydrology of these wetlands is variable, and includes headwater swamps fed by groundwater seepage, as well as seasonally-flooded swamps associated with low-gradient streams and small rivers. Floristically, these minerotrophic swamps tend to be more diverse than the peat swamps, with greater variety of herbaceous species associated with marshes and forest seeps.

Justification (Reason for Concern in NH)

Wetlands are habitats that provide a number of critical functions such as flood control, pollutant filters, shoreline stabilization, sediment retention and erosion control, food web productivity, wildlife habitat, recreation, and education (Tiner 1984, North American Waterfowl Management Plan 1986, New Hampshire Office of State Planning 1989).

Protection and Regulatory Status

Federal

- Clean Water Act-Section 404; administered by the USACE and USEPA: regulates discharge of dredge or fill material into “waters of the United States” including wetlands.
- Migratory Bird Treaty Act (1918)
- Emergency Wetlands Resources Act (1986): requires the Secretary of Interior (through USFWS) to produce updated reports every ten years on the status and trends of wetlands and deepwater habitats in the conterminous United States (Dahl and Johnson 1991); Section 303- requires inclusion of wetlands in statewide comprehensive outdoor recreation plans (SCORP).

State

- Fill and Dredge in Wetlands; NHDES (NHDES, RSA 482-A)- requires applicant to obtain a permit to fill or dredge jurisdictional wetland habitats. The NHDES has placed emphasis on preserving bogs and marshes based upon rarity and difficulty in restoration of value and functions (NHDES Wt 302.01). For all major (> 1,800 m2) and minor (270- 1,800 m2) impact projects, the applicant must assess impacts to plants, fish, and wildlife including rare, special concern species, state and federally listed threatened and endangered species, species at the extremities of their ranges, migratory fish and wildlife, and exemplary Natural communities identified by the NHNHB (NHDES Wt 302.04). The NHDES Wetlands Bureau does not require construction setbacks from non-tidal freshwater wetlands (except under RSA 485-A).
- Water Pollution and Waste Disposal Statute (RSA 485-A)- subsurface wastewater disposal systems must be greater than 15 m (50 ft) from poorly drained (hydric B) soils and 23 m (75 ft) from very poorly drained (hydric A) soils.
- New Hampshire Endangered Species Conservation Act (RSA 212-A)
- Nongame Species Management Act (1988) (RSA 212-B)—the NHFG Nongame and Endangered Species Program has responsibility and authority to conduct research, management, and education related to those species not hunted, fished, or trapped.
- Native Plant Protection Act (RSA 217-A); HNHB

Local

- Designation of Prime Wetlands (RSA 482:a-15): towns may designate individual wetlands as 'prime' based on NHDES protocol (NHDES Wt 700). Projects located in or adjacent to designated prime wetlands under RSA 482-A:15 are considered major impact projects and require a full application to NHDES.
- Local wetland regulations and zoning vary considerably. Recommended buffer distances are summarized in Chase et al. (1995).

Distribution and Research

Temperate swamps are found primarily in central and southern New Hampshire, with the greatest concentration in the Seacoast region. There are some temperate swamps mapped in Coos County, but these areas would probably be better classified as northern swamps. Research should focus on surveying these locations to determine their proper classification.

Relative Health of Populations

Temperate swamps occupy roughly 2% of New Hampshire's land area, with 22% occurring on conservation lands.

Between 2004 and 2015, NH DES documented approximately 950 acres of wetlands lost in New Hampshire through development activities (Crystal, pers. comm).

Habitat Condition

A set of GIS data was used to assess ecological condition of each habitat type. Chapter 3 describes the methodology. The data used for this habitat is described below.

Biological Condition:
Species richness of rare animals within polygon
Species richness of rare animals within their dispersal distances from the polygon
Species richness of rare plants in polygon
Richness of rare and exemplary natural communities in polygon

Landscape Condition:
Area of largest swamp in the Complex
Number of dominant NWI vegetation classes (FO, EM, SS, PUB, AB) in the Complex
Number of swamp polygons in the Complex
Local Connectedness
Landscape Complexity

Human Condition:
Index of Ecological Integrity
Road density is within 250 meters of the Complex Distance to nearest road (meters)

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation from insect pests (Hemlock woolly adelgid invasion) (Threat Rank: High)

The hemlock wooly adelgid (*Adelges tsugae*), a small, sap-sucking insect native to Japan and China, became established in the Pacific Northwest in 1924 (na.fs.fed.us/fhp/hwa,). This insect became established in Virginia in the early 1950s and has since been spreading in the northeastern United States. As of 2015, infestations have been identified in 82 towns in eight counties in the state (NHDFL 2015). This species can be spread through the transportation of infected nursery stock as well as by wind, birds, and mammals. Eastern hemlock (*Tsuga canadensis*) has demonstrated little or no resistance to adelgid damage and mortality (McClure et al. 2001).

Although rarely dominant, hemlock is a common component of temperate peat swamps across New Hampshire, so the potential impacts to this habitat are significant. The hemlock wooly adelgid sucks sap from young hemlock twigs, resulting in needle drop, twig die-back, growth reduction, and tree mortality over the course of several years (Havill et al. 2014).

Habitat degradation from sedimentation (Threat Rank: Medium)

Elevated levels of sediments entering wetlands arrive through runoff from roads, construction sites, and agricultural fields. Sediment deposition in wetlands can lead to decreased plant species diversity and favorable conditions for the spread of invasive plants (Wright et al. 2006).

Sediment deposition in wetlands can influence the ability of seeds to germinate and grow by altering light availability, temperature, and oxygen levels in the soil (Wardrop & Brooks 1998). A study of Atlantic white cedar swamps in New Jersey found that increased runoff from developed areas, including sedimentation, led to changes in plant species composition, including failure of cedar seedlings to survive (Simpson 2000).

Species impacts from insecticide use (mosquito treatment) (Threat Rank: Medium)

New Hampshire permits the control of mosquitoes using larvicides (bacteria and insect growth regulators) and adulticides (pyrethroid synthetic pesticides) (NH DHHS 2008). Many of these pesticides can affect a broad spectrum of insect and other invertebrate species.

Larvicides are applied specifically to wetlands. Insect growth regulators like methoprene are broadly toxic to invertebrates, particularly crustaceans. Bacterial controls like Bacillus thuringiensis var. israelensis (BTI) are toxic to non-biting midges, which are an important food source in wetlands for a variety of wildlife species, including invertebrates, fish, amphibians, and birds. Pyrethroid adulticides are highly toxic to many aquatic organisms and are specifically prohibited from being applied to wetlands and water bodies. However, these chemicals can enter wetlands through drift from aerial spraying (Mazzacano & Black 2013).

Habitat degradation from fertilizer that increases eutrophication (Threat Rank: Medium)

Increased nutrient input through runoff, decaying woody debris, or hydrologic alterations changes the nutrient content of the water in wetlands, particularly peat swamps. This increases the rate of peat decomposition, which in turn affects water transport through the soil and nutrient availability. Increases in nutrient levels may result in a change in plant species composition, in particular making the wetland more suitable for the establishment of invasive plants.

Temperate peat swamps are nutrient poor systems where organic decomposition is very slow and organic matter (peat) accumulates over time. Peatlands are inhabited by a suite of plants adapted to nutrient-poor conditions (Sperduto and Nichols 2011). Increases in nutrient concentrations will change the plant community and the rate of organic decomposition (Aerts et al. 2001), resulting in a degradation of habitat. Land conversion and other human activities near peat swamps can alter natural nutrient regimes through the combined effects of erosion, runoff, fertilizers, or hydrologic alteration. The rate of land conversion in New Hampshire, particularly in the two southeastern ecoregions, is quite high (NHNHB, unpublished data).

Habitat degradation from forestry occurring in a swamp that modifies forest structure (Threat Rank: Medium)

Timber harvesting in forested wetlands changes the vegetation structure and the amount of decaying woody debris in the wetland. It can cause rutting and increase compaction of the soil, leading to increased runoff and nutrient inputs.

In New Hampshire, any activity that involves dredging material from or adding material to a wetland requires a permit (NHDES 2015). However, forestry activities can occur in wetlands under frozen conditions, since neither dredge nor fill occurs under such circumstances. Forested wetlands are not always properly delineated, particularly on NWI maps (Dan Sperduto, NHNHB, personal communication), so attempts to avoid wetlands during timber harvesting may not be successful. Forestry activities can also compact soil, particularly organic soils such as peat (New Hampshire Forest Sustainablility Standards Work Team 1997), leading to increased runoff. Decomposition of slash left near the edge of a peat swamp can alter the structure and density, and thus the water transport abilities, of the peat (Damman and French 1987).

Mortality and habitat impacts (fragmentation) from roads (Threat Rank: Medium)

Depending on the extent of fragmentation and loss or degradation of upland habitat, wildlife may be affected differently. Most species associated with wetlands use a portion of surrounding uplands for foraging, dispersing, reproduction, egg laying, resting, cover, and overwintering (Semlitsch and Bodie 2003). Extent and area of upland use can vary widely among species. Impacts to upland habitats from development can result in direct mortality of individuals, create barriers to dispersal, fragment species populations, eliminate or reduce the quality of nesting or forage habitat, and increase predation of nests or young as a result of generalist predators benefiting from an abundance of forage.

Habitat fragmentation can influence many species including those with limited mobility (Mader 1984, Reh and Seitz 1990, Herrmann et al. 2005). Marsh and other wetland taxa are more likely to disperse through forested uplands than non-forested uplands (deMaynadier and Hunter 1999, Nekola et al. 2002), so habitat fragmentation could alter the upland to the extent that individuals are no longer able to migrate. Marshes and other wetlands are patchy habitats within an upland landscape, and the wildlife that depend on them often exhibit little migration between patches (Gibbs 2000). With this limited migration and limited genetic exchange, any further hindrance to migration between habitats could render local populations vulnerable to extinction.

Habitat conversion due to the direct filling of wetlands for development (Threat Rank: Medium)

On National Wetland Inventory Maps, roughly half of all freshwater wetlands in New Hampshire are forested. However, forested wetlands are often difficult to photointerpret, and as a group may be under-represented on by NWI (Tiner 2007).

The loss and degradation of wetland habitats is a major threat to most groups of wildlife including waterfowl (North American Waterfowl Management Plan 1986, 2000) and other birds (Hunt 2005), and reptiles and amphibians (Mitchell 2003). NHDES currently has regulations that limit the amount of wetland filling (RSA 482-A). Between 2004 and 2014, 957 wetland acres were impacted in New Hampshire, with a high of 197 acres in 2006 and a low of 41 acres in 2012 (S. Crystall NHDES, pers. comm). Wetland types were not described in impact totals and impacts to wildlife resulting from loss of uplands were not considered. Under NHDES regulations, marshes receive some priority for protection and large marshes are not likely to be filled. However, driveway and road crossing placement in wetlands in order to gain access to developable uplands occurs frequently (M. N. Marchand, NHFG, personal observation).

Habitat conversion due to development of surrounding uplands (Threat Rank: Medium)

Depending on the extent of fragmentation and loss or degradation of upland habitat, wildlife may be affected differently. Most species associated with wetlands use a portion of surrounding uplands for foraging, dispersing, reproduction, egg laying, resting, cover, and overwintering (Semlitsch and Bodie 2003). Extent and area of upland use can vary widely among species. Impacts to upland habitats from development can result in direct mortality of individuals, create barriers to dispersal, fragment species populations, eliminate or reduce the quality of nesting or forage habitat, and increase predation of nests or young as a result of generalist predators benefiting from an abundance of forage. In forested wetlands, hydrologic changes caused by habitat fragmentation generally reduce species richness and abundance of plants, macroinvertebrates, amphibians, and birds with greater numbers of invasives and exotics (Faulkner 2004).

Habitat fragmentation can influence many species including those with limited mobility (Mader 1984, Reh and Seitz 1990, Herrmann et al. 2005). Swamp and other wetland taxa are more likely to disperse through forested uplands than non-forested uplands (deMaynadier and Hunter 1999, Nekola et al. 2002), so habitat fragmentation could alter the upland to the extent that individuals are no longer able to migrate. Swamps and other wetlands are patchy habitats within an upland landscape, and the wildlife that depend on them often exhibit little migration between patches (Gibbs 2000). With this limited migration and limited genetic exchange, any further hindrance to migration between habitats could render local populations vulnerable to extinction.

List of Lower Ranking Threats:

Habitat degradation from non-point and point contaminants

Habitat degradation from introduced or invasive plants

Habitat degradation from groundwater and surface withdrawals

Mortality from legal and illegal OHRV activity

Mortality from hiking and biking trails

Habitat degradation from livestock use near or in wetlands: disturb and compact soil, degrade water quality

Habitat degradation from increased vulnerability to invasive species

Actions to benefit this Habitat in NH

Work with foresters to promote use of BMPs presented in Good Forestry in the Granite State.

Primary Threat Addressed: Habitat degradation from forestry occurring in a swamp that modifies forest structure

Specific Threat (IUCN Threat Levels): Biological resource use

Objective:
The objective is to reduce impacts from forestry activities on forested wetlands.

General Strategy:
Through NH Cooperative Extension, promote adherence to Best Management Practices related to wetlands as presented in Good Forestry in the Granite State. Groups such as the Society of American Foresters and the Timberland Owners' Association conduct workshops and professional development courses that can disseminate information on this subject.

Political Location:
Statewide

Watershed Location:

Support the Division of Forests and Lands in the implementation of the hemlock woolly adelgid action plan.

Primary Threat Addressed: Habitat degradation from insect pests (Hemlock woolly adelgid invasion)

Specific Threat (IUCN Threat Levels): Invasive & other problematic species, genes & diseases

Objective:
The objective is to minimize the impact of hemlock woolly adelgid on NH forests and control its spread in the state.

General Strategy:
The "Action Plan to Restrict the Spread and Manage Hemlock Woolly Adelgid Within the State of New Hampshire" is designed to guide the appropriate agencies and personnel in the management of hemlock woolly adelgid. The action plan was developed by the NH Division of Forests and Lands and recommended by the state's Forest Pest Advisory Group which is comprised of pest specialists representing the NH Division of Forests and Lands, USDA Forest Service, NH Department of Agriculture Markets and Foods, UNH Cooperative Extension, The Society for the Protection of New Hampshire's Forests, The Nature Conservancy, the Granite State Society of American Foresters, and the USDA Animal and Plant Health Inspection Service. These organizations are brought together by the State Forester to provide oversight in the management of major forest pest outbreaks.

Political Location:

Watershed Location:

Promote measures to protect wetlands as described in "Innovative Land Use Planning Techniques."

Primary Threat Addressed: Habitat degradation from fertilizer that increases eutrophication

Specific Threat (IUCN Threat Levels): Pollution

Objective:

The objective is reduce impacts to wetlands from other land uses, including development, transportation, and agriculture.

General Strategy:

"Innovative Land Use Planning Techniques" is a document developed by the Department of Environmental Services to present ideas on land use planning to New Hampshire municipalities. Included among these ideas are suggestions for protecting wetlands from various forms of human disturbance, focusing on the creation of local ordinances to establish buffers around wetlands and watercourses. NHFG should work with the NH Association of Conservation Commissions to emphasize the value of such protections to wildlife resources.

Political Location: **Watershed Location:**

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Peter Bowman, NHNHB

2005 Authors:

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Vernal Pools

Photo by Pete Bowman

Acres in NH: not available
Percent of NH Area:
Acres Protected:
Percent Protected:

Habitat Distribution Map Not Available

Habitat Distribution Map

Habitat Description

Vernal pools are depressional wetlands characterized by generally small size, physical isolation, and alternating periods of flooding and drying. Precipitation and groundwater levels determine hydroperiod, though some are fed by spillover from nearby water bodies or intermittent streams. Vernal pools with a hydroperiod shorter than two months (in spring or summer) may be more properly characterized as ephemeral, as they are not inundated long enough for vernal pool species to complete their life cycle (Colburn 2004). Pools inundated less than four months following spring ice-out might not support a full array of vernal-pool dependent amphibians (Paton and Couch 2002, Babbitt et al. 2003).

The regular drying of vernal pools prevents fish from becoming established. Larvae of vernal pool amphibians lack (or have weakly developed) anti-predator mechanisms to cope with fish predation (Wellborn et al. 1996, Skelly 1997). Technically, vernal pools are hydrologically isolated from other water bodies; however, sites that form periodic connections with other bodies, or that do not dry every year can support vernal pool species if fish populations do not become established.

Vernal pools often have little vegetation. However, pools with a long hydroperiod often have a variety of wetland plants such as *Sphagnum* mosses, sedges, rushes, ferns, shrubs, and trees. Common shrubs and trees in vernal pool depressions include buttonbush (*Cephalanthus occidentalis*), highbush blueberry (*Vaccinium corymbosum*), winterberry (*Ilex verticillata*), red maple (*Acer rubrum*), speckled alder (*Alnus rugosa*), and eastern hemlock (*Tsuga canadensis*) (Colburn 2004, Sperduto and Nichols 2011).

Justification (Reason for Concern in NH)

Concern for vernal pool conservation is that they are small and easily overlooked (because they are seasonally dry), thus more likely to be filled during development. Because they are temporary, they historically received weaker regulatory oversight than larger permanent wetlands. Increasing population growth in the state and associated development will result in loss of vernal pools and disruption of dispersal capabilities (via increased roads and road traffic) of species that rely on them. Significant loss of vernal pool habitat can result in local extirpation of obligate vernal pool species such as the fairy shrimp (*Eubranchipus* spp.), wood frog (*Lithobates sylvatica*), spotted salamander (*Ambystoma maculatum*), blue-spotted salamander (*Ambystoma laterale*), Jefferson salamander (*Ambystoma jeffersonianum*), and the state endangered marbled salamander (*Ambystoma opacum*). In addition, other species of concern such as the Blanding's turtle (*Emydoidea blandingii*) and spotted turtle (*Clemmys guttata*) feed in vernal pools and use them as staging areas during migration (Joyal et al. 2001, Jenkens and Babbitt 2003).

Protection and Regulatory Status

Vernal pools do not have any special regulatory protection at the state level. Local wetland regulations and zoning vary considerably. Some towns (e.g., Litchfield) have initiated upland buffer protection around vernal pools. Because vernal pools are generally small and regulatory review of wetland impacts often focuses on size of impacts, vernal pools could be overlooked (M. Marchand, NHFG, personal communication). The NHDES Wetlands Bureau does not require construction setbacks from non-tidal freshwater wetlands (except under RSA 485-A).

- State Fill and Dredge in Wetlands; NHDES, RSA 482-A: Requires applicant to obtain a permit to fill or dredge jurisdictional wetland habitats. Although vernal pools should be identified as jurisdictional wetlands, they will not necessarily be identified as breeding habitat for obligate vernal pool amphibians and invertebrates.
- Nongame Species Management Act (1988) (RSA 212-B): The NHFG Nongame and Endangered Species Program has responsibility and authority to conduct research, management, and education related to those species not hunted, fished, or trapped.

Distribution and Research

Vernal pools are widespread throughout New Hampshire and the Northeast, but generally are less abundant in mountainous regions. Because vernal pools are under-reported on National Wetland Inventory (NWI) maps, the location and abundance of vernal pools in New Hampshire are not known. Further, historical records of vernal pool distribution and abundance are lacking. Vernal pools have been identified in areas of New Hampshire for various purposes including research (e.g., Turtle 2000, Babbitt et al. 2003, Jenkens and Babbitt 2003, Mattfeldt 2004, Hermann et al. 2005), natural resource inventories, and citizens documenting vernal pools using the Identification and Documentation of Vernal Pools in New Hampshire manual (Tappan and Marchand 2014). However, these data have not been compiled into one database.

There is a critical need to map vernal pools in New Hampshire and create a database (including GIS data layers) to store data for documented vernal pools. Information on vernal pool spatial distribution, density, hydroperiod, and breeding suitability for vernal pool obligates should also be collected.

Relative Health of Populations

Knowledge about the distribution of vernal pools in the state is lacking and is needed. No assessment of quality of vernal pool habitats has been conducted.
The relative health of vernal pools is closely tied to the quality of surrounding upland habitat. Hydroperiod and land use strongly influence the suitability of vernal pools for pool-dependent wildlife (Semlitsch 2000, Snodgrass et al. 2000, Paton and Couch 2002, Babbitt et al. 2003, Mattfeldt 2004, Hermann et al. 2005, Babbitt 2005). It would be instructive to develop a bioassessment program for vernal pools that is stratified by relevant spatial scale (e.g., country, bioregion) and land use (e.g. urban, suburban, forested, agriculture, protected). Measures of health or quality could include measures of amphibian use (e.g., species richness of vernal-pool dependent species, amphibian egg mass counts), species richness/abundance of aquatic insect taxa, standard water quality measures (e.g., pH, conductivity, nitrogen, phosphorus, BOD, temperature, DOC), and contaminants. Presence of fish or invasive species should be documented. Wetland hydroperiod should be measured, and the bioassessment program must be developed with a critical examination of land use and land use change attributes.

Habitat Condition

A set of GIS data was used to assess ecological condition of each habitat type. Chapter 3 describes the methodology. The data used for this habitat is described below.

Biological Condition:
To be updated at a later date

Landscape Condition:
To be updated at a later date

Human Condition:
To be updated at a later date

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Species impacts from insecticide use (mosquito treatment) (Threat Rank: High)

New Hampshire permits the control of mosquitoes using larvicides (bacteria and insect growth regulators) and adulticides (pyrethroid synthetic pesticides) (NH DHHS 2008). Many of these pesticides can affect a broad spectrum of insect and other invertebrate species.

Larvicides are applied specifically to wetlands. Insect growth regulators like methoprene are broadly toxic to invertebrates, particularly crustaceans. Bacterial controls like Bacillus thuringiensis var. israelensis (BTI) are toxic to non-biting midges, which are an important food source in wetlands for a variety of wildlife species, including invertebrates, fish, amphibians, and birds. Pyrethroid adulticides are highly toxic to many aquatic organisms and are specifically prohibited from being applied to wetlands and water bodies. However, these chemicals can enter wetlands through drift from aerial spraying (Mazzacano & Black 2013).

Mortality and habitat impacts (fragmenation) from roads (Threat Rank: High)

Vehicle traffic can kill vernal pool-dependent species by hitting and crushing them as they cross roads. This can have a significant impact on some species, particularly rare turtles, and in severe cases could result in local extirpation. Roads may act as partial barriers to overland dispersal or migration, perhaps resulting in decreased gene flow between populations and decreased colonization of unpopulated vernal pools. This could disrupt metapopulation dynamics and long-term viability of some species.

Roads also create edge habitat. Along these edges, soil and air moisture may be reduced, leading to increased salamander desiccation. Roads may act as conduits for predators that prey on amphibians or turtle eggs (e.g., skunks and raccoons), and dispersal avenues for invasive plants and animals. Runoff from roads can also reduce habitat quality of vernal pools via pollution, increased salt levels, sedimentation, and erosion in pools and adjacent habitats.

Roads significantly threaten turtles, causing skewed sex and age ratios (Marchand and Litvaitis 2004, Gibbs and Steen 2005). Computer modeling by Gibbs and Shriver (2002) predicted that relatively low road densities (e.g., 1 km/km2 with > 100 vehicles/lane/day) could result in severe negative impacts on semi-terrestrial turtles. Roads are a significant source of direct mortality for migrating amphibians (Fahrig et al. 1995, Ashley and Robinson 1996, Mazerolle 2004, Forman 2003), and salamander abundance in roadside habitats may be reduced (deMaynadier and Hunter 2000). Gibbs (1998) found that forest-road edges are less permeable to ambystomatid salamanders than are forest interior and forest-open land edges. Recent research conducted in southern New Hampshire suggests that roads have a negative impact on wood frogs (*Lithobates sylvatica*) and spotted salamanders (*Ambystoma maculatum*), two species of amphibians that breed in vernal pools (Mattfeldt 2004). Amphibians can experience delayed development or mortality from runoff contamination from roads, including road salt (Trombulak and Frissell 2000, Turtle 2000). Negative effects of roads have been well documented for a variety of animal and plant species, and likely apply generally to vernal-pool dependent species (Vos and Chardon 1998, Forman and Deblinger 2000, Carr and Fahrig 2001, Forman 2003, Mazerolle 2004).

Habitat conversion and impacts due to development of surrounding uplands (Threat Rank: High)

Development may affect breeding habitat (loss and degradation of vernal pools), upland habitat (loss and degradation of forests), and dispersal corridors (by fragmenting landscapes), and may even directly kill vernal pool wildlife (vehicle traffic, land clearing activity, etc). Runoff from roads and other impervious surfaces can pollute and degrade nearby wetland habitat. Opportunistic predators (e.g., raccoons) and invasive plant and animal species are more common near human development. Myriad stressors associated with development collectively reduce local population sizes of amphibians, reduce gene flow between populations, and may ultimately extirpate local populations.

The evidence provided below is focused on amphibians. Vernal pools often occur in discrete patches within a matrix of terrestrial habitat, and amphibians that breed in these habitats may exist as metapopulations (e.g., Gill 1978, Sjögren 1991, Sinsch 1992, Marsh and Trenham 2001). The long-term persistence of populations depends on the exchange of individuals through dispersal and the colonization probability of vernal pools from terrestrial adult populations (Hanski and Gilpin 1991, Sjögren, 1991, Dodd 1997, Semlitsch and Bodie 1998, Skelly et al. 1999). Most amphibians use terrestrial habitat to obtain food and shelter from predation, desiccation, or freezing (Madison 1997, Lamoureaux and Madison 1999, Knutson et al. 1999). Therefore, the suitability of terrestrial habitat surrounding a vernal pool is likely to have a significant influence the composition and abundance of amphibians that breed in or otherwise utilize a vernal pool.

Mortality from various diseases (ranavirus, chytrid) (Threat Rank: Medium)

Amphibian populations are vulnerable to several established diseases such as Chytrid fungus and Ranavirus with concern for additional emerging diseases such as salamander Chytrid (*Batrachochytrium salamandrivorans*) currently known in Europe but not the United States.

Habitat conversion from the direct filling of vernal pools for development (Threat Rank: Medium)

Vernal pools are filled to provide non-wet areas for residential and commercial development, recreation, agriculture, and road development. Vernal pool filling results in immediate loss of habitat and, for certain species, population extirpation. Wetland filling also increases the distance that dispersing amphibians must travel to reach suitable breeding habitat, resulting in decreased gene flow between local populations and decreased colonization of unpopulated breeding pools. This could disrupt metapopulation dynamics and long-term viability of the species.

Amphibians, particularly ambystomatid salamanders, generally breed in the same wetland every year (Semlitsch et al. 1993, Semlitsch 1998). It is not well known how these species respond when a breeding wetland is no longer available (i.e., filled). Some ambystomatid salamanders will return to breeding wetlands even after those wetlands have been filled, whereas others have been able to disperse to nearby created wetlands (Pechmann et al. 2001). Created mitigation wetlands usually are unsuccessful at replicating the functions or wildlife habitat of the wetlands they are intended to replace (Brown 1999).

List of Lower Ranking Threats:

Disturbance from fertilizer use near wetlands

Disturbance from toxins and contaminants that impact species

Disturbance from acid deposition

Habitat impacts from introduced or invasive species

Mortality from hiking and biking trails

Mortality and degradation from legal and illegal OHRV activity

Mortality and habitat degradation from forestry activities near wetland

Habitat degradation and mortality from higher temperatures

Actions to benefit this Habitat in NH

Promote measures to protect vernal pools as described in “Innovative Land Use Planning Techniques.”

Primary Threat Addressed: Habitat conversion and impacts due to development of surrounding uplands

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
The objective is to reduce impacts to vernal pools and vernal pool wildlife from other land uses, including development, transportation, and agriculture.

General Strategy:
"Innovative Land Use Planning Techniques" is a document developed by the Department of Environmental Services to present ideas on land use planning to New Hampshire municipalities. Included among these ideas are suggestions for protecting wetlands from various forms of human disturbance, focusing on the creation of local ordinances to establish buffers around wetlands and watercourses. The document specifically recommends a buffer of 400 feet around existing vernal pools and maintaining a mostly closed canopy of trees within 100 feet of any vernal pool. NHFG should work with the NH Association of Conservation Commissions to emphasize the value of such protections to wildlife resources.

Political Location: **Watershed Location:**

Minimize the effect of new road construction on wildlife mortality and habitat fragmentation

Primary Threat Addressed: Mortality and habitat impacts (fragmenation) from roads

Specific Threat (IUCN Threat Levels): Transportation & service corridors

Objective:
The objective is to ensure that new roads are designed and located with the goal of minimizing effects on wildlife mortality and habitat fragmentation

General Strategy:
New roads should be avoided where possible. When road construction is justified, roads should be located to avoid bisecting wetlands, wetland/upland interfaces, large blocks of contiguous habitat, and other habitat types that organisms traverse during their life-history cycle (for example, adjacent to known snake hibernacula). Where new roads will cross known or likely wildlife movement paths or fragment previously contiguous habitat, an evaluation of the most appropriate mitigation strategies should be conducted based on the threat status of the species, the biophysical setting and corresponding nature of the wildlife crossing (for example organisms concentrated in a narrow corridor of suitable habitat or spread along a long road segment), and traffic volume. On high traffic volume roads, a combination of regularly maintained barrier fences and suitable crossing structures should be used. On low traffic volume roads, ensuring that curbs and other barriers do not prevent crossing may be the most appropriate strategy (i.e. facilitating the passage of organisms over the roadway). Signage as a strategy for reducing mortality should be used with consideration due to concerns that this approach is not effective. Reducing vehicle speed through road-design elements can be an effective tool for reducing wildlife-vehicle collision. This strategy requires information regarding appropriate road location and design being readily available in an appropriate format for use by decision-makers. The efficacy of this strategy will be greatly increased by ensuring that best management practices are embedded in policies and procedures of transportation management agencies, state agencies, and local municipalities.

Political Location: **Watershed Location:**

Prioritize locations and mitigation strategies to reduce direct mortality of wildlife on existing roads and promote connectivity among fragmented habitat

Primary Threat Addressed: Mortality and habitat impacts (fragmenation) from roads

Specific Threat (IUCN Threat Levels): Transportation & service corridors

Objective:
The objective is to identify important locations and appropriate strategies for mitigating the effects of roads on mortality of wildlife species and connectivity among populations in habitat patches fragmented by roads.

General Strategy:

Political Location: **Watershed Location:**

Promote measures to protect vernal pools as described in "Good Forestry in the Granite State".

Primary Threat Addressed: Mortality and habitat degradation from forestry activities near wetland

Specific Threat (IUCN Threat Levels): Biological resource use

Objective:
The objective is to reduce impacts to vernal pools and vernal pool wildlife from forest management activities.

General Strategy:
Through NH Cooperative Extension, promote adherence to Best Management Practices related to wetlands as presented in Good Forestry in the Granite State. This document presents a number of recommendations focused specifically on minimizing impacts to vernal pools.

Political Location: **Watershed Location:**

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Peter Bowman, NHNHB, Michael Marchand, NHFG

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Appendix B: Habitats

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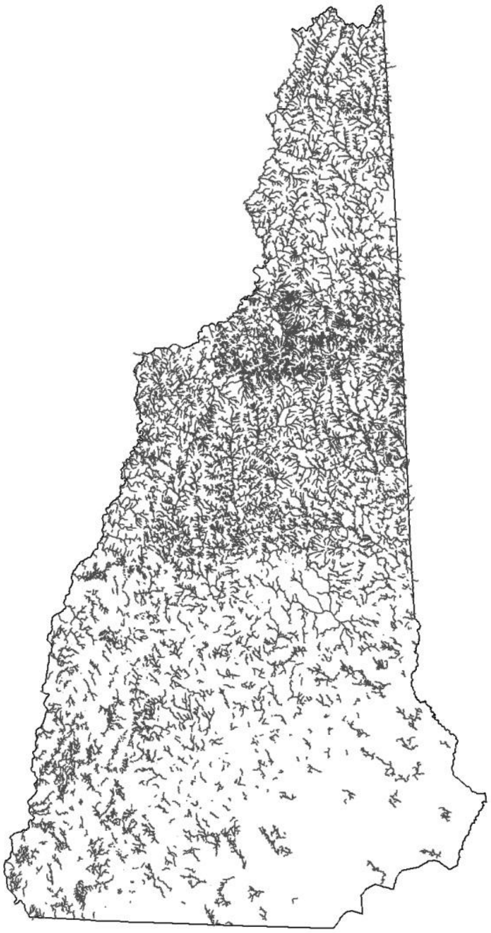
Coldwater Rivers and Streams


Photo by NHFG

Kilometers in NH: 16,970 km

Acres of Shoreline within a 100m Buffer Protected: 304,794 ac

Percent Buffer Protected: 38%


Habitat Distribution Map

Habitat Description

Coldwater rivers and streams are defined by their ability to maintain cold water temperatures during the hot summer months. The presence of coldwater fish species, including brook trout and slimy sculpin, is often an indicator of coldwater river or stream habitat. Brook trout are rarely found in rivers or streams that exceed a mean temperature of 20°C during the months of July and August. Although temperatures may rise above 20°C for short durations, extended periods of higher water temperatures typically preclude the presence of brook trout. Coldwater Rivers and streams are more common in northern New Hampshire and at higher elevations where a cooler local climate causes less warming throughout the summer. In southern New Hampshire and at lower elevations, the presence of coldwater streams depends primarily on the influence of groundwater, maintains suitable temperatures during periods of hot weather.

Coldwater streams vary in size and gradient. High gradient coldwater streams, typical of the mountainous regions in northern and western New Hampshire, are characterized by cascades and small waterfalls flowing over boulders and ledge. Flows are highly variable and water levels often react quickly to rainfall. There are relatively few aquatic species that are able to survive in this unstable environment. Resident species include brook trout and stream salamanders (e.g. spring salamanders). In streams with moderate gradient, substrate usually shifts from boulder to cobble or gravel. Riffles, pools, meander bends, and undercut banks are common habitat features and slimy sculpin, longnose sucker, and burbot may be present in addition to brook trout. Low gradient spring fed streams, typically found at lower elevations, are characterized by stable flows due to a steady supply of groundwater and by stream channels that meander over a sand or gravel substrate. These streams support a wider variety of species, including the state endangered American brook lamprey, but brook trout are typically the dominant species. As rivers become wider with larger drainage areas, they tend to become warmer. With less shading from the forest canopy and a higher ratio of surface water to groundwater, larger rivers tend to retain more heat from the rising air temperature.

Justification (Reason for Concern in NH)

Cold water river and stream habitat is declining as average air temperatures increase with climate change. The increased frequency of intense rainfall events associated with climate change, in these often flashy systems, leads to habitat degradation associated with elevated levels of erosion and sedimentation, especially at the intersection of roads, bridges, and other infrastructure. Cold water streams are also vulnerable to habitat degradation such as streamside vegetation removal and stormwater runoff from impervious surfaces. Much of the coldwater stream habitat in the northeast has been fragmented by dams and undersized stream crossings, which restrict the movements of coldwater fish species.

Protection and Regulatory Status

Coldwater rivers and streams are protected by the Clean Water Act.

Regulatory Protections:
Rivers Mngmt and Protection Program – NHDES
Comprehensive Shoreland Protection Act – NHDES
Clean Water Act-Section 404

Regulatory Comments: The Clean Water Act is difficult to enforce without baseline temperature and biological community data.

Management Guidelines

- Maintain vegetated riparian buffers of at least 30m on all perennial streams, regardless of size.
- Provide land use guidance that keeps impervious surface coverage below 4% within the watersheds of coldwater rivers and streams.
- Reduce fragmentation by replacing undersized stream crossings and removing dams.
- Protect intact networks of unfragmented coldwater river and stream habitat.
- Limit groundwater extraction in the watersheds of coldwater streams, especially in southeastern New Hampshire.
- Prevent stormwater and the contaminants conveyed by runoff from directly entering rivers and streams.

Distribution and Research

Statewide

In 2008 The Nature Conservancy (TNC) developed a regional stream and river classification to represent flowing water habitat types in the Northeast based on four major variables: size class, gradient, geology, and temperature. This map was used as the starting point for representing aquatic habitat types in New Hampshire, but the distribution of coldwater stream habitat needed to be refined. NH Department of Environmental Services provided an update to the state's coldwater rivers and streams classification using predictions based on a logistic regression model using latitude, longitude, and upstream drainage area. Coldwater determination was made where the probability of occurrence was >/= 50% (see NHDES publication R-WD-07-38), or where two (2) or more brook trout or slimy sculpin were observed (observations by NHFG and NHDES through spring 2014). This combination of predictive modelling and survey data provides a relatively accurate distribution map of coldwater river and stream habitat in New Hampshire. This map will be refined and ground-truthed with future surveys conducted by NHFG and NHDES biologists.

Relative Health of Populations

Coldwater river and stream habitat is largely intact in northern and western New Hampshire. The White Mountain region, in particular, contains large networks of relatively pristine coldwater river and stream habitat. South of the lakes region and east of the Contoocook River watershed, coldwater river and stream habitat becomes increasingly dependent on abundant sources of groundwater to maintain cool temperatures and consistent flow during the summer. Coldwater stream habitat in southern New Hampshire is vulnerable to sprawling development pressure, which may alter the hydrology of some streams and push water temperatures above the threshold for supporting coldwater species.

Habitat Condition

A set of GIS data was used to assess ecological condition of each habitat type. Chapter 3 describes the methodology. The data used for this habitat is described below.

River and Stream Reaches in each of four Very High Quality categories
Minimum Linear Connectivity Length met: Functional Network Length >= 10 miles for all systems except for tidal headwaters and creeks which have naturally small network lengths and any functional network length was acceptable.
Low Riparian Development and Agriculture Impacts: Riparian index score <= 25
No dam on reach and upstream dam water storage volume as percent of mean annual flow <10%
Low Impervious surface < 2%
Condition assessment completed by The Nature Conservancy

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation due to stream crossings (Threat Rank: High)

Poorly sized stream crossings alter the natural sediment transport characteristics of a river or stream, which leads to erosion and excess sediment deposition in the stream channel. The cumulative effect of under sized stream crossings can lead to increased sedimentation and turbidity throughout a watershed during storm events. Road fill from washed out stream crossings during flood events accumulates in the stream channel and buries the natural stream bed substrate.

Observations of stream crossings during fish surveys in New Hampshire suggest that there are very few streams that do not show some habitat damage from stream crossings (Ben Nugent, NHFG

Biologist, personal communication).

Habitat impacts from fragmentation due to impassable stream crossings (Threat Rank: High)

Undersized stream crossings can function as a barrier to the movement of aquatic species. Undersized crossing often constrict flows, creating an increase in flow velocity through the structure. As a result, increased scour at the structure outlet occurs and a drop or “perch” is formed between the stream bed and bottom of structure. Many stream crossings restrict aquatic organism movement at certain

flows due to high velocities, insufficient depth within the crossing, or an outlet that consists of a small waterfall. These barriers prevent access to critical habitat, reduce gene flow, and result in local extirpations of isolated populations.

A number of studies have demonstrated reductions in fish species richness and abundance upstream of impassable stream crossings (Nislow et al. 2011; Jackson 2003).

Habitat degradation from point source pollution (Threat Rank: Medium)

Industrial pollutants and pollution from untreated wastewater have been greatly reduced since the passage of the Clean Water Act. However, there are still isolated areas such as superfund sites or combined sewer overflows (CSO's) where pollutants continue to enter aquatic habitats at known locations.

There are 23 Superfund sites and 33 CSO's in New Hampshire (NHDES 2008; NHDES 2012). These sites are carefully monitored with long term plans for reducing their environmental impact.

Habitat degradation from agricultural run-off (Threat Rank: Medium)

Pesticides, herbicides, and fertilizers wash into aquatic habitats from agricultural fields, which are often located in the fertile floodplains of medium to large size rivers. Agricultural fields can also lead to increased turbidity, bank erosion, and sediment deposition in adjacent aquatic habitats. The degradation of water quality in watershed with a high proportion of agricultural land use can be toxic to many aquatic species.

The influence of land use on aquatic habitats within a watershed has been well documented (Allan 2004). The most obvious influences of agricultural activity are found along the Connecticut and Merrimack Rivers, where minimal to no vegetated buffers along the river bank have contributed to bank erosion and sedimentation. Coldwater streams flowing through agricultural areas often lack fully functioning riparian buffers due to stream side mowing or grazing activity.

Habitat degradation from acid deposition (Threat Rank: Medium)

Acid deposition has extirpated or reduced population densities of brook trout and other species in the northeast, especially in naturally acidic small streams and ponds at high elevations.

Episodic acidification of small streams has been shown to reduce brook trout densities and cause fish to seek refuge downstream in streams with higher pH (Baker et al.1996). Overall, episodes of acid rain are being reduced by tighter regulations on coal plants, but the buffering capacity of watersheds where calcium has been leached from the soil may not recover on its own (Huggett et al. 2007).

Habitat degradation from stormwater run-off from impervious surfaces (Threat Rank: Medium)

Stormwater runoff from impervious surfaces changes the hydrology and water chemistry of local rivers and streams. Flashier flows cause an increase in erosion and sediment deposition along stream banks and in the stream channel. More surface flow can lead to a decrease in groundwater infiltration, which results in lower base flows during dry periods. Oil based pollutants, sediment, and road salt are washed from roads and parking lots into surrounding waterbodies which can lead to chronic declines in water quality. Runoff from pavement warmed by the sun can also lead to increased water temperatures in local streams when stormwater flows directly into surface waters.

The impacts of impervious land cover on aquatic habitats have been well documented (Wang et al. 2001; Cuffney et al. 2010; Stranko et al. 2008).

Habitat degradation from water withdrawal for irrigation, public water supply, or commercial use (Threat Rank: Medium)

The coldwater streams most vulnerable to groundwater use are the small, spring fed streams found scattered throughout southeastern New Hampshire. These streams, which depend entirely on groundwater to maintain consistent flow, support small, isolated populations of brook trout. In most cases, water levels in these streams are not monitored. New groundwater withdrawals are permitted by NHDES with requirements to reduce impacts on local aquatic habitats. Grandfathered withdrawals or the cumulative effects of small water withdrawals may be influencing stream flow in some areas.

Groundwater withdrawals have the potential to alter the hydrology of local rivers and streams. A decrease in the flow of groundwater can also reduce dissolved oxygen levels and increase stream water temperatures. Groundwater extraction was determined to be the cause of extremely low streamflows in the Ipswich River, Massachusetts (USGS 2001).

Habitat degradation from altered flow regimes due to water level management of dams (Threat Rank: Medium)

River and stream habitat below lakes and ponds may be impacted as flows are shutdown in an attempt to refill lakes or increased rapidly to lower the water level. Surface waters impounded by dams are generally exposed to solar raditation and typically exceed the temperature tolerance of coldwater fish. Dams on coldwater rivers and streams not only fragment habitat, but increase water temperatures both upstream and downstream of the impoundment.

Changes in fish and invertebrate communities that result from artificial flow manipulation involve a shift to habitat generalist species. These changes have been have been well documented in studies related to instream flow (Kanno and Vokoun 2010).

Habitat degradation from stream crossings on logging roads and OHRV and snowmobile trails that cause fragmentation and sedimentation (Threat Rank: Medium)

Logging roads, OHRV and snowmobile trails, and private roads frequently cross coldwater river and stream habitat. These crossings, which can consist of either temporary or permanent structures, are often less regulated than those crossings maintained for public roads. When crossings are not designed according to the specific geomorphology of a stream, local bank erosion, stream bed scouring, and sediment deposition can occur. At a watershed scale, the cumulative effect of these crossings on headwater streams may increase sedimentation issues downstream.

Effects of stream crossings over logging roads and recreational trails vary significantly by site and construction. Many logging road crossings are temporary, but may cause significant erosion and sediment deposition to a stream before they are removed. Often snowmobile clubs build bridges that have very little impact on a stream. However, undersized culverts can cause long term habitat degradation and restrict the movement of species in areas with permanently constructed trail networks. The cumulative impacts of privately constructed road stream crossings in a watershed have not been well studied.

Habitat impacts from increased flood damage (Threat Rank: Medium)

Changes in flow conditions due to climate change may alter seasonal flow patterns as well as the intensity and frequency of flood events. Increased water temperature can increase mortality or restrict the seasonal movements of native aquatic species and also shift community assemblages.

Damage to aquatic habitats from increased flooding is exacerbated by human activity (Poff 2002). Efforts to protect infrastructure and property in floodplains, by installing armoring and diversion structures, have increased ecological damage to river and stream habitat during recent floods in New Hampshire.

Habitat impacts from flood control or erosion control (Threat Rank: Medium)

Floodplains allow rivers and streams to disperse flows and dissipate energy during flood events. River and stream habitat is frequently altered in an effort to control or prevent flood damage to local infrastructure. Channel straightening, bank armoring, berm construction, and other practices result in a confined stream channel that no longer has access to floodplain habitat. These practices result in a loss of important habitat features, such as undercut banks, large in-stream wood, and streamside vegetation. While achieving the goal of protecting infrastructure at one location, these practices often exacerbate flooding downstream. Often done in response to recent flooding, river and stream bank modifications are rarely completed according to a long term plan that attempts to combine river restoration and flood prevention. Efforts to address flood damage should be evaluated at the watershed level.

Flooding during Hurricane Irene caused severe flood damage in northern New Hampshire and Vermont. Much of this damage was exacerbated by river and stream channel alterations to protect infrastructure and property in floodplains. Attempts to rebuild structures that would accommodate more streamflow and improve habitat for aquatic species were hindered by reimbursement requirements for the Federal Emergency Management Agency (Clancy and Grannis 2013). Active floodplain areas should be mapped and left intact. Damage to roads and other structures would be minimized if active floodplain areas were avoided.

List of Lower Ranking Threats:

Habitat impacts from wastewater treatment sites and associated unmonitored contaminants

Habitat impacts from mercury toxicity

Habitat degradation from power plant effluent causing thermal pollution

Habitat degradation from run-off pollution

Habitat degradation from excess nutrients from fertilizer and run-off

Habitat degradation from excess nutrients due to septic systems

Habitat degradation from stormwater run-off

Habitat degradation due to invasive or introduced plants

Habitat impacts from introduced animal species

Habitat impacts from various diseases and parasites

Habitat impacts from fragmentation due to impassable dams

Habitat impacts from unsuitable water temperatures that disturb species life cycles

Habitat impacts from unsuitable water temperatures for coldwater species

Habitat degradation due to shoreline development

Actions to benefit this Habitat in NH

Stormwater Management

Primary Threat Addressed: Habitat degradation from stormwater run-off from impervious surfaces

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
To reduce the impacts of runoff from impervious surfaces by using Low Impact Development Technology.

General Strategy:
Stormwater runoff from impervious surfaces has been shown to damage aquatic habitats (Wang et al. 2001; Cuffney et al. 2010). Much of this damage can be prevented by stormwater management practices that filter runoff through the ground before it enters surface water. This practice not only removes much of the sediment and toxins that are typically washed into streams, but it also reduces the rapid fluctuation in temperature, as well as the excess erosion and sediment deposition that have become a chronic issue for rivers and streams in developed areas. The University of New Hampshire Stormwater Center is an excellent resource for Low Impact Development (LID) practices for stormwater management.

Political Location: **Watershed Location:**

Dam removal

Primary Threat Addressed: Habitat impacts from fragmentation due to impassable dams

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Improve habitat connectivity and reduce the impacts of dams on coldwater river and stream habitat.

General Strategy:
Dam removal projects on coldwater streams should target dams that either fragment large networks of coldwater stream habitat or dams that create unsuitable water tempetures for coldwater species. Once a dam is identified for removal, the process is the same as it is for projects targeting diadromous fish restoration. A dedicated project manager is critical for meeting permitting deadlines and managing the many issues that often arise during dam removal projects, such as contaminated sediment removal or historical resource documentation at the site. Despite efforts to prioritize, dam

removal projects often come up opportunistically as smaller dams fall into disrepair and become expensive to maintain or repair. Grant funding for dam removal projects is available, but limited, so resources should be directed at projects with the greatest benefit to coldwater stream habitat.

Political Location: **Watershed Location:**

River and stream habitat restoration

Primary Threat Addressed: Habitat impacts from flood control or erosion control

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
Restore the natural habitat qualities of a river or stream with practices such as wood additions, bank re-vegetation, floodplain restoration, or stream channel reconstruction.

General Strategy:
River and stream restoration techniques have been used to restore natural habitat features to areas that have been altered by urban development, agricultural land use, logging, or flooding. The principles of fluvial geomorphology are used to design appropriate channel characteristics according to watershed size, local climate, and substrate type at the site (Rosgen 1996). Restoration activities may range from the complete physical reconstruction of the stream channel to planting shrubs and trees to improve bank stabilization. Other common practices include floodplain restoration and wood additions (Cramer 2012).

Political Location: **Watershed Location:**

Stream crossing restoration

Primary Threat Addressed: Habitat degradation due to stream crossings

Specific Threat (IUCN Threat Levels): Transportation & service corridors

Objective:
Increase connectivity and reduce habitat degradation caused by stream crossings.

General Strategy:
There are two phases to stream crossing restoration. The first phase is assessment. Stream crossing surveys are currently being completed in watersheds throughout the state. It is important that these surveys follow the standardized methods and protocols outlined by the New Hampshire Geological Survey (NHGS). NHGS maintains a statewide database of stream crossing survey data. Once the data is collected, stream crossing restoration projects can be prioritized to achieve the greatest benefits to aquatic organism passage, along with reductions in flood damage and habitat degradation. Prioritization may take place within small watersheds or across a large region. The second phase is implementation. Once a stream crossing is identified as a good candidate for restoration there are many obstacles to a completed project, including fund raising, permitting, and cost. Streamlining the permitting process for crossing restoration, increasing available funding sources, and developing innovative stream crossing design and construction techniques that significantly reduce cost would greatly increase the number of stream crossing restoration projects in New Hampshire.

Political Location: **Watershed Location:**

Stream crossing restoration

Primary Threat Addressed: Habitat impacts from fragmentation due to impassable stream crossings

Specific Threat (IUCN Threat Levels): Transportation & service corridors

Objective:
Increase connectivity and reduce habitat degradation caused by stream crossings.

General Strategy:
There are two phases to stream crossing restoration. The first phase is assessment. Stream crossing surveys are currently being completed in watersheds throughout the state. It is important that these surveys follow the standardized methods and protocols outlined by the New Hampshire Geological Survey (NHGS). NHGS maintains a statewide database of stream crossing survey data. Once the data is collected, stream crossing restoration projects can be prioritized to achieve the greatest benefits to aquatic organism passage, along with reductions in flood damage and habitat degradation. Prioritization may take place within small watersheds or across a large region. The second phase is implementation. Once a stream crossing is identified as a good candidate for restoration there are many obstacles to a completed project, including fund raising, permitting, and cost. Streamlining the permitting process for crossing restoration, increasing available funding sources, and developing innovative stream crossing design and construction techniques that significantly reduce cost would greatly increase the number of stream crossing restoration projects in New Hampshire.

Political Location: **Watershed Location:**

Land Protection

Primary Threat Addressed: Habitat degradation from stormwater run-off

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
Preserve the natural ecological functions of an area by protecting land from development.

General Strategy:
Land protection is a strategy that can be used to ensure a level of habitat quality that is necessary to support certain species and habitats of conservation concern. For aquatic species, land protection prevents many of the impacts caused by sprawling development. Groundwater recharge, intact riparian zones, and unrestricted migration corridors are some of the benefits. Species with limited ranges in New Hampshire may be protected almost entirely through land conservation. For wider ranging species, such as brook trout, land protection will be part of a greater restoration strategy. Land protection projects in New Hampshire usually require the coordination of a variety of funding sources, with involvement from town conservation commissions, local land trusts and watershed associations, government agencies, and state or national NGO's. Since 2005, the NH Wildlife Action Plan has helped direct land protection efforts toward conserving habitat for species and habitats of concern. The effectiveness of land conservation could be improved by identifying and addressing barriers to land conservation in New Hampshire and increasing outreach to help prioritize projects that benefit species and habitats of concern.

Political Location: **Watershed Location:**

Protect instream flow

Primary Threat Addressed: Habitat degradation from water withdrawal for irrigation, public water supply, or commercial use

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Manage water withdrawal and protect groundwater recharge to ensure adequate flow for supporting aquatic species in rivers and streams.

General Strategy:
Surface water and groundwater withdrawals for drinking water, irrigation, and other uses can reduce river flows, especially during critical periods of low flow during the summer months. Water level management at dams also affects the streamflow in a watershed. The NHDES Instream Flow Program works to balance water use while maintaining flow for aquatic life. Two pilot studies, one in the Souhegan River and one in the Lamprey River, have been conducted and Water Management Plans have been approved. The lessons learned from these studies and management plans should be expanded into other watersheds throughout New Hampshire. The practices implemented in the Water Management Plans for the Souhegan and Lamprey Rivers should be monitored to ensure that they are achieving the desired level of protection for instream flow. Dam managers should seek to manage water levels so that raising or lowering the water level in a lake or pond does not excessively decrease or increase the stream flow downstream of the dam. Headwater streams are especially vulnerable to water withdrawal and should not be overlooked during the permitting process.

Political Location: **Watershed Location:**

Prevent invasive species introductions

Primary Threat Addressed: Habitat impacts from introduced animal species

Specific Threat (IUCN Threat Levels): Invasive & other problematic species, genes & diseases

Objective:
Prevent the introduction of invasive species, which alter the composition of native ecological communities.

General Strategy:
Whether they are accidental or intentional, invasive aquatic species introductions are notoriously hard to prevent and even more difficult to control. NHDES, NH Lakes Association and other individual lake and pond groups have had some success preventing invasive aquatic species introductions with public outreach and by staffing boat ramps with trained inspectors, called Lake Hosts. Prevention and early detection is the most effective strategy for limiting the spread of invasive species. Once an introduced species has become established it is nearly impossible to eradicate it. Management efforts to control the species can be costly and requires long term planning. An angler determined to create a new fishing opportunity by stocking a new fish species into a waterbody is hard to deter. Education on the ecological damage that can be caused by introducing nonnative species into a waterbody will help prevent some, but not all deliberate species introductions. In some cases, anglers invested in the existing fishery may make the best advocates against new species introductions. However, outreach will not persuade everyone, so laws, penalties, and adequate funding for enforcement are the last line of defense against species introductions. It is important that penalties are severe enough and the

presence of law enforcement is noticeable enough to act as a deterrent. New species introductions are inevitable, but the rate and overall extent of introductions may be contained.

Political Location: **Watershed Location:**

Riparian Buffer Protection

Primary Threat Addressed: Habitat degradation due to shoreline development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
Preserve the water and habitat quality of rivers, streams and the shorelines of lakes and ponds by preventing development in the riparian zone.

General Strategy:
Riparian buffer protection can be achieved through town ordinances, state law (i.e. the Shoreland Water Quality Protection Act), deed restriction, conservation easement, or voluntary land use practices (such as forestry best management practices). In general, the wider the buffer protected, the more ecological benefit. A buffer of at least 10 m will provide a minimum level of water quality and habitat benefits. A protected buffer of 100 m or greater provides maximum water quality and habitat benefits while also acting as a migration corridor for larger species of wildlife. Buffer protection is lacking on headwater streams despite the cumulative effect that intact riparian zones in headwater streams have on downstream water quality.

Political Location: **Watershed Location:**

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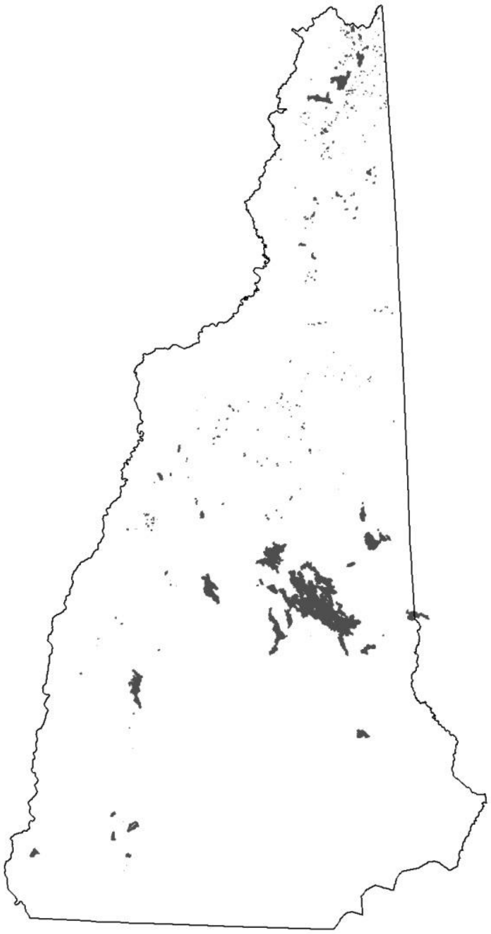
Lakes and Ponds with Coldwater Habitat

Photo by NHFG

Acres in NH: 88,380 ac
Percent of NH Area: 1.48%
Acres of Shoreline within a 100m Buffer Protected: 12,623 ac
Percent Buffer Protected: 26% of coldwater lakes
88% of coldwater ponds



Habitat Distribution Map

Habitat Description

Lakes and ponds with coldwater habitat include lakes with deep, well oxygenated, coldwater that support naturally reproducing populations of coldwater fish species and ponds at higher elevations (above 1,900 ft) which maintain cooler water temperatures despite their shallow depth.

Justification (Reason for Concern in NH)

Lakes and ponds with coldwater habitat are a limited resource in New Hampshire. They are critical habitat for a number of native coldwater fish species with restricted ranges in the state. Ponds and smaller lakes with marginal coldwater habitat are vulnerable to the effects of climate change, which may cause local extirpations of coldwater dependent species (Thill 2014).

Protection and Regulatory Status

Surface waters are regulated by the clean water act.

Regulatory Protections:
Comprehensive Shoreland Protection Act – NHDES
Clean Water Act-Section 404

Management Guidelines

Maintain water levels for reef spawning fish, such as lake trout and round whitefish, to prevent exposure of eggs due to winter draw down.

Distribution and Research

The distribution of the larger lakes with cold, deep water habitat is well known, but there is little information on the distribution and status of coldwater pond habitat. The threshold of >1,900 ft was loosely based on a study of a marginal brook trout population in an unstratified coldwater pond in the Adirondack Mountains, near the southern extent of the brook trout's lentic range (Robinson et al. 2010). It is assumed that, with some exceptions, unstratified ponds below 1,900 feet will not support coldwater species due to unsuitably warm summer water temperatures. Not all high elevation ponds above the 1,900 ft threshold may offer suitable habitat conditions for coldwater communities due to natural and anthropogenic reasons. Some ponds may not be suitable due to winter conditions (they may freeze completely or develop low dissolved oxygen levels). Other ponds may offer suitable winter conditions but episodic acid deposition may have precluded the presence of coldwater fish communities. More research is needed on the actual distribution and status of higher elevation coldwater pond habitat in New Hampshire, including any unique communities of species which they may support.

Relative Health of Populations

Large lakes with an abundant quantity of deep, coldwater habitat, including Lake Winnipesauke, Newfound Lake, and Lake Sunapee, will be more resistant to climate change than smaller lakes and coldwater ponds (Thill 2014). Maintaining healthy coldwater fish populations will require water level management practices that protect spawning reefs. Although water quality in most lakes and ponds with coldwater habitat is relatively good, high levels of development along the shoreline and in the surrounding watersheds of some lakes may lead to issues, such as eutrophication, in the future.

Habitat Condition

A set of GIS data was used to assess ecological condition of each habitat type. Chapter 3 describes the methodology. The data used for this habitat is described below.

Local Condition (200m shoreline buffer) Categories

1	buffer >=90% natural/ no dams/ nearest road or trail is >1 mi
2	buffer >=90% natural/ no dams/ nearest road or trail is .5 – 1 mile
3	buffer >=90% natural/ no dams/ nearest road 500m -.5 mile
4	buffer >= 90% natural/no dams/ nearest road < 500m
5	buffer < 90% natural/no dams/ any remoteness
6	Dams

Watershed (HUC12) Condition Categories

1	HUC12 Watershed Very Intact: >= 90% Natural Cover
2	HUC12 Watershed Lightly Impacted: 80-90% Natural Cover and <10% developed
3	HUC12 Watershed Impacted: All Others

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation from altered flow regimes due to water level management (Threat Rank: High)

Unnatural water level fluctuations alter upstream lake and pond habitat. Lake drawdowns, usually during winter, reduce shoreline plant communities and expose aquatic organisms to desiccation. Poor recruitment may be an issue for species that spawn on shallow reefs or along the shoreline, depending on the timing and extent of the drawdown.

Water level drawdowns in waterbodies such as Newfound Lake and the Connecticut Lakes may impact the spawning success of coldwater fish species. Flow agreements for hydropower operation may also influence lake level management throughout the year.

Habitat degradation from point source pollution (Threat Rank: Medium)

Industrial pollutants and pollution from untreated wastewater have been greatly reduced since the passage of the Clean Water Act. However, there are still isolated areas such as superfund sites or combined sewer overflows (CSO's) where pollutants continue to enter aquatic habitats at known locations.

There are 23 Superfund sites and 33 CSO's in New Hampshire (NHDES 2008; NHDES 2012). These sites are carefully monitored with long term plans for reducing their environmental impact.

Habitat degradation and impacts from aquatic herbicide application (Threat Rank: Medium)

Large scale aquatic herbicide applications (usually used to treat invasive plants) remove submerged aquatic vegetation, which is critical habitat to many aquatic species. Rapid plant decomposition, particularly in the summer, may cause low oxygen levels in areas of poor circulation. The long term effects of herbicides and their chemical components on aquatic species are not well understood (Relyea 2014).

Although native plants are preferable to invasive plants, the removal of all aquatic plant species from an area causes the greatest harm to aquatic species, regardless of plant species composition (Valley et al. 2004). While large monocultures of invasive plants tend to support fewer species, areas with mixes of both native and nonnative plant species generally cause little change to the diversity and abundance of aquatic species.

Habitat degradation from agricultural run-off (Threat Rank: Medium)

Nutrients from agricultural sources, sedimentation, lawn fertilizers, and poorly functioning septic systems contribute to increased algal growth in aquatic habitats. This excess productivity causes reductions in water quality and eventually lowers dissolved oxygen levels as microorganisms consume the dead algal cells, using up oxygen in the process.

Many lakes and ponds in New England show signs of degraded water quality due to cultural eutrophication (EPA 2010). Although this threat is less prevalent in lakes and ponds with coldwater habitat, the potential for oxygen depletion could have serious impacts on coldwater species. Shallow areas along the periphery of larger coldwater lakes can have the same impacts associated with eutrophication of warmwater lakes and ponds.

Habitat degradation from acid deposition (Threat Rank: Medium)

Emissions from powerplants, automobiles, and other sources lead to an increase in nitric and sulfuric acids in the atmosphere. The prevailing winds move these acids far from there source, eventually falling to the earth as acidic rain or snow. Acid deposition leaches calcium from soil, increases aluminum concentrations to levels that can be toxic to fish, and increases the acidity of aquatic habitats to levels that can reduce growth rates, inhibit reproduction, and at high levels, cause direct mortality to aquatic organisms (Haines 1981).

High elevation coldwater ponds are particularly vulnerable to acid deposition in the northeast due to the prevailing weather pattern, which brings emissions from powerplants in Mid-Atlantic and Midwestern states. The higher rates of rainfall and acidic fog at higher elevations and the relatively low buffering capacity of the soils in most New Hampshire mountains can create very acidic conditions in some coldwater ponds (NHDES 2004).

Habitat impacts from fragmentation due to impassable dams (Threat Rank: Medium)

Dams prevent the movement of aquatic species between riverine and lacustrine habitat. Some diadromous species once depended on accessing larger coldwater lakes and ponds for spawning and juvenile development.

Most of the large lakes with coldwater habitat in New Hampshire have a dam at their outlet. Many of the larger tributaries flowing into these lakes also contain dams. Few, if any, of these dams provide safe upstream or downstream fish passage.

List of Lower Ranking Threats:

Habitat degradation due to invasive or introduced plants

Habitat impacts from unsuitable water temperatures for coldwater species

Habitat impacts from unsuitable water temperatures that disturb species life cycles

Habitat impacts from increased flood damage

Habitat impacts from reduced oxygen levels at depth

Habitat impacts from fragmentation due to impassable stream crossings

Habitat degradation from water withdrawal for irrigation, public water supply, or commercial use

Habitat degradation due to shoreline development

Habitat impacts from introduced or invasive animals

Habitat impacts from wastewater treatment sites and associated unmonitored contaminants

Habitat degradation from stormwater run-off

Habitat degradation from excess nutrients due to septic systems

Habitat degradation from excess nutrients from fertilizer and run-off

Habitat degradation from run-off pollution (pesticides)

Habitat degradation from stormwater run-off

Habitat impacts from mercury toxicity

Habitat impacts from various diseases and parasites

Actions to benefit this Habitat in NH

Map Spawning Habitat

Objective:
Map the distribution of coldwater fish spawning habitat in deep water lakes.

General Strategy:
Although some important spawning reefs have been well documented, the extent of spawning habitat for coldwater fish species remains undocumented in most lakes where they occur. Acoustic or radio telemetry, gill or fyke net surveys, underwater cameras, and visual observations are potential methods for identifying important spawning areas. Depth recordings at spawning areas well help inform water level management policy.

Political Location: **Watershed Location:**

Stormwater Management

Primary Threat Addressed: Habitat degradation from stormwater run-off

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
To reduce the impacts of runoff from impervious surfaces by using Low Impact Development Technology.

General Strategy:
Stormwater runoff from impervious surfaces has been shown to damage aquatic habitats (Wang et al. 2001; Cuffney et al. 2010). Much of this damage can be prevented by stormwater management practices that filter runoff through the ground before it enters surface water. This practice not only removes much of the sediment and toxins that are typically washed into streams, but it also reduces the rapid fluctuation in water temperature, as well as the excess erosion and sediment deposition that have become a chronic issue for rivers and streams in developed areas. Pollution from stormwater runoff is cumulative. As more headwater streams become degraded by stormwater runoff from impervious surfaces, declines in water quality and habitat may be observed in lakes, larger rivers, and estuaries. The University of New Hampshire Stormwater Center is an excellent resource for Low Impact Development (LID) practices for stormwater management. The long term goal is to make rivers and streams in developed watersheds mimic the hydrology of similar habitats in undeveloped watersheds.

Political Location: **Watershed Location:**

Calcium supplementation

Primary Threat Addressed: Habitat degradation from acid deposition

Specific Threat (IUCN Threat Levels): Pollution / Air-borne pollutants / Acid rain

Objective:
Supplement calcium in the watersheds of select coldwater ponds to mitigate the effects of acid deposition.

General Strategy:
The buffering capacity of soils in the northeast has been greatly reduced by the chronic effects of acid deposition. Researchers at the Hubbard Brook Experimental Forest have shown that adding supplemental calcium pellets to a watershed can offset the long term effects of acidification (Huggett et al. 2007). This technique would be cost prohibitive at a large scale, but may be an appropriate strategy for reducing the acidity of high elevation ponds with small watershed sizes. These ponds are very sensitive to acid deposition and may respond well to the treatment, especially as acid deposition rates decrease with tighter regulations on power plant emissions.

Political Location: **Watershed Location:**

Land Protection

Primary Threat Addressed: Habitat degradation from stormwater run-off

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
Preserve the natural ecological functions of an area by protecting land from development.

General Strategy:
Land protection is a strategy that can be used to ensure a level of habitat quality that is necessary to support certain species and habitats of conservation concern. For aquatic species, land protection prevents many of the impacts caused by sprawling development. Groundwater recharge, intact riparian zones, and unrestricted migration corridors are some of the benefits. Protecting land is a proactive strategy for preventing water quality issues due to surface runoff from urban, agricultural, and residential land uses. Land protection projects in New Hampshire usually require the coordination of a variety of funding sources, with involvement from town conservation commissions, local land trusts and watershed associations, government agencies, and state or national NGO's. Since 2005, the NH Wildlife Action Plan has helped direct land protection efforts toward conserving habitat for species and habitats of concern. The effectiveness of land conservation could be improved by identifying and addressing barriers to land conservation in New Hampshire and increasing outreach to help prioritize projects that benefit species and habitats of concern.

Political Location: **Watershed Location:**

Prevent invasive species introductions

Primary Threat Addressed: Habitat impacts from introduced or invasive animals

Specific Threat (IUCN Threat Levels): Invasive & other problematic species, genes & diseases

Objective:

Prevent the introduction of invasive species, which alter the composition of native ecological communities.

General Strategy:

Whether they are accidental or intentional, invasive aquatic species introductions are notoriously hard to prevent and even more difficult to control. NHDES, NH Lakes Association, and other individual lake and pond groups have had some success preventing invasive aquatic species introductions with public outreach and by staffing boat ramps with trained inspectors, called Lake Hosts. Prevention and early detection is the most effective strategy for limiting the spread of invasive species. Once an introduced species has become established it is nearly impossible to eradicate it. Management efforts to control the species can be costly and requires long term planning. An angler determined to create a new fishing opportunity by stocking a new fish species into a waterbody is hard to deter. Education on the ecological damage that can be caused by introducing nonnative species into a waterbody will help prevent some, but not all deliberate species introductions. In some cases, anglers invested in the existing fishery may make the best advocates against new species introductions. However, outreach will not persuade everyone, so laws, penalties, and adequate funding for enforcement are the last line of defense against species introductions. It is important that penalties are severe enough and the presence of law enforcement is noticeable enough to act as a deterrent. New species introductions are inevitable, but the rate and overall extent of introductions may be contained.

Political Location:

Watershed Location:

Shoreline Buffer Protection

Primary Threat Addressed: Habitat degradation due to shoreline development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:

Protect important habitat features along the shorelines of lakes, ponds, and larger rivers.

General Strategy:

The NH Shoreland Water Quality Protection Act provides a minimum level of protection for shoreline habitat along New Hampshire's lakes, ponds, and rivers (third order and larger). While the Shoreland Water Quality Protection Act does a good job of protecting natural vegetation along the shoreline, it falls short of protecting other important habitat features such as submerged aquatic vegetation and trees that fall into the water. Landowners often remove plants and trees from the water to improve access for swimming and boating. These trees and submerged aquatic plants offer important structure for spawning, foraging, and evading predators. Increasing the percentage of natural or undeveloped shoreline will improve the overall habitat quality in a lake or pond. Conservation easements, changes in zoning, legislative acts, or landowner outreach programs may be used to restore natural shoreline features to New Hampshire lakes and ponds, many of which have little remaining undeveloped shoreline.

Political Location:

Watershed Location:

Reduce nutrient loading

Primary Threat Addressed: Habitat degradation from excess nutrients from fertilizer and run-off

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
Reduce the impacts of eutrophication by removing excess sources of nutrients.

General Strategy:
The primary sources of excess nutrients are lawn fertilizers in residential and commercial developments, agricultural fertilizers, and poorly functioning septic systems. Reducing nutrient loads can be achieved on two fronts. One is through outreach, which includes creating awareness about the effects of fertilizers on water quality and offering alternatives to fertilization practices that lead to the greatest amount of nutrient loading in nearby waterbodies. Best management practices can be developed for property owners with a focus on reducing runoff, minimizing or eliminating fertilizer use, and landscaping in a way that reduces the need for fertilization. In the case of septic failure, shoreline property owners with older septic systems can be targeted with incentives for upgrading. The second front is legislative. Laws that set limits on fertilizer use and require upgrades to septic systems will have long term benefits on water quality throughout New Hampshire. Requirements for new septic systems have greatly improved in recent years. The challenge is identifying and upgrading older systems that were constructed before septic systems were required to meet modern standards.

Political Location: **Watershed Location:**

Water level management

Primary Threat Addressed: Habitat degradation from altered flow regimes due to water level management

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Reduce the aquatic habitat impacts associated with artificial water level fluctuation at dams.

General Strategy:
Work with dam managers to achieve water level fluctuations that mimic natural flow regimes. Practices such as rapid changes in water level, excessive winter drawdown, and shutting off downstream flow to refill a waterbody should be avoided. For coldwater species that spawn on shallow reefs, including lake trout, round whitefish, lake whitefish, and burbot, it is important that water levels do not drop significantly after the spawning season, such that the eggs would be exposed. Engaging stakeholders, including shorefront property owners, boaters, anglers, and hydropower project owners is critical to changing long established water level management traditions. The NH Dam Bureau is the lead on dam management issues in New Hampshire. The best strategy for improving water level management practices for fish and wildlife is to work with the Dam Bureau to identify opportunities to create more natural water level fluctuations at a certain dams and then make slow incremental changes. This allows stakeholders to adjust to the changes and make comments when conflicts arise.

Political Location: **Watershed Location:**

Coldwater Pond Surveys

Objective:

Assess the distribution and status of high elevation coldwater pond habitat in New Hampshire.

General Strategy:

Conduct surveys to identify high elevation coldwater ponds that support unique species assemblages or populations of naturally reproducing brook trout.

Political Location:

Watershed Location:

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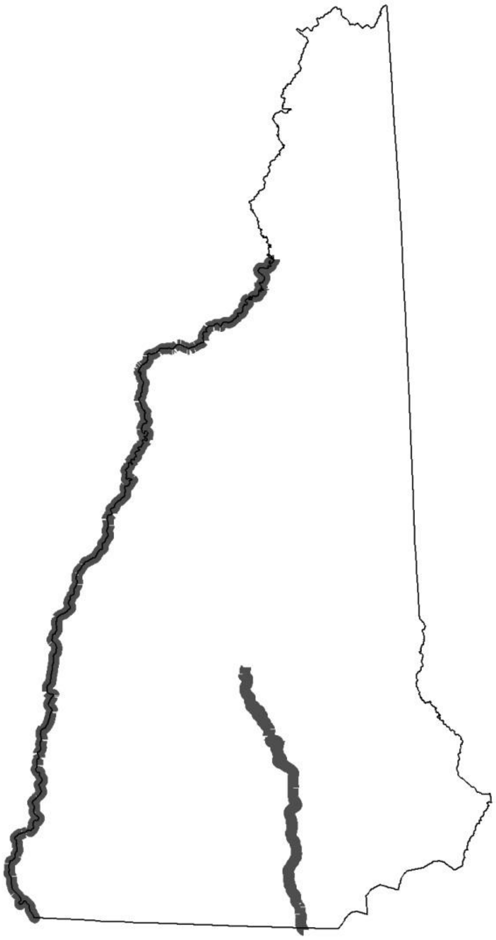
Large Warmwater Rivers

Photo by NHFG

Kilometers in NH: 412 km

Acres of Shoreline within a 100m Buffer Protected: 1140 ac

Percent Buffer Protected: 6%



Habitat Distribution Map

Habitat Description

Large warmwater rivers are defined as having watersheds greater than 1,000 square miles and an average bankfull width of over 250 feet (Anderson 2013). In New Hampshire, two rivers have been grouped into this category: the Merrimack River and the Connecticut River, downstream of the confluence with the Upper Ammonoosuc River. Large warmwater rivers alternate between meandering river channels flowing through broad flood plain valleys and more confined sections flowing over boulders and rocky ledges. These rivers support a diverse array of both aquatic and terrestrial species. Large warmwater rivers are important habitat for many diadromous fish species, which migrate in large numbers from the ocean to spawn or live in freshwater. Erosion, ice scour, sediment deposition, and periodic flooding caused by large warmwater rivers creates unique habitat features such as floodplain forests, sandy bluffs, and cobble bars. These habitats support a number of species of concern, including the state endangered cobblestone tiger beetle and the bank swallow.

Justification (Reason for Concern in NH)

Large warmwater rivers support a wide range of both aquatic and terrestrial species, from bald eagles to swamp darters. They connect upland habitats with the Atlantic Ocean, and each year diadromous fish species provide an abundant influx of marine derived nutrients and energy to predators that forage in freshwater. Their broad floodplains act as migration corridors for birds and large mammals. Large warmwater rivers have been centers of human activity for centuries and they have suffered widespread habitat degradation from dams, development, and agriculture.

Protection and Regulatory Status

Regulatory Protections:
Comprehensive Shoreland Protection Act – NHDES
Clean Water Act-Section 404

Regulatory Comments: Dams have a major impact on large warmwater river habitat. They are regulated by the Federal Energy Regulatory Commission (FERC), which requires mitigation for impacts to the ecological functions of the river, including fish passage.

Management Guidelines

- Work through the FERC dam relicensing process to build or improve fish passage at dams and reduce impacts of water level fluctuations on upstream and downstream habitat.
- Reduce infrastructure and development in the floodplains and along the shorelines of large warmwater rivers.
- Increase riparian buffers along the river in agricultural zones and decrease the use of fertilizers and pesticides.
- Avoid river bank armoring and restore the natural sinuosity of the river channel where possible.

Distribution and Research

Relative Health of Populations

Large warmwater rivers once supported an incredible abundance of diadromous fish species, which migrated from the ocean each spring. Most of these species were extirpated by dams built in the 1800's. Over the past three decades, fish passage facilities have restored access for diadromous fish species to portions of their historical range. Although some populations have increased, they remain at a small fraction of their former abundance. Dams also alter normal flow regimes, which impacts resident aquatic species. Improvements in fish passage and more natural water level fluctuations have the potential to improve the quality of large warmwater river habitat. River channel straightening, bank armoring, and infrastructure built in the floodplain has reduced the natural sinuosity and river bank characteristics of much of this habitat type in New Hampshire.

Habitat Condition

A set of GIS data was used to assess ecological condition of each habitat type. Chapter 3 describes the methodology. The data used for this habitat is described below.

River and Stream Reaches in each of four Very High Quality categories
Minimum Linear Connectivity Length met: Functional Network Length >= 10 miles for all systems except for tidal headwaters and creeks which have naturally small network lengths and any functional network length was acceptable.
Low Riparian Development and Agriculture Impacts: Riparian index score <= 25
No dam on reach and upstream dam water storage volume as percent of mean annual flow <10%
Low Impervious surface < 2%

Condition assessment completed by The Nature Conservancy

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat impacts from fragmentation due to impassable dams (Threat Rank: High)

Dams restrict access to freshwater habitat for diadromous fish species, which were once a major component of large river ecosystems.

Populations of all diadromous fish species in the Connecticut and Merrimack Rivers are well below their historical abundance before dams were constructed in the 1800's (Noon 2003).

Habitat degradation from altered flow regimes due to water level management (Threat Rank: High)

Water level fluctuations at dams on large warmwater rivers are usually related to hydropower generation. Rapid changes in flow, either increasing or decreasing, may impact both resident and migratory species at critical phases of their life cycles. Changes in flow alter the availability and quality of spawning habitat for fish, both upstream and downstream of the dam. Varying levels of attraction flows at fishways influence the effectiveness of fish passage at a dam. The state endangered cobblestone tiger beetle depends on exposed cobble bars that form upstream of islands in large warmwater rivers. This habitat may become inundated by unnatural increases in flow caused by water releases at upstream dams.

A number of proposed studies are currently investigating the influence of fluctuating river flows on aquatic species and habitat in the Connecticut River as part of the relicensing process for the dams owned by the TransCanada Corporation.

Habitat degradation from point source pollution (Threat Rank: Medium)

Industrial pollutants and pollution from untreated wastewater have been greatly reduced since the passage of the Clean Water Act. However, there are still isolated areas such as superfund sites or combined sewer overflows (CSO's) where pollutants continue to enter aquatic habitats at known locations.

There are 23 Superfund sites and 33 CSO's in New Hampshire (NHDES 2008; NHDES 2012). These sites are carefully monitored with long term plans for reducing their environmental impact. CSO's were cited as one of the major contributors to poor water quality following rain events in the Merrimack River watershed (USACE 2006).

Habitat degradation and impacts from aquatic herbicide application (Threat Rank: Medium)

Habitat degradation from power plant effluent causing thermal pollution (Threat Rank: Medium)

Increased temperatures from power plant effluent may influence local species composition and affect the spawning success of migratory fish species.

Effluent from the Bow Powerplant continues to be discharged into the Merrimack River, but the decommissioning of the Vermont Yankee Nuclear Power Plant has reduced concerns for heated effluent in the Connecticut River. Sprankle (2013) provides a detailed summary of concerns related to heated effluent in a large river system.

Habitat degradation from stormwater run-off from impervious surfaces (Threat Rank: Medium)

Stormwater runoff from impervious surfaces changes the hydrology of local rivers and streams. Flashier flows cause an increase in erosion and sediment deposition along stream banks and in the stream channel. More surface flow leads to a decrease in groundwater infiltration, which results in lower base flows during dry periods. Oil based pollutants, sediment, and road salt are washed from roads and parking lots into surrounding waterbodies which can lead to chronic declines in water quality.

The impacts of impervious land cover on aquatic habitats have been well documented (Wang et al. 2001; Cuffney et al. 2010; Stranko et al. 2008). Runoff from urban areas was identified as one of the major sources of pollution in a watershed assessment of the Merrimack River (USACE 2006).

Habitat degradation from stormwater run-off from impervious surfaces (Threat Rank: Medium)

Stormwater runoff from impervious surfaces changes the hydrology of local rivers and streams. Flashier flows cause an increase in erosion and sediment deposition along stream banks and in the stream channel. More surface flow leads to a decrease in groundwater infiltration, which results in lower base flows during dry periods.

The impacts of impervious land cover on aquatic habitats have been well documented (Wang et al. 2001; Cuffney et al. 2010; Stranko et al. 2008).

Habitat degradation from agricultural run-off (Threat Rank: Medium)

Pesticides, herbicides, and fertilizers wash into aquatic habitats from agricultural fields, which are often located in the fertile floodplains of medium to large size rivers. Agricultural practices can also lead to increased turbidity, bank erosion, and sediment deposition in adjacent aquatic habitats. The degradation of water quality in watersheds with a high proportion of agricultural land use can be toxic to many aquatic species.

The influence of landuse on aquatic habitats within a watershed has been well documented (Allan 2004). The most obvious influences of agricultural activity are found along the Connecticut and Merrimack Rivers, where minimal to nonexistent vegetated buffers along the river bank have contributed to bank erosion, sedimentation, and nutrient loading.

Habitat impacts from introduced animal species (Threat Rank: Medium)

Introduced species may alter the species composition of aquatic ecosystems through direct competition or by altering habitat conditions.

The Asian clam, which has been introduced into a number of waterbodies in NH, may impact aquatic food webs by consuming large quantities of phytoplankton (Souza et al. 2008). A long history of introduced fish species has altered the species composition in most New Hampshire lakes and rivers (Noon 2003).

Habitat impacts from increased flood damage (Threat Rank: Medium)

Changes in flow conditions due to climate change may alter seasonal flow patterns as well as the intensity and frequency of flood events. Increased water temperature can increase mortality or restrict the seasonal movements of native aquatic species and also shift community assemblages.

Damage to aquatic habitats from increased flooding is exacerbated by human activity (Poff 2002). Efforts to protect infrastructure and property in floodplains, by installing armoring and diversion structures, have increased ecological damage to river and stream habitat during recent floods in New Hampshire.

Habitat impacts from flood control or erosion control (Threat Rank: Medium)

River and stream habitat is frequently altered in an effort to control or prevent flood damage to local infrastructure. Channel straightening, bank armoring, berm construction, and other practices result in a confined stream channel that no longer has access to floodplain habitat. These practices result in a loss of important habitat features, such as undercut banks, large in-stream wood, and streamside vegetation. While achieving the goal of protecting infrastructure at one location, these practices often exacerbate flooding downstream. Often done in response to recent flooding, river and stream bank modifications are rarely completed according to a long term plan that attempts to combine river restoration and flood prevention. Efforts to address flood damage should be evaluated at the watershed level.

The Connecticut and Merrimack Rivers have been highly altered due to river bank armoring, channel straightening, and flood control projects.

List of Lower Ranking Threats:

Habitat impacts from wastewater treatment sites and associated unmonitored contaminants

Habitat impacts from mercury toxicity

Habitat degradation from run-off pollution (pesticides)

Habitat degradation from excess nutrients from fertilizer and run-off

Habitat degradation from excess nutrients due to septic systems

Habitat degradation from acid deposition

Habitat degradation due to invasive or introduced plants

Habitat impacts from various diseases and parasites

Habitat degradation from water withdrawal for irrigation, public water supply, or commercial use

Habitat impacts from unsuitable water temperatures that disturb species life cycles

Habitat degradation due to shoreline development

Actions to benefit this Habitat in NH

Improve fish passage at dams

Primary Threat Addressed: Habitat impacts from fragmentation due to impassable dams

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Construct, maintain, and monitor fishways at dams that currently limit access to suitable freshwater habitat for diadromous fish.

General Strategy:
At sites where dam removal is not an option, fish passage construction can improve connectivity between freshwater and marine habitats. Fish passage construction may be negotiated during the Federal Energy Regulatory Commission (FERC) dam relicensing process. Fish passage engineers with the USFWS are available to assist with designing the appropriate fishway for a particular site, depending on the needs of the species and the size of the dam (among other factors). At some sites outside of FERC jurisdiction, funding may have to come from other sources. Once installed, there should be a plan for fish passage operation, maintenance, and monitoring. Identifying the party responsible for each aspect of fishway operation is critical for maintaining effective passage over the long term. Periodic performance evaluations should also be completed at each fishway to ensure that fish are moving efficiently through the project without excessive delays.

Political Location: **Watershed Location:**

River and stream habitat restoration

Primary Threat Addressed: Habitat impacts from flood control or erosion control

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
Restore the natural habitat qualities of a river or stream with practices such as wood additions, bank revegetation, floodplain restoration, or stream channel reconstruction.

General Strategy:
River and stream restoration techniques have been used to restore natural habitat features to areas that have been altered by urban development, agricultural land use, logging, or flooding. The principles of fluvial geomorphology are used to design appropriate channel characteristics according to watershed size, local climate, and substrate type at the site (Rosgen 1996). Restoration activities may range from the complete physical reconstruction of the stream channel to planting shrubs and trees to improve bank stabilization. Other common practices include floodplain restoration and wood additions (Cramer 2012).

Political Location: **Watershed Location:**

Reduce nutrient loading

Primary Threat Addressed: Habitat degradation from agricultural run-off

Specific Threat (IUCN Threat Levels): Pollution / Agricultural & forestry effluents / Herbicides & pesticides

Objective:
Reduce the impacts of eutrophication by removing excess sources of nutrients.

General Strategy:
The primary sources of excess nutrients are lawn fertilizers in residential and commercial developments, agricultural fertilizers, and poorly functioning septic systems. Reducing nutrient loads can be achieved on two fronts. One is through outreach, which includes creating awareness about the effects of fertilizers on water quality and offering alternatives to fertilization practices that lead to the greatest amount of nutrient loading in nearby waterbodies. Best management practices can be developed for property owners with a focus on reducing runoff, minimizing or eliminating fertilizer use, and landscaping in a way that reduces the need for fertilization. Incentives for agricultural practices that reduce fertilizer use and runoff should be provided to farmers in river floodplains (USEPA 2010).

Political Location: **Watershed Location:**

Prevent invasive species introductions

Primary Threat Addressed: Habitat impacts from introduced animal species

Specific Threat (IUCN Threat Levels): Invasive & other problematic species, genes & diseases

Objective:
Prevent the introduction of invasive species, which alter the composition of native ecological communities.

General Strategy:
Whether they are accidental or intentional, invasive aquatic species introductions are notoriously hard to prevent and even more difficult to control. NHDES, NH Lakes Association, and other individual lake and pond groups have had some success preventing invasive aquatic species introductions with public outreach and by staffing boat ramps with trained inspectors, called Lake Hosts. Prevention and early detection is the most effective strategy for limiting the spread of invasive species. Once an introduced species has become established it is nearly impossible to eradicate it. Management efforts to control the species can be costly and requires long term planning. An angler determined to create a new fishing opportunity by stocking a new fish species into a waterbody is hard to deter. Education on the ecological damage that can be caused by introducing nonnative species into a waterbody will help prevent some, but not all deliberate species introductions. In some cases, anglers invested in the existing fishery may make the best advocates against new species introductions. However, outreach will not persuade everyone, so laws, penalties, and adequate funding for enforcement are the last line of defense against species introductions. It is important that penalties are severe enough and the presence of law enforcement is noticeable enough to act as a deterrent.

New species introductions are inevitable, but the rate and overall extent of introductions may be contained.

Political Location: **Watershed Location:**

Stormwater Management

Primary Threat Addressed: Habitat degradation from stormwater run-off from impervious surfaces

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
To reduce the impacts of runoff from impervious surfaces by using Low Impact Development Technology.

General Strategy:
Stormwater runoff from impervious surfaces has been shown to damage aquatic habitats (Wang et al. 2001; Cuffney et al. 2010). Much of this damage can be prevented by stormwater management practices that filter runoff through the ground before it enters surface water. This practice not only removes much of the sediment and toxins that are typically washed into streams, but it also reduces the rapid fluctuations in water temperature, as well as the excess erosion and sediment deposition that have become a chronic issue for rivers and streams in developed areas. Pollution from stormwater runoff is cumulative. As more headwater streams become degraded by stormwater runoff from impervious surfaces, declines in water quality and habitat may be observed in lakes, larger rivers, and estuaries. The University of New Hampshire Stormwater Center is an excellent resource for Low Impact Development (LID) practices for stormwater management. The long term goal is to make rivers and streams in developed watersheds mimic the hydrology of similar habitats in undeveloped watersheds.

Political Location: **Watershed Location:**

Riparian Buffer Protection

Primary Threat Addressed: Habitat degradation due to shoreline development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
Preserve the water and habitat quality of rivers, streams and the shorelines of lakes and ponds by preventing development in the riparian zone.

General Strategy:
Riparian buffer protection can be achieved through town ordinances, state law (i.e. the Shoreland Water Quality Protection Act), deed restriction, conservation easement, or voluntary land use practices (such as forestry best management practices). In general, the wider the buffer protected, the more ecological benefit. A buffer of at least 10 m will provide a minimum level of water quality and habitat benefits. A protected buffer of 100 m or greater provides maximum water quality and habitat benefits while also acting as a migration corridor for larger species of wildlife. Riparian buffer protection is lacking on headwater streams despite the cumulative effect that intact riparian zones in headwater streams have on downstream water quality.

Political Location: **Watershed Location:**

Water level management

Primary Threat Addressed: Habitat degradation from altered flow regimes due to water level management

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Reduce the aquatic habitat impacts associated with artificial water level fluctuation at dams.

General Strategy:
Work with dam managers to achieve water level fluctuations that mimic natural flow regimes. Practices such as rapid changes in water level, excessive winter drawdown, and reducing downstream flow to refill a waterbody should be avoided. Engaging stakeholders, including shorefront property owners, boaters, anglers, and hydropower project owners is critical to changing long established water level management traditions. The NH Dam Bureau is the lead on dam management issues in New Hampshire. The best strategy for improving water level management practices for fish and wildlife is to work with the Dam Bureau to identify opportunities to create more natural water level fluctuations at a certain dams and then make slow incremental changes. This allows stakeholders to adjust to the changes and make comments when conflicts arise.

Political Location:

Watershed Location:

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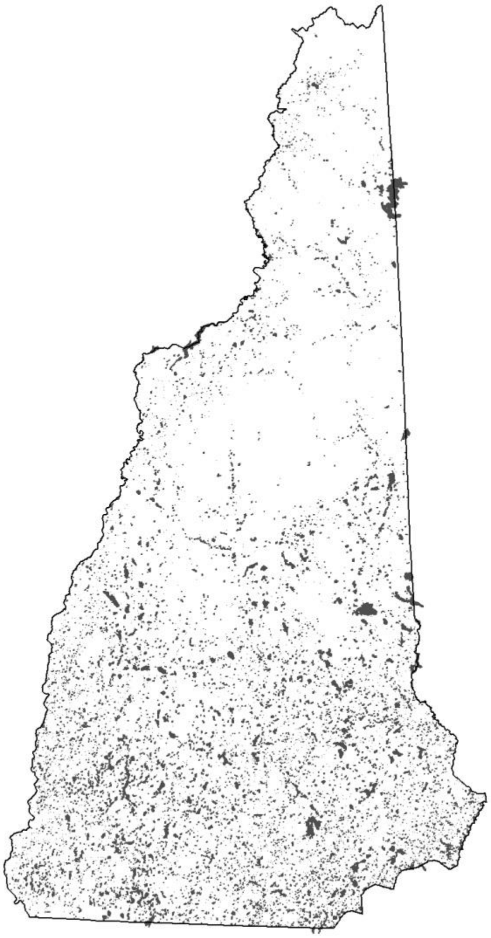
Warmwater Lakes and Ponds

Photo by NHFG



Habitat Distribution Map

Acres in NH: 99,702 ac
Percent of NH Area: 1.68%
Acres of Shoreline within a 100m Buffer Protected: 64,368 ac
Percent Buffer Protected: 37% of warmwater lakes
23% of warmwater ponds

Habitat Description

Warmwater lakes and ponds are defined by their inability to support naturally reproducing populations of coldwater fish species due to a lack of cold, well oxygenated water in the summer. Coldwater fish species are frequently supplemented in these waters but long term survival and reproduction is thought to be minimal. Warmwater lakes and ponds are widespread in New Hampshire and they vary in size, shape, and depth. Bottom substrates also vary from boulder, to sand or mud. One important component of most warmwater lakes and ponds is submerged aquatic vegetation. Usually along the shoreline or in shallow areas of the lake, submerged aquatic vegetation provides critical spawning and nursery habitat for a number of fish species. Predators use aquatic vegetation as cover for ambushing prey. Turtles, amphibians, and fish feed on the abundant invertebrate species that are found on aquatic plants. In warmwater lakes and ponds with undeveloped shorelines, waterfowl and many terrestrial species will use the lake or pond as nesting or foraging habitat.

Justification (Reason for Concern in NH)

Warmwater lakes and ponds are important habitat for a great diversity of aquatic and upland species. Shoreline development and other threats have impacted water quality and degraded habitat in many warmwater lakes and ponds in New Hampshire.

Protection and Regulatory Status

Regulatory Protections:
Comprehensive Shoreland Protection Act – NHDES
Clean Water Act-Section 404

Regulatory Comments: Although the Shoreland Water Quality Protection Act provides some level of protection for maintaining the water quality of a lake or pond, protected areas of undeveloped shoreline are critical for maintaining healthy aquatic communities. Municipal regulations related to aquatic habitats vary widely throughout the state.

Management Guidelines

- Where water levels are maintained by a dam, avoid unnatural water level fluctuations or deep drawdowns of the lake or pond.
- Protect areas of shoreline from development.
- Manage development and stormwater in the watershed of the lake or pond to reduce the influx of nutrients and other pollutants.
- Avoid broad scale herbicide treatments when managing invasive plant species. These treatments can temporarily reduce oxygen levels and their long term impacts on native plant and animal species are not well understood.

Distribution and Research

The distribution of warmwater lake and pond habitat in New Hampshire is well known. Lake assessment surveys are conducted periodically by NHDES at waterbodies throughout the state.

Relative Health of Populations

The habitat quality of warmwater lakes and ponds varies greatly in New Hampshire. At one end of the spectrum are lakes and ponds with completely developed shorelines and chronic issues with nutrient loading and cyanobacteria blooms. At the other end of the spectrum are remote ponds with undeveloped shorelines and unpolluted water. Ponds with largely undeveloped shorelines are relatively rare in New Hampshire due to the popularity of shorefront real estate. Relatively undeveloped lakes and ponds should be the focus of land protection efforts due to the value of the upland and aquatic interface to so many different species. Many studies have documented the impairment of aquatic communities that results from high densities of shoreline development (Bryan and Scarnecchia 1992; Hicks and Frost 2011). Some lakes and ponds in New Hampshire are also impacted by excessive water level drawdowns which degrade submerged aquatic plant communities and may expose reptiles, amphibians, and aquatic invertebrates to desiccation and freezing temperatures during hibernation. Invasive species are altering both aquatic plant and animal communities in a growing number of water bodies. Once established, invasive species are nearly impossible to eradicate and some removal efforts may cause further damage to native species.

Habitat Condition

A set of GIS data was used to assess ecological condition of each habitat type. Chapter 3 describes the methodology. The data used for this habitat is described below.

Local Condition (200m shoreline buffer) Categories

1	buffer >=90% natural/ no dams/ nearest road or trail is >1 mi
2	buffer >=90% natural/ no dams/ nearest road or trail is .5 – 1 mile
3	buffer >=90% natural/ no dams/ nearest road 500m -.5 mile
4	buffer >= 90% natural/no dams/ nearest road < 500m
5	buffer < 90% natural/no dams/ any remoteness
6	Dams

Watershed (HUC12) Condition Categories

1	HUC12 Watershed Very Intact: >= 90% Natural Cover
2	HUC12 Watershed Lightly Impacted: 80-90% Natural Cover and <10% developed
3	HUC12 Watershed Impacted: All Others

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation from altered flow regimes due to water level management (Threat Rank: High)

Unnatural water level fluctuations alter upstream lake and pond habitat. Lake drawdowns, usually during winter, reduce shoreline plant communities and expose aquatic organisms to desiccation. Poor recruitment may be an issue for species that spawn on shallow reefs or along the shoreline, depending on the timing and extent of the drawdown. River and stream habitat below lakes and ponds may also be impacted as flows are reduced in an attempt to refill lakes or increased rapidly during lake drawdowns.

Aquatic habitat in the littoral zone becomes degraded during excessive water level drawdown, including declines in aquatic macrophytes, invertebrate density, and species diversity. These impacts are linked to overall lake function, including potential influences on nutrient cycling (Zohary and Ostrovsky 2011).

Habitat degradation from point source pollution (Threat Rank: Medium)

Industrial pollutants and pollution from untreated wastewater have been greatly reduced since the passage of the Clean Water Act. However, there are still isolated areas such as superfund sites or combined sewer overflows (CSO's) where pollutants continue to enter aquatic habitats at known locations.

There are 23 Superfund sites and 33 CSO's in New Hampshire (NHDES 2008; NHDES 2012). These sites are carefully monitored with long term plans for reducing their environmental impact.

Habitat degradation from agricultural run-off (Threat Rank: Medium)

Nutrients from agricultural sources, sedimentation, lawn fertilizers, and poorly functioning septic systems contribute to increased algal growth in lakes and ponds. This excess productivity causes reductions in water quality and eventually lowers dissolved oxygen levels as microorganisms consume the dead algal cells, using up oxygen in the process.

Many lakes and ponds in New England show signs of degraded water quality due to cultural eutrophication (USEPA 2010).

Habitat degradation from stormwater run-off from impervious surfaces (Threat Rank: Medium)

Oil based pollutants, sediment, and road salt are washed from roads and parking lots into surrounding waterbodies which can lead to chronic declines in water quality.

Oil based pollutants, sediment, and road salt are washed from roads and parking lots into surrounding waterbodies which can lead to chronic declines in water quality. Warmwater lakes fed by tributaries that flow through urban or suburban areas are more susceptible to pollutants from impervious surface runoff.

Habitat degradation from nutrient loading from lawn fertilizers and contaminated run-off (Threat Rank: Medium)

Nutrients from agricultural sources, sedimentation, lawn fertilizers, and poorly functioning septic systems contribute to increased algal growth in lakes and ponds. This excess productivity causes reductions in water quality and eventually lowers dissolved oxygen levels as microorganisms consume the dead algal cells, using up oxygen in the process.

Many lakes and ponds in New England show signs of degraded water quality due to cultural eutrophication (USEPA 2010). Increasing development pressure in southern New Hampshire has led to eutrophication issues with many of the water bodies that support aquatic species of concern, including banded sunfish, bridle shiner, redfin pickerel, swamp darter, and eastern pondmussel.

Habitat degradation from nutrient loading due to septic systems (Threat Rank: Medium)

Failed or poorly designed septic systems contribute excess nutrients to aquatic habitats. These nutrients contribute to increased algal growth which may cause reductions in water quality and eventually lower dissolved oxygen levels as microorganisms consume the dead algal cells, using up oxygen in the process. Although septic systems are gradually being improved as older homes are resold and upgraded to meet stricter standards, even well designed septic systems can leach excess nutrients (NHDES 2008).

Many lakes and ponds in New England show signs of degraded water quality due to cultural eutrophication (USEPA 2010). Increasing development pressure in southern New Hampshire has led to eutrophication issues with many of the water bodies that support aquatic species of concern, including banded sunfish, bridle shiner, redfin pickerel, swamp darter, and eastern pondmussel.

Habitat degradation and impacts from introduced or invasive plants (Threat Rank: Medium)

Invasive plant species alter the composition of aquatic plant communities, which may influence the aquatic species that depend on this habitat type.

The density, composition, and structure of aquatic plant communities have a strong influence on the types of species that inhabit nearshore areas. Dense monocultures of nonnative plant species generally support a less diverse community of aquatic species than native communities of aquatic plant species or patchworks of both native and nonnative species (Valley et al. 2004).

Habitat degradation from water withdrawal for irrigation, public water supply, or commercial use (Threat Rank: Medium)

Water withdrawals for irrigation and drinking water can alter seasonal water level fluctuations in lakes and ponds. When these fluctuations are excessive, they can alter shoreline plant communities in lakes and ponds (Zohary and Ostrovsky 2011).

There are a number of waterbodies used as drinking water supplies in New Hampshire. These waterbodies are usually managed to protect water quality, which generally benefits the resident aquatic species. Issues are most likely to occur during periods of drought, when water levels may be drawn down to unusually low levels.

Habitat impacts from fragmentation due to impassable dams (Threat Rank: Medium)

Dams restrict the movement of aquatic species. Most aquatic species make daily and seasonal movements to access spawning habitat and foraging areas. Movement is also required in response to changes in water level, temperature, or water chemistry. Dispersal and colonization of new habitat is critical for long term population viability.

The effect of dams on diadromous fish species have been well documented (Limburg and Waldman 2009). Resident freshwater species are also impacted by dams, but the effects have been less studied. Dams have clearly restricted the dispersal of freshwater mussel species (Watters et al. 1996).

Habitat conversion or degradation due to shoreline development (Threat Rank: Medium)

Development along the shoreline of lakes, ponds, and larger rivers degrades critical habitat for aquatic species.

Aquatic plant removal, clearing of trees and branches that fall into the water, shoreline armoring, dock construction, tree and shrub thinning, and lawn maintenance are common practices associated with shoreline development. The cumulative effects of shoreline development combine to reduce habitat quality throughout a waterbody (Bryan and Scarnecchia 1992; Hicks and Frost 2010).

List of Lower Ranking Threats:

Habitat impacts from wastewater treatment sites and associated unmonitored contaminants

Habitat impacts from mercury toxicity

Habitat degradation from run-off pollution (pesticides)

Habitat degradation and impacts from aquatic herbicide application

Habitat degradation from acid deposition Habitat

degradation from stormwater run-off Habitat

impacts from introduced or invasive animals Habitat

impacts from various diseases and parasites

Habitat impacts from fragmentation due to impassable stream crossings

Habitat impacts from increased flood damage

Habitat impacts from unsuitable water temperatures that disturb species life cycles

Actions to benefit this Habitat in NH

Prevent invasive species introductions

Primary Threat Addressed: Habitat degradation and impacts from introduced or invasive plants

Specific Threat (IUCN Threat Levels): Invasive & other problematic species, genes & diseases

Objective:
Prevent the introduction of invasive species, which alter the composition of native ecological communities.

General Strategy:
Whether they are accidental or intentional, invasive aquatic species introductions are notoriously hard to prevent and even more difficult to control. NHDES, NH Lakes Association, and other individual lake and pond groups have had some success preventing invasive aquatic species introductions with public outreach and by staffing boat ramps with trained inspectors, called Lake Hosts. Prevention and early detection is the most effective strategy for limiting the spread of invasive species. Once an introduced species has become established it is nearly impossible to eradicate it. Management efforts to control the species can be costly and requires long term planning. An angler determined to create a new fishing opportunity by stocking a new fish species into a waterbody is hard to deter. Education on the ecological damage that can be caused by introducing nonnative species into a waterbody will help prevent some, but not all deliberate species introductions. In some cases, anglers invested in the existing fishery may make the best advocates against new species introductions. However, outreach will not persuade everyone, so laws, penalties, and adequate funding for enforcement are the last line of defense against species introductions. It is important that penalties are severe enough and the presence of law enforcement is noticeable enough to act as a deterrent. New species introductions are inevitable, but the rate and overall extent of introductions may be contained.

Political Location: **Watershed Location:**

Land Protection

Primary Threat Addressed: Habitat degradation from stormwater run-off

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
Preserve the natural ecological functions of an area by protecting land from development.

General Strategy:
Land protection is a strategy that can be used to ensure a level of habitat quality that is necessary to support certain species and habitats of conservation concern. Many warmwater lakes and ponds have been impacted by shoreline development. Land protection is one strategy for preserving the natural shoreline characteristics that are important to aquatic species. Land protection in the surrounding watershed can also reduce the impacts of nonpoint source pollution on the water quality of a lake or pond. It is rarely practical to protect the entire shoreline or watershed of a waterbody, but land protection can play an important role in a greater conservation strategy. Land protection projects in New Hampshire usually require the coordination of a variety of funding

sources, with involvement from town conservation commissions, local land trusts and watershed associations, government agencies, and state or national NGO's. Since 2005, the NH Wildlife Action Plan has helped direct land protection efforts toward conserving habitat for species and habitats of concern. The effectiveness of land conservation could be improved by identifying and addressing barriers to land conservation in New Hampshire and increasing outreach to help prioritize projects that benefit species and habitats of concern.

Political Location: **Watershed Location:**

Water level management

Primary Threat Addressed: Habitat degradation from altered flow regimes due to water level management

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:

Reduce the aquatic habitat impacts associated with artificial water level fluctuation at dams.

General Strategy:

Work with dam managers to achieve water level fluctuations that mimic natural flow regimes. Practices such as rapid changes in water level, excessive winter drawdown, and reductions in downstream flow to refill a waterbody should be avoided. Engaging stakeholders, including shorefront property owners, boaters, anglers, and hydropower project owners is critical to changing long established water level management traditions. The NHDES Dam Bureau is the lead on dam management issues in New Hampshire. The best strategy for improving water level management practices for fish and wildlife is to work with the Dam Bureau to identify opportunities to create more natural water level fluctuations at a certain dams and then make slow incremental changes. This allows stakeholders to adjust to the changes and make comments when conflicts arise.

Political Location: **Watershed Location:**

Shoreline Buffer Protection

Primary Threat Addressed: Habitat conversion or degradation due to shoreline development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:

Protect important habitat features along the shorelines of lakes, ponds, and larger rivers.

General Strategy:

The NH Shoreland Water Quality Protection Act provides a minimum level of protection for shoreline habitat along New Hampshire's lakes, ponds, and rivers (third order and larger). While the Shoreland Water Quality Protection Act does a good job of protecting natural vegetation along the shoreline, it falls short of protecting other important habitat features such as submerged aquatic vegetation and trees that fall into the water. Landowners often remove plants and trees from the water to improve access for swimming and boating. These trees and submerged aquatic plants offer important

structure for spawning, foraging, and evading predators. Increasing the percentage of natural or undeveloped shoreline will improve the overall habitat quality in a lake or pond. Conservation easements, changes in zoning, legislative acts, or landowner outreach programs may be used to restore natural shoreline features to New Hampshire lakes and ponds, many of which have little remaining undeveloped shoreline.

Political Location: **Watershed Location:**

Reduce nutrient loading

Primary Threat Addressed: Habitat degradation from nutrient loading from lawn fertilizers and contaminated run-off

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
Reduce the impacts of eutrophication by removing excess sources of nutrients.

General Strategy:
The primary sources of excess nutrients are lawn fertilizers in residential and commercial developments, agricultural fertilizers, and poorly functioning septic systems. Reducing nutrient loads can be achieved on two fronts. One is through outreach, which includes creating awareness about the effects of fertilizers on water quality and offering alternatives to fertilization practices that lead to the greatest amount of nutrient loading in nearby waterbodies. Best management practices can be developed for property owners with a focus on reducing runoff, minimizing or eliminating fertilizer use, and landscaping in a way that reduces the need for fertilization. In the case of septic failure, shoreline property owners with older septic systems can be targeted with incentives for upgrading. The second front is legislative. Laws that set limits on fertilizer use and require upgrades to septic systems will have long term benefits on water quality throughout the developed watersheds of southern New Hampshire. Requirements for new septic systems have greatly improved in recent years. The challenge is identifying and upgrading older systems that were constructed before septic systems were required to meet modern standards.

Political Location: **Watershed Location:**

Stormwater Management

Primary Threat Addressed: Habitat degradation from stormwater run-off from impervious surfaces

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
To reduce the impacts of runoff from impervious surfaces by using Low Impact Development Technology.

General Strategy:
Stormwater runoff from impervious surfaces has been shown to damage aquatic habitats (Wang et al. 2001; Cuffney et al. 2010). Much of this damage can be prevented by stormwater management practices that filter runoff through the ground before it enters surface water. This practice not only removes much of the sediment and toxins that are typically washed into streams, but it also reduces the rapid fluctuation in temperature, as well as the excess erosion and sediment deposition that have become a chronic issue for rivers and streams in developed areas. Pollution from stormwater runoff is cumulative. As more headwater streams become degraded by stormwater runoff from impervious surfaces, declines in water quality and habitat may be observed in lakes, larger rivers, and estuaries. The University of New Hampshire Stormwater Center is an excellent resource for Low

Impact Development (LID) practices for stormwater management. The long term goal is to make rivers and
streams in developed watersheds mimic the hydrology of similar habitats in undeveloped watersheds.

Political Location: **Watershed Location:**

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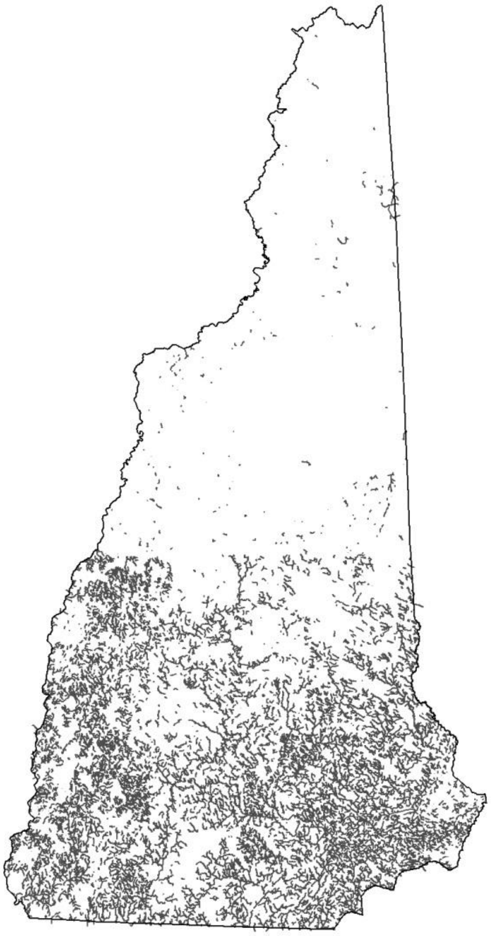
Warmwater Rivers and Streams

Photo by NHFG

Kilometers in NH: 12,466 km

Acres of Shoreline within a 100m Buffer Protected: 116,040 ac

Percent Buffer Protected: 19%



Habitat Distribution Map

Habitat Description

Warmwater rivers and streams have an average water temperature above 20C during the months of July and August, which is above the temperature tolerance of brook trout. Coldwater fish species are frequently supplemented in these waters but long term survival and reproduction is thought to be minimal. Warmwater rivers and streams are more common in southern New Hampshire, but they may be found anywhere in the state. They vary widely in size, gradient, and substrate. Often found in watersheds with abundant wetland or pond lentic habitat, warmwater rivers and streams are frequently influenced by beaver activity. The larger the drainage area of a river or stream, the more likely it is to contain warmwater due to the diminishing influence of groundwater on surface flow. Low gradient, slow flowing warmwater rivers and streams often contain submerged aquatic vegetation and share similarities with the shoreline habitat of warmwater lakes and ponds. Faster flowing warmwater rivers and streams may have the appearance of a coldwater stream, but they are home to a different community of fish species, including fallfish, longnose dace, and creek chubs.

Justification (Reason for Concern in NH)

Warmwater rivers and stream support a wide variety of both aquatic and terrestrial species. They are critical habitat for a number of species of conservation concern, including the state threatened bridle shiner, the banded sunfish, and the state endangered brook floater.

Protection and Regulatory Status

Third order streams and higher have development restrictions under the Comprehensive Shoreland Water Quality Protection Act. Many town zoning laws require setbacks for development or protect riparian buffers along rivers and streams.

Regulatory Protections:
Rivers Mngmt and Protection Program - NHDES
Comprehensive Shoreland Protection Act – NHDES
Clean Water Act-Section 404

Regulatory Comments: The Clean Water Act protects the integrity of aquatic communities in all rivers and streams, but this is difficult to enforce without adequate baseline data. Most small headwater streams have no protection under the Shoreland Water Quality Protection Act. Municipal regulations related to aquatic habitats vary widely throughout the state.

Management Guidelines

Distribution and Research

The distribution of warmwater stream habitat is based on fish surveys conducted by NHFG and NHDES biologists. Warmwater rivers and streams occur throughout New Hampshire, but they become more common as one moves southeast and lower in elevation. In northern New Hampshire, where there is an abundance of coldwater stream habitat, most rivers begin to shift to cool/warmwater species assemblages at watershed areas of greater than 15 square miles (see NHDES publication R-WD-07-38). These wider streams are less shaded by canopy cover and tend to be influenced more by surface water than by groundwater. Examples of warmwater stream habitat can be found in the Exeter river watershed, the lower Ashuelot River, and the Ossipee River. The warmwater stream habitat map will be further refined with future surveys.

Relative Health of Populations

Warmwater river and stream habitat is vulnerable to the effects of urbanization (Wang et al. 2001), and therefore the highest quality habitat is found away from population centers such as Manchester, Nashua, Concord, and Portsmouth. Water level management also has a large influence over warmwater river and stream habitat and unnatural water level fluctuations can reduce the abundance and diversity of species downstream of dams (Kanno and Vokoun 2010). Larger, low gradient warmwater streams surrounded by extensive wetlands are less vulnerable to the effects of development than small streams in upland habitat, which are often highly fragmented by undersized stream crossings and heavily influenced by stormwater runoff from impervious surfaces.

Habitat Condition

A set of GIS data was used to assess ecological condition of each habitat type. Chapter 3 describes the methodology. The data used for this habitat is described below.

River and Stream Reaches in each of four Very High Quality categories
Minimum Linear Connectivity Length met: Functional Network Length >= 10 miles for all systems

except for tidal headwaters and creeks which have naturally small network lengths and any functional network length was acceptable.
Low Riparian Development and Agriculture Impacts: Riparian index score <= 25

No dam on reach and upstream dam water storage volume as percent of mean annual flow <10%
Low Impervious surface < 2%
Condition assessment completed by The Nature Conservancy

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation from stormwater run-off from impervious surfaces (Threat Rank: High)

Stormwater runoff from impervious surfaces changes the hydrology of local rivers and streams. Flashier flows cause an increase in erosion and sediment deposition along stream banks and in the stream channel. More surface flow leads to a decrease in groundwater infiltration, which results in lower base flows during dry periods. Oil based pollutants, sediment, and road salt are washed from roads and parking lots into surrounding waterbodies which can lead to chronic declines in water quality. Runoff from pavement warmed by the sun can also lead to increased temperatures in local streams when stormwater flows directly into surface waters.

The impacts of impervious land cover on aquatic habitats have been well documented (Wang et al. 2001; Cuffney et al. 2010; Stranko et al. 2008). Most warmwater rivers and streams in the populated areas of the southern Merrimack River and coastal watersheds show signs of bank erosion and sedimentation due to alterations in hydrology caused by impervious surface runoff (Ben Nugent, NHFG Biologist, personal communication).

Habitat degradation from altered flow regimes due to water level management (Threat Rank: High)

River and stream habitat below lakes and ponds may be impacted as flows are reduced in an attempt to refill lakes or increased rapidly during lake drawdowns.

Changes in fish communities that result from artificial flow manipulation involve a shift to habitat generalist fish species. These changes have been have been well documented in studies related to instream flow (Kanno and Vokoun 2010).

Habitat degradation due to stream crossings (Threat Rank: High)

Poorly sized stream crossings alter the natural sediment transport characteristics of a river or stream, which leads to erosion and excess sediment deposition in the stream channel. The cumulative effect of under sized stream crossings can lead to increased sedimentation and turbidity throughout a watershed during storm events. Road fill from washed out stream crossings during flood events accumulates in the stream channel and buries the natural stream bed substrate.

Observations of stream crossings during fish surveys in New Hampshire suggest that there are very few streams that do not show some habitat damage from stream crossings (Ben Nugent, NHFG

Biologist, personal communication).

Habitat degradation from point source pollution (Threat Rank: Medium)

Industrial pollutants and pollution from untreated wastewater have been greatly reduced since the passage of the Clean Water Act. However, there are still isolated areas such as superfund sites or combined sewer overflows (CSO's) where pollutants continue to enter aquatic habitats at known locations.

There are 23 Superfund sites and 33 CSO's in New Hampshire (NHDES 2008; NHDES 2012). These sites are carefully monitored with long term plans for reducing their environmental impact. Although limited in scope, their local impacts can be severe.

Habitat degradation and impacts from aquatic herbicide application (Threat Rank: Medium)

Large scale aquatic herbicide applications (usually used to treat invasive plants) remove submerged aquatic vegetation, which is critical habitat to many aquatic species. Rapid plant decomposition may cause low oxygen levels in areas of poor circulation. The long term effects of herbicides and their chemical components on aquatic species are not well understood (Relyea 2014).

Although native plants are preferable to invasive plants, the removal of all aquatic plant species from an area causes the greatest harm to aquatic species, regardless of plant species composition (Valley et al. 2004). While large monocultures of invasive plants tend to support fewer species, areas with mixes of both native and nonnative plant species generally cause little change to the diversity and abundance of aquatic species.

Habitat degradation from agricultural run-off (Threat Rank: Medium)

Pesticides, herbicides, and fertilizers wash into aquatic habitats from agricultural fields, which are often located in the fertile floodplains of medium to large size rivers. Agricultural practices can also lead to increased turbidity, bank erosion, and sediment deposition in adjacent aquatic habitats. The degradation of water quality in watershed with a high proportion of agricultural land use can be toxic to many aquatic species.

The influence of land use on aquatic habitats within a watershed has been well documented (Allan 2004). Although agricultural influences on aquatic habitats are less prevalent in New Hampshire, which is largely forested, impacts can be severe where they occur.

Habitat degradation from stormwater run-off from impervious surfaces (Threat Rank: Medium)

Oil based pollutants, sediment, and road salt are washed from roads and parking lots into surrounding waterbodies which can lead to chronic declines in water quality. Runoff from pavement warmed by the sun can also lead to increased temperatures in local streams when stormwater flows directly into surface waters.

Stormwater runoff into the warmwater rivers and streams in coastal New Hampshire has been identified as one of the major contributors to declining water quality in the Great Bay Estuary (PREP 2013).

Habitat degradation from nutrient loading from lawn fertilizers and contaminated run-off (Threat Rank: Medium)

Nutrients from agricultural sources, sedimentation, lawn fertilizers, and poorly functioning septic systems contribute to increased algal growth in lakes and ponds. This excess productivity causes reductions in water quality and eventually lowers dissolved oxygen levels as microorganisms consume the dead algal cells, using up oxygen in the process.

Many lakes and ponds in New England show signs of degraded water quality due to cultural eutrophication (USEPA 2010). Increasing development pressure in southern New Hampshire has led to eutrophication issues with many of the water bodies that support aquatic species of concern, including banded sunfish, bridle shiner, redfin pickerel, swamp darter, and eastern pondmussel.

Habitat degradation from water withdrawal for irrigation, public water supply, or commercial use (Threat Rank: Medium)

Groundwater or surface water extraction may lower water levels and influence streamflow in local rivers and streams. In most cases, water levels in these streams are not monitored. New groundwater withdrawals are permitted by NHDES with requirements to reduce impacts on local aquatic habitats. Grandfathered withdrawals or the cumulative effects of small water withdrawals may be influencing stream flow in some areas.

Groundwater extraction was determined to be the cause of extremely low streamflows in the Ipswich River, Massachusetts (USGS 2001).

Habitat impacts from fragmentation due to impassable dams (Threat Rank: Medium)

Dams restrict the movement of aquatic species. Most aquatic species make daily and seasonal movements to access spawning habitat and foraging areas. Movement is also required in response to changes in water level, temperature, or water chemistry. Dispersal and colonization of new habitat is critical for long term population viability.

The effect of dams on diadromous fish species have been well documented (Limburg and Waldman 2009). Freshwater species are also impacted by dams, but the effects have been less studied. Dams have clearly restricted the dispersal of freshwater mussel species (Watters 1995).

Habitat impacts from fragmentation due to impassable stream crossings (Threat Rank: Medium)

Undersized stream crossings can function as a barrier to the movement of aquatic species. Undersized crossing often constrict flows, creating an increase in flow velocity through the structure. As a result, increased scour at the structure outlet occurs and a drop or “perch” is formed between the stream bed and bottom of structure. Many stream crossings restrict aquatic organism movement at certain flows due to high velocities, insufficient depth within the crossing, or an outlet that consists of a small waterfall. These barriers prevent access to critical habitat, reduce gene flow, and result in local extirpations of isolated populations.

A number of studies have demonstrated reductions in fish species richness and abundance upstream of impassable stream crossings (Nislow et al. 2011; Jackson 2003).

Habitat impacts from increased flood damage (Threat Rank: Medium)

Changes in flow conditions due to climate change may alter the seasonal timing, magnitude, and temperature of river flows, which could cause damage to river and stream habitat and increase mortality or restrict the seasonal movements of aquatic species.

Damage from increased flooding is exacerbated by human activity (Poff 2002). Efforts to protect infrastructure and property in floodplains have increased ecological damage to river and stream habitat during recent floods in New Hampshire.

Habitat impacts from flood control or erosion control (Threat Rank: Medium)

River and stream habitat is frequently altered in an effort to control or prevent flood damage to local infrastructure. Channel straightening, bank armoring, berm construction, and other practices result in a confined stream channel that no longer has access to floodplain habitat. These practices result in a loss of important habitat features, such as undercut banks, large in-stream wood, and streamside vegetation. While achieving the goal of protecting infrastructure at one location, these practices often exacerbate flooding downstream. Often done in response to recent flooding, river and stream bank modifications are rarely completed according to a long term plan that attempts to combine river restoration and flood prevention. Plans for repairing or preventing flood damage should be developed at the watershed level.

Damage from increased flooding is exacerbated by human activity (Poff 2002). Efforts to protect infrastructure and property in floodplains have increased ecological damage to river and stream habitat during recent floods in New Hampshire.

List of Lower Ranking Threats:

Habitat impacts from wastewater treatment sites and associated unmonitored contaminants

Habitat impacts from mercury toxicity

Habitat degradation from power plant effluent causing thermal pollution

Habitat degradation from run-off pollution (pesticides)

Habitat degradation from excess nutrients due to septic systems

Habitat degradation from acid deposition

Habitat degradation due to invasive or introduced plants

Habitat impacts from introduced or invasive animals

Habitat impacts from various diseases and parasites

Habitat degradation from stream crossings on logging roads and OHRV and snowmobile trails that cause fragmentation and sedimentation

Habitat impacts from unsuitable water temperatures that disturb species life cycles

Habitat impacts from unsuitable water temperatures for coldwater species

Habitat degradation due to shoreline development

Actions to benefit this Habitat in NH

River and stream habitat restoration

Primary Threat Addressed: Habitat impacts from flood control or erosion control

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
Restore the natural habitat qualities of a river or stream with practices such as wood additions, bank re-vegetation, floodplain restoration, or stream channel reconstruction.

General Strategy:
River and stream restoration techniques have been used to restore natural habitat features to areas that have been altered by urban development, agricultural land use, logging, or flooding. The principles of fluvial geomorphology are used to design appropriate channel characteristics according to watershed size, local climate, and substrate type at the site (Rosgen 1996). Restoration activities may range from the complete physical reconstruction of the stream channel to planting shrubs and trees to improve bank stabilization. Other common practices include floodplain restoration and wood additions (Cramer 2012).

Political Location: **Watershed Location:**

Prevent invasive species introductions

Primary Threat Addressed: Habitat impacts from introduced or invasive animals

Specific Threat (IUCN Threat Levels): Invasive & other problematic species, genes & diseases

Objective:
Prevent the introduction of invasive species, which alter the composition of native ecological communities.

General Strategy:
Whether they are accidental or intentional, invasive aquatic species introductions are notoriously hard to prevent and even more difficult to control. NHDES, NH Lakes Association, and other individual lake and pond groups have had some success preventing invasive aquatic species introductions with public outreach and by staffing boat ramps with trained inspectors, called Lake Hosts. Prevention and early detection is the most effective strategy for limiting the spread of invasive species. Once an introduced species has become established it is nearly impossible to eradicate it. Management efforts to control the species can be costly and requires long term planning. An angler determined to create a new fishing opportunity by stocking a new fish species into a waterbody is hard to deter. Education on the ecological damage that can be caused by introducing nonnative species into a waterbody will help prevent some, but not all deliberate species introductions. In some cases, anglers invested in the existing fishery may make the best advocates against new species introductions. However, outreach will not persuade everyone, so laws, penalties, and adequate funding for enforcement are the last line of defense against species introductions. It is important that penalties are severe enough and the presence of law enforcement is noticeable enough to act as a deterrent. New species introductions are inevitable, but the rate and overall extent of introductions may be contained.

Political Location: **Watershed Location:**

Improve fish passage at dams

Primary Threat Addressed: Habitat impacts from fragmentation due to impassable dams

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Construct, maintain, and monitor fishways at dams that currently limit access to suitable freshwater habitat for diadromous fish.

General Strategy:
At sites where dam removal is not an option, fish passage construction can improve connectivity between freshwater and marine habitats. Fish passage construction may be negotiated during the FERC relicensing process. Fish passage engineers with the USFWS are available to assist with designing the appropriate fishway for a particular site, depending on the needs of the species and the size of the dam (among other factors). At some sites outside of FERC jurisdiction, funding may have to come from other sources. Once installed, there should be a plan for fish passage operation, maintenance, and monitoring. Identifying the party responsible for each aspect of fishway operation is critical for maintaining effective passage over the long term. Periodic performance evaluations should also be completed at each fishway to ensure that fish are moving efficiently through the project without excessive delays.

Political Location: **Watershed Location:**

Dam removal

Primary Threat Addressed: Habitat impacts from fragmentation due to impassable dams

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:
Remove barriers to migration.

General Strategy:
When the opportunity presents itself, dam removals provide the best long term solution to reconnecting diadromous fish with their historical freshwater spawning habitat. Dam removal projects are challenging and they often stall without a dedicated project manager. Hiring and training staff to identify and facilitate dam removal projects will increase the number of projects that can be completed each year. Creating priority lists of dam removal projects for each species would also help focus resources on the projects with the most benefit as well as help generate funding.

Political Location: **Watershed Location:**

Stream crossing restoration

Primary Threat Addressed: Habitat impacts from fragmentation due to impassable stream crossings

Specific Threat (IUCN Threat Levels): Transportation & service corridors

Objective:

Increase connectivity and reduce habitat degradation caused by stream crossings.

General Strategy:

There are two phases to stream crossing restoration. The first phase is assessment. Stream crossing surveys are currently being conducted in several watersheds throughout the state. It is important that these surveys follow the standardized methods and protocols outlined by the New Hampshire Geological Survey (NHGS). NHGS maintains a statewide database of stream crossing survey data. Once the data is collected, stream crossing restoration projects can be prioritized to achieve the greatest benefits to aquatic organism passage, along with reductions in flood damage and habitat degradation. Prioritization may take place within small watersheds or across a large region. The second phase is implimentation. Once a stream crossing is identified as a good candidate for restoration there are many obstacles to a completed project, including permitting and cost. Streamlining the permitting process for crossing restoration, increasing available funding sources, and developing innovative stream crossing design and construction techniques that significantly reduce cost would greatly increase the number of stream crossing restoration projects in New Hampshire.

Political Location: **Watershed Location:**

Protect instream flow

Primary Threat Addressed: Habitat degradation from water withdrawal for irrigation, public water supply, or commercial use

Specific Threat (IUCN Threat Levels): Natural system modifications

Objective:

Manage water withdrawal and protect groundwater recharge to ensure adequate flow for supporting aquatic species in rivers and streams.

General Strategy:

Surface water and groundwater withdrawals for drinking water, irrigation, and other uses can reduce river flows, especially during critical periods of low flow during the summer months. Water level management at dams also affects the streamflow in a watershed. The NHDES Instream Flow Program works to balance water use while maintaining flow for aquatic life. Two pilot studies, one in the Souhegan River and one in the Lamprey River, have been conducted and Water Management Plans have been approved. The lessons learned from these studies and management plans should be expanded into other watersheds throughout New Hampshire. The practices implemented in the Water Management Plans for the Souhegan and Lamprey Rivers should be monitored to ensure that they are achieving the desired level of protection for instream flow. Dam managers should seek to manage water levels so that raising or lowering the water level in a lake or pond does not excessively decrease or increase the stream flow downstream of the dam. Headwater streams are especially vulnerable to water withdrawal and should not be overlooked during the permitting process. Chesley Brook, which supports a population of American brook Lamprey, is potentially vulnerable and should continue to be monitored for any impacts in water levels related to water withdrawals from the Spruce Hole Aquifer, which supplies drinking water to the town of Durham.

Political Location: **Watershed Location:**

Stormwater Management

Primary Threat Addressed: Habitat degradation from stormwater run-off from impervious surfaces

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:
To reduce the impacts of runoff from impervious surfaces by using Low Impact Development Technology.

General Strategy:
Stormwater runoff from impervious surfaces has been shown to damage aquatic habitats (Wang et al. 2001; Cuffney et al. 2010). Much of this damage can be prevented by stormwater management practices that filter runoff through the ground before it enters surface water. This practice not only removes much of the sediment and toxins that are typically washed into streams, but it also reduces the rapid fluctuation in water temperature, as well as the excess erosion and sediment deposition that have become a chronic issue for rivers and streams in developed areas. The University of New Hampshire Stormwater Center is an excellent resource for Low Impact Development (LID) practices for stormwater management.

Political Location: **Watershed Location:**

Riparian Buffer Protection

Primary Threat Addressed: Habitat degradation due to shoreline development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
Preserve the water and habitat quality of rivers, streams and the shorelines of lakes and ponds by preventing development in the riparian zone.

General Strategy:
Riparian buffer protection can be achieved through town ordinances, state law (i.e. the Shoreland Water Quality Protection Act), deed restriction, conservation easement, or voluntary land use practices (such as forestry best management practices). In general, the wider the buffer protected, the more ecological benefit. A buffer of at least 10 m will provide a minimum level of water quality and habitat benefits. A protected buffer of 100 m or greater provides maximum water quality and habitat benefits while also acting as a migration corridor for larger species of wildlife. Buffer protection is lacking on headwater streams despite the cumulative effect that intact riparian zones in headwater streams have on downstream water quality.

Political Location: **Watershed Location:**

Land Protection

Primary Threat Addressed: Habitat degradation from stormwater run-off from impervious surfaces

Specific Threat (IUCN Threat Levels): Pollution / Domestic & urban waste water / Run-off

Objective:

Preserve the natural ecological functions of an area by protecting land from development.

General Strategy:

Land protection is a strategy that can be used to ensure a level of habitat quality that is necessary to support certain species and habitats of conservation concern. For aquatic species, land protection prevents many of the impacts caused by sprawling development. Groundwater recharge, intact riparian zones, and unrestricted migration corridors are some of the benefits. There are still large areas of relatively undisturbed warmwater river and stream habitat in New Hampshire. Protecting functional warmwater rivers, streams, and associated wetlands will help prevent declines in many aquatic species of concern, especially in southern New Hampshire, where impacts from development are increasing. Land protection projects in New Hampshire usually require the coordination of a variety of funding sources, with involvement from town conservation commissions, local land trusts and watershed associations, government agencies, and state or national NGO's. Since 2005, the NH Wildlife Action Plan has helped direct land protection efforts toward conserving habitat for species and habitats of concern. The effectiveness of land conservation could be improved by identifying and addressing barriers to land conservation in New Hampshire and increasing outreach to help prioritize projects that benefit species and habitats of concern.

Political Location:

Watershed Location:

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Coastal Islands/Rocky Shore

Photo by Dan Sperduto

Acres in NH:	335
Percent of NH Area:	<1
Acres Protected:	77
Percent Protected:	23

Habitat Distribution Map Not Available

Habitat Distribution Map

Habitat Description

Coastal islands and rocky shores are habitats that share two basic characteristics: rocky substrate and exposure to the marine environment. The habitat as a whole grades from rock or cobble that is inundated at high tide to sparsely-vegetated rock above the high tide line to higher ground that supports terrestrial plant communities (Sperduto and Kimball 2011). Habitats within this range are all shaped by their exposure to tides, wave action, wind, salt spray, and ice, with the greatest exposure at the Isles of Shoals and least on Great Bay. The interiors of the larger coastal islands support simple plant communities dominated by grasses, forbs, and dense shrubs (Sperduto and Kimball 2011), and are also influenced by guano deposits from seabird colonies. These islands can be relatively remote and undisturbed, and because of intervening water many are free of terrestrial predators (Percy 1997). Intertidal areas are dominated by algae, mollusks, and barnacles, and exposed rock above high tide by lichens and blue-green algae (Sperduto and Kimball 2011). Included in this habitat are man-made structures such as breakwaters that mimic rocky shorelines and support similar marine algae and invertebrate communities.

Justification (Reason for Concern in NH)

Many species of colonial seabirds, water birds, waterfowl, shorebirds, and marine mammals use coastal islands as breeding grounds (DeGraaf and Yamasaki 2001, Kushlan et al. 2002), and rocky shorelines are additionally used for foraging or resting by shorebirds and other species during the non-breeding season. The Isles of Shoals also provide an important stopover area for many Neotropical migrants (Borror and Holmes 1990). Numerous species of invertebrates (amphipod crustaceans, periwinkles, barnacles, mussels) and rockweeds reside in the rocky intertidal areas. Islands increase the productivity of nearby waters by agitating currents, sediments, and nutrients, and increase the amount of shoreline available for use by plant and animal species (Percy 1997).

Historically, several of New Hampshire's coastal islands were home to large breeding colonies of terns (Sterna sp.), but a loss of habitat and increasing numbers of Herring (*Larus argentatus*) and Great Black-backed gulls (*Larus marinus*) led to declines in tern populations resulted in their decline and near extirpation from the state (USFWS 1998). Beginning in 1997, restoration efforts have resulted in the reestablishment of state-threated Common Terns on Seavey Island, and these have been accompanied by smaller numbers of federally endangered roseate terns and a few pairs of Arctic terns (*Sterna paradisaea*) (NHFG 2004).

Protection and Regulatory Status

Islands that serve as breeding grounds for federal and state listed species are protected through the Endangered Species Act and the State Endangered Species Act respectively. Marine mammals are protected under the Marine Mammal Protection Act.

Distribution and Research

Rockingham County

Within the Gulf of Maine watershed, New Hampshire has 40-60 coastal islands that are all located in the southeast corner of the state (USGS 2001). They occur in four main waterbodies: Little Bay, Great Bay, Portsmouth Harbor, and the Atlantic Ocean. Offshore islands include the Isles of Shoals group located roughly 10 miles off the coast of New Hampshire. Mainland islands are scattered throughout Portsmouth harbor, the Piscataqua River and its tributaries, and Little and Great bays. Mainland rocky shorelines occur from Portsmouth south along the immediate coast to Hampton. Similar habitats occur around Great Bay but are limited in extent.

Relative Health of Populations

The 9 islands (4 of which are in New Hampshire) that comprise the Isles of Shoals provide the highest quality of coastal habitat. Nevertheless, large colonies of herring and great black-backed gulls that were established between 1950 and 1970 have reduced habitat values for other species. Gull management on White and Seavey Islands has restored their function as tern nesting areas. The islands in the Portsmouth Harbor and Great Bay have more limited habitat value because of their small size and proximity to the mainland.

The current condition of coastal islands and rocky shores is highly variable. Some of the larger islands (particularly Star Island) have limited development, but most are not heavily impacted by direct human activity. Shorelines along the immediate coast are generally close to roads and/or development, although the effects of such on the habitat itself are poorly understood. A secondary indicator of habitat condition for islands is the presence of nesting seabirds. In this case, most historical colonies are no longer extant, and of those that remain only Seavey Island is of significant size. See species profiles for Roseate and Common Terns for more details.

Habitat Condition

Biological Condition:
Species richness of rare animals within their dispersal distances from the polygon
Species richness of rare animals within polygon
Species richness of rare plants in polygon
Richness of rare and exemplary natural communities in polygon

Landscape Condition:
Area (hectares) Local Connectedness

Human Condition:
Index of Ecological Integrity

Habitat Management Status:

Most coastal islands and rocky shores are not specifically managed in New Hampshire. An MOA between DRED and NHFG provides the basis for tern restoration on White and Seavey Islands. In general, Seavey Island is managed exclusively as a nesting area for terns and other birds during the breeding and nesting season. White Island is managed to provide access to historic buildings and a buffer is maintained between the structures and terns that nest on the Island. Periodic controlled burns, hand cutting, and herbicides are used on Seavey to maintain a mix of openings and herbaceous growth.

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation from oil spills (Threat Rank: High)

Oil can enter marine waters because of platform construction, drilling, shipping and spillage, and low-level seepage from surface runoff or subsurface sources (Boesch et al. 2001). Species can become coated in oil, resulting in direct mortality or reduced reproductive success, food can become contaminated, toxins can build up in upper trophic feeders, and oil can coat the shores resulting in habitat degradation (Kushlan et al. 2002).

Because coastal rocky shores are exposed to continuous wave action, any oil that is deposited is rapidly removed, however, contaminated waters that wash over tide pools could result in direct mortality of their inhabitants and heavy oil might remain on rocks over the high tide line. Any impacts usually do not last long except where heavy concentrations of light oil come ashore quickly.

The harmful effects of oil on birds have been well documented, including contamination from chronic oil pollution and mortality from major oil spills (Chardine 1990). Externally, even a small amount of oil contamination can destroy the weatherproofing and insulating properties of the plumage. This in turn can cause hypothermia and inability to fly, stay afloat, and forage. Internally, the ingestion of oil can be equally life threatening. Direct toxic effects on the gastrointestinal tract, pancreas, and liver have all been documented (Pierce 1991). Johnston (1984) has summarized various studies and reports regarding effects of oil spills on marine species and habitats:

- Plants, mollusks, and other invertebrates that are attached to rocks are initially impacted but quickly recover
- Birds suffer the greatest impacts, resulting in rapid death if they are coated in heavy oil and do not receive immediate assistance
- Internal organs are affected through ingestion of oil through preening, and oiled birds transfer oil to eggs causing a reduction in egg permeability and reduced productivity
- Marine mammals are not at great risk when encountering oil since it is usually washed off when diving, but when they come into contact with oil-coated shorelines, serious and possible life-threatening skin irritations occur
- Oil on rocks can last for as long as 8 years, particularly if the coated rock has been dried and warmed by the sun.

During a 1996 spill, the Hen Island tern colony in Little Bay was oiled as the birds were incubating eggs. Perhaps as disruptive was that the island was used to anchor containment booms and serve as point for cleanup activity. In addition to the direct disturbance, data from the New Hampshire Gulfwatch monitoring program documented high levels of polycyclic aromatic hydrocarbons in mussels immediately following the spill followed by a gradual recovery to baseline levels within 2 years (GOMC 2003).

Bird and Ram Islands (Massachusetts), which support close to 50% of the northeastern roseate tern population, were significantly affected by a 2003 spill in Buzzards Bay. Ram Island was the most heavily oiled of the affected islands. According to Carolyn Mostello of the Massachusetts Division of Fisheries and Wildlife, more than 20 birds were found dead on Ram Island immediately following the spill and many more birds, including terns, were oiled to varying degrees. To limit further oiling of terns and their eggs, hazing was initiated on Ram to keep the birds off island.

Mortality and habitat degradation from subsidized or introduced predators (Threat Rank: High)

Seabirds nesting on coastal islands are vulnerable to predation by a variety of species, particularly gulls. Although gull populations are currently declining slowly in response to closing landfills and other actions that have reduced supplemental food supplies, two species continue to nest in numbers on the Isles of Shoals, and thus pose a risk to terns and other birds. In addition to direct mortality, continued disturbance by predators can cause colony abandonment and the subsequent loss of an entire year’s productivity.

Great Black and Herring Gulls colonization of the Isle of Shoals in the 20th century is well documented along with the subsequent loss of tern colonies (Borror and Holmes 1990).

Habitat impacts from increased storm intensity and frequency that alter community distribution (Threat Rank: Medium)

Rocky coastal habitats are naturally dynamic systems constantly subjected to wave and tidal action, and most organisms that live in them are adapted to such conditions. However, the increases in storm frequency and intensity that a predicted by some climate change models, in conjunction with rising sea levels, are likely to result in significant changes to intertidal communities. In extreme cases, large waves can overwash coastal islands and potentially kill or reduce vegetation needed by nesting birds. If such storms occur during the breeding season there is also the possibility of reduced productivity.

The number of extreme storms is predicted to increase up to threefold by 2099 (Wake et al 2014a and 2014b). Extreme storms can disrupt bird migrations and make breeding and nesting sites inhospitable, forcing birds into marginal habitats. Coastal ecosystems are particularly susceptible to storms which disrupt dunes, salt marshes, and estuaries, and bring additional stress to species living there (Michener et al. 1997).

Habitat degradation from docks (Threat Rank: Medium)

Docks modify the vegetation in adjacent coastal habitat.

Docks are common along coastal shorelines.

Habitat conversion due to development (Threat Rank: Medium)

Coastal habitats are under severe development pressure, and once developed my permanently lose ecological function. However, the development potential for coastal islands and rocky shores is extremely limited and this threat may not rank as highly as indicated.

Star and Lunging Islands are privately owned.

List of Lower Ranking Threats:

Habitat degradation and mortality from mercury deposition

Habitat impacts from introduced or invasive plants

Disturbance and habitat impacts from boating, picnicking on islands, and visiting the lighthouse

Habitat conversion from tower and turbine development

Habitat degradation from sea level rise

Habitat conversion and species disturbance due to development

Actions to benefit this Habitat in NH

Coordinate with Oil Spill Response Team to update the oil spill response in proximity to Isles of Shoals including the purchase of survey and hazing equipment. Document habitat quality and food resources prior to spill to serve as baseline for assessing effects of spills.

Primary Threat Addressed: Habitat degradation from oil spills

Specific Threat (IUCN Threat Levels): Pollution / Industrial & military effluents / Oil spills

Objective:
With 99% of the common tern and 100% of the roseate tern population in New Hampshire nesting on Seavey Island it is critical to minimize the impacts of a catastrophic event such as an oil spill.

General Strategy:
Through careful planning, the purchase of equipment, and enforcement of safe shipping and operational proce-dures, an oil spill may be more easily contained. • Oil spill response planning will allow for more immediate and appropriate response to an oil spill in close proximity to the Seavey Island seabird colony. The purchase of ap-propriate equipment to contain and clean up an oil spill at

this location will improve the chances for minimal impact to the colony. • Oil spill response planning that is specific to the Isles of Shoals and seabird nesting areas will help to protect the Seavey Island colony. • Oil spill response planning should be ongo-ing and year round. Plans should include breeding and non-breeding periods. Pur-chase of equipment is an immediate need. • Baseline documentation of the habitat quality and available food resources will be important in assessing the impacts of an oil spill, responding to impacts, and improving the outcome of any future spill response.

Political Location:	**Watershed Location:**
Rockingham County	Coastal Waterhsed

Coordinate with the Coastal Islands Refuge and other partners interested in the protection of seabird nesting habitat on New Hampshire's coastal islands.

Primary Threat Addressed: Habitat conversion and species disturbance due to development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
Coordinate and support protection of coastal islands in New Hampshire.

General Strategy:
Duck and Smuttynose Islands are both protected under the National Wildlife Refuge System as seabird nesting habitat. It is important to coordinate and sup-port protection at these and potential future sites in New Hampshire.

Political Location:	**Watershed Location:**

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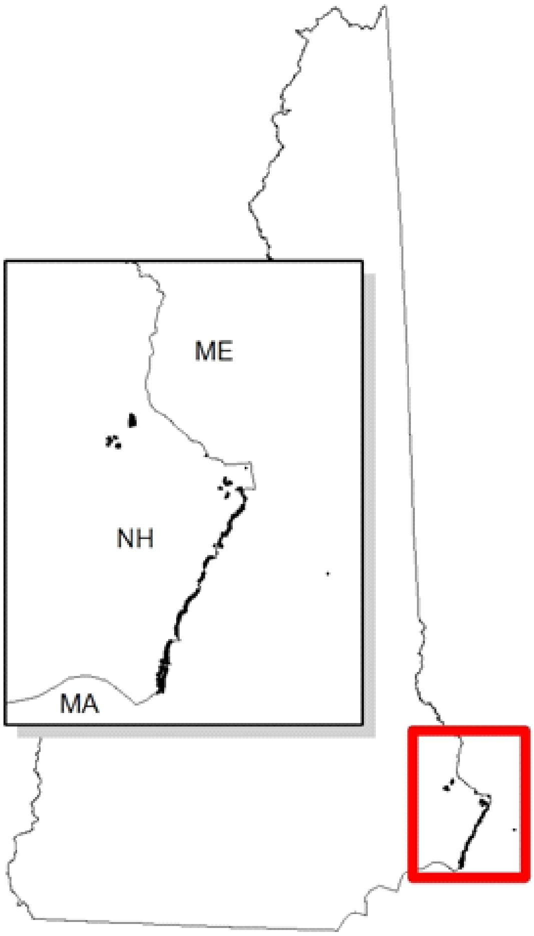
Dunes

Photo by Ben Kimball

Acres in NH:	694
Percent of NH Area:	<1
Acres Protected:	285
Percent Protected:	41



Habitat Distribution Map

Habitat Description

Coastal sand dunes are areas of sand and gravel that are deposited by wave and wind action within a marine beach system. Dunal formations include beach berms, frontal dunes, dune ridges, interdunes, freshwater wet swales, back dunes, and other sand and gravel areas. The coastal sand dune system is characterized primarily by American beach grass (*Ammophila breviligulata*) in the frontal dunes and by beach plum (*Prunus maritimus*) in the back dunes (Maine Department of Environmental Protection (MDEP) 2004, Sperduto and Nichols 2004).

Coastal sand dunes are typically transverse dunes that form at right angles to prevailing winds (Lutgens and Tarbuck 2000). Waves bring sand to the shore where it is transported by onshore winds. Sand is considered any loose, granular material with grains 0.05 to 2.0 millimeters in diameter. Sand comes from igneous, metamorphic, and sedimentary rock.

Obstacles such as driftwood, wrack (organic matter deposited at the high tide line), fencing, or vegetation reduce wind speed and cause sand to accrete. As sand accumulates, plants adapted to the beach environment take root, stabilizing the surface and promoting further dune formation (Broome 2004). Dune plants are subject to fluctuating environmental conditions that affect their growth, survival, and community structure. The most important factors include temperature, desiccation, low moisture retention, soil erosion, sand accretion, soil salinity, salt spray, changes in organic matter and pH (Maun 1994).

Other types of vegetation that occur in the shifting sands of the frontal dunes and dune ridges include seaside goldenrod (*Solidago sempervirens*), hairy hudsonia (*Hudsonia tomentosa*), beach pea (*Lathyrus japonicus*), American sea rocket (*Cakile edentula*), Fernald sage (*Carex merritt-fernaldii*), poverty oatgrass (*Danthonia spicata*), little bluestem (*Schizachyrium scoparium*), beach vetchling (*Lathyrus japonicus var. maritimus),* beach pinweed (*Lechea martima*), coastal jointed knotweed (*Polygonum articulatum*), Great Plains umbrella sedge (*Cyperus lupulinus var. macilentus*), seaside threeawn (*Aristida tuberculosa*) and Gray's umbrella-sedge (*Cyperus grayi*) among others (Dunlop and Crow 1985, Dunlop et al. 1983).

Sandy soils are typically more stable in the back dunes, allowing other types of vegetation to grow, including poison ivy (*Toxicodendron radicans*), Virginia rose (*Rosa virginiana*), little evening-primrose (*Oenothera perennis*), common yarrow (*Achillea millefolium ssp. Lanulosa*), bayberry (*Myrica pennsylvanica*) and climbing bindweed (*Fallopia scandens*) (Dunlop and Crow 1985, Dunlop et al. 1983).

Justification (Reason for Concern in NH)

Many avian species depend on coastal sand dunes. The state endangered and federally threatened piping plover (*Charadrius melodus*) and state endangered least tern (*Sterna antillarum*) use coastal sand dunes for breeding while the semipalmated plover (*Charadrius semipalmatus*), semipalmated sandpiper (*Calidris pusilla*), sanderling (*Calidris alba*), short-eared owl (*Asio flammeus*), horned lark (*Eremophila alpestris*) and Ipswich (savannah) sparrow (*Passerculus sandwichensis*) use coastal sand dunes for migration. The sanderling, short-eared owl, horned lark, and Ipswich sparrow also may use coastal sand dunes for wintering (Hunt 2004).

Coastal sand dune systems include sand deposits within a marine beach system that have been artificially covered by structures, lawns, roads, and fill (MDEP 2004). Prior to World War II, more than 90% of the nation's coastal barrier real estate existed as natural areas, largely inaccessible to the public (United States Fish and Wildlife Service (USFWS) 1996). Today coastal sand dunes have been lost to construction of homes, roads, parking lots, jetties, seawalls, and other structures in New Hampshire and along the entire Atlantic coast.

Development has reduced more than 70% of historic dune nesting habitat in Maine (USFWS 1996) and more than 83% in New Hampshire (Eberhardt and Burdick 2009). Protection of coastal development against strong ocean storms is important because damage from storms can result in billions of dollars of damage. Because they are both natural and economical, coastal sand dune systems provide coastal development with the best protection against storms, wind, waves, erosion, and sea level rise (MDEP 2004)

Protection and Regulatory Status

Coastal sand dune systems are protected under the Federal Coastal Zone Management Act of 1972 as well as New Hampshire RSA 482-A pertaining to Fill and Dredge in Wetlands. The New Hampshire Department of Environmental Services (NHDES), Watershed Management Bureau, Coastal Program has regulatory authority regarding RSA 482-A and associated administrative rules pertaining to coastal sand dune systems.

Coastal sand dune systems that serve as breeding grounds for federal and state listed species are protected through the Federal Endangered Species Act (1973).

Coastal sand dune systems that occur in the Hampton Harbor, Hampton Beach State Park and Odiorne State Park are state owned lands open to the public for recreation but are protected from development. The Seabrook dune system is owned by the town and has restrictions on use including the building of structures or boardwalks. Sections of dune habitats in Seabrook and Hampton are closed seasonally to protect nesting shorebirds.

Local town ordinances and New Hampshire State Parks rules help protect dune habitats by prohibiting such activities as the use of fireworks and campfires and restricting motorized vehicle use on dunes and beaches.

Distribution and Research

New Hampshire has 18.57 miles of coastline along the Atlantic Ocean (NHDES 2004), most of which is rocky shore. According to the Coastal Sand Dune Systems map that was created for this process, coastal sand dune systems comprise approximately 1.78 miles of the immediate coastline and occur primarily in Hampton and Seabrook.

The current distribution of coastal dunes is well documented. Further research should include surveys to determine the extent of invasive species impacts and control methods, the causes of beachgrass die-off, methods of increasing sand deposits into backdunes, and the potential for restoring dunes or dune hybrids along the NH coast.

Relative Health of Populations

The majority of coastal sand dune systems that remain occur along the Atlantic coast in the towns of Hampton and Seabrook. Heavy development and jetties have impeded the natural replenishment of sand and precluded the ability of the shoreline to shift (Eberhardt and Burdick 2009). The intensive recreational use of the beaches has degraded many sections. In Hampton the majority of dune habitat occurs on Hampton Beach State Park where, despite symbolic fencing to protect piping plover nesting areas, many of the dune crests receive heavy foot-traffic which has left some areas devoid of vegetation. The dune system in Seabrook, while fairly extensive, has been impacted by several private footpaths that run from oceanfront houses to the beach.

The dune system along Hampton Harbor has been heavily traversed by recreationalists and a network of pathways bisects the parcel. The largest section of backdune adjacent to Route 1A appears to receive minimal human use but the status of invasive species has not been thoroughly evaluated. Areas of beachgrass die-off have been observed on several patches (Alyson Eberhardt, personal communication).

Habitat Condition

Biological Condition:
Species richness of rare animals within their dispersal distances from the polygon
Species richness of rare animals within polygon
Species richness of rare plants in polygon
Richness of rare and exemplary natural communities in polygon

Landscape Condition:
Area (hectares) Local Connectedness

Human Condition:
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Habitat Management Status:

In areas where piping plovers are known to occur, habitat is managed to protect nesting areas during the breeding season. Management activities include fencing suitable habitat areas, restricting motorized vehicle use, and coordinating beach management activities such as beach raking and boardwalk maintenance. Habitat management for piping plovers is conducted by NHFG according to USFWS Atlantic Coast Piping Plover Population Revised Recovery Plan guidelines and in cooperation with town officials.

Dredging of Hampton/Seabrook harbor and the inlet occurs periodically. Dredge spoil is used to replenish the beaches where it then accretes along the existing foredunes. While active management has not targeted dune maintenance and restoration, the desire to maintain property protection and beach access have had some benefits. Artificial dunes have been created to protect against winter storms (which are removed the following spring) and sand fencing is annually installed in the fall to reduce build-up on designated walkways.

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation from oil spills (Threat Rank: High)

Oil can enter marine waters as a result from platform construction, drilling, shipping and spillage, and low-level seepage from surface runoff or subsurface sources (Boesch et al 2001). Oil that washes onshore may cause the die-off of dune vegetation. The effect of oil spills may be localized or very extensive depending on the source and timing of the contamination and the affected species or habitat.

Habitat degradation from OHRVs on the beach that kill vegetation and prevent dune formation (Threat Rank: High)

The use of motorized vehicles causes deterioration of beach grass and other vegetation that helps to trap and hold the sand to create and maintain dunes. In backdune habitat rare and long-lives species are vulnerable to mortality.

ATVs are used on the beach by lobstermen, police officers and life guards. Vehicle tracks are occasionally observed along the edge of the foredunes or through pathways that have been cut through the dunes over time.

Habitat conversion and degradation from human activity in the dunes (Threat Rank: High)

Sunbathing, swimming, jogging, dog walking, kite-flying, volleyball, jet skiing, surfing and fishing are all popular recreational activities that occur in or close to dune habitats. Additionally, residents that live adjacent to dunes often encroach on dune habitat by installing patios and fire pits or storing equipment. These activities may affect the dune ecosystem by altering the natural processes of dune formation, increasing erosion and trampling and killing native plant species.

Hampton Beach State Park receives over 100,000 visitors annually (J. Lyons, New Hampshire Department of Resource and Economic Development, personal communication). Several unauthorized paths through the dunes have been created over time by beachgoers in Seabrook and on the Harborside dune system. Symbolic fencing to protect piping plover breeding areas is effective in keeping the public off the dunes is Hampton but has not been as effective in Seabrook where many people ignore the signs. The symbolic fencing is typically removed once the plovers have fledged in July or August leaving the dunes with no protection from recreationalists until the following spring.

Habitat degradation from dredging and the dumping of spoils (Threat Rank: Medium)

The process of the depositing and grading of dredge material may negatively impact existing dune vegetation.

Habitat degradation from nuclear contamination (Threat Rank: Medium)

The Seabrook Nuclear Power Station is located less than 2 miles from the existing dune habitats.

To date dune systems have not been affected by nuclear contamination.

Habitat degradation from parasites or disease (beachgrass die-off) (Threat Rank: Medium)

Beach grass traps wind-blown sand which builds dune systems. Parasites or disease that cause mortality of beach grass may destabilize dunes and slow dune growth.

Beach-grass die-off has been observed in Maine and on multiple dune parcels in New Hampshire (Alyson Eberhardt, personal communication). The extent or severity of the die-off is unknown.

Habitat degradation from introduced or invasive plants (Threat Rank: Medium)

Invasive plants may out-compete native vegetation and change th community structure of dunes systems.

Some invasive plants have been observed on the interdune and backdune sections on the Harborside dune system and the backdune section adjacent to Route 1A but a detailed assessment has not been conducted (Alyson Eberhardt, personal communication).

Habitat conversion due to recreational management and shoreline modification (Threat Rank: Medium)

High recreational use is supported in turn by intensive management including installation and maintenance of boardwalks for human access, mechanical raking to clean beaches and public safety operations such as OHRV patrols by lifeguards or local police. These activities degrade the vegetation that traps and holds sand to create and maintain dune habitats.

Beach access points and boardwalks are maintained annually with tractors to remove or grade the accreted sand. Mechanical beach raking is conducted from May through August and often removes all wrack up the edge of the foredunes. Police and lifeguards often patrol beaches daily, particularly at Hampton Beach State Park.

Habitat conversion from infrastructure that prevents sediment movement and dune formation (Threat Rank: Medium)

Man-made structures along the shoreline, or manipulation of natural inlets, disrupt the natural forces necessary for beach and dune creation and renewal and can result in habitat loss or degradation (Melvin et al. 1991). Artificial barriers block the natural flow of sand and sediment, preventing the formation and maintenance of dunes.

Habitat degradation from increasing storm intensity and sea level rise (Threat Rank: Medium)

Dune habitats are naturally dynamic systems where sand is lost and accreted annually. However the combination of increasing storms and sea level rise that is predicted from climate change is likely to erode dune habitats by removing sand and vegetation faster than it can be replenished. As sea level rises storm surges are likely to cause dune scarping leaving a steep slope devoid of vegetation.

Dune scarping is visible at Hampton Beach State Park and on the Harborside dune system.

Habitat conversion due to development (Threat Rank: Medium)

Coastal habitats are under severe development pressure. Once developed, habitats are permanently lost.

The existing sand dune habitats are protected from development. However, the surrounding areas that may serve as migration sites for sand dunes may be targeted for development.

List of Lower Ranking Threats:

Habitat degradation from trash blown into dunes and wrack

Actions to benefit this Habitat in NH

Create and maintain official, designated pathways for access to and from beaches

Primary Threat Addressed: Habitat conversion and degradation from human activity in the dunes

Specific Threat (IUCN Threat Levels): Human intrusions & disturbance

Objective:
Establish designated recreational access points to limit the disturbance to dune vegetation from foot or vehicle traffic.

General Strategy:

Work with town and state officials to identify current access points that are desirable for use as public pathways. Re-vegetate or fence undesirable pathways and consider strategies to redesign existing pathways with walk-overs to allow for increased sand movement or at angles to decrease the funneling of storm energy.

Political Location:	**Watershed Location:**
Rockingham County	Coastal Watershed

Provide technical assistance to dredge applicants regarding the deposition of spoils on beaches

Primary Threat Addressed: Habitat degradation from dredging and the dumping of spoils

Specific Threat (IUCN Threat Levels): Transportation & service corridors

Objective:

Minimize the negative impacts to dune habitats from the deposition of dredge spoils.

General Strategy:

Participate in meetings and site walks during the planning phase of dredge operations.

Political Location:	**Watershed Location:**
Rockingham County	Coastal Watershed

Coordinate recreational management activities on beaches and dunes, including boardwalk installation and maintenance, beach raking and motorized vehicle use

Primary Threat Addressed: Habitat conversion due to recreational management and shoreline modification

Specific Threat (IUCN Threat Levels): Human intrusions & disturbance

Objective:

Minimize the impacts to dune habitats during recreational management activities.

General Strategy:

Maintain communication with beach managers during piping plover monitoring efforts to coordinate management activities. Consider meeting with town and state officials prior to or after the plover breeding season during boardwalk maintenance or snow fence installations.

Political Location:	**Watershed Location:**
Rockingham County	Coastal Watershed

Create and implement a comprehensive education and outreach plan for residents, day visitors, community and town officials

Primary Threat Addressed: Habitat conversion and degradation from human activity in the dunes

Specific Threat (IUCN Threat Levels): Human intrusions & disturbance

Objective:
Increase the community support and involvement in the protection and management of dune habitats

General Strategy:
Create and install educational displays at all main beach entrances. Give informative presentations to town officials, local conservation commissions, community groups involved in beach management, local police departments and state parks personnel. Create and distribute an informational mailing to all residents who live adjacent to dunes

Political Location:	**Watershed Location:**
Rockingham County	Coastal Watershed

Educate police officers and lifeguards about the negative impacts that OHRVs may have on dune habitats

Primary Threat Addressed: Habitat degradation from OHRVs on the beach that kill vegetation and prevent dune formation

Specific Threat (IUCN Threat Levels): Human intrusions & disturbance

Objective:
Reduce the impacts to dune habitats from OHRVs

General Strategy:
Hold annual spring meetings to reinforce guidelines for minimizing habitat destruction and species disturbance in dune habitats. Maintain regular communication during piping plover monitoring to reinforce the sensitivity of dune habitats.

Political Location:	**Watershed Location:**
Rockingham County	Coastal Watershed

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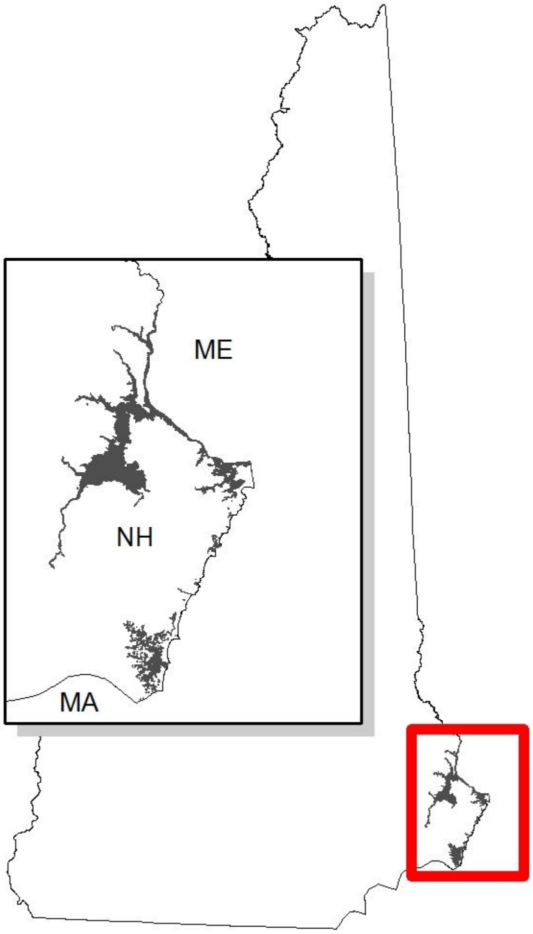
Estuarine

Photo by Rachel Stevens

Acres in NH:	11, 101
Percent of NH Area:	
Acres Protected:	
Percent Protected:	



Habitat Distribution Map

Habitat Description

Estuarine systems form where rivers meet the sea. They include subtidal and intertidal areas that are usually dominated by soft sediments (NH Fish and Game, 2013). Typical examples include eelgrass beds, oyster reefs, and intertidal mudflats. Salt marsh, an important estuarine habitat, is addressed as a separate habitat profile. Rivers carry nutrients, organic matter, and sediments to estuaries. All of these inputs combine to make estuaries extremely productive habitats with a great abundance of plants and animals. Estuaries are constantly changing transition areas, so animals and plants that live there need to be able to adapt to living in a wide range of conditions.

Justification (Reason for Concern in NH)

Estuarine habitats occur only in the Great Bay and Coastal watersheds. New Hampshire's systems are coastal plain estuaries. They support uniquely adapted plant and animal species not found in other parts of the state. Both the Hampton-Seabrook and Great Bay estuaries have been designated an Important Bird Area. Great Bay is also a National Estuarine Research Reserve, contains a National Wildlife Refuge and has been designated an International Focus Area in the North American Wetland Conservation Plan and a Resource Protection Project by the Environmental Protection Project. Species that use estuarine waters for spawning and nursery habitat include smelt, American shad, blueback herring, and horseshoe crabs. The shallow waters of estuaries provide feeding opportunities for osprey and waterfowl. Great Bay is an important wintering area for waterfowl and bald eagles.

Protection and Regulatory Status

There are regulations relating to the harvest of many marine species from New Hampshire's coastal waters, generally by means other than hook and line. These are coordinated by the New Hampshire Fish and Game Department's Marine Fisheries Division. The Hampton-Seabrook and Great Bay estuaries are protected under the Coastal Zone Management Act of 1972 and so are the focus of the NH Department of Environmental Service's Coastal Program. Both estuarine systems are also part of the EPA's National Estuary Program. In New Hampshire this is coordinated by the Piscataqua Region Estuaries Partnership under UNH's Marine Program. Great Bay is part of NOAA's National Estuarine Research Reserve System and contains a National Wildlife Refuge.

Regulatory Protections: Fill and Dredge in Wetlands - NHDES, Comprehensive Shoreland Protection Act - NHDES, Clean Water Act-Section 404

Regulatory Comments: Protection designations refer to marine habitat itself, not the array of associated wildlife species.

Distribution and Research

Rockingham, Strafford

Relative Health of Populations

The Piscataqua Regions Estuaries Partnership publishes an assessment of the health of New Hampshire's estuaries every three years. The latest report was released in 2013 and included 14 indicators that directly assess estuarine health (PREP, 2013). Of note is a significant increase in concentrations of dissolved inorganic nitrogen, a long term decline in eelgrass, periods of low oxygen in tidal rivers and an increase of nuisance seaweeds. On the positive side, work has been taking place to restore oyster beds and increase river connectivity to support migratory fish passage.

Trend (% +/-)): -2.3

Habitat Condition

A set of GIS data was used to assess ecological condition of each habitat type. Chapter 3 describes the methodology. The data used for this habitat is described below.

Biological Condition:
To be updated at a later date

Landscape Condition:
To be updated at a later date

Human Condition:
To be updated at a later date

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation from oil spills (Threat Rank: High)

Oil may spill from shipping vessels or other industrial infrastructure.

Species impacts from disease (oyster-specific and others) (Threat Rank: High)

Oyster reefs and eelgrass beds, components of the "estuarine" habitat category in this Wildlife Action Plan, are susceptible to species-specific diseases that have expanded their northern range into the state. Warming temperatures associated with climate change are likely to exacerbate the speed and geographic extent of such range expansions.

Barber et al. (1997) documents the disease MSX impacting oyster beds in the Piscataqua River starting in 1995. Eelgrass die off due to wasting disease was significant throughout the Atlantic coast in the 1930s and has impacted NH eelgrass beds significantly again from the 1980s to present (Short et al. 1986). See lobster profile for disease impacts on this species.

Habitat degradation from excess nutrients (including algal blooms) (Threat Rank: Medium)

Nitrogen has been monitored more comprehensively in Great Bay than the Seabrook-Hampton estuary. However, the major contributors of nitrogen to all NH estuary habitats are related to population growth and the associated increase in impervious surfaces. Consequently there appears to be a relationship between total nitrogen load and rainfall. Non-point sources account for 68% of total nitrogen entering Great Bay, municipal wastewater treatment plants are another significant source and tend to discharge concentrated sources of nitrogen, primarily in the reactive DIN form (PREP 2013).

Nuisance macroalgae such as *Ulva lactuca* can grow quickly in high nutrient environments and form expansive mats that crowd out, or smother, slower growing eelgrass populations (Fox et al., 2008). Native macroalgae that grow aggressively due to atypical environmental factors can have habitat impacts similar to those of invasive plants.

Total nitrogen load to the Great Bay Estuary in 2009-2011 was measured at 1,225 tons per year (PREP 2013). In addition to high macroalgae growth, this system is showing other signs of excess nitrogen including low dissolved oxygen in tidal rivers and declining eelgrass.

Habitat degradation from contamination of studied contaminants (Threat Rank: Medium)

Shellfish may collect toxic contaminants in their flesh when they filter water during feeding. The Gulf of Maine Council's Gulfwatch Program assesses toxic contaminants by measuring the amount accumulated in blue mussels (*Mytilus edulis*) (PREP, 2013). Study of implications of habitat degradation from contaminants is limited in NH, but shellfish sampling acts as a proxy indicator. Although study in NH is limited, at this time concentrations have seem to be generally been declining.

Concentrations of toxic contaminants in mussel tissue have been tested at 20 sites in NH. They have been found to be within U.S. Food and Drug Administration guidelines at all of sites except for South Mill Pond in Portsmouth. This initial study suggests that the amount of toxic contaminants in estuarine waters is of minimal concern (PREP 2013).

Research by Sunderland et. al. (2012) reported the amount of mercury in the muddy bottom of the Piscataqua Region estuaries was similar to Boston Harbor and other estuaries located close to cities.

Habitat impacts from introduced or invasive plants (Threat Rank: Medium)

The invasive red algae (*Heterosophonia japonica*), found in subtidal habitats and has been found in New Hampshire. The algae grow in water along the shoreline, and can detach and create vast decaying piles in the intertidal zone along the shore. It is thought to have been transported to the Atlantic Coast on boat hulls or by shellfish aquaculture. It was first discovered in southern New England on Rhode Island’s eastern seaboard in 2009. It was first found at the Isle of Shoals in 2011 and in Great Bay in 2012.

Nuisance macroalgae such as *Ulva lactuca* can grow quickly in high nutrient environments. They may form expansive mats that crowd out, or smother, slower growing eelgrass populations (Fox et al., 2008). Native macroalgae that grow aggressively due to atypical environmental factors can have habitat impacts similar to those of invasive plants.

Habitat impacts from tidal restrictions (Threat Rank: Medium)

Culverts and other tidal restrictions, including head-of-tide dams, may compromise full tidal exchange and can potentially block fish passage. As sea level rises relative to local land height the severity of current impacts and the number of restricting structures are likely to increase.

Habitat degradation due to siltation and turbidity from multiple sources (Threat Rank: Medium)

Estuarine turbidity varies with natural processes, such as rainfall that affects the amount of sediment washed off the land. Wind and tidal action can further increase the amount of suspended sediment. Anthropomorphic activities can increase turbidity in the estuary. Examples include soil erosion, nonpoint source runoff and in-stream sediment suspension.

In Great Bay and its tributaries, the average annual turbidity has increased in recent years, but long-term changes in turbidity are highly variable (Mills, 2009).

Habitat degradation from shoreline hardening (Threat Rank: Medium)

Seawalls, rip rap and other “hardening” structures are sometimes installed for erosion control or to prevent flooding. This infrastructure can have direct impact on naturally occurring habitats, or may indirectly alter local hydrology and/or sediment dynamics.

Habitat degradation from dredging and the dumping of spoils (Threat Rank: Medium)

Dredging to maintain navigation channels takes place in both the Great Bay and Seabrook-Hampton estuaries. This activity directly impacts the estuarine subtidal surface and dumping of spoils smothers the habitat it is placed on.

Habitat impacts from motorized boating (eelgrass) (Threat Rank: Medium)

Localized impacts to eelgrass and mudflats may take place due to boat use. Examples are propeller damage, and construction of docks and moorings.

Eelgrass populations were impacted under and directly adjacent to docks, as shown by depressed shoot density and canopy structure (Burdick and Short, 1999).

Habitat impacts from harvesting key species (oysters, lobsters, clams) (Threat Rank:

Localized impacts to eelgrass and mudflats may take place from boat use associated with harvesting key species. Example activities are propeller damage, and construction of docks and moorings. Raking or digging shellfish can have significant localized impacts.

Habitat impacts from increased freshwater run-off (Threat Rank: Medium)

Frequency and intensity of rain events are expected to increase as a consequence of climate change. Also, a higher proportion of winter precipitation is expected to fall as rain. These events will result in an increase of freshwater run-off entering the system, and consequently, periods of decreased salinity, and increased turbidity, erosion and nutrient load (NHFG 2013).

Annual precipitation recorded in Durham NH from 1895 to 2009 shows an increased rate of +0.59 inches/decade, or +6.73 inches over the past 114 years (Wake et al, 2011). Other weather stations in New England show a similar trend.

<u>List of Lower Ranking Threats:</u>

Habitat impacts from marine debris

Habitat degradation from emerging or unmonitored contaminants

Habitat degradation from docks

Habitat impacts from moorings

Habitat impacts from non-motorized boating

Species and habitat impacts from aquaculture

Habitat impacts from coastal acidification related to climate change and nutrient run-off

Habitat impacts from higher temperatures that cause anoxia

Habitat degradation from sea level rise that alters communities

Habitat and species impacts from phenology shifts

Actions to benefit this Species or Habitat in NH

Support multi-agency minor and major oil spill response plan coordinated by DES.

Primary Threat Addressed: Habitat degradation from oil spills

Specific Threat: Oil spills

Objective:
Contain and clean up any oil spill as soon as possible.

General Strategy:

Political Location:
Coastal Watershed

Watershed Location:

Develop statewide habitat risk assessment model for eelgrass beds.

Primary Threat Addressed: Habitat impacts from motorized boating (eelgrass)

Specific Threat: Recreational activities

Objective:
Develop statewide habitat risk assessment model for eelgrass.

General Strategy:
The New Hampshire Estuary Spatial Planning Project is in the final stages of development for Great Bay estuary and incorporates a Habitat Risk Assessment model for eelgrass. Expansion of the spatial extent of this project to the Seabrook-Hampton estuary would give a complete evaluation of this resource in NH.

Political Location:
Coastal Watershed

Watershed Location:

Reduce the amount of nitrogen entering New Hampshire's estuarine systems.

Primary Threat Addressed: Habitat degradation from excess nutrients (including algal blooms)

Specific Threat: Nutrient loads

Objective:
Reduce the amount of nitrogen entering New Hampshire's estuarine systems.

General Strategy:
Using multiple strategies including protection of undeveloped buffers around wetlands and along

waterbodies, Low Impact Development techniques, encourage picking up of pet waste, upgrading sewage treatment plants, maintenance of private septic systems, and reduction of fertilizer use to reduce the amount of all forms of nitrogen entering estuarine habitats.

Political Location: **Watershed Location:**

Remove, or increase the diameter of, current restrictions to tidal passage. Do the same for features that are likely to become restricting in the future as local sea level rises relative to land height.

Primary Threat Addressed: Habitat impacts from restrictions to tidal flow.

Specific Threat: Other ecosystem modifications

Objective:
Limit restrictions to full tidal exchange taking into account current and future local water levels.

General Strategy:
Remove, or increase the diameter of current, and likely future, tidal restrictions.

Political Location: **Watershed Location:**

Increase knowledge base

Primary Threat Addressed: Habitat degradation from contaminants

Specific Threat: Oil spills

Objective:
Increase understanding of habitat degradation by contaminants.

General Strategy:

Political Location: **Watershed Location:**

Encourage best management practices that limit turbidity impacts caused by human activities. Examples include maintaining vegetated buffers adjacent to waterbodies; cleaning out stormwater catchments; minimizing and carefully timing dredging activities; and using silt socks and sediment basins at construction sites.

Primary Threat Addressed: Habitat degradation due to siltation and turbidity from multiple sources

Specific Threat: Run-off

Objective:
Reduce human caused sources of turbidity.

General Strategy:
Encourage best management practices that limit turbidity impacts caused by human activities.

Political Location: **Watershed Location:**

Expand the New Hampshire Estuary Spatial Planning Project statewide

Primary Threat Addressed: Habitat impacts from harvesting key species (oysters, lobsters, clams)

Specific Threat: Fishing & harvesting aquatic resources

Objective:
Develop statewide habitat risk assessment models for eelgrass and oyster beds.

General Strategy:
The New Hampshire Estuary Spatial Planning Project is in the final stages of development for Great Bay estuary and incorporates a Habitat Risk Assessment model for eelgrass and oyster beds. Expansion of its spatial extent to the Hampton-Seabrook estuary would give a complete evaluation of these resources in NH.

Political Location: **Watershed Location:**
Coastal Watershed

Maintain sampling of toxic contamination in shellfish as a proxy indicator for potential habitat degradation.

Primary Threat Addressed: Habitat degradation from contaminants

Specific Threat: Oil spills

Objective:
Sample toxic contamination in shellfish as a proxy indicator for potential their impacts on estuarine habitats.

General Strategy:
Maintain sampling of toxic contamination in shellfish as a proxy indicator for potential habitat degradation.

Political Location: **Watershed Location:**

Mechanical removal.

Primary Threat Addressed: Habitat impacts from introduced or invasive plants

Specific Threat: Invasive non-native/alien species/diseases

Objective:
Remove decomposing red algae from intertidal zone.

General Strategy:
Towns in Massachusetts have been mechanically removing from the intertidal zone with beach combs and composting. In NH it is still currently an early detection species and surveys have been organized to assess its spread.

Political Location: **Watershed Location:**

Continue multi-organization oyster and eelgrass restoration projects established in NH.

Primary Threat Addressed: Species impacts from disease (oyster-specific and others)

Specific Threat: Invasive & other problematic species, genes & diseases
Objective:
Restore oyster reefs and eelgrass beds in areas they have been documented historically with disease-resistant strains when possible. Monitor both spatial extent and health of restored populations.

General Strategy:
Continue multi-organization oyster and eelgrass restoration projects established in NH.

Political Location: **Watershed Location:**
Coastal Watershed

Research

Primary Threat Addressed: Habitat degradation from excess nutrients (including algal blooms)

Specific Threat: Nutrient loads

Objective:

General Strategy:
Although typical nutrient-related problems have been observed, additional research is needed to determine and optimize nitrogen load reduction actions to improve habitat conditions

Political Location: **Watershed Location:**

Conservation of undeveloped land along estuarine shores.

Primary Threat Addressed: Habitat impacts from increased freshwater run-off

Specific Threat: Storms & flooding

Objective:
Maintain natural buffers that slow freshwater inputs and filter nutrients.

General Strategy:
Land conservation.

Political Location: **Watershed Location:**
Coastal Watershed

Oyster bed restoration.

Primary Threat Addressed: Habitat impacts from coastal acidification related to climate change and nutrient run-off

Specific Threat: Other impacts

Objective:

Increase acreage of oyster reefs in areas where they have been documented historically.

General Strategy:

Conduct oyster reef restoration using calcium carbonate amendments (shell) which provides substrate for spat recruitment as well as local pH buffering to counter acidification.

Political Location: **Watershed Location:**

Coastal Watershed

Develop a set of BMPs for shoreline buffers alternative to hard structures.

Primary Threat Addressed: Habitat degradation from shoreline hardening

Specific Threat: Human intrusions & disturbance

Objective:

Use natural shoreline buffers to prevent shore erosion in new and retroactive development when possible.

General Strategy:

Political Location: **Watershed Location:**

Coastal Watershed

Strategic use of dredging spoils for salt marsh and dune restoration projects.

Primary Threat Addressed: Habitat degradation from dredging and the dumping of spoils

Specific Threat: Shipping lanes

Objective:

Use dredging spoils from disturbed sediment floor to restore salt marsh or dune habitat where appropraite.

General Strategy:

Surface elevation is an important component of well-designed salt marsh and dune restoration projects. When increasing surface height, use of locally sourced materials is ideal to maintain local biodiversity and minimize transportation costs.

Political Location: **Watershed Location:**

Develop demonstration sites for shoreline buffers alternative to hard structures.

Primary Threat Addressed: Habitat degradation from shoreline hardening

Specific Threat: Human intrusions & disturbance

Objective:

Encourage living shoreline alternative approaches to hardening.

General Strategy:

Encourage living shoreline alternative approaches to hardening.

Political Location:	**Watershed Location:**
Coastal Watershed	

References and Data Sources

2015 Authors:

Rachel Stevens, Great Bay National Estuarine Research Reserve and NHFG

2005 Authors:

Literature:

Barber, B.J., R. Langan and T.L. Howell. 1997. Haplosporidium nelson (MSX) Epizootic in the Piscataqua River Estuary (Maine/New Hampshire, USA). Faculty Publications from the Harold W. Manter Laboratory of Parasitology. Paper 748.

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Marine

Photo by Rachel Stevens

Acres in NH:	51, 686
Percent of NH Area:	
Acres Protected:	
Percent Protected:	

Habitat Distribution Map Not Available

Habitat Distribution Map

Habitat Description

New Hampshire's marine habitats comprise a portion of the Gulf of Maine offshore the Atlantic Ocean coastline. These marine habitats are purely aquatic, in contrast to other coastal habitats such as salt marshes, rocky shores, dunes, and the intertidal portions of estuaries where significant portions are exposed to air over the course of the tidal cycle. Marine habitat can be generalized to refer to offshore waters including both pelagic and benthic zones as well as the surface of the waters where organisms such as waterfowl may periodically be found. Although State jurisdiction only extends three miles offshore, this delineation has no ecological basis, and marine systems shared by neighboring states are considered in their entirety for the purposes of this summary (NH Fish and Game, 2013).

Justification (Reason for Concern in NH)

Marine habitats support uniquely adapted plant and animal species not found in other parts of the state. Waters within 3 miles of New Hampshire's coast provide essential habitat for these species. Coastal migratory fish such as striped bass, mackerel and bluefish frequent nearshore waters. Other important commercially and recreationally harvested species include Atlantic cod, haddock, Pollock and lobsters. Seals and harbor porpoises are common mammals associated with nearshore marine systems in NH.

Protection and Regulatory Status

There are regulations relating to the harvest of many marine species from New Hampshire's coastal waters, generally by means other than hook and line. These are coordinated by the New Hampshire Fish and Game Department's Marine Fisheries Division. Nearshore waters are protected under the Coastal Zone Management Act of 1972 and so are the focus of the NH Department of Environmental Service's Coastal Program. The Coastal Zone Management Act provides a mechanism for states to manage coastal uses and resources and to facilitate cooperation and coordination with federal agencies. Regulations that either directly, or indirectly, impact wildlife species include protection of coastal resources, recreation and public access, coastal development, and marine research.

Regulatory Protections: Fill and Dredge in Wetlands - NHDES, Comprehensive Shoreland Protection Act - NHDES, Clean Water Act-Section 404

Regulatory Comments: Protections refer to marine habitat itself, not the array of wildlife species associated with this habitat.

Distribution and Research

Relative Health of Populations

Habitat Condition

A set of GIS data was used to assess ecological condition of each habitat type. Chapter 3 describes the methodology.

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat and species impacts from resource depletion resulting from commercial harvest (Threat Rank: High)

Species and habitat impacts from increasing sea surface temperatures (Threat Rank: High)

Increasing sea surface temperatures appear to be the climate change stressor with the greatest potential to impact marine systems. Higher ocean temperatures could result in thermal stress for marine life, stronger thermal stratification and alterations of marine currents. Thermal impacts may be far-reaching and include: range changes in sensitive species including important commercial and recreational fish and shellfish species; disruption of migratory routes; varied life stage impacts of survival and growth; disruption of ecosystem integrity from loss of diversity or changes in phenology; increased success of invasive species; and alterations of key chemical processes including nutrient cycling to phytoplankton in the surface waters. Increased sea surface temperature also contributes to sea level rise through both thermal expansion of sea water and melting of polar ice.

Habitat degradation from oil spills (Threat Rank: Medium)

Oil may spill from oil and gas drilling infrastructure.

Habitat degradation from oil spills (Threat Rank: Medium)

Oil may spill from small boats, shipping vessels or other industrial infrastructure.

Habitat impacts from mercury deposition (Threat Rank: Medium)

Primarily atmospheric deposition, but this has been mitigated in last few years as "scrubbers" are installed at power plants. Mercury levels bioaccummulate in species that consume fish, including humans.

Habitat impacts from introduced or invasive plants (Threat Rank: Medium)

Some of the anthropogenic mechanisms of invasive species introduction to marine environments include ballast water, boat hulls, and aquaculture escapes. They can also enter a system through range expansion, particularly as sea temperature increases due to climate change.

Habitat impacts from gear effects related to commercial harvest (Threat Rank: Medium)

Habitat impacts and mortality from shipping activity (Threat Rank: Medium)

See whale species profiles. Strikes are not a direct impact on marine habitat. Oil spills are treated as a separate threat.

Species and habitat impacts from ocean acidification (Threat Rank: Medium)

Ocean acidification associated with climate change. Increased CO2 concentrations in seawater will lower pH, potentially to the point that marine invertebrates with calcareous shells, such as diatoms and shellfish, suffer reduced survival and reproduction. Resultantly, important components of some food webs may be lost.

Responses of some species to laboratory ocean acidification experiments include decrease in calcification rate, reduced thermal tolerance, lack of pH regulation and reduced feeding (Cooley and Doney, 2009, Fabry, 2008, Doney et al. 2009)

List of Lower Ranking Threats:

Habitat impacts and mortality from power plant effluent causing thermal pollution

Habitat impacts from marine debris

Habitat degradation from nutrients from shore and ships

Habitat degradation from shore-based contamination

Habitat degradation from moorings

Habitat degradation from dredging and the dumping of spoils

Habitat impacts and disturbance from recreation and ecotourism

Habitat conversion from turbine development and underwater lines, and oil and gas drilling

Species and habitat impacts from aquaculture

Habitat impacts from increased wave action that causes bottom disturbance

Habitat impacts from increased storm events that send plumes including erosion, sedimentation, and salinity changes

Habitat and species impacts from phenology shifts

Actions to benefit this Species or Habitat in NH

Use research and modeling to increase understanding of potential shifts in marine food web.

Primary Threat Addressed: Species and habitat impacts from ocean acidification

Specific Threat: Habitat shifting & alteration

Objective:
Increase understanding of potential shifts in marine food web

General Strategy:
Use research and modeling to increase understanding of potential shifts in marine food web.

Political Location:	**Watershed Location:**
Coastal Watershed	

See whale species profiles. Strikes are not a direct impact on marine habitat.

Primary Threat Addressed: Habitat impacts and mortality from shipping activity

Specific Threat: Shipping lanes

Conduct stock assessment surveys in order to maintain sustainable harvest limits.

Primary Threat Addressed: Habitat and species impacts from resource depletion resulting from commercial harvest

Specific Threat: Fishing & harvesting aquatic resources

Objective:
Conduct stock assessment surveys in order to maintain sustainable harvest limits.

General Strategy:
Conduct stock assessment surveys in order to maintain sustainable harvest limits.

Political Location: **Watershed Location:**

Support DES coordinated oil spill response plan

Primary Threat Addressed: Habitat degradation from oil spills

Specific Threat: Oil spills

Objective:
Minimize the spread of any oil spilled into the marine environment.

General Strategy:
Implement DES coordinated minor and major oil spill protocols.

Political Location: **Watershed Location:**

Support multi-agency minor and major oil spill response plan coordinated by DES.

Primary Threat Addressed: Habitat degradation from oil spills

Specific Threat: Oil spills

Objective:
Contain and clean up any oil spill as soon as possible.

General Strategy:

Political Location: **Watershed Location:**
Coastal Watershed

Clean boat hulls before entering new water bodies and implement Coast Guard recommended ballast water discharge management regulations.

Primary Threat Addressed: Habitat impacts from introduced or invasive plants
Specific Threat: Invasive non-native/alien species/diseases

Objective:
Prevent new invasive species entering an area.

Support the EPA's 2011 national standards to reduce mercury and other toxic air pollution from coal and oil-fired power plants.

Primary Threat Addressed: Habitat impacts from mercury deposition

Specific Threat: Mercury

Objective:
Limit the amount of mercury and other toxic air pollution from coal and oil-fired power plants.

General Strategy:

Political Location:

Coastal Watershed

Watershed Location:

Monitor impacts of thermal change

Primary Threat Addressed: Species and habitat impacts from increasing sea surface temperatures

Specific Threat: Temperature extremes

References and Data Sources

2015 Authors:

Rachel Stevens, Great Bay National Estuarine Research Reserve and NHFG

2005 Authors:

Literature:

Cooley, S.R., and S.C. Doney. 2009. Anticipating ocean acidification's economic consequences for commercial fisheries. Environ. Research Letters 4: 024007 (online: 8pp).

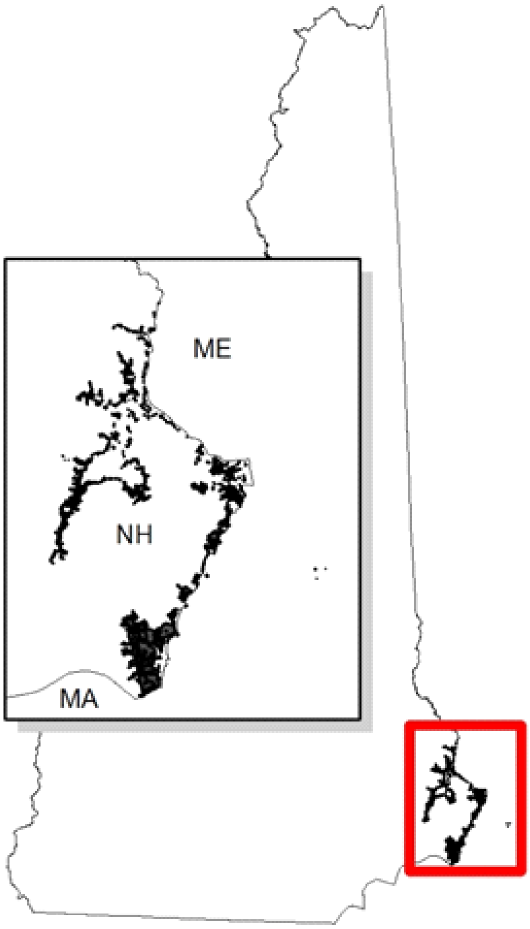
Doney, S. C., V. J. Fabry, R. A. Feely, and J. A. Kleypas. 2009. Ocean Acidification: The Other CO2 Problem. Annual Review of Marine Science, Vol. 1: 169 -1920

Fabry V J, Seibel B A, Feely R A and Orr J C 2008 Impacts of ocean acidification on marine fauna and ecosystem processes ICES J. Mar. Sci.65 414–32

New Hampshire Fish and Game Department. 2013. Ecosystems and Wildlife: Climate Change Adaptation Plan. http://www.wildlife.state.nh.us/Wildlife/Wildlife_Plan/climate.html

Salt Marshes

Photo by Rachel Stevens



Habitat Distribution Map

Acres in NH:	6,039
Percent of NH Area:	
Acres Protected:	
Percent Protected:	

Habitat Description

Salt marshes are coastal wetlands that are flooded and drained by salt water brought in by the tides and are found where there is shelter from high-energy ocean wave action. They are among the most productive ecosystems in the world and are dominated by detritus-based food chains (Mitsch and Gosselink 2000). In addition to wildlife habitat, they provide multiple benefits to humans including flood mitigation, healthy fisheries, storm protection, and long term carbon storage.

Salt marsh plants are adapted to fluctuating extremes of water and salinity. They are composed of three vegetative zones in response to tidal regime: low marsh, high marsh, and the terrestrial transition zone.

The low marsh occurs as a narrow band along the water's edge and is flooded twice daily. Tall-form smooth cordgrass (*Spartina alterniflora*) is the predominant plant species found in the low marsh and can grow up to 2 meters in length.

High marsh occurs between the low marsh and the terrestrial transition zone. The high marsh platform is flooded only during extreme high water, such as the new and full-moon tides. Throughout the high marsh, grasses and rushes dominate. Species such as salt marsh hay (*Spartina patens*), spike grass (*Distichlis spicata*), black grass (*Juncus gerardii*), short-form smooth cordgrass (*Spartina alterniflora*), salt marsh aster (*Aster tenufolius*), and sea lavender (*Limonium nashii*) are common. Pannes and pools found in the high marsh zone are also important habitat components. Pannes are shallow depressions of standing water that typically dry out during long, dry periods (e.g., end of summer). Only the most salt-tolerant plant species can occur at panne edges, such as common glasswort (*Salicornia europaea*), seaside plantain (*Plantago maritima*), and short-form smooth cordgrass. Pools are larger and deeper than pannes and hold submerged aquatic vegetation, such as widgeon grass (*Ruppia maritima*).

The terrestrial transition zone is located at the upland edge of a salt marsh and can also be found in pockets of the marsh, such as a berm, where elevation level is higher than that of the high marsh. The marsh border has the highest plant diversity in a salt marsh, with the dominant species being marsh elder (*Iva frutescens*), sweet gale (*Myrica gale*), seaside goldenrod (*Solidago sempervirens*), and switchgrass (*Panicum virgatum*).

Frequency and duration of tidal flooding are the dominant factors that create and influence salt marsh vegetative patterns (Niering and Warren 1980, Mitsch and Gosselink 2000). In addition, salinity, sediment availability, fine-scale topography, availability of nutrients and oxygen, and human modifications influence vegetative patterns (Niering and Warren 1980). Nutrients that stimulate marsh plant growth are carried in with the tides, and organic matter that feeds fish and other organisms is carried out by the tides.

Salt marshes in New Hampshire exist both as expansive meadows and narrow fringing marshes. The boundary between high and low marsh is a vegetative demarcation of local mean high water level. As such, changes in location of this boundary are one of the earliest ecological indicators of climate change (Stevens et al 2012). As sea level rises, if there is enough sediment available in the system, salt marshes can build up their peat and migrate inland. Current sediment accretion rates are similar to sea level rise in New Hampshire (Stacey et al, 2012) so salt marshes have the potential to migrate inland if there are no natural or human-created barriers. If barriers to migration are present, change will take place in two stages. First the relative proportion of low marsh will increase and slowly take over the area occupied by high marsh. Eventually the entire marsh will become “pinched” against the barrier and will slowly disappear and convert to intertidal mudflat.

Justification (Reason for Concern in NH)

Since colonial times, more than 50% of coastal and estuarine marshes in the United States have vanished, and the Northeast region is one of four “hotspots” with the most significant loss (Benoit and Askins 1999). In addition, by the 1930s, about 90% of salt marshes from Maine to Virginia were ditched for mosquito control (Clarke et al. 1984, Post and Greenlaw 1994). In New Hampshire, an estimated 18-50% of the state’s original salt marsh habitat has been lost to development or inadequate tidal flow (Bromberg and Bertness, 2005, Eberhart and Burdick 2009). Additional loss has taken place due to the spread of the invasive common reed (*Phragmites australis*). The reduced salinity and increased nutrient levels associated with expected climate change is likely to facilitate the growth of this invasive species further (Bertness et al. 2002). Excessive nutrient input has impacted the quality of some expanses of remaining salt marsh (Odell et al. 2006). Protecting and restoring remaining salt marsh habitat is of high priority.

Salt marsh habitat is an important conservation concern because it has many values and functions, such as supporting biodiversity, scenic, and recreational values and serving as an upland buffer for storms (Mitsch and Gosselink 2000). Salt marshes act as nurseries for several commercially and recreationally important fish species. They provide breeding, foraging, and migratory stopover habitat for many species of birds. Four species of greatest conservation concern (SGCN), the willet, Nelson's sparrow, saltmarsh sparrow, and seaside sparrow are obligate salt marsh breeders in New Hampshire. Other SGCN associated with this habitat are the American Black Duck, and Migratory Shorebirds.

Protection and Regulatory Status

Salt marshes are regulated by NHDES. Activities that may involve filling, dredging, or destroying wetlands in any way are subject to strict guidelines, and approved permits must be obtained before work can commence (RSA 482-A).

Regulatory Protections: NH NHB Database - current, NH NHB Database - historic, Fill and Dredge in Wetlands - NHDES, Comprehensive Shoreland Protection Act - NHDES

Regulatory Comments: The dominant *Spartina* species are not tracked by NH NHB, but several other salt marsh plants are. Examples include the American reed (*Phragmites australis ssp. americanus*) and perennial glasswort (*Salicornia ambigua*). Protections listed refer to salt marsh habitat itself, not the array of wildlife species associated with this habitat.

Distribution and Research

Rockingham, Strafford

Most of New Hampshire's salt marsh habitat is located along the open coast, with only 10% located in and around Great Bay (NHCP). Salt marshes are found in New Hampshire's coastal zone, which encompasses the following towns: Seabrook, Hampton, Hampton Falls, North Hampton, Rye, Portsmouth, New Castle, Newington, Greenland, Stratham, Exeter, Newfields, Newmarket, Durham, Madbury, Dover, and Rollinsford .

Relative Health of Populations

Historically, the introduction of railroads and roads resulted in reduced or no tidal influence to marsh habitat. Currently, negative effects of these transportation systems are still impacting some of New Hampshire's salt marshes. Tidally restricted marshes are less productive than unrestricted marshes (Roman et al. 1984). Burdick et al. (1997) noted that observed trends in marsh degradation indicate that tidal restrictions negatively affect the entire salt marsh ecosystem. For instance, tidal restrictions result in a decrease in flooding frequency and salt and sediment exchange, as well as an increase in freshwater from rain and snowmelt. These conditions result in the loss of salt marsh habitat, and typical salt marsh vegetation is replaced with invasive reeds and grasses, such as cattails and common reed (Sinicrope et al. 1990, Burdick et al. 1997, Brawley et al. 1998).
In New Hampshire, there are currently 2,4444 ha (6,039 ac) of salt marsh habitat (Stevens and Callahan, 2015). An estimated 18-50% of New Hampshire's original salt marsh habitat has been lost to development or inadequate tidal flow (Bromberg and Bertness, 2005).

Habitat Condition

A set of GIS data was used to assess ecological condition of each habitat type. Chapter 3 describes the methodology. The data used for this habitat is described below.

Biological Condition:
Species richness of rare animals within their dispersal distances from the polygon (2015)
Species richness of rare animals within polygon (2015)
Species richness of rare plants in polygon (2015)
Richness of rare and exemplary natural communities in polygon (2015)

Landscape Condition:
Area (hectares)
Local Connectedness

Human Condition:
Index of Ecological Integrity

Habitat Management Status:

There is no ongoing population management specifically for salt marsh birds in New Hampshire, but inventory work is under way. With historical records from ASNH and ongoing research being conducted at UNH, potentially important sites for New Hampshire's salt marsh birds are being identified. Lack of data (e.g., habitat suitability and effects of restoration practices) is a significant hurdle in developing effective management guidelines, although NHFG and GBNERR have developed a regional analysis of habitat quality and priority areas for conservation and restoration opportunities (Stevens and Callahan, 2015).

In a 1994 report, the NRCS identified 31 tidal restriction sites in New Hampshire. Of these, 16 have been rectified, 6 are in the planning stages of restoration, and the remaining restrictions are either infeasible or unnecessary to fix (NHCP).

Threats to this Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat degradation from shoreline hardening (Threat Rank: High)

Salt marsh is a natural, little to no cost, buffer to shoreline erosion. Sea walls, rip rap and other "hardening" structures are sometimes installed for erosion control or to prevent flooding of adjacent areas. This infrastructure can have direct impacts to salt marsh, or may affect it indirectly by altering local hydrology and/or sediment dynamics.

Habitat degradation and mortality from oil spills (Threat Rank: High)

Oil may spill from shipping vessels or other industrial infrastructure.

Habitat impacts from roads and culverts that restrict tidal flow (Threat Rank: High)

Roads and culverts can restrict tidal and sediment flow limiting the extent and quality of salt marsh that lies to their inland side. Current DES regulations limit, or prevent, the potential for future infrastructure that restricts tidal flow to be installed. The effects of current tidal restrictions are likely to be exacerbated in the future as sea level rises.

Habitat degradation from sea level rise (Threat Rank: High)

Sea level is rising relative to land height in New Hampshire due to ocean warming and global ice melt. Salt marshes can keep pace with sea level rise by migrating landward if there is adequate sediment supply or peat build up and no natural, or human created, barriers are present. When an obstruction to inland migration exists, increasing sea level initially converts high marsh to low marsh and eventually will drown the marsh converting it to mudflat.

Global and local sea level changes are summarized in Kirshen and Wake (2014). Predicted short and long term impacts to salt marsh habitat are evaluated in Stevens and Callahan (2015).

Habitat impacts from fragmentation (Threat Rank: High)

Railways and roads bisect several areas of salt marsh, with Route 1 being a particularly significant fragmenting feature. Historically marsh has been drained to build parking areas, harbor structures, and other residential and commercial development. Current DES regulations limit, or prevent, the potential for future fragmenting infrastructure to be installed. Existing habitat stress comes from existing features reducing tidal and sediment flow. This is likely to be exacerbated in the future as sea level rises and these fragmenting features will frequently act as barriers to inland migration.

Bromberg and Bertness (2005) estimate 18-50% of New Hampshire's historic salt marsh has been lost. They found salt marsh loss to be significantly correlated to urban growth in New England.

Habitat degradation from debris brought in on tides, run-off, direct deposit and storms) (Threat Rank: Medium)

Large debris such as docks, tires, or plywood can be washed in with the tide and cause significant, but very localized, impacts by blocking light and smothering salt marsh plant growth.

Habitat impacts from insecticide use (mosquito treatment) (Threat Rank: Medium)

Some towns contract with commercial pesticide companies to apply the mosquito larvicide *Bacillus thuringiensis israelensis* (Bti) to their salt marshes. Under certain conditions insecticides are also sprayed to kill adult mosquitos. These decisions are made at the community level. RSA 142-A is policy that says mosquito control must be allowed on state lands when a public health threat is declared.

Habitat degradation from stormwater run-off from impervious surfaces (Threat Rank: Medium)

Run-off can have direct erosion impacts, but associated nutrient load is commonly of most significance, particularly in the low marsh. Increased nutrients stimulates above ground growth of cord grass (*Spartina alterniflora)*. However, it also causes a reduction in root and rhizome growth which destabilizes the marsh edge. This is exacerbated as increased nutrients boost microbial decomposition of organic marsh peat (Deegan et al. 2012).

Habitat impacts from introduced or invasive animals (Threat Rank: Medium)

European green crabs (*Carcinus maenus*) impacts on salt marsh and other coastal habitats are of particular concern. It is thought their burrowing activity results in clipping off plant roots and so die back of the low salt marsh and consequently a significant increase in erosion potential. Belknap and Wilson (2014) present preliminary evidence for southern Maine. A pilot study using the same protocols was implemented in Great Bay National Estuarine Research Reserve in 2015.

Habitat impacts from mosquito ditching (Threat Rank: Medium)

Salt marshes have been ditched historically to limit the amount of standing surface water that can provide opportunities for salt marsh mosquitos to breed and larvae develop. During the 1930's, 90% of Atlantic coastal marshes were ditched (Bourn, W. S. and C. Cottam, 1950).

List of Lower Ranking Threats:

Habitat impacts and mortality from shipping activity

Habitat degradation from eutrophication from run-off

Habitat impacts from mercury deposition

Habitat impacts from introduced or invasive plants

Habitat impacts from ditch plugs that cause peat to break down faster

Habitat degradation due to mowing and filling

Habitat impacts from storm surge and sea level rise infrastructure

Habitat impacts from increased temperatures that accelerate peat decomposition

Habitat impacts from altered precipitation patterns

Habitat impacts from shifting precipitation patterns that decrease ice-born sediment inputs

Habitat impacts from shifting precipitation patterns that erode channels

Habitat degradation from docks

Habitat Conversion due to development

Actions to benefit this Species or Habitat in NH

Support multi-agency minor and major oil spill response plan coordinated by DES.

Primary Threat Addressed: Habitat degradation and mortality from oil spills

Specific Threat: Oil spills

Objective:
Contain any oil spill as soon as possible and limit, or prevent, the amount reaching shore.

General Strategy:

Political Location: **Watershed Location:**

Remove or reroute existing fragmenting features when possible.

Primary Threat Addressed: Habitat impacts from fragmentation

Specific Threat: Residential & commercial development

Objective:
Restore salt marsh by removal, or retrofit of, currently fragmenting features

General Strategy:

Political Location: **Watershed Location:**
Coastal Watershed

Increase culvert size / road porosity.

Primary Threat Addressed: Habitat impacts from roads and culverts that restrict tidal flow

Specific Threat: Other ecosystem modifications

Objective:
Remove, or increase the size of, culverts that restrict tidal flow.

General Strategy:
Remove, or increase the size of, culverts that restrict tidal flow.

Political Location: **Watershed Location:**
Coastal Watershed

Support multi-agency minor and major oil spill response plan coordinated by DES.

Primary Threat Addressed: Habitat degradation and mortality from oil spills

Specific Threat: Oil spills

Objective:
Prevent oil from being washed onto salt marsh.

General Strategy:
Remove oil from water before reaches salt marsh.

Political Location: **Watershed Location:**

Coastal Watershed

Conserve low lying areas of undeveloped adjacent upland

Primary Threat Addressed: Habitat degradation from sea level rise

Specific Threat: Habitat shifting & alteration

Objective:

Protect low lying areas of undeveloped upland adjacent to exisiting salt marsh to allow migration as sea level rises

General Strategy:

Use the Sea Level Affecting Marshes Model (SLAMM) results to identify priority parcels for conservation that are adjacent to highest quality salt marsh and are likely to support largest pieces of contiguous salt marsh for the longest period of time.

Political Location: **Watershed Location:**

Coastal Watershed

Support multi-agency minor and major oil spill response plan coordinated by DES.

Primary Threat Addressed: Habitat degradation and mortality from oil spills

Specific Threat: Oil spills

Objective:

Contain any oil spill as soon as possible and limit the amount, or prevent it, reaching shore.

General Strategy:

Political Location: **Watershed Location:**

Coastal Watershed

Encourage use of low impact development (LID) infrastructure in new and retrofit development

Primary Threat Addressed: Habitat degradation from stormwater run-off from impervious surfaces

Specific Threat: Run-off

Objective:

Reduce the amount of run off reaching salt marshes

General Strategy:

Increase the amount of low impact development infrastructure to manage storm water.

Political Location: **Watershed Location:**

Coastal Watershed

Leave vegetative buffers next to salt marsh that are as wide as possible using both voluntary and regulatory actions.

Primary Threat Addressed: Habitat degradation from stormwater run-off from impervious surfaces
Specific Threat: Run-off

Objective:
Maintain a wide vegetative buffer next to salt marshes where possible to reduce amount of run off reaching the marsh.

General Strategy:
Outreach on effectiveness of buffers in mitigating run off to town conservation commissions, zoning and planning boards.

Political Location:	**Watershed Location:**
Coastal Watershed	

Target insecticide application for public health, rather than annoyance, concerns.

Primary Threat Addressed: Habitat impacts from insecticide use (mosquito treatment)

Specific Threat: Pollution

Objective:
Protect public health in the most cost effective and ecologically sensitive manner.

General Strategy:
Strategic application of mosquito insecticides to focus on habitats that vector carrying mosquito species are primarily associated with e.g., red maple swamps. Salt marshes are traditionally sprayed for the annoyance mosquito species.

Political Location:	**Watershed Location:**
Coastal Watershed	

Encourage debris removal by supporting International Coastal Cleanup and informal volunteer activities.

Primary Threat Addressed: Habitat degradation from debris brought in on tides, run-off, direct deposit and storms

Specific Threat: Pollution

Objective:
Remove debris from salt marsh before it impacts vegetation.

General Strategy:
Encourage marine debris removal activities in salt marsh as well as beach environments. The Blue Ocean Society is currently most involved in organizing these activities and they have at least one salt marsh they regularly patrol.

Political Location: **Watershed Location:**

Coastal Watershed

Develop a set of BMPs for shoreline buffers alternative to hard structures.

Primary Threat Addressed: Habitat degradation from shoreline hardening

Specific Threat: Human intrusions & disturbance

Objective:

Use natural shoreline buffers to prevent shore erosion in new and retroactive development when possible.

General Strategy:

Develop BMPs and local demonstration areas that demonstrative effective alternatives to hardened shoreline structures.

Political Location: **Watershed Location:**

Coastal Watershed

Remove green crabs by trapping

Primary Threat Addressed: Habitat impacts from introduced or invasive animals

Specific Threat: Invasive non-native/alien species/diseases

Objective:

Reduce the number of green crabs burrowing in the salt marsh

General Strategy:

Trap

Political Location: **Watershed Location:**

Coastal Watershed

Restore natural wetland hydrology

Primary Threat Addressed: Habitat impacts from mosquito ditching

Specific Threat: Natural system modifications

Objective:

Restore natural wetland hydrologic flow.

General Strategy:

Restore natural wetland hydrology by allowing excavated ditches to collpase and fill in naturally or by active restoration.

Political Location: **Watershed Location:**

Coastal Watershed

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