APPENDIX B

Habitat Profiles

HABITAT PROFILE

Alpine

Associated Species: White Mountain Arctic Butterfly (Oeneis Melissa semidea), White Mountain Fritillary (Boloria titania montinus)

Global Rank: Not ranked
State Rank: Alpine herbaceous snowbank/rill (S1)
Moist alpine herb-heath meadow (S1)
Alpine ravine shrub thicket (S1S2)
Diapensia shrubland (S1)
Alpine heath snowbank (S1S2)
Bigelow's sedge meadow (S1)
Sedge-rush-heath meadow (S1)
Dwarf shrub-bilberry-rush barren (S2)
Labrador tea heath-krummholz (S2)
Sheep laurel-labrador tea heath-krummholz (S2)
Wet alpine/subalpine bog (S1)
Wooded subalpine bog/heathsnowbank (S1S2)
Subalpine sliding fen (S1)
Felsenmeer (S2)
Alpine cliff (S2)

Authors: Celine T. Goulet and Steven G. Fuller, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 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. This region endures high winds, precipitation, cloud cover, and fog, resulting in low annual temperatures and a short growing season (Bliss 1963, Sperduto and Crowley 2001). 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 1996, Sperduto and Crowley 2001). 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 systems are comprised of 5 broad groups of communities: diapensia shrublands, alpine herbaceous snowbank/wet-mesic alpine communities, alpine/subalpine bogs, heath-krummholz communities, and dwarf shrub-sedge-rush meadow communities (Sperduto and Cogbill 1999). Diapensia shrublands occur on exposed windblown ridges above 4,300 ft and are characterized by a high abundance of *Diapensia lapponica* supported on a rock or gravel substrate. Alpine herbaceous snowbank/wet-mesic alpine communities are typically sloped, have shallow organic soils, and associated with late-melting snowpacks, seeps, rills, and ravine settings. They are by dominated by *Geum peckii, Solidago macrophylla,* and *Calamagrostis canadensis* and occur between 4,400 and 5,500 ft. Alpine/subalpine bogs occur at elevations ranging from 2,900 to 4,900 ft within concavities and are dominated by *Vaccinium uliginosum* and *Empetrum nigrum*.

In parts of the White Mountain National Forest (WMNF), these communities form a mosaic with heath-krummholz communities composing structures referred to as "heath balds." Heath-krummholz communities are composed of wind-dwarfed thickets of trees, primarily *Picea mariana* or *Abies balsamea*, distributed as a continuous zone between 3,800 and 4,800 ft or intermixed with heath shrubs, primarily bilberry, cranberry, and blueberry. Dwarf shrub-sedge-rush meadow communities dominate much of the vegetated portion of the alpine zone at elevations ranging from 4,600 to 5,600 ft. *Carex bigelowii*, *Juncus trifidus*, bilberry heaths, and cranberry heaths characterize this habitat.

1.2 Justification

Alpine habitat is a rare community throughout the Northeast, occurring mostly as isolated "islands" on high peaks. Unique alpine plant communities, extreme climate, 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.

There is widespread consensus that alpine habitat is extremely susceptible to climate change (Kimball and Weihrauch 2000). Climatic changes documented within the WMNF (Climate Change Research Center 1998, Harvey 2003, Grant and Pszenny 2004) are expected to cause interdependent shifts in species distribution and phenology as demonstrated in other alpine areas, and may eventually result in irreversible changes to the composition and structure of alpine plant communities (Halloy and Mark 2003, Lesica and McCune 2004). Isolated populations of low vagility alpine-dependent wildlife, especially insects, will be heavily influenced by the extirpation of climate-sensitive plants, rising treeline, and increasing woody plant cover.

1.3 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.

1.4 Population and Habitat Distribution

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 (6,288 ft); Edmunds Col (4,938 to 5,100 ft) on Mt. Madison (5,367 ft); Bumpus Brook (5,799 ft) on Mt. Adams; Monticello Lawn (5390 ft); Mt. Clay (5533 ft); King's Ravine (3825-5000 ft) on Mt. Jefferson; Mt. Franklin (5001 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).

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

The definition of alpine habitat used in this analysis was areas with vegetation 8 ft in height that graduated down to bare rock. Alpine habitat was identified by isolating patches larger than 5 ac containing both krummholz and open rock per Hale and Rock's (2003) landcover classification for the WMNF. The resulting cover was appended with the Appalachian Mountain Club's (AMC) data depicting alpine areas in the Presidential Range and Franconia Ridge as well as New Hampshire Natural Heritage Bureau's (NHNHB) data depicting exemplary alpine communities. The NHNHB natural communities that were omitted included the following (with the exception of South Twin Mountain, Mt. Clinton, and Baldface): NHNHB alpine communities smaller than 5 ac; NHNHB alpine communities below 3,400 ft elevation, despite the appearance of diagnostic features; NHNHB peripheral/occasional alpine communities above 3,400 ft but greater than one quarter mile from a diagnostic community; and NHNHB peripheral/occasional alpine communities above 3,400 ft but greater than one quarter mile from the results of the other data sources. Other lower elevation habitat types will absorb alpine communities excluded in this analysis.

1.7 Sources of Information

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.

1.8 Extent and Quality of Data

The vegetation of New Hampshire's Presidential Range has been the subject of considerable study over the past 150 years. Plant and community databases, herbaria records, published reports, regional hiking guides, and articles on early exploration provide relatively thorough historical and current information about the Presidentials, but outlying occurrences in the state have received relatively little attention (Sperduto and Cogbill 1999). Although invertebrates dominate alpine-dependent fauna, very little is known about their distribution. Strong altitudinal and landform relationships make predicted alpine habitat occurrences reliable, and model validation should emphasize predicted habitat at marginal elevations.

1.9 Distribution Research

Surveys need be conducted to delineate alpine habitat outside the Presidential Range. Alpine invertebrate distributions need study.

Element 2: Species/Habitat Condition

2.1 Scale

Alpine habitat polygons derived from the mapping process were clustered by mountain range in which they occurred to facilitate conservation planning. Clustering helped define 6 conservation-planning units.

2.2 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.

2.3 Population Management Status

N/A

2.4 Relative Quality of Habitat Patches

The Presidential Range supports the largest and most ecologically diverse alpine community, containing more susceptible plants than any other habitat type (Kimball and Weihrauch 2000). It also supports the highest level of recreational use, containing the largest trail (50 mi), road (3.3 mi), and rail (1.4 mi) systems. Highly sensitive communities (e.g., snowbank) occur in Tuckerman's, Huntington, and King ravines, the Alpine Garden, Lakes of the Clouds, and Red Pond on Mt. Eisenhower.

2.5 Habitat Patch Protection Status

Alpine habitat within the WMNF is protected by the United States Forest Service (USFS) as designated by the National Wilderness Preservation System. National scenic trails bisecting alpine habitat throughout these Wilderness Areas will be protected and regulated in accordance with the Appalachian Trail regulations delineated in the Appalachian National Scenic Trail Comprehensive Plan (ATPO 1981). Further protection will be granted upon approval of the Proposed Land and Resource Management Plan for the White Mountain National Forest: Standards and Guidelines for Management Area 8.1- Alpine Zone.

2.6 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).

National scenic trails bisecting alpine habitat will be administered in accordance with the Wilderness Act (ATPO 1981) and are under the management authority of the Cooperative Management System (1984 memorandum of understanding (MOU) USFS and Appalachian Trail Conference), composed of the AMC, Dartmouth Outing Club (DOC), New Hampshire Department of Environmental Resources (DES), and WMNF. In addition, an MOU between the New Hampshire Fish and Game (NHFG), United States Fish and Wildlife Service (USFWS), and the USFS was established in 1996 delegating authority to develop, maintain, and manage all of the fish and wildlife resources and their habitats within the WMNF to NHFG. Further management guidance of alpine habitat will be granted upon approval of the Proposed Land and Resource Management Plan for the White Mountain National Forest: Standards and Guidelines for Management Area 8.1- Alpine Zone.

2.7 Sources of Information

Information regarding the management and protection of alpine habitat was obtained from the Proposed Land and Resource Management Plan for the White Mountain National Forest; 2001 MOU between the Bureau of Land Management (BLM), National Park Service (NPS), USFS, United States Department of Transportation (USDOT), and National Endowment for the Arts (NEA); 1996 MOU between NHFG, USFWS, and USFS; Appalachian National Scenic Trail comprehensive management plans; and documents delineating the Wilderness Act. Habitat patch identification and quality were determined utilizing WMNF landcover analysis, Presidential Range and Franconia Ridge alpine habitat polygons, NHB, and Vermont Institute of Natural Sciences (VINS) alpine natural community delineations.

2.8 Extent and Quality of Data

See Species/Habitat Condition Technical Assessment

2.9 Condition Ranking

See Species/Habitat Condition Technical Assessment

2.10 Condition Assessment Research

Data on alpine habitat condition need to be compiled. Parameters for relative condition, including extent of recreational impacts and rare natural communities, need to be identified and measured.

Element 3: Species and Habitat Threat Assessment

3.1.1 Recreation

(A) Exposure Pathway
Recreational use of alpine habitat is high. Structures, designated trails, undesignated trails, climbing routes, popular ski areas, and viewpoints co-occur with some of the most sensitive alpine communities, such as ravines and snowbanks. Disturbance from snow compaction and trampling may result in vegetative stress, mortality, and erosion, thereby reducing recolonization within these sensitive communities.

(B) Evidence
The alpine zone throughout the Presidential Range is highly recreated, enduring high levels of foot traffic and snow compaction (USDA Forest Service 2004). Magnitude of response is strongly correlated with trampling intensity (Cole 1995, USDA Forest Service 2004). While robust in their ability to withstand severe environmental conditions, alpine communities and soils have low tolerances for trampling. Trampling substantially reduces vegetation cover and height and increases soil erosion. Communities dominated by dwarf heath shrubs and erect forbs are the least resistant to trampling (Cole 1995, Cole and Monz 2002). Despite varying tolerances of trampling resistance and resiliency among alpine communities, they all have a threshold beyond which impacts become irreversible (D. Sperduto, New Hampshire Natural Inventory Bureau, personal communication).

3.1.2 Climate Change

(A) Exposure Pathway
The composition of the earth's atmosphere is changing, altering temperature, precipitation, air quality, and frequency of extreme weather (Climate Change Research Center 1998). Climate change could significantly alter the phenology and distribution of alpine vegetation (Kimball and Weihrauch 2000). Alpine communities could be further disrupted by alterations in snow cover and ice extent, causing stress or mortality to snowbank vegetation (Ingersoll et al.

1995, Walther et al. 2002, Sperduto and Nichols 2004).

(B) Evidence
Alpine communities are strongly influenced by edaphic and microclimatic gradients, increasing their vulnerability to climate change (Grabherr and Pauli 2000, Kimball and Weihrauch 2000, Harvey 2003). Climate change has been extensively demonstrated regionally and locally (Harvey 2003). In New Hampshire, temperatures have increased by 0.7 °F, 2 to 3 times the regional average, (NERA 2001, Harvey 2003). This same trend has been documented on the summit of Mt. Washington, where a 69-year temperature record has demonstrated a 0.3+/-0.08°C increase for the period 1935 to 2003, with a sharper rise in minimum temperatures than in maximum temperatures (Grant and Pszenny 2004). In response, freeze-free periods in many subalpine/alpine regions are lengthening, decreasing snow cover and ice extent (Walther et al. 2002). Alterations in annual snowpack in the alpine zone negatively impacts the herbaceous snowbank/rill communities which depend on these late-melting snowbanks to abbreviate their growing season and limit exposure to extreme conditions (Ingersoll et al. 1995, Sperduto and Nichols 2004). Additionally, Walther (2002) has documented poleward and upward shifts of species ranges including treeline advancement toward higher altitudes, elevation shift of alpine plants, and northward range shifts of 39 butterfly species, each of which is linked to global warming (Gottfried et al. 1998; Grabherr et al. 1994, Pauli et al. 1996, Harvey 2003). Changing climatic regimes will ultimately alter species distributions and composition, disrupting community structure and function (Walther et al. 2002).

3.1.3 Acid Deposition

(A) Exposure Pathway
In alpine communities, acid deposition may change community structure, spatial distribution of ecosystems, soil properties, and soil fauna (Rusek 1993). These reactions are compounded by similar reactions to climate change (Rusek 1993). The reactions of alpine grassland communities precede changes in the lower elevation subalpine zone and mountain forests (Rusek 1993). Bioaccumulation of contaminants (such as mercury) and other interactive chemical impacts may be high in wet, high-elevation environments with reduced pH.

(B) Evidence
Exposure to acid deposition is high at high elevation and in areas with frequent direct exposure to clouds. Extensive studies have demonstrated the detrimental consequences of acid deposition on alpine communities. Data have linked acid deposition to decreased soil pH, increased range of acidophilic species, disappearance of calciphilic species, and changes in plant community distribution (Rusek 1993). Methylation of abiotic mercury is accelerated in acidic environments. The communities most sensitive to acid deposition were found in locations with snow accumulation and water runoff gullies (Rusek 1993).

3.1.4 Mercury
(See Threats, Mercury)

3.2 Sources of Information

Information regarding alpine threats was compiled from expert review and consultation, management plans, technical field reports, and scientific journals. AMC, WMNF, and DRED trail data were used to assess recreational impacts.

3.3 Extent and Quality of Data

Recreational impacts, climate change, and acid deposition are fairly well documented.

3.4 Threat Assessment Research

Further research should focus on range shifts of alpine flora and fauna, phenological changes, and pollution-induced wildlife stress/mortality. Measuring the effects of local alpine point sources of pollution, such as the cog railway, is a high priority. Responses of invertebrate and avian foodwebs to interactions among atmospheric pollutants and among pollutants and climate change need to be assessed.

Element 4: Conservation Actions

4.1.1 Advise Land Managers on Mitigating Trail Impacts, Regulation, and Policy

(see also Strategies, Inter-Agency Regulation and Policy)

(A) Trails in Sensitive Areas/ Trampling

(B) Justification

1. Restricting trail use, placement, and width in sensitive areas will reduce the area of exposure.
2. Alpine communities have historically responded positively to scree-walls and other trail design modifications.
3. Trail advisories will be designated for high-use trails through delineated sensitive areas.
4. Advisories will be provided immediately upon entry into trail management agreements (see G: Implementation).
5. Trail use and design will be modified based on habitat response indicators.

(C) Conservation Performance Objective

Eliminate the co-occurrence of trail impacts with delineated S1-ranked natural communities and rare alpine lepidopteran habitats. Performance will be indicated by entry into trail management agreements, modification of trails, and adoption of trail advisories.

(D) Performance Monitoring

Advisories will include trail use and design modification reporting protocols.

(E) Ecological Response Objective

Restore S1-ranked natural communities and rare alpine lepidopteran habitats to delineated areas. Advisories will include restoration and monitoring recommendations.

(F) Response Monitoring

Cover of alpine vegetation and soils will be measured in delineated areas prior to implementation of advisories and in subsequent years. Responses will be used to revise advisories.

(G) Implementation

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. NHFG will review the 1996 MOU between the Department, USFWS, and the USFS.

(H) Feasibility

Given that NHFG is one of the only New England states not party to the ATC, the ATC's success and trail maintenance resources, and the Department's regulatory authority, it is highly feasible for the Department to enter the ATC and assert that trail managers adopt activities to mitigate wildlife impacts.

- Advise IAFWA Regional Coordination Team on Climate Change and Acid Deposition Impacts, Regulation and Policy (see Strategies: Regional Coordination)
- Engage in Inter-Agency Risk Assessments for Climate Change and Acid Deposition, Regulation and Policy (see Strategies: Inter-Agency Regulation and Policy)
- Identify High Risk Areas, Conservation Planning (see Strategies: Conservation Planning)
- Monitor Indicator Species for Climate Change and Acid Deposition, Monitoring (see Strategies: Monitoring)
- Restrict Access to Sensitive Areas, Regulation and Policy (see Strategies: Inter-Agency Regulation and Policy)
- Cultivate Recreational User Stewardship, Education and Outreach (see Strategies: Education and Outreach)

4.2 Conservation Action Research

Baseline surveys need to be conducted to better identify diagnostic species for sensitive alpine habitat areas and indicators of climate change and acid deposition. A permanent monitoring scheme needs to be developed and implemented in order to assess habitat changes across space and time.

Element 5: References

5.1 Literature

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HABITAT PROFILE

Appalachian Oak Pine Forest

Associated Species: Timber rattlesnake, eastern hognose snake, whip-poor will, veery, eastern pipistrelle, eastern red bat, northern myotis, silver haired bat, bobcat, black bear

Global Rank: Not ranked
State Rank: Not ranked
Author: Carol R. Foss, Audubon Society of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat description

Appalachian oak pine forest systems are found mostly below 900 ft elevation in southern New Hampshire south of and at lower elevations than the hemlock-hardwood-pine forest system. The southern-most portions of the state are associated with the warmer and drier climatic conditions and apparently more fire-influenced landscapes that prevail south of New Hampshire in lower New England. 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 correspond to pitch pine sand plain; those with a less frequent fire regime (i.e., more than 50 to 100 years) are classified as oak pine forest or sometimes hemlock hardwood pine forest systems depending on the composition of trees. More isolated patches of oak pine forest systems are found to the north in central New Hampshire associated with dry rocky ridges or sand plains with a historic fire regime.

1.2 Justification

Appalachian oak pine forest currently has a limited distribution in New Hampshire, covering less than 10% of the state's land area. Available data indicate that only 7.3% 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 osprey, Cooper's hawk, timber rattlesnake, and eastern hognose snake. In New Hampshire, intense development has dramatically reduced the area of this forest type 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.

1.3 Protection and Regulatory Status

Most of New Hampshire's Appalachian oak pine forest occurs on small, privately owned parcels. Less than 15% of this forest type 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" (Cullen 1996) and "Good Forestry in the Granite State" (FSSWT 1996) provide recommended management practices for sustainable forestry in New Hampshire.

1.4 Distribution

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.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

To develop a map of Appalachian oak pine forest in New Hampshire, a model was developed for each ecoregion subsection of the state based on the 2001 New Hampshire Land Cover Assessment, elevation, landform, and soils. The model was developed by experts from The Nature Conservancy (TNC), the New Hampshire Natural Heritage Bureau (NHNHB), and New Hampshire Fish and Game (NHFG).

First, relevant forested 2001 New Hampshire Land Cover Assessment grid values were combined with elevation ranges from sea level to 900' (CSRC 2001, USGS 2003). Ecological Land Units, created by The Nature Conservancy's Conservation Science Support, were then added to capture additional areas likely to have geo-physical conditions favorable to Appalachian oak pine, or remove areas likely to have geo-physical conditions unfavorable to Appalachian oak pine (TNC 2003). Specifically, north-facing side slopes and north-facing coves were removed from some land cover/elevation classes, and some land cover/elevation classes were restricted to only south-facing sideslopes and south-facing coves.

During previous fieldwork, NHNHB mapped exemplary Dry Appalachian oak-hickory forest, Mesic Appalachian oak-hickory forest, Appalachian oak-mountain laurel forest, and Semi-rich Appalachian oak-sugar maple forest systems in the state. These areas were added to ensure that known Appalachian oak pine locations were captured (NHNHB 2005). These data do not capture all existing locations of these communities, only those that have been mapped by NHNHB.

To further refine the model, soil types associated with Appalachian oak pine were identified by Natural Resource Conservation Service scientists and selected from digitized county soil data, where available (e.g., Merrimack county soils have not been digitized) (NRCS 2002, Homer 2005). The soils were selected, and then clipped to only include forested areas based on the New Hampshire Landcover Assessment, and added to the existing model information. The same was done for hemlock-hardwood-pine, and then Appalachian oak pine was used to erase areas from hemlock-hardwood-pine where there was overlap, so that Appalachian oak pine takes precedence over hemlock-hardwood-pine. NHFG then applied a filter to determine the majority forest type between neighboring polygons in the TNC model, and smoothed the boundaries to generalize the transition between matrix forest types. This process is expected to somewhat over-predict current locations of Appalachian oak pine, but it captures better broad distribution patterns of the type.

Model results were reviewed by experts from TNC, NHFG, and NHNHB, who agreed that the broad patterns depicted by the model align with reasonable expectations. No ground truthing was conducted.

1.7 Sources of Information

The Appalachian oak pine map was developed based on expert input from scientists from the NHNHB, NHFG, and the New Hampshire Chapter of The Nature Conservancy. The results were reviewed by additional scientists from NHFG and the Audubon Society of New Hampshire. A variety of GIS data was used to generate the map including elevation data from the United States Geological Survey, landform data from The Nature Conservancy's eastern regional office, landcover data from the New Hampshire Landcover Assessment, and soils data from the Natural Resource Conservation Service, among others.

1.8 Extent and Quality of Data

The Appalachian oak pine habitat map is a depiction of broad landscape patterns with limited fine-scale accuracy. Additional refinements will likely be necessary based on ground truthing of the existing map. The Natural Resource Conservation Service provided a table of soil series that were believed to be strongly correlated with Appalachian oak pine and other forest types (Homer 2005). Soil series were provided by ecoregional subsection and elevation ranges. There was considerable overlap between series outlined for Appalachian oak pine and other forest types, especially hemlock-hardwood-pine. The transition between Appalachian oak pine and hemlock-hardwood-pine

was especially difficult to delineate, as disturbance is a driving factor in the distribution of Appalachian oak pine. The soil series considered to be most strongly correlated with Appalachian oak pine that did not overlap with hemlock-hardwood-pine were used in mapping Appalachian oak pine. Additional review of soils data, as well as land use history and paleoecology information, are necessary for future iterations.

1.9 Distribution Research

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.

Element 2: Species/Habitat Condition

2.1 Scale

County

2.2 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. An additional approximately 5% decrease is projected to occur between 2001 and 2025 (calculated from data in SPNHF 2005).

2.4 Relative Quality of Habitat Patches

Analysis pending

2.5 Habitat Patch Protection Status

Approximately 10% of potential Appalachian oak pine forest in the 4-county area where approximately 90% of this forest type occurs is in conservation ownership (calculated from TNC data). Approximately 14% of this type occurs on lands with some form of conservation protection (calculated from NHFG data).

2.6 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).

2.7 Sources of Information

See 1.7

2.8 Extent and Quality of Data

See 1.8 regarding extent and quality of data associated with the TNC matrix forest map. Tree farm data from Thorne and Sundquist 2001 are based on a New Hampshire Tree Farm program database issued in August 2000. Data regarding changes in forest area from SPNHF 2005 include information from the New Hampshire Land Cover Assessment, 2001 and results of predictive modeling.

2.9 Condition Assessment Research

- Research is needed to determine the extent of this forest type that occurs in large unfragmented blocks.
- Research is needed to determine the age class distribution of this forest type on the landscape.

Element 3: Species and Habitat Threat Assessment

3.1.1 Transportation Infrastructure

(A) Exposure Pathway

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 matrix forest wildlife (Forman et al. 2003).

(B) Direct Evidence
Large carnivores may be unable to maintain sustainable populations in landscapes with road densities exceeding 1 mi/ mi^2 (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).

3.1.2. Development (Habitat Loss and Conversion)

(A) Exposure Pathway
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.

(B) Direct Evidence
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).

3.1.3. Development (Land Use Planning)

(A) Exposure Pathway
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.

(B) Direct Evidence
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)

3.1.5 Altered Natural Disturbance (Succession)

(A) Exposure Pathway
Extinction of the passenger pigeon, fire suppression, development, and accompanying land-use policies have essentially eliminated the major historical natural disturbances for this forest type. Parcelization and extensive residential development now preclude forest management in much of New Hampshire's Appalachian oak pine forest. Habitat for wildlife species requiring early successional stages of this forest type has been substantially reduced.

(B) Direct Evidence
Forest inventory data for New Hampshire show major deficits in the 2-inch diameter class for hickory and the 4-inch diameter class for white oaks (Miles 2005).

3.2 Sources of Information

Threat information was derived from a work session with forestry professionals and stakeholders, available data, published literature, and personal experience.

3.3 Extent and Quality of Data

Threats to Appalachian oak pine forest resulting directly or indirectly from land conversion and development are well documented.

3.4 Threat Assessment Research

The major threats are adequately documented. Re-

search should be directed to condition assessment and conservation actions.

Element 4: Conservation Actions

4.1.1 Incorporate Habitat Conservation into Local Land Use Planning

See Strategies: Local Regulation and Policy

4.1.2 Advise Conservation Commissions and Open Space Committees

See Strategies: Local Regulation and Policy, Education and Outreach

4.1.3 Promote Role of the Regional Planning Commissions in Landscape-Scale Conservation

See Strategies: Local Regulation and Policy

4.1.4 Protect unfragmented blocks and other key wildlife habitats

See Strategies: Land Protection

4.1.5 Develop a comprehensive land protection support program

See Strategies: Land Protection

4.1.6 Advocate adoption of sustainable forestry

See Strategies: Education and Outreach

4.2 Conservation Action Research

Research is needed to provide a sound scientific basis for new tools to help municipalities maintain large forest blocks and significant wildlife habitat in the face of development. Such research could include:

- Road noise effects on forest bird distribution and breeding status
- Behavior and land use of mesocarnivores in relation to development and road densities
- Bear use of mast stands relative to proximity of development
- Effects of residential lot sizes on habitat suitability and landscape permeability for selected wildlife species

Element 5. References

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HABITAT PROFILE

Caves and Mines

Associated Species: Northern Myotis, Eastern Small-Footed Bat, Myotis sodalis, , Eastern Pipistrelle
Global Rank: G5
State Rank: S1
Authors: Jacques Veilleux and Scott Reynolds, Franklin Pierce College; St. Paul's School

Element 1: Distribution and Habitat

1.1 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.

1.2 Justification

Six of New Hampshire's 9 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. Some individuals, such as *Eptesicus fuscus*, undoubtedly hibernate in buildings (Whitaker and Gummer 1992). Managers need better knowledge of hibernacula sites to conserve overwintering animals.

3.3 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.

1.4. Population and Habitat Distribution

There are 7 known abandoned mines that serve as winter hibernacula in New Hampshire. Within the Northeast region, approximately 198 hibernacula have been documented to date (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 (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).

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

Profile authors visited each mine during the summer of 2004 and GPS coordinates were gathered using a Garmin 12XL receiver. Map coordinates were provided to the habitat mapper. Coordinates provide accurate localities of each mine.

1.7 Sources of Information

The main source of information pertaining to mine locations was the New Hampshire Natural Heritage Inventory: Bat Hibernaculum Records for abandoned mines. Existing GPS coordinates were found to be inaccurate for some mines (e.g., Mt. Kearsarge Mine) and therefore only the coordinates provided to the habitat mapper from the 2004 field work (section 1.6) should be used.

Several sources were used to identify potential hibernacula including databases, published literature, and consultation with state agencies, local spelunkers, historical societies, and landowners. The main database used to determine historical mine sites was the United States Bureau of Mines, Minerals Availability System Domestic Deposit Listing (maintained by the Utah State Historical Society). Morrill (1960; New Hampshire Mines and Mineral Localities) provided more detailed information about potential mines.

Authors consulted with the state geologist (David Wunsch, New Hampshire Department of Environmental Services) and a land manager (Bill Carpenter, New Hampshire Department of Resources and Economic Development, Land Management Bureau). For each mine identified as a potential hibernacula, the local historical society was contacted about mine ownership, condition, etc. Two active New Hampshire spelunkers (Michele Tremblay and Steven Landry) were consulted about the presence of additional mines that we had not identified, as well as data about the condition of known mines. Finally, local landowners near potential sites were consulted during the survey to gather additional data on mine location and condition.

1.8 Extent and Quality of Data

Trends in the habitat quality of New Hampshire's mines are unknown. In addition, the lack of data on caves/mines in New Hampshire precludes an accurate assessment of the statewide or regional significance of New Hampshire's mines.

1.9 Distribution Research

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.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the relatively small number of New Hampshire mines that are known to provide habitat or potentially provide habitat, each mine is treated individually as a conservation planning unit.

2.2 Relative Health of Populations

The 7 mines that have been surveyed for bats in New Hampshire have hibernating populations ranging in size from 12 bats (Beebe River Mine) to 1,579 bats (Mascot Lead Mine). Species diversity within these mines ranges from 2 species (Carter Mine) to 5 species (Mascot Mine). Although Bristol Mine was only surveyed once (1989), the remaining 6 mines have been surveyed at least three times since 1986. From these data, it appears that hibernating populations of bats are generally stable, with 5 of the mines having larger populations in recent surveys. The only mine to see a decline was the Beebe River Mine, which saw a 79% reduction from 1988 to 1991.

A *Hibernacula of Special Concern* is defined as any cave or mine that contains at least four species of bats, at least 1,000 individuals, or any threatened or endangered species (Butchkowski 2003). New Hampshire has two Hibernacula of Special Concern: Mascot Lead Mine and the Red Mine.

To estimate the hibernating population of bats in New Hampshire, we assumed changes in population size between surveys were a linear function of

time and conducted a smoothed-line interpolation of data between surveys. We took two approaches to estimate the current population of bats in hibernacula. The first approach assumed all populations would remain stable since the last survey; because all but one of the mines had increasing population trends, this was considered a conservative estimate. The second method involved extrapolating data from the last survey date using the rate of increase estimated from prior surveys; this was considered the potential estimate. The conservative estimate was 2,928 bats and the potential estimate was 3,283. Because the largest mine (Mascot Lead Mine) was surveyed in 2004, the potential estimate is only 12% higher than the conservative estimate.

The little brown bat (*Myotis lucifugus*) is the dominant hibernating bat in New Hampshire, being found in all seven mines and representing 86.5% of all bats. Northern myotis (*Myotis septentrionalis*) are also found in each of the known mines and represent 12.5% of the total hibernating population. Northern myotis is the only species that appears to be declining, with the 2004 estimate reflecting a 36% decrease from 1989 estimates. This decline may be due to population pressures outside the hibernacula, but may also reflect differences in survey methods and misidentification of little brown bats as northern myotis. Big brown bats (*Eptesicus fuscus*) represent 0.3% of the current hibernating population and are currently known from two hibernacula (Red Mine and Beebe River Mine), although they were found in the Paddock Copper Mine as recently as 1991. Similarly, eastern pipistrelle bats (*Pipistrellus subflavus*) represent 0.3% of the current hibernating population and are currently known from two hibernacula (Dodge Mine and Mascot Lead Mine), although they were found in the Mt. Kearsarge Mine as recently as 1991. Eastern small-footed bats (*Myotis leibii*) represent 0.3% of the current hibernating population and are only known from Mascot Lead Mine. The 2004 population estimate of eastern small-footed bats (9 animals) reflects an increase from the previous survey, but a 43% reduction from the peak estimate in 1987.

2.3 Population Management Status

2.4 Relative Quality of Habitat Patches

Several physical characteristics are predictive of hibernacula. These include cool and stable interior temperatures (Hall 1956, McManus 1974, Harmata 1987, Jones et al. 1995, Tuttle and Kennedy 2002, Tuttle 2003), low air flow (Jones et al. 1995, Kath 2002), long or complex adits (Lopez-Gonzalez and Torres-Morales 2004), and a high degree of protection from human disturbance and vandalism (Martin et al. 2002, Tuttle and Kennedy 2002). Updates on population information and physical attributes of known hibernacula suggest that New Hampshire Natural Heritage ranks need revision.

2.5 Habitat Patch Protection Status

Mascot Lead Mine is the only mine that currently contains (state) endangered species. Mascot Lead Mine, Paddock Copper Mine, and Mt. Kearsarge Mine are the three largest hibernacula in the state. Five of the seven known mines (Carter's Mine, Beebe River Mine, Bristol Mine, Paddock Copper Mine, and Red Mine) are located on private land. Two mines (Mascot Lead Mine and Mt. Kearsarge Mine) are managed by the Department of Resources and Economic Development (DRED). Each mine identified as potential habitat is located on private land. The exact location of one mine (Keyes Mine) could not be determined, and therefore protection status is unknown.

2.6 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 conserva-

tion 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.

2.7 Sources of Information

The physical attribute information on four of the known bat hibernacula (Mt. Kearsarge Lead Mine, Paddock Copper Mine, Carter's Mine, and Red Mine) were collected by Durham (2000). Measured variables included temperature, relative humidity, shaft height, shaft width, bat cluster temperature, species composition, roost height, and roost depth. These data were used to generate mine maps and look at species-specific thermal preferences.

2.8 Extent and Quality of Data

The quality and extent of data collected varies between the mines. There have been four winter surveys at Mascot Lead Mine since 1987; two were conducted since installation of the bat gate in 1992. Red Mine has been surveyed four times since 1986 and the Mt. Kearsarge Lead Mine and Paddock Copper Mine have been surveyed five times since 1986. The smaller hibernacula have generally been surveyed less frequently, including Carter's Mine (three surveys since 1989), Beebe River Mine (three surveys since 1988), and Bristol Mine (one survey in 1989). With the exception of data collected in 1999 and 2000 at Red Mine, Paddock Copper Mine, Carter's Mine, and Mt. Kearsarge Lead Mine (Durham 2000), no microclimate data have been collected at any of these sites. Furthermore, bats have not been surveyed at Ruggle's Mine.

2.9 Condition Assessment Research

It is important for the conservation of bats in the Northeast to identify and determine the importance of mines as winter roost habitat (Ellison et al. 2002). This requires establishing a monitoring program that will assess the physical attributes of a mine to determine its' potential suitability as a hibernacula, document the population status of hibernating bats using non-intrusive monitoring techniques, and evaluate the need for, and effectiveness of, mine gates to minimize disturbance.

One priority should be to continue to seek additional mines that may contain hibernating bats. Previous surveys across the country have shown that approximately half of abandoned mines show some evidence of bat use (Tuttle 1995). In New Hampshire, a small fraction of the summer bat population can be accounted for by existing hibernacula. Therefore, it is likely that additional surveys will discover new hibernacula.

For each potential hibernaculum, it is important to measure the physical characteristics of the mine and key microclimate conditions that influence bat occupancy. Foremost of these microclimate variables is core mine temperature (Tuttle and Kennedy 2002). Most bats prefer mines that maintain a stable winter temperature slightly above freezing (1°C - 10°C: Tuttle 2003). This is consistent with the temperatures recorded in Red Mine near hibernating bats (6°C - 9°C; Durham 2000). Most rigorous surveys now rely on battery-operated data logger probes (such as the Hobo Pro ™ series) to record mine temperature throughout the hibernation period (Tuttle and Kennedy 2002). These devices can be installed in the autumn and programmed to record temperature each hour during the winter. Devices can be recovered in the spring without disturbing the bats. Air flow can also be important in larger mines because it indicates air exchange within the mine and may be the result of chimney-effect air flow that is produced by a secondary opening. Chimney-effect air flow maintains cool air in mines and often enhances temperature stability (Tuttle and Kennedy 2002).

For mines with hibernating bats, periodic monitoring is essential to assess population stabil-

ity. Surveys involving Species of Concern should be conducted every second or third year (Johnson et al. 2002, Tuttle 2003). Hibernacula surveys should be conducted during December through February when bats are most abundant. Details of the survey protocol are available from Veilleux and Reynolds (2005). Technical climbing support may be required to access the habitats. Microclimate needs to be measured to determine a mines' suitability as hibernacula.

For mines subject to vandalism and disturbance, it may be necessary to install bat gates across the mine entrance. Well-designed bat gates can protect bats from disturbance without impacting cave microclimate. Although gates can be expensive to install, they appear to be the only effective method of reducing human disturbance. Research into the value of chain-link fences and signage suggests they do not deter vandalism at all (Johnson et al. 2002). Johnson et al. (2002) did find, however, that a motion-activated alarm reduced human entrance into a mine in Indiana.

Element 3: Species and Habitat Threat Assessment

3.1.1 Recreation

(A) Exposure Pathway
Humans that enter New Hampshire mines during winter may disturb hibernating bats and cause individual bats to arouse from hibernation. These disturbances may expend a portion of an individual's energy reserve that is required for successful hibernation. If human disturbance of wintering bats and the subsequent arousals from hibernation occur too frequently, energy reserves may be depleted and individuals may die before spring emergence. As evidence of this, Johnson et al. (1998) documented lower body masses in Indiana bats hibernating in caves that were subject to human disturbance.

(B) Evidence
Thomas (1995) examined whether non-tactile disturbance by humans (i.e. disturbance by light and sound, rather than direct physical contact with bats) visiting hibernacula during the hibernation period affected winter arousal rates of bats. Data indicated that the presence of humans in hibernacula causes a dramatic increase in arousal of bats (little brown bats and northern myotis) and an increase in flight activity. Thomas (1995) suggested that non-tactile disturbance may cause bats to attempt to copulate (males) with hibernating females, and attempt to reposition themselves within a hibernating cluster of non-aroused bats. Aroused bats may arouse others due to tactile disturbance.

Costs for normal metabolic functions during hibernation and natural periodic arousals likely consume the majority of available fat reserves during winter. Each time human disturbance causes arousal by bats in a hibernaculum, limited energy supplies are exhausted, and this may lead to mortality. This is particularly important for juvenile bats that enter hibernation with limited fat reserves.

3.1.2 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Landowners with abandoned mines on their property may try to reduce risk of litigation by backfilling (closing) the mine entrance. If backfilling occurs in the fall or early spring, hibernating bats may be trapped in the mine and experience direct mortality from the mine closure. If backfilling occurs during summer, it is unlikely that bats would be trapped in the mine, but bats returning to the mine in the fall would not be able to gain entrance. Natural again also contributes to mine collapse, which may trap bats within mines, exclude them entirely, or merely disturb them during the winter.

(B) Evidence
Five of the known mine hibernacula and each mine identified as a potential hibernaculum are located on private land, and therefore may be at risk of landowner modification in the form of backfilling. Some of these mines have vertical shafts that present a potential hazard. Limited investigation yielded no information on serious injury or death of individuals entering New Hampshire mines for recreational purposes. Other Northeast states with more intensive mining histories have had injuries or deaths at abandoned mines. For example, in Pennsylvania, at least 45 deaths and 19 injuries at abandoned mines sites have been reported in the past 30 years (<www.doi.gov/news/040206d>, accessed 7 April 2005).

It is difficult to estimate the likelihood of a land-

owner backfilling a hibernaculum, but if the threat materializes, it may have severe consequences for bat populations. Conservation efforts should be pro-active. By identifying important hibernacula on private lands and initiating a protection program for the mine (for example, bat gating), wildlife management agencies can work to mitigate this threat.

3.2 Sources of Information

Sources of information on threats to cave/mine habitat included peer-reviewed scientific articles, gray literature, expert review by John O. Whitaker of Indiana State University, and information from New Hampshire residents familiar with local mines.

3.3 Extent and Quality of Data

The threats described under element 3.1 and their potential impact on bat populations are well documented, both for caves/mines in general, and for New Hampshire mines. The available data for the severity and likelihood of the threats for the mines located in New Hampshire are moderately well understood, but more data are required to fully realize the impact of each threat.

3.4 Threat Assessment Research

It is important to document the level of human disturbance at mines that serve as hibernacula A potential indicator of the threat could be a system (e.g. infrared monitoring devices) that would document human visitation rates at each non-gated hibernaculum. Such data could be correlated with costs of arousal for hibernating bats (see Element 3.1.1 B) to generate a probability of mortality to hibernating bats (and the corresponding decrease in habitat suitability) resulting from disturbance. This analysis would provide managers with criteria for aiding management decisions, such as whether to construct a bat gate.

It is important to assess the structural stability of each hibernaculum. A potential indicator of stability could be the degree of fissuring at mine entrances and other areas within the mine (Fig. 1). Such data could be used to determine which mines contain structural components (entrance, wall, or ceiling) that may be stressed and eventually collapse. This would provide managers with specific locations within mines that may require support structures.

The probability of a landowner blocking mine access by backfilling should be assessed. It is not recommended that state (or other) agencies inform landowners of the potential for litigation if a person was to be injured in a mine located on their property. Such action is likely outside the purview of state wildlife agencies. Rather, if a mine was to be documented as a high priority site for conservation, such information may be useful in convincing landowners of the utility of installing bat gates at their mines (e.g. excluding humans but allowing bats to utilize the mine).

Element 4: Conservation Actions

4.1.1 Gating, Habitat Protection

(A) Direct Threats
Human disturbance at mines, Landowner backfilling of mines

(B) Justification

1. Installing bat gates at high priority hibernacula will restrict human access to the mine during the winter. Therefore, the immediate threat of human disturbance causing arousals will be eliminated at the gated site. Convincing private landowners to install bat gates at high priority hibernacula will also remove the threat of potential litigation for personal injury, as cavers and spelunkers will be unable to enter the mines.

2. Too few data exist on historical bat populations to know whether gating will have a measurable impact on the number of hibernating bats present at a hibernaculum. Pre-gating surveys during winter at each hibernaculum will provide a current estimate of the number of species and individuals utilizing the mine. Post-gating surveys will allow managers to determine whether the gate has had a positive, negative, or neutral impact on hibernating bat populations. In addition, pre-gating measurements of mine microclimate will help determine whether gate construction significantly alters microclimate.

3. Several hibernacula in New Hampshire are currently experiencing human disturbance during winter. For example, Paddock Copper Mine (containing several hundred hibernating bats) was recently determined to be a popular site for "geocaching" activity. Geocaching involves placing an object at a specific GPS (latitude/longitude) location. The location is posted on the Internet for other individuals to locate. A cache was placed within the Paddock Copper Mine (approximately 70 m into the mine) and it appears that several individuals are entering the mine during winter. Carter Mine and Beebe River Mine also show signs of human activity during the winter.
4. Once a gate is constructed, it may be difficult to adapt the gate if new information arises about the effects of gating on bats. The gate could be removed if the gate was found to be a strong negative influence on the hibernating bats within a particular mine.

(C) Conservation Performance Objective
Construct bat gates that will restrict human access to the mine during winter and remove the threat of personal injury litigation against landowners from unauthorized humans entering at privately owned mine. A measurable performance indicator for this conservation action is periodic monitoring of the gate during the winter to ensure that the gate is not vandalized or opened by humans (this has been observed at the Roxbury Mine in Roxbury, CT, J. Veilleux personal observation).

(D) Performance Monitoring
During the first winter after a gate is installed, visit the mine three times (one visit every 2 months beginning in November and ending in April). If a gate shows signs of tampering, or the mine has been entered, personnel could enter the mine to assess evidence of disturbance (presence of trash, evidence of fire, etc.). Subsequently, the gate could be assessed every 2-3 years for evidence of tampering.

(E) Ecological Response Objective
The habitat protection response objective is to maintain or increase the current number of bats hibernating in each mine that is gated (conservation action). The minimal ecological response should be to maintain the current population size. An increase in population size at a hibernaculum following gate construction may suggest that gating has restored habitat quality (lower disturbance rate).

(F) Response Monitoring
A suggested long-term monitoring protocol for determining whether bat populations are being maintained or enhanced following gate construction is to survey gated mines every three years. This will provide detailed demographic data for each species of bat hibernating in the mine.

(G) Implementation
After high priority hibernacula are identified (see Section 2.5), the state should coordinate gaining landowner permission to construct the gate if the mine is on private land, purchasing gating materials, hiring a contractor (welder) to construct the gate, and delivering gate materials to the mine site. Gates should be constructed at each hibernaculum where bats are at risk.

Preliminary survey work to document current species distribution and abundance at known and potential hibernacula, as well as the documentation of human visitation rates at the hibernacula during winter, should be initiated as soon as possible.

The Office of Surface Mining (under the Bureau of Land Management) offers grant opportunities for the construction of bat gates at abandoned hibernacula. Additional funding opportunities may be available through the Nature Conservancy and other NGOs. Bat Conservation International provides construction specifications for the design of bat gates.

(H) Feasibility
Two bat gates have been constructed in New Hampshire (both at Mascot Lead Mine), and several bat gates have been constructed in other Northeast states (e.g. Connecticut, Vermont, and New York). Therefore, the technical competence to complete the construction of bat gates is available. The overall feasibility of gating hibernacula is limited by the availability of funding for pre-gating hibernacula surveys and gate construction.

4.1.2 Mine Condition Assessment, Habitat Protection

(A) Direct Threats
Shaft/adit collapse due to weathering

(B) Justification

1. One historic hibernaculum (North Woodstock Silver Mine) is known to have experienced at least one adit collapse. Nancy Mine No. 2, a potential hibernaculum, shows evidence of structural compromise at the main entrance.
2. Assessing the structural integrity of mine walls and ceilings will allow managers to determine the mines, and the sections of a particular mine, that are structurally compromised. Managers can then develop strategies for constructing physical support structures for protecting an area, thereby reducing the threat of collapse.
3. Maintaining the structural integrity of hibernacula will preserve the hibernating population of bats within the mine.
4. Once a mine is assessed for structural integrity, periodic assessments (perhaps once per 10 years) for structural integrity, as well as general assessments of integrity during hibernacula surveys, should allow managers to continually gather new information about the integrity of hibernacula.

(C) Conservation Performance Objective
Assessing hibernacula for structural integrity will determine whether sections of a mine are structurally compromised. A method to reinforce structural weaknesses must be developed to ensure structural integrity and long-term habitat protection. There is no definite endpoint of the conservation action, since the threat level can change as a mine system modifies over time. A partial endpoint goal is to assess each known and potential hibernacula and develop a plan for addressing any high priority breach in the mine structure.

(D) Performance Monitoring
Following the initial assessment, surveys to assess changes in structural integrity could be completed every ten years. A general bat survey could be conducted every three years. If a reinforcement action was required and completed, the action should be assessed at least once during the winter following construction, and then during each general assessment as described above.

(E) Ecological Response Objective
The habitat protection response objective is to maintain current number of bats hibernating in the mine by maintaining the structure stability of the mine. Populations would not be expected to decrease or increase due to the implemented conservation action, since the action is only maintaining habitat.

(F) Response Monitoring
A suggested (long-term) monitoring protocol for determining whether bat populations are being maintained is to perform hibernacula survey every three years at affected hibernacula. Such monitoring efforts will provide detailed demographic data for each species of bat hibernating within the mine as they respond to the action.

(G) Implementation
High priority sites for receiving reinforcement will have a combination of presence of rare/listed species, high population numbers, and high threat level to habitat/bats. After high priority sites are identified, the state should coordinate gaining landowner permission to modify the mine structure if the mine is on private land, purchasing reinforcement materials, hiring a contractor to construct the reinforcement structure, and delivering reinforcement materials to the mine site.

(H) Feasibility [Categorical Rank]
The technical competence to assess the structural condition of New Hampshire mines should be available within state agencies (e.g. USGS) and in colleges and universities (geology faculty). The overall feasibility of reinforcing hibernacula is limited by funds to purchase materials and construct the reinforcement structure.

4.2 Conservation Action Research:

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HABITAT PROFILE

Cliffs

Associated Species: American peregrine falcon (Falco peregrinus anatum), Golden Eagle (Aquila chrysaetos)
Global Rank: Not ranked
State Rank: Montane acidic (S5), Montane circumneutral (S2S3), Lowland acidic (S4), Lowland circumneutral (S2), Cliff seep (S3S4), Calcareous
Authors: Alina J. Pyzikiewicz and Steven G. Fuller, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

Cliffs are steep rocky outcrops greater than 65° in slope and 3 m in height. They are more fractured and limited in soil accumulation than other types of rocky outcrops (Sperduto and Nichols 2004). 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 (NatureServe 2004). Although cliffs are generally dry, seeps do occur and may influence vegetation, pH, and nutrients (Sperduto and Nichols 2004).

Vegetation of acidic cliffs commonly includes three-toothed cinquefoil (*Potentilla tridentata*), fragile fern (*Cystopteris fragilis*), mountain cranberry, (*Vaccinium vitis-idaea*), sheep laurel (*Kalmia angustifolia*), and stunted trees such as red oak (*Quercus rubra*) and paper birch (*Betula papyrifera* var. *papyrifera*) (Sperduto and Nichols 2004). Circumneutral cliffs—which are rare in New Hampshire—are often vegetated with the state endangered smooth woodsia (*Woodsia glabella*) and creeping juniper (*Juniperus horizontalis*), state threatened fragrant fern (*Dryopteris fragrans*), and rare bryophytes such as *Distichium capillaceum, Gymnostemum aeruginosum*, and *Tortella tortuosa* (Sperduto and Nichols 2004). Calcareous cliffs are even more rare than circumneutral cliffs and support species such as bulblet bladder fern (*Cystopteris bulbifera*), zig-zag goldenrod (*Solidago flexicaulis*), and small trees and shrubs, such as eastern red cedar (*Juniperus virginiana*) and downy arrow-wood (*Viburnum rafinesquianum*) (Edinger et al. 2002).

1.2 Justification

Cliffs are primary nesting sites for the state endangered 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 and Yamasaki 2001). 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. Cliffs will also likely be targeted for wind energy development.

1.3 Protection and Regulatory Status

There are no laws explicitly protecting cliffs in New Hampshire. 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.

1.4 Population and Habitat Distribution

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). Lowland acidic and lowland 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 2004). Seeps can occur in any of these cliff types.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

The 10-m Digital Elevation model provided by the Society for the Protection of New Hampshire Forests was analyzed to identify areas greater than 65% slope and was combined with the cliff landforms identified by The Nature Conservancy's (TNC) Ecological Landunit datalayer and the New Hampshire Natural Heritage Bureau's (NHB) exemplary cliff communities. A 200-m buffer was placed around these cliff polygons since research indicates the area within 200 m of a peregrine falcon nest (the primary species using cliff habitats) is the zone of predator defense (Cade 1960, White et al. 2002).

1.7 Sources of Information

Guides to the natural communities of New Hampshire and the NatureServe database were used as sources regarding habitat and distribution of cliffs. Field guides were used to identify species that utilize cliffs. The WMNF management plan was used to gather information regarding climbing rules and regulations. The NHNHB (is this right?) Element Occurrence Database (2004) listed endangered, threatened, or rare animal species associated with cliffs, including known breeding sites of peregrine falcons. In addition, a peregrine falcon assessment produced by the Audubon Society of New Hampshire (ASNH) was used to identify potential breeding sites. Rock climbing guides were used to locate recreational cliffs and assess use levels.

1.8 Extent and Quality of Data

NHB??? field surveys are the only known source of field data for cliff communities. The relative inaccessibility and remoteness of cliff habitats has prevented biologists from fully documenting cliff communities (Farris 1995). Predicted cliff polygons need field verification; however, aerial photographic interpretation may be a viable alternative.

1.9 Distribution Research

Research is needed to relate the patterns of plant and animal diversity to the chemical and physical attributes 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.

Element 2: Species/Habitat Condition

2.1 Scale

Habitat planning units were delineated primarily by mountain ridges, roads, and proximity to other cliffs, which resulted in 51 distinct units.

2.2 Relative Health of Populations

According to New Hampshire Fish and Game (NHFG), the Crawford Notch (828 ac), Carter-Wildcat (551 ac), Presidential (524 ac), Franconia-Whaleback (512 ac), and Carrigain (467 ac) units contain the greatest amounts of cliff habitat. Patterns of decline or loss are unknown.

2.3 Population Management Status

N/A

2.4 Relative Quality of Habitat Patches

Of the 316 cliffs mapped by NHFG, 68 (26% of total cliff areal extent) contain known climbing routes. Of 74 (27% of total cliff areal extent) current or historic peregrine falcon nesting sites, 46 (84% of occupied areal extent) contain known climbing routes. Thirty-three percent of the total areal extent of cliffs has potential for commercial wind turbine development, and 35% has potential for small turbines.

2.5 Habitat Patch Protection Status

Of the mapped cliff polygons, 66% are federally owned (USFS, WMNF), 23% are state owned (DRED), 1% are owned by private organizations, and less than 1% are town or county owned. Nine percent are protected.

2.6 Habitat Management Status

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 fewer 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 PEFA-related display on the Kancamaugus 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."

2.7 Sources of Information

Information on management and regulations was obtained from the WMNF Protection Plan. GIS datalayers were used to identify key habitat areas and determine the quality of habitat patches.

2.8 Extent and Quality of Data

Peregrine falcon breeding and nesting is well documented by the ASNH peregrine falcon monitoring program, but is lacking for other bird species. Little is known about habitat use by other taxa, especially invertebrates.

2.9 Condition Assessment Research

- Establish baseline data regarding habitat quality
- Identify indicator species of high quality habitat, and survey for the existence of these species in potential habitat
- Determine the climbability of different cliffs, the impact of climbing at critical habitat areas, and the presence and location of rare species on cliffs used for recreational activity
- Assess the intensity of recreational use including infrastructure on cliff tops

Element 3: Species and Habitat Threat Assessment

3.1.1 Recreation

(A) Exposure Pathway
Cliffs, especially in the White Mountains, are often heavily used for hiking and rock climbing. Rare plants, soil, and sensitive communities may be trampled or removed to create new routes, or displaced by non-native species. Climbers and sight-seeing tours that repeatedly get too close to nesting birds can frighten birds off nesting sites, potentially causing nest abandonment.

(B) Evidence
New Hampshire has a long climbing history, dating back to 1910 (Webster 1996). In a 1969 rock climbing guidebook, 18 climbing routes were described for Cathedral Ledge, an area where peregrine falcons have nested for the past 10 years (ASNH unpublished data). By 1996, 222 new routes were established (Webster 1996). Statewide, New Hampshire has 106 cliffs with over 2,000 established climbing routes (Webster 1996, Smith 2001, Sykes 2001).

A common result of increased climbing activity is the establishment of informal trails (Pyke 2001). Climbers hiking to climbing routes and assembling at cliff plateaus cause minimal damage to vegetation (McMillan and Larson 2002), although seed viability and productivity may be reduced (Maschinski et al. 1997). On the face of the Niagara Escarpment in Canada, the density and composition of vascular plants, bryophytes, and lichens were lower in climbed areas than in unclimbed areas (McMillan and Larson 2002). The removal of vegetation to create new climbing routes can cause wind and rain to wash away soil, slowing the establishment of new plants (Camp and Knight 1998). Rock climbing can introduce non-native species through seeds transported on climbing equipment, shoes, and clothing (McMillian and Larson 2002).

The presence of low flying aircraft can frighten cliff-nesting birds from their nests, inadvertently knocking eggs or chicks from the nest (White et al. 2002). Nest disturbance can expose eggs and chicks to unfavorable environmental conditions that may result in mortality, or complete nest abandonment (White et al. 2002).

3.1.2 Energy and Communication Infrastructure

(A) Exposure Pathway
Construction of cell towers or wind turbines could directly impact the cliff top and indirectly affect the cliff face via increased erosion. There is an increased risk of migratory bird mortality in areas with towers and turbines (Kerlinger 2000).

(B) Evidence
There were 60 known towers sited in New Hampshire as of 1998 (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 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).

3.2 Sources of Information

Expert review and consultation provided input on identifying and ranking threats. Rock climbing guides provided information on recreational cliffs. Peer-reviewed journal articles provided evidence for threats.

3.3 Extent and Quality of Data

Extensive information is available regarding rock climbing and its impacts on cliff vegetation. Little is known about rock climbing impacts on animal species other than peregrine falcons. There is no documentation on avian mortality or habitat degradation resulting from wind turbine or telecommunications tower collisions/construction in New Hampshire.

3.4 Threat Assessment Research

Plant harvest, climate change, forestry operations, acid deposition, development, succession/revegetation, and mining operations were identified as low ranking threats to cliff habitat. More research is needed to determine whether these could become more significant in the future.

Element 4: Conservation Actions

4.1.1 Cultivate Recreational User Stewardship, Education and Outreach

(see also Strategies, Education and Outreach)

(A) Human disturbance

(B) Justification
Existing education and outreach programs have engaged recreational enthusiasts, especially rock-climbers, to support conservation and management designed to protect cliffs from recreational impacts. Stewardship activities will target high-use areas and specific audiences. Adverse human-wildlife interactions are expected to increase as the human population and recreational use of cliffs increases. Thus, stewardship programs need to be cultivated immediately. Stewardship programs can be modified to target new areas, audiences, and user groups.

(C) Conservation Performance Objectives
Eliminate the co-occurrence of adverse recreational impacts in delineated S1-ranked natural communities and rare cliff habitats.

(D) Performance Monitoring
Performance will be evaluated based on implementation of management and stewardship agreements and subsequent decreases in recreational impacts. Stewardship agreements will include recommendations for monitoring.

(E) Ecological Response Objective
Restore S1-ranked natural communities and rare wildlife to delineated cliff habitat areas. Increased native vegetation and wildlife use will indicate a beneficial response.

(F) Response Monitoring
Monitor cliffs for changes in vegetation and wildlife. Stewardship agreements will include recommendations for monitoring.

(G) Implementation
NHFG will delineate high-risk cliffs and cultivate user stewardship or support existing approaches. ASNH has successfully implemented stewardship programs. NHFG will review existing agreements with other agencies and planning entities, including WMNF, USFWS, DRED, SCORP, and ATC, and modify them or provide input to support stewardship. Recommended activities include the following:

- Install signs regarding cliff ecology along access routes and in New Hampshire and Massachusetts climbing shops
- Produce and distribute educational and outreach materials to delineated areas and target audiences
- Recruit stewards and volunteer outreach personnel
- Contribute material to guidebooks
- Develop and train volunteer group to assist with habitat mapping
- Develop a website on climbing and cliffs that is linked to existing rock-climbing websites

(H) Feasibility
Given that implementation will build on current ASNH methods and existing agreements, it is reasonable to expect these objectives can be accomplished.

4.1.2 Advise Land Managers on Mitigation of Recreational Impacts, Regulation and Policy

(see also Strategies, Inter-Agency Regulation and Policy)

(A) Human disturbance

(B) Justification
Restricting use, placement, and width of trails, rock-climbing routes, or other modes of access to sensitive areas will reduce disturbance. Cliff species benefit from efforts to restrict access to sensitive areas. Advisories will be designated for sensitive areas immediately upon entry into management agreements and may be modified based on habitat response indicators.

(C) Conservation Performance Objective
Eliminate recreational impacts on rare cliffs and wildlife. Performance will be assessed based on management agreements, modification of recreational management practices, and adoption of trail advisories.

(D) Performance Monitoring
Advisories will include reporting protocols to docu-

ment the modification of recreational management practices.

(E) Ecological Response Objective
Restore rare natural communities and cliff species to delineated areas. Advisories will include restoration and monitoring recommendations.

(F) Response Monitoring
Vegetative cover, soils, and presence of rare species will be measured prior to the implementation of advisories and in subsequent years. Responses will be used to revise advisories.

(G) Implementation
NHFG will delineate sensitive areas and provide advisories to all managing agencies and organizations to mitigate recreational impacts on cliffs and associated wildlife. Recreational users will be engaged to develop or provide input on advisories. NHFG will participate in the ATC Cooperative Management System. NHFG will help develop, review, and approve the Appalachian Trail Local Management Plan (see Alpine habitat profile for detail). NHFG will review existing agreements with other agencies and planning entities, including WMNF, USFWS, DRED, SCORP, and ATC, and modify them or provide input in accordance with the health of wildlife and wildlife habitats. In particular, NHFG will review or revise its 996 MOU with USFWS and the USFS, and the 1993 MOU with DRED.

(H) Feasibility
Given that implementation will build on current methods and existing agreements (see above), it is reasonable to expect these objectives can be accomplished. Limiting factors may include personnel to enforce climbing regulations and resistance of user groups to new regulations.

4.1.3 Engage in Inter-Agency Risk Assessment for Recreation and Wind Energy Development, Regulation and Policy

(see Strategies, Inter-Agency Regulation and Policy)

4.1.4 Identify High Risk Areas for Recreation and Wind Energy Development, Conservation Planning

(see Strategies, Conservation Planning)

4.1.5 Restrict Access to High Risk Areas, Regulation and Policy

(see Strategies, Inter-Agency Regulation and Policy)

4.1.7 Advise Wind Energy Developers on Best Management Practices for Construction, Regulation and Policy

(see Strategies, Inter-Agency Regulation and Policy)

4.1.8 Prioritize Cliffs for Protection, Land Protection

(see Strategies, Conservation Planning)

4.1.9 Protect Unfragmented Blocks, Land Protection

(see Strategies, Land Protection)

4.2 Conservation Action Research

Develop methods to monitor the response of cliff wildlife and natural communities to recreational pressures.

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HABITAT PROFILE

Coastal Islands

Associated Species: roseate tern (Sterna dougallii dougallii), common tern (Sterna hirundo), Arctic tern (Sterna paradisaea), black guillemot (Cepphus grylle), purple sandpiper (Calidris maritima)
Global Rank: Not Ranked
State Rank: Not Ranked
Author: Alina J. Pyzikiewicz, Steven G. Fuller, Diane L. De Luca, and John J. Kanter, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

Off the New Hampshire coast, islands are exposed to and battered by the maritime environment. Natural disturbances such as severe storms affect the rocky intertidal zones by causing mechanical weathering, disrupting succession, and influencing local levels of species diversity (Sousa 1979). Coastal islands have rocky shores, are usually remote, undisturbed, and free of predators (Percy 1997). Coastal islands are vegetated by grasses, herbaceous plants, and shrub thickets that grow among rocky outcrops, and have few to no trees (Nichols 2004). Historical accounts of the Isles of Shoals describe the islands as rocky and barren, and overgrown by grasses, herbaceous plants, and dense shrubs (Borror and Holmes 1990). The rocky intertidal areas are dominated by blue-green algae, lichens (Nichols 2004), and various mollusks and gastropods. The vegetation on mainland islands closely reflects the upland and wetland communities that are typical of the mainland near that island (B. Nichols, NHNHB, personal communication.).

1.2 Justification

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). The Isles of Shoals group serves as a major premigratory staging area and migratory stopover for many Neotropical birds and provides wintering habitat for land birds (Borror and Holmes 1990). Numerous species of invertebrates (amphipod crustaceans, periwinkles, barnacles, mussels) and rockweeds reside in the rocky intertidal areas.

Several of these islands were home to large breeding colonies of terns (*Sterna* sp.), but a loss of habitat and an increase in numbers of herring gull (*Larus argentatus*) and great black-backed gulls (*Larus marinus*) preying on and displacing the terns resulted in their decline (USFWS 1998). Since 1997, Seavey Island has been the site of an intense tern restoration project. Efforts to restore breeding colonies of the federally endangered roseate tern (*Sterna dougallii dougallii*), state endangered common tern (*Sterna hirundo*), and state threatened Arctic tern (*Sterna paradisaea*) have been successful through gull control measures before and during the tern breeding seasons (NHFG 2004). Islands increase the productivity of waters by agitating currents, sediments, and nutrients, and increase the amount of shoreline available for use by plant and animal species (Percy 1997).

1.3 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. Islands located in Great Bay National Wildlife Refuge are

protected under the National Wildlife Refuge System, along with the Great Bay National Estuarine Research Reserve (Short 1992). Various laws and agreements exist that protect marine waters such as the Clean Water Act, the MARPOL Act, the Rivers and Harbors Act, Marine Mammal Protection Act, and the Marine Protection, Research, and Sanctuaries Act (Boesch et al. 2001).

1.4 Population and Habitat Distribution

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 in Great Bay National Wildlife Refuge.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

GRANIT was accessed to identify coastal islands. Very small islands were grouped to their nearest adjacent neighboring island. In total, 96 polygons were grouped into 48 islands,

1.7 Sources of Information

Information on habitat and distribution of coastal islands in New Hampshire was taken from the New Hampshire natural communities guide, scientific literature, conservation plans, field guides, databases, and technical reports.

1.8 Extent and Quality of Data

There is no defined coastal island natural community type in New Hampshire. However, the presence of Shoals Marine Lab has led to extensive research on the Isles of Shoals. Changes in bird species composition and abundance have periodically been documented (Borror and Holmes 1990). Other smaller islands have been surveyed irregularly to determine presence of nesting common terns. An ongoing island ownership debate between New Hampshire and Maine has added to the uncertainty of the number of coastal islands that are under New Hampshire jurisdiction.

1.9 Distribution Research

A formal assessment and classification of New Hampshire coastal island natural communities and intertidal communities is needed.

Element 2: Species/Habitat Condition

2.1 Scale

The 48 islands were clustered into 15 conservation units based on geographic location.

2.2 Relative Health of Populations

The Isles of Shoals have been identified as key habitats for nesting and migrating birds. The islands also serve as haul-outs for harbor and other seal species. Historical habitats for nesting colonial birds include unnamed islands of Back Channel/New Castle, Colony Cove and Hen Island in Little Bay, and Footman and Nannie islands in Great Bay (New Hampshire Audubon Society unpublished data). Little is known about the health of other islands due to their remoteness or small size.

2.3 Population Management Status

N/A

2.4 Relative Quality of Habitat Patches

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.

2.5 Habitat Patch Protection Status

- The Isles of Shoals have varying degrees of protection. White and Seavey Islands have been under the ownership of the DRED Parks Division as part of Odiorne State Park since 1993 (Appledore Engineering 1999). Seavey Island was deeded to the State of New Hampshire after the White Island Lighthouse was automated in 1987. A Memorandum of Agreement between DRED Parks Division and NHFG exists relative to tern restoration. Seavey Island is managed by NHFG as an endangered species nesting area and is afforded both state and federal protection under endangered species law.
- The Star Island Corporation privately owns Appledore and Star Island, and both are open to the public through various touring companies.
- The Coastal Islands National Wildlife Refuge purchased Duck Island in July 2003. This island will be managed for its wildlife resources, protected as a seabird colony, posted for closure during the breeding season, and evaluated for habitat management and restoration (B. Benedict, USFWS, personal communication).
- Lunging, Malaga, and Cedar Islands are privately owned. There is no protection status at these islands beyond current shoreline and wetland regulations.
- Smuttynose Island is privately owned but was protected in August of 2001 by a conservation easement held by the Coastal Islands National Wildlife Refuge. This conservation easement allows the refuge to manage the site for wildlife resources (B. Benedict, USFWS, personal communication).
- Hen Island is owned by the Town of Newington. Since the early 1990s, the town has worked with NHFG and ASNH to post signs to close the island during the breeding season. The area is used only by town residents, and they have acted as stewards for this colony. The proximity of the island to the mainland leaves the terns vulnerable to predation and the Hen Island tern colony has been disrupted by rats, Canada geese, great horned owl, and human disturbance.
- Islands in Great Bay National Wildlife Refuge have protection under the National Wildlife Refuge System and the Great Bay National Estuarine Research Reserve.
- The protection status of islands in Portsmouth Harbor and Piscataqua Rivers is unknown.

2.6 Habitat Management Status

A management program for Great Bay has been established by the Great Bay National Estuarine Research Reserve, the National Oceanic and Atmospheric Administration, and the Marine Division of the New Hampshire Fish and Game Department, whose goal is to preserve the estuarine resources for research and education. There is no organization for management of Little Bay or Piscataqua River. An MOA between the DRED and NHFG exists relative to tern restoration on White and Seavey Islands. The Marine Fisheries Division of NHFG has authority over management activities of coastal natural resources. Various governmental and nongovernmental programs collaborate (e.g., Gulf of Maine Council on the Marine Environment and Gulf of Maine Seabird Working Group) work to protect and restore coastal island habitats.

2.7 Sources of Information

Habitat maps were examined to identify key habitats. Information on protection and management status was found in management and conservation plans.

2.8 Extent and Quality of Data

Numerous studies have been conducted and published on the flora and fauna of the Isle of Shoals and the surrounding marine environment. Currently, the University of New Hampshire Jackson Estuarine Laboratory conducts long term monitoring of the health of the Great Bay estuary and Portsmouth Harbor. Due to their remoteness or small size, little is known about the relative condition of mainland coastal island habitat.

2.9 Condition Assessment Research

A formal assessment and classification of New Hampshire coastal island natural communities and intertidal communities is needed. Mainland island vegetation and wildlife use needs to be assessed to define priority habitats.

Element 3: Species and Habitat Threat Assessment

3.1.1 Non-Point Source Pollution, Mercury

(A) Exposure Pathway
Moderate forms of atmospheric pollution are widespread among coastal environments. Chemicals in the environment from industrial and municipal discharges, atmospheric deposition, and polluted runoff can accumulate in marine sediments at harmful levels and, accumulate in aquatic plants, invertebrates, fish, and mammals (Beckvar 1996). Accumulation of contaminated sediment in prey species may be transferred to higher trophic levels.

Once mercury is converted to methylmercury, it can be consumed by organisms. Methylmercury can then both accumulate and increase in concentration as it moves up the food chain. Seabirds are at risk for high levels of mercury as they feed relatively high on the ocean's food chain (Evers 2005).

(B) Evidence
The two basic routes of exposure are transport of dissolved contaminants through porous tissue and ingestion of contaminated prey or sediment particles. Metals are easily absorbed into the tissue of aquatic organisms and are not easily eliminated. Mercury has the highest potential of being biomagnified and transferred along the intertidal food chain (Blackmore and Wang 2004, Marsden and Rainbow 2004). Marine mammal tissues have some of the highest concentrations of mercury found in all marine organisms (Beckvar 1996).

Mercury Connections, a report that summarizes the findings of mercury patterns in northeastern North America, identified nine areas where mercury concentrations were significantly elevated in fish and wildlife. These locations were identified as "biological hotspots" where high levels of methylmercury pose an ecological risk (Evers 2005). The lower Merrimack River watershed that borders New Hampshire and Massachusetts was identified: Seavey Island is in close proximity to the outflow of this river. Mercury has been shown to have negative effects on individual seabirds, as well as the overall populations, through changes in reproduction, behavior, and physiology that result in lowered productivity and survival.

3.1.2 Recreation

(A) Exposure Pathway
An increase in recreational activities near or on coastal islands can cause nesting species to abandon nests causing eggs or chicks to become vulnerable to predators, or prevent species from returning to suitable nesting sites. Carelessly walking across islands could result in trampling of vegetation or destruction of bird nests. Pets may destroy nests and frighten nesting birds, resulting in nest abandonment.

The lighthouse renovations scheduled to take place on White Island in 2005 – 2006 will bring many more visitors to White and Seavey Islands. Preservation of the White Island Light Station is being supported, in part, by a grant under the Save America's Treasures program which stipulates that visitation to the island be permitted for a minimum number of days each year. The potential exists for an increased number of island visitors after the renovation is complete.

(B) Evidence
Boaters have been seen dumping garbage into the ocean, which eventually washes up onto island shores. Remains of illegal campfires have been found on White Island, Isles of Shoals, adjacent to the tern colony on Seavey Island. Vandalism on Higgins Beach, Maine resulted in a complete least tern (*Sterna antillarum*) colony failure (Kress and Hall 2004). Offshore boating activities (whale watching, fishing, tour boats) can cause species to be flushed from the islands causing them to use up energy (USFWS 1994). Studies that investigated the effects of recreation and trampling on rocky intertidal zones showed that species occupying these areas are under intense pressure and their populations fluctuate based on the intensity of the disturbance (Keough and Quinn 1998, Aleesa et al. 2003).

Beyond the direct impact that taking terns on the wintering grounds has on the survival of this species,

it is harder to correlate human disturbance with common and roseate tern productivity. Impacts from the intermittent disturbance of recreation and tourism are likely to cause some negative impacts to common tern productivity, but are unlikely to result in permanent disruption to nesting. Human disturbance at the inland colonies in New Hampshire has been known to cause abandonment in the past. Both Hen Island and the Hampton salt marsh colonies suffer negative impacts from human intrusion.

3.1.3 Climate Change

(A) Exposure Pathway
The melting of glacial ice and thermal expansion of ocean water is the main pathway for sea level rise (Gulf of Maine Council Habitat Restoration Subcommittee 2004). Low elevation habitats are important for nesting and loafing for seabirds and marine mammals and will be flooded by rising sea levels or overwashed more frequently by storm surges (Gulf of Maine Council Habitat Restoration Subcommittee 2004). These changes affect habitat availability and the timing of nesting and migration (Kushlan et al. 2002).

(B) Evidence
Sea levels are rising along mainland and island shores due to rising temperatures (Kushlan et al. 2002). Air temperatures are expected to rise 1.4 - 5.8 ° C in the twenty-first century (Church et al. 2001). Along much of the United States coast, the sea level is rising 2.5-3.0 mm/yr, and global warming, resulting from an increase in carbon dioxide and other gasses in the atmosphere, could raise the sea level 15 cm by 2050 and 34 cm by 2100, and increase storm frequency (Titus and Narayanan 1995, Titus 1990). According to Titus (1990), barrier islands respond to a rise in sea level by either washing over landward and remaining intact or breaking up and drowning in place.

3.1.4 Oil Spills

(A) Exposure Pathway
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 (New Hampshire Estuaries Program and NHDES 2004).

(B) Evidence
The harmful effect of oil on birds has been well documented, both through contamination from chronic oil pollution and 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, which support close to 50% of the northeastern roseate population, were especially affected by a 2003 spill. Ram Island was the most heavily oiled of the affected islands. According to Carolyn Mostello of the Massachusetts Division of Fisheries and Wildlife there were more than 20 birds 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.

3.1.5 Aquaculture

(A) Exposure Pathway
Marine aquaculture spreads over 26,000 hectares (100 mi^2) of marine waters and accounts for 1/3 of global seafood farming by weight (Goldburg et al. 2001). The production of marine finfish and shellfish has been the fastest growing portion of aquaculture (Goldburg et al. 2001). Aquaculture facilities attract seabirds that take advantage of new food sources. Distressed farmers may result to harassment and legal or illegal killing of these species to protect their stock (Kushlan et al. 2002, Goldburg et al. 2001). Fish can escape and harm wild populations by way of competition, interbreeding, spread diseases and parasites, and cause the displacement or extinction of native populations (Goldburg et al. 2001). Some aquaculture practices use wild fish as feed and can indirectly affect marine environments thousands of miles away (Goldburg et al. 2001). Aquaculture also contributes to nutrient pollution, primarily nitrogen pollution (through uneaten food and waste discharge), which can lead to eutrophication (Boesch et al. 2001, Goldburg et al. 2001).

(B) Evidence
In the southeastern United States, 108,000 waterbirds that feed at aquaculture sites were legally destroyed between 1987 and 1995 and more were probably illegally destroyed, which increases the impact of aquaculture-related mortality (Kushlan et al. 2002, Goldburg et al. 2001). Escapes of native species that are farmed can harm wild populations, especially when genetic differences exist between the farmed and wild populations (Goldburg et al. 2001). In Maine, a storm in 2000 resulted in the escape of 100,000 farmed Atlantic salmon of European origin (Goldburg et al. 2001).

Farmed mollusks, which are grown on the bottoms of bays along the East Coast, are sometimes harvested by dredging that can alter the bottom habitat and reduce biodiversity (Goldburg et al. 2001).
Organic wastes from aquaculture contribute to 80% of nitrogen released into the marine system (Goldburg et al. 2001). One finfish and shellfish aquaculture site in New Hampshire is less than 2 km south of White and Seavey Island. Two oyster aquaculture sites exist near Adams and Durham Points in Little Bay.

3.1.6 Energy and Communication Infrastructure

(A) Exposure Pathway
Three types of impacts to birds that may occur at offshore wind turbine facilities are short term disturbance and displacement during construction, long-term disturbance and displacement resulting from the presence of turbines and other structures, and mortality resulting from collision with moving turbine rotors (Kerlinger and Curry 2002). Waters may be disturbed and sediment released into the water column (Kerlinger and Curry 2002).

(B) Evidence
Few studies exist regarding impacts of offshore wind turbine facilities on birds. In the Netherlands and the United Kingdom, bird fatalities resulting from collision with turbines have been low to moderate (Kerlinger and Curry 2002). Other studies reveal that birds generally avoid sites within 100-200 m of the turbines (Kerlinger and Curry 2002). In some coastal situations, studies have observed water and shorebirds flying around turbines and not foraging beneath them (Kerlinger and Curry 2002). Even though the footprint of the wind turbine structure can take up

a small fraction of the project area, disturbance and displacement of birds has been known to occur (Kerlinger and Curry 2002).

3.2 Sources of Information

Information regarding threats was taken from peer-reviewed scientific studies, field observations, and technical reports from state and federal environmental agencies, and reports from non-governmental environmental organizations. Threats were compiled and ranked internally, and sent out for expert review. Known contamination sources, heliports, staging areas, recreational fishing, marinas, and aquaculture locations were provided by NHDES. Airport locations were provided by NHDOT.

3.3 Extent and Quality of Data

There is a vast amount of data pertaining to predator overpopulation, atmospheric deposition, recreation and tourism, climate change, aquaculture, and oil spills being major threats to marine environments, primarily resulting from scientific research studies and federal environmental agency programs. Little is known about the risks of offshore wind turbines. To date, there are few "best industry practices" for preventing and/or mitigating impacts to birds at wind power facilities (Kerlinger and Curry 2002).

3.4 Threat Assessment Research

- Better linkage of biological response to contaminants with exposure and dose (Luoma 1999) and evaluation of wildlife bioindicators for New Hampshire are priority research topics.
- Intense monitoring and reporting of recreational usage of coastal islands are needed to assess impacts and recreational tour boat effects on coastal island species (Kress and Hall 2004).
- Continue to monitor changes in sea level resulting from changes in air temperature. Study the effects of short and long-term climate change on ocean habitats and species (Kushlan et al. 2002).
- Long-term assessments and biodiversity surveys of coastal islands before and after oil spills to determine effects.
- Develop improvements to aquaculture facilities such as escape-proof pens, non-lethal predator control, and effluent treatment systems (Goldburg et al. 2001).
- Monitor legal/illegal seabird take.
- Studies showing how offshore wind turbines affect birds need to be conducted and should be designed to provide necessary information to assess risk, including flight patterns, frequency of use of the site, and seasonal population sizes (Kerlinger and Curry 2002).

Element 4: Conservation Actions

4.1.1 Advise Interagency Risk Assessment Team on climate change risks to marine wildlife

(see interagency regulation and policy strategy)

(A) Direct threats addressed: Predation and Herbivory, Non-Point Source Pollution (Chemical Contaminants)

(B) Justification
Evidence in the North Sea has shown that the warming of the ocean waters can have a drastic impact on the availability of seabird food resources. In 2004, the majority of the seabird nests along the coast of Scotland produced no chicks. Scientists believe that the shift in phytoplankton to colder waters caused a massive decline in the preferred seabird food. It will be important to collect adequate data in the Gulf of Maine to document changes in water temperature and food availability.

4.1.2 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.

(A) Direct Threats Affected: Oil spills, Habitat Loss, Predation and Herbivory

(B) Justification
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. Through careful planning, the purchase of equipment, and enforcement of safe shipping and operational procedures, 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 appropriate 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 ongoing and year round. Plans should include breeding and non-breeding periods. Purchase 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.

(G) Implementation
Implementation of improved oil spill response to the waters surrounding the Isles of Shoals will require the collaboration and cooperation of Tern Restoration Project personnel from NHFG and ASNH with the Oil Spill Response team to ensure that information on tern nesting and habitat usage is incorporated into the plan. Purchase of the proper equipment to deal with an oil spill near Seavey Island will require dedicated funds. Baseline data collection will need coordination and input from all partners.

4.1.3 Coastal Predator Overpopulation Management Plan, Population Management

(see predation and herbivory strategy)

4.1.4 Protect Lunging Island as seabird nesting habitat by approaching landowners with land protection options including conservation easement, conservation tax abatements and incentives, fee acquisition or voluntary agreements, Habitat Protection

(A) Direct Threats Addressed: Habitat Loss

(B) Justification
Lunging Island provided the most important documented historical habitat for terns in New Hampshire. The future protection of this site is important to prevent any further habitat losses and for the expansion of tern nesting habitat at the Isles of Shoals.

4.1.5 Coordinate with the Coastal Islands Refuge in the protection of Duck and Smuttynose Islands as seabird nesting habitat, Habitat Protection

(A) Direct Threats Addressed: Habitat Loss

(B) Justification
Duck and Smuttynose Islands are both protected under the National Wildlife Refuge System as seabird nesting habitat. It is important to coordinate and support protection at these sites.

4.1.6 Endorse Research on Aquaculture Impacts Effluent guidelines, improved state oversight including wastewater discharges, and introduction of new species. Develop voluntary guidelines.

Element 5: References

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HABITAT PROFILE

Connecticut River Mainstem Watersheds

Associated Species: Alewife (Alosa pseudoharengus), American Eel (Anguilla rostrata), American Shad (Alosa sapidissima), Atlantic Salmon (Salmo salar), Atlantic Sturgeon (Acipenser oxyrhynchus), Blueback Herring (Alosa aestivalis), Brook Trout (Salvelinus fontinalis), Rainbow Smelt (Osmerus mordax), Sea Lamprey (Petromyzon marinus), Slimy Sculpin (Cottus cognatus), Tessellated Darter (Etheostoma olmstedi)
Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Authors: New Hampshire Fish and Game and The Nature Conservancy

Element 1: Distribution and Habitat

1.1 Habitat Description

The unifying feature of the Connecticut River watershed group is the Connecticut River mainstem and its smaller tributaries on both sides of the Vermont-New Hampshire border. Bedrock geology is more calcareous in this watershed group than in any other in New Hampshire. Bedrock geology changes dramatically on the Vermont side, becoming even more enriched. This enriched bedrock extends into New Hampshire towns immediately adjacent to the Connecticut River. Despite the potentially distinct geologic difference between New Hampshire and Vermont, the aquatic species moving throughout the Connecticut River and its immediate tributaries are likely to be similar. Large-scale threats and land-use patterns are similar throughout the Connecticut River corridor.

Watersheds in this group have moderate elevations and moderate or gentle hill and side slopes. Every watershed in this group borders or encompasses the mainstem of the Connecticut River, and so there are also low floodplain terraces and wet flat landforms.

The Connecticut River mainstem, tributaries, and small headwater streams provide a wide range of aquatic habitats for both warm and coldwater species. Small coldwater streams that only support brook trout can occur in close proximity to larger, warmer streams. Rivers in this watershed group can have diverse habitats with moderate and slow moving sections and a variety of substrates and vegetation.

Connecticut River fine scale systems: 1, 2
Elevation is the dominant characteristic that splits the Connecticut River watershed group into two distinct systems. Fine scale system 1 is a more northerly, upstream collection of watersheds. It is higher in elevation with slightly more side slope and hilltop landforms. The Connecticut River mainstem meanders through large adjacent floodplains in this region. Fine scale system 2 has slightly more calcareous bedrock, more than any other watershed type in the state, which is mixed with acidic bedrock. In this area, the Connecticut River mainstem is more confined, flowing through deep coarse sediment rather than the deep fine sediment of wetlands and floodplains in fine scale system 1.

1.2 Justification

Like the Merrimack River, the Connecticut River represents one of the few large river habitats in the state or in the region that has the potential to support the full suite of diadromous fish species, such as Atlantic salmon (*Salmo salar*), American eel (*Anguilla rostrata*), river herring (*Alosa pseudoharengus* and *Alosa aestivalis*), American shad (*Alosa sapidissima*), and sea lamprey (*Petromyzon marinus*). Large rivers provide critical and unique habitats for wide-ranging species, and they require representation across wide geographies.

The Connecticut River watershed is the focus of rare species restoration and monitoring. For example, it is one of the few rivers in the world that still supports healthy and reproducing populations of the dwarf wedgemussel (*Alasmidonta heterodon*), a federally endangered species, and the cobblestone tiger beetle (*Cicindela marginipennis*), a state endangered species. The Ashuelot River, a tributary of the Connecticut River, also supports the dwarf wedgemmussel. The Connecticut River has been the subject of rare diadromous fish restoration, focusing on Atlantic salmon.

1.4 Habitat Distribution

Except the Lower Ashuelot River, watersheds in this group include substantial portions of the Connecticut River mainstem. The Ashuelot River watershed extends up through Keene, sharing landform, geology and elevation characteristics. The northernmost extent of this watershed group (approximately in Northumberland) occurs where the Connecticut River becomes less like the mainstem of a large river and more like the headwater tributary to a large river.

1.8 Extent and quality of data

The strongest parameter defining this watershed group is the enriched calcareous geology along the Connecticut River mainstem. The moderate elevation and the combination of landforms were similar to other moderate elevation watershed groups. The watersheds in the southwestern corner of New Hampshire were particularly difficult to assign to a specific watershed group, given their similarity with watersheds in other parts of New Hampshire. Despite these uncertainties, the Connecticut River mainstem unifies this collection of watersheds. The connected geography, the need to consider the Connecticut River mainstem as one system, and the similar human uses and threats all support the definition of this watershed group.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the large land area covered by the major watershed groups (Figure 3), a fine scale classification (Figure 4) was used, when possible, to assess the relative condition of aquatic habitats across the state. The types and sources of information were extremely variable and covered many different scales, and so the following sections refer to both the major and fine scale systems. The actual scale at which the natural conditions and processes lead to differences in aquatic communities is uncertain.

The large river ecosystem of this watershed group is divided into two fine scale systems (Figure 4). Fine scale system 1 includes 5 watersheds of the Connecticut River in central western New Hampshire (from Northumberland to Lebanon). Fine scale system 2 includes 6 watersheds of the Connecticut River in southwestern New Hampshire (from Lebanon to the New Hampshire/Massachusetts border). All watersheds in the Connecticut River watersheds group have similar connectivity and large river ecosystem characteristics.

2.4 Relative Quality of Habitat Patches

Fine scale system 1 encompasses 1078 km^2 (266,308 acres) in New Hampshire. Headwater streams (watershed area <48.28 km^2) are the most dominant stream/river type in this system, comprising 75% of the total stream area. Large rivers (watershed area >2589.99 km^2) comprise 24% and small rivers (watershed area of 77.70-518.00 km^2) comprise 1%. The most dominant elevations are moderate (243.84-518.16 m) and low (6.10-243.84 m) elevations, at 68.2% and 23.2%, respectively.

The Connecticut River Rapids Macrosite is recognized for high concentrations of ecologically significant habitats and rare, threatened, and endangered species at both federal and global levels (Francis and Mulligan 1997). It extends from the confluence of the Connecticut and Ompompanoosuc Rivers (across from Hanover) to Claremont. A section of the macrosite falls within fine scale system 1. The greatest percentages of rare, threatened, and endangered species occur in the Hanover-Lebanon area. Dwarf wedgemussels occur within the macrosite. The area is used by migratory shorebirds, provides summer habitat for bald eagles, and supports Jesup's milk vetch (*Astragalus robbinsii* var. *jesupii)* in its floodplains (Francis and Mulligan 1997).

Fine scale system 2 encompasses 1097 km^2 (271,020 acres). Headwater streams are the most

dominant stream/river type in this system, comprising 86% of the total stream area. Large rivers, medium rivers (watershed area of 518.00-2,589.99 km^2), and small rivers comprise 7%, 4%, and 2%, respectively. Moderate and low elevations dominate the area, at 51.6% and 46.8% of the watershed.

Within fine scale system 2, the Connecticut River offers a mosaic of habitat types for aquatic species. Numerous rapids and riffles provide suitable coldwater fish habitat. The Connecticut River Rapids Macrosite continues from fine scale system 1 downstream to Claremont. Deeper and slower water further downstream provides habitat to warmwater fish species. Confluences of feeder tributaries and the Connecticut River mainstem are important aquatic habitats that provide thermal refuges (Francis and Mulligan 1997).

Areas around the Vernon Dam impoundment and Ashuelot River confluence in Hinsdale provide necessary nesting and wintering habitat for waterfowl, ospreys, and eagles (Francis and Mulligan 1997, Zankel 2004). The Ashuelot River watershed provides suitable habitat for great blue heron (*Ardea herodias*) colonies and rookeries, containing 7.5% of the statewide population. Common loons (*Gavia immer*), blue-gray gnatcatchers (*Polioptila caerulea*), and common nighthawks (*Chordeiles minor*) have been observed nesting and feeding along the Ashuelot River (NHDES 1993).

Throughout the lower and middle sections of the Connecticut River watershed group, lakes and ponds with surface areas less than 4.05 hectares (10 acres) are the most abundant (96% of the total number of lakes and ponds). There are relatively few larger lakes and ponds. For lakes and ponds greater than 4.05 hectares, there is an average density of 1.25 lakes/ponds per 100 km^2 of land. Moore Reservoir (3,490 acres) is the only lake greater than 405 hectares (1,000 acres). Fifty-three percent of lakes and ponds are at elevations of 6.10-243.84 m (20-800 ft) and 46% are at elevations of 243.84-518.16 m (800-1,700 ft).

2.2 Relative Health of Populations

Land Use

Bank erosion from water level fluctuations, boat wakes, and upstream bank stabilization projects have been identified as significant problems, especially in Haverhill. Bank erosion is projected to increase from rising trends in recreation and development (Francis and Mulligan 1997). A survey of 1,300 landowners along the Connecticut River indicates bank erosion as the primary landowner concern (NHDES 1999).

In fine scale system 1, most land within 0.40 km (0.25 mi) of the Connecticut River consists of sparsely settled farms and forests, with 8.4% of total land area classified as agricultural (Francis and Mulligan 1997). There is less fragmentation compared to downstream areas of the Connecticut River. Total land area consists of 79% unfragmented land and 2.9% developed land. The highest densities of development (residential, commercial, and industrial) occur in the Lebanon and Hanover areas (Francis and Mulligan 1997). The estimated population for 2005 is 25,869 people (15 people/km^2). The density of roads (expressed as km of road/ km^2 of total land area) maintained by the New Hampshire Department of Transportation (NHDOT) is 0.66 km/km^2 and the density of private/gravel roads is 0.42 km/km^2.

The northern areas of the Connecticut River in fine scale system 2 are predominately rural and undeveloped. Fine scale system 2 has the highest density of agricultural land in New Hampshire at 8.5% of total land area. Total land area consists of 74% unfragmented land and 4.3% developed land. The estimated population for 2005 is 37,696 people (20 people/km^2). The density of roads maintained by NHDOT is 0.79km/km^2 and the density of private/gravel roads is 0.66km/km^2.

Housing increases for census blocks adjacent to lakes and ponds in the Connecticut River watershed group were estimated using 1990 values and projected 2020 values (see Lake Type Classification for methods). Changes between rural (<0.063 housing units/ha), exurban (0.063 to 0.25 units/ha), and suburban (0.25 to 2.5 units/ha) housing densities could indicate increases in shoreline development, impervious surfaces, and non-point source pollution. Census blocks are expected to change from exurban to suburban around 38 lakes and from rural to exurban around 120 lakes.

Water Quality

Water quality in the Connecticut River watershed has gradually improved over the past few decades. Algal blooms, sedimentation, erosion, and bacterial, point,

and non-point source pollution still occur (Francis and Mulligan 1997). In 1986 and 1987, chromium and PCBs were found in fish tissue in the Connecticut River.

The Connecticut River Management Plan expressed the need for more long-term water quality monitoring data. A 1995 NHDES survey of Moore Reservoir indicates an improvement in water quality. The reservoir was classified as eutrophic by NHDES in 1979 and reclassified as oligotrophic in 1995 (NHDES 1995).

In 2004, levels of dissolved oxygen, pH, specific conductance, temperature, and bacteria were adequate to support aquatic habitats at 24 of 29 sampling stations in the middle and lower Connecticut River. In five sampling stations, there were low pH levels, invasive species (Eurasian milfoil (*Myriophyllum spicatum*)), or high concentrations of metals (aluminum and copper), which render these areas not fully supportive as aquatic habitat (Connecticut River Joint Commission 2004).

A wastewater treatment facility in Lebanon has a combined sewer outflow (CSO) that can be overwhelmed during heavy storms. Two treatment facilities in Vermont (St. Johnsbury and Springfield) have CSOs that may deposit untreated waste into tributaries of the Connecticut River mainstem during storms (Francis and Mulligan 1997).

Surface water quality monitoring of the Ashuelot River was conducted in 2003 as part of the NHDES Volunteer Rivers Assessment Program (VRAP). Dissolved oxygen and turbidity levels met state requirements for class B waters at all sample sites. Increased turbidity levels were observed near urban areas. The range of pH values (pH 5.47-7.36) was below state water quality standards for class B waters (pH 6.50-8.0). Natural environmental conditions (e.g., soils, geology, and wetland drainage) and acid deposition can lower pH values. In some locations, total phosphorus exceeded the NHDES total phosphorus level of concern (>0.05 mg/L). Phosphorus values increased near urban locations (NHDES 2003).

The number of National Pollution Discharge Elimination System (NPDES) permits regulated by NHDES per river kilometer is 0.029 permits/river km for fine scale system 1 and 0.014 permits/river km for fine scale system 2. The number of NPDES permits in fine scale system 1 is relatively high when compared to other systems in New Hampshire.

Invasive Species

There is a high potential for the spread of introduced invasive species in the Connecticut River watershed. The high recreation rate, suitable water chemistry, and close proximity to infected waterbodies (e.g., zebra mussels (*Dreissena polymorpha*) in Lake Champlain) could lead to exotic species infestations (Francis and Mulligan 1997). There are no documented occurrences of exotic aquatic plants in fine scale system 1 (Smagula 2004). In fine scale system 2, there have been 3 infestations of exotic aquatic plants. Eurasian milfoil was detected in the Connecticut River (Charlestown) in 1995. Variable milfoil (*Myriophyllum heterophyllum*) was found in Forest Lake (Winchester) in 1998 and the Ashuelot River (Winchester) in 2000 (Smagula 2004).

Several non-native fish populations have become naturalized in the Connecticut River. Increased water temperatures and enhanced habitat from large impoundments facilitate proliferation of these species. Several of these fish provide sport-fishing opportunities. Largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), walleye (*Stizostedion vitreum vitreum*), black crappie (*Pomoxis nigromaculatus*), northern pike (*Esox lucius*), rock bass (*Ambloplites rupestris*), and rainbow trout (*Oncorhynchus mykiss*) are examples of species that have naturalized populations (Francis and Mulligan 1997, Estuarine and Freshwater Working Group 2005).

To assess the likelihood of recreation or stocking contributing to invasive fish and aquatic plant introductions, the degree of remoteness of lakes and ponds was analyzed using GIS. The results indicate that 92% of lakes and ponds are within 500 m of a trail or road, 5% are enclosed by a protective buffer of 500-805 m without a mapped road or trail, and 3% are enclosed by a protective buffer of 805-1609 m without a mapped road or trail. No lakes or ponds have a buffer greater than 1609 m (1 mile).

Hydrology

There are approximately 111 active dams/impoundments in fine scale system 1 and 214 in fine scale system 2, which vary from large river impoundments for hydroelectricity production to small earthen dams that create wildlife ponds.

There are 0.034 impoundments/river km in fine

scale system 1 and 0.044 impoundments/river km in fine scale system 2. Fifty-three percent of the Connecticut River mainstem in New Hampshire and Vermont is impounded by 14 dams (Francis and Mulligan 1997). Targeted research on the ecological implications of flood control and hydroelectric dams along the Connecticut River mainstem and tributaries showed that altered flow rates affect the characteristics of river bottoms and adjacent floodplains. Impoundments resulted in habitat fragmentation and affected natural aquatic communities (NHDES 1999).

Moore Reservoir in Littleton is New Hampshire's largest undeveloped lake and New England's largest hydroelectric facility. New England Power Company owns the 49.6 km shoreline of this 1,412.35 ha reservoir (NHDES 1995, Francis and Mulligan 1997). Seasonal water level drawdowns of Moore Reservoir and Comerford Reservoir in Monroe vary from 9.14-12.19 m (30-40 ft) (Francis and Mulligan 1997). In both 1979 and 1995, NHDES noted the absence of rooted plants in Moore Reservoir due to water levels fluctuations (NHDES 1995).

2.3 Population Management Status

N/A

2.5 Habitat Patch Protection Status

Conserved land in fine scale system 1 comprises 17.8% of the total land area. Twenty-one percent of unfragmented land is protected through conservation. In fine scale system 2, 13% of the total land area and 16% percent of the unfragmented land is protected through conservation.

The Ashuelot and Connecticut Rivers are designated in the New Hampshire River Management and Protection Program (RMPP)(NHDES 2004). The RMPP regulates dam construction, instream water flow levels, channel modification, water quality, solid waste and hazardous waste storage/treatment facilities, and motorized boating traffic.

2.6 Habitat Management Status

It is difficult to assess the efforts to restore and manage habitats at such a broad level. A database of conservation groups may enhance cooperative efforts and eliminate repetitive or redundant projects.

There are conservation and management plans for the Ammonoosuc, Ashuelot, and Connecticut River watersheds. These plans identify ecologically significant areas and guide human use and management of these areas (Francis and Mulligan 1997, Ammonoosuc Conservation Trust 2004, Zankel 2004). Public outreach and education are identified as useful tools for conserving and restoring these watersheds. These plans provide highly detailed information at localized levels and should be used to help identify sensitive areas, local impacts, and management actions. The Connecticut River Management Plan (1997) is currently under revision.

Several agencies are actively involved in habitat restoration projects and identifying potential areas of habitat enhancement or improvement. Ongoing or recently completed projects include riparian buffer stabilization, stream bank erosion inventories, creating a task force for dam removal, landowner education, NHDES fish biomonitoring, and annual river clean ups. Ongoing habitat restoration focuses on Atlantic salmon, American shad, and blueback herring.

2.7 Sources of Information

A watershed classification based on geological, topographical, climactic, and connectivity attributes, developed by TNC, was used to define scale. Watershed management plans, GIS analyses, and anadromous fish restoration plans were used to identify significant habitats, relative condition, quality, and ongoing management and restoration efforts.

2.8 Extent and Quality of Data

Information on current habitat quality and restoration was highly concentrated on larger rivers. Smaller rivers in this watershed group were not well represented. Information from GIS analyses may not accurately represent all physical features.

2.9 Condition Assessment Research

Increased sampling of aquatic communities and water quality will provide more conclusive, long-term trend data. Additional monitoring would help identify the impacts of water flow alterations (e.g. erosion, changes in dissolved oxygen, and impoundments) on plants, fish, and other aquatic wildlife. Increased sampling of fish tissue throughout these watersheds may recognize

areas affected by contaminants. Habitat assessments, water quality monitoring, and aquatic community data are needed for the headwater streams and small tributaries of this watershed group. The pilot projects initiated by TNC in the Ashuelot River watershed should be expanded to other watersheds in this group to identify and protect additional areas of significant habitat.

Element 3: Species and Habitat Threat Assessment

Existing river management plans and GIS analyses indicate that non-point source pollution (especially sedimentation and stormwater runoff), altered hydrology, and invasive species are the primary threats to habitats in this watershed group.

Refer to the general threats section for Transportation Infrastructure, Development (Fragmentation, General), Non-Point Source Pollution (Runoff and Sedimentation), Acid Deposition, Introduced Species, Altered Hydrology, Recreation, Unsustainable Harvest (Forestry Operations and Management), and Agriculture.

Element 4: Conservation Actions

The Connecticut River Management Plan, The Ashuelot River Management Plan, and the Ammonoosuc Watershed Region Conservation Plan contain strategies for conservation in this area.

Refer to the general threats section for Transportation Infrastructure, Development (Fragmentation, General), Non-Point Source Pollution (Runoff and Sedimentation), Acid Deposition, Introduced Species, Altered Hydrology, Recreation, Unsustainable Harvest (Forestry Operations and Management), and Agriculture.

Element 5: References

5.1 Literature

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HABITAT PROFILE

Dunes

Associated Species: Piping Plover (Charadrius melodus), semi-palmated plover (Charadrius semipalmatus), Semipalmated Sandpiper (Calidris pusilla), Least Tern (Sterna antillarum), Horned Lark (Eremophila alpestris), "Ipswich" Savannah sparrow (P. s. princeps)
Global Rank: Not ranked
State Rank: Beach grass grassland (S1), Bayberry – beach plum maritime shrubland (S1)
Author: Allison M. Briggaman, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 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, 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 maritime) 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, fencing, or vegetation—reduce wind speed and cause sand to accrete. As sand accumulates, plants adapted to the beach environment emerge, 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), hair hudsonia (Hudsonia tomentosa var. tomentosa), poverty oat grass (Danthonia spicata), little bluestem (Schizachyrium scoparium), beach pea (Lathyrus japonicus), seabeach pinweed (Lechea martima), jointweed (Polygonella articulata), perennial umbrella-sedge (Cyperus lupulinus), seabeach needlegrass (Aristida tuberculosa) and Gray's umbrella-sedge (Cyperus grayi) (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 climbing poison ivy (Toxicodendron radicans), Virginia rose (Rosa virginiana), small sundrops (Oenothera perennis), yarrow (Achillea millefolium) and large climbing false buckwheat (Polygonum scandens) (Dunlop and Crow 1985, Dunlop et al. 1983).

1.2 Justification

Many avian species depend on coastal sand dunes. The state endangered and federally threatened piping plover (*Charadrius melodus*), horned lark (*Eremophila alpestris*), and least tern (*Sterna antillarum*) use coastal sand dunes for breeding while the semi-palmated plover (*Charadrius semipalmatus*), semi-palmated sandpiper (*Calidris pusilla*), sanderling (*Calidris alba*), short-eared owl (*Asio flammeus*), horned lark and Ipswhich/Savannah sparrow (*P. s. princeps*) use

coastal sand dunes for migration. The sanderling, short-eared owl, horned lark, and Ipswhich/Savannah sparrow 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.

In Maine, historic dune nesting habitat has been reduced over 70% due to development (USFWS 1996). Significant development has also occurred along the New Hampshire coast in recent decades. However, no data are available to quantify the severity of dune habitat loss in the state. 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).

1.3 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), and New Hampshire RSA 212-A:6 IV(a) Endangered Species Conservation Act (1979). Coastal sand dune systems that occur in the Hampton Harbor Wildlife Management Area, Hampton Beach State Park and Odiorne State Park are state owned lands open to the public for recreation and protected from development. 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.

1.4 Population and Habitat Distribution

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.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

Polygons representing any of the diagnostic natural communities, as defined by New Hampshire Natural Heritage Bureau (NHNHB), within the coastal sand dune system were selected for this habitat. These communities are beach grass grassland, bayberry–beach plum maritime shrubland, coastal interdunal marsh/swale, and maritime wooded dune. Communities with overlapping polygons were dissolved to form one polygon with the dominant community name. The result was a shape-file of four small polygons along the coast of New Hampshire.

These polygons were then reviewed by New Hampshire Fish and Game (NHFG) personnel and modified to include known and potential occurrence of coastal sand dune systems from survey efforts conducted along the coast. The result was 13 polygons comprised of 7 known coastal dunes locations and 6 potential dune locations.

1.7 Sources of Information

Sources regarding habitat and distribution include NHNHB Natural Communities of New Hampshire, NHFG Nongame and Endangered Wildlife Program, piping plover monitoring data, and personal knowledge

1.8 Extent and Quality of Data

Dune occurrence is well documented by NHFG surveys. The Nongame and Endangered Wildlife Program monitors breeding piping plovers along the seacoast and conducts a census of the entire coast annually. NHNHB has conducted extensive field surveys documenting the occurrence of American beach grass (Sperduto and Nichols 2004).

1.9 Distribution Research

The current distribution of coastal dunes is well documented. Further research should include determining the historic distribution and abundance of coastal sand dunes and the magnitude of habitat lost in recent history (50 years). In addition, areas of potential dune habitat restoration should be identified.

Element 2: Species/Habitat Condition

2.1 Scale

Polygons representing coastal sand dune systems were grouped by geographic location. Those polygons that comprised more than one jurisdiction were split by land ownership. Grouping in this manner resulted in 13 conservation-planning units.

2.2 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 (33.0 acres and 117.7 acres respectively). Two smaller areas occupy 9.1 acres in Hampton/Seabrook Harbor and 7.4 acres at Odiorne State Park in Rye.

2.3 Population Management Status

Not addressed for this habitat.

2.4 Relative Quality of Habitat Patches

Seabrook Town Beach hosts the most extensive coastal sand dune systems that remain in the state. Smaller remnants of dunes occur at various locations along the coast including state owned lands in Hampton/Seabrook harbor, at Hampton Beach State Park and Odiorne State Park. All coastal sand dune systems are under severe pressure from human recreation and development.

2.5 Habitat Patch Protection Status

See element 1.3 above.

2.6 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.

NHFG owns the Hampton Harbor Wildlife Management Area (WMA), which is comprised of 9.13 acres of dunes. No habitat management plan is in place for this WMA, and no active management has occurred at this site.

Dredging of Hampton/Seabrook harbor and the inlet typically takes place annually between November and March. Dredge spoil is dumped on the dunes in Hampton and Seabrook to stabilize dunes and replenish beaches. Mechanical maintenance of coastal sand dune systems is carried out by local towns and New Hampshire State Parks and includes, but is not limited to, bulldozing of dunes, planting vegetation, installation and maintenance of boardwalks and pathways, and mechanical cleaning of the beach.

The town of Seabrook established the Seabrook/Sun Valley Beach Management Committee, a volunteer committee, in 2001. The purpose of the committee is to establish a long-term management plan for the Seabrook town-maintained beach and Sun Valley beach, which falls under the town of Hampton's jurisdiction. This committee has worked with NHDES to obtain funding and has worked with an engineering consultant to develop a management plan for the town beach. The final version of the management plan was completed in June 2004 and includes primary objectives such as, "maintaining control of dune heights and protection of private properties abutting the beach" (Seabrook 2004).

2.7 Sources of Information

Information on management and regulations was obtained from the USFWS Atlantic Coast Piping Plover Population Revised Recovery Plan and from local communities. Geographic Information Systems data-layers were used to identify key habitat areas and determine quality of habitat patches.

2.8 Extent and Quality of Data

Dune occurrence is well documented by NHFG surveys. The Nongame and Endangered Wildlife Program monitors breeding piping plovers along the seacoast and conducts a census of the entire coast annually. The Marine Fisheries Division conducts MRFFS at over 40 recreational fishing sites along the seacoast annually. NHNHB has conducted extensive field surveys documenting the occurrence of American beach grassSperduto and Nichols 2004).

2.9 Condition Assessment Research

A coastal geological survey of the New Hampshire coast is important. The survey should determine the current health and condition of existing dunes, project likely changes to current dunes in future decades, and determine protocol for managing, protecting and improving the health of existing dunes.

Element 3: Species and Habitat Threat Assessment

3.1.1 Recreation (General Disturbance), 4.00, Critical

(A) Exposure Pathway
Sunbathing, swimming, jogging, dog walking, kite flying, volleyball, jet skiing, surfing and fishing are all popular recreational activities in or nearby dune habitats, and the effects of human presence on the dunes are long lasting. Unrestricted access has lead to many unofficial pathways, which have allowed trampling, loss of vegetation, and erosion on the dunes. Increased human presence also deters native species from nesting and/or feeding, can result in trampling of nests and chicks, and can lead to nest abandonment. Additionally, human refuse attracts predators

High recreational use is supported in turn by intensive management including installation and maintenance of boardwalks for human access, mechanical raking to clean beaches, removal of wrack and debris, and public safety operations such as patrol by local police on horseback and in vehicles.

(B) Evidence
During summer 2003, Hampton Beach State Park reported 122,890 visitors (J. Lyones, New Hampshire Department of Resource and Economic Development, personal communication). These numbers are in keeping with the fact that beach visits are the second most popular recreational activity, and visits are likely to rise as population increases (National Survey on Recreation and the Environment 1994, New Hampshire Office of State Planning 2003).

Recreational management activities affect the dune ecosystem by altering the natural processes of dune formation, increasing erosion, trampling and killing native plant and animal species, and altering species' natural behaviors.

The piping plover, which breeds among sandy dunes and beaches along the Atlantic coast, is a state endangered and federally threatened species. The decline of piping plovers beginning in the 1940s has been attributed primarily to habitat loss and disturbance by humans and their pets (USFWS 1996).

3.1.2 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
The natural shifting of sand from wind and wave action can have negative impacts on property value and industry along the coast. Hampton/Seabrook harbor and the inlet are dredged annually for navigation. Dredge spoil is dumped on the dunes in both Hampton and Seabrook to stabilize dunes and replenish beaches.

Increased shoreline development raised property owner concern regarding beach and dune stabilization. Dune stabilization efforts include planting American beach grass, bulldozing, and snow fencing. Shoreline modification efforts include seawall and jetty construction. Stabilization and modification interrupt natural dune succession, disturb native natural communities, and limit reestablishment.

(B) Evidence
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. In addition, beach ecosystems are threatened by the removal of wrack, which provides nutrients and beach stability (Gulf of Maine Council Habitat Restoration Subcommittee 2004). Dredging of inlets can affect spit formation adjacent to inlets, and jetties can cause widening of islands as well as growth of vegetation on inlet shores (USFWS 1996).

3.2 Sources of Information

Information regarding dune threats was compiled from expert review and consultation, literature review, fact sheets and the Internet.

3.3 Extent and Quality of Data

Recreational uses and their impacts on coastal sand dune systems as well as the effects of shoreline stabilization on coastlines are well documented.

3.4 Threat Assessment Research

Additional research is needed to determine the impact of shoreline stabilization efforts, including dredging, beach replenishment, jetties, seawalls, mechanical manipulation of dunes, and the establishment and removal of vegetation on New Hampshire coastal dunes.

Element 4: Conservation Actions

4.1.1 Create and maintain official, designated pathways for access to and from beaches

(A) Direct threats include: human disturbance, recreational management and shoreline/dune modification.

(B) Justification

- Directing foot traffic along designated pathways for access to and from beaches will reduce the number of paths over dunes and will reduce trampling and loss of vegetation.
- Official paths should be installed and maintained at all main beach access points as well as at designated areas along the length of the beach.
- Some official paths and boardwalks are in place and maintained. Spacing of these walkways should be evaluated to determine where additional paths and boardwalks are needed and will be most effective.
- Placement of new walkways should be a decision made by representatives from the local communities as well as by town, state, and federal officials.

(C) Conservation Performance Objective
The objective of creating and maintaining official designated walkways is to direct all human access to and from beaches along designated paths to reduce trampling and loss of vegetation on dunes and prevent erosion.

(D) Performance Monitoring
Monitoring should be performed daily during the summer months when recreational use of beaches is at its peak. Monitoring should include observing the number of people using official walkways, observing other locations where people are using the beach, recording the number of people using these other areas, and noting the distance from these areas to official designated access points.

(E) Ecological Response Objective
The goal of installing and maintaining designated official walkways is to reduce human foot traffic over dunes and to allow natural dune formation and growth as well as succession of dune vegetation. Successful protection of existing dunes will be indicated by the natural succession of distinct natural communities in the frontal dune and back dune areas.

(F) Response Monitoring
Response monitoring should include vegetation sampling and monitoring at predetermined areas throughout the dunes. Response monitoring should note the types and density of vegetation occurring. Over time, a reduction in the amount of open space and an increase in the amount of vegetation should be observed. In addition, long term response monitoring should show a change in vegetative structure,

especially in the back dunes where a variety of shrub species should become established.

(G) Implementation
A cooperative agreement should be established between NHFG, United States Fish and Wildlife Service (USFWS), the NHDES, and local town officials to determine the most appropriate locations, maintenance techniques, and monitoring protocol for official pathways.

(H) Feasibility
Local town public works departments and DRED have the expertise to install and maintain paths and boardwalks. NHFG and the NHDES have the expertise to carry out monitoring.

4.1.2 Improve enforcement of existing laws and regulations, Regulation and Policy.

(A) Direct threats include: human disturbance, recreational management, and shoreline/dune modification.

(B) Justification

- Improving enforcement of existing laws and regulations will help to reduce the number of unofficial paths leading from private residences over the dunes and thus reduce trampling and loss of vegetation and erosion. It will also help promote natural dune succession. Improving existing laws and regulations will help to ensure that dredgers follow permit requirements.
- Improving enforcement of existing laws and regulations will promote natural dune formation and growth as well as the establishment and succession of natural dune vegetative communities.
- Improving enforcement of existing laws and regulations should be targeted to all existing dune areas and any restored areas.
- Improving enforcement of existing laws and regulations is needed immediately and should be a continuous year-round effort. Enforcement efforts should be increased during the summer months when recreational use of beaches and dunes is most intense.
- Enforcement efforts can be adjusted depending on public response and the results of performance and response monitoring efforts.

(C) Conservation Performance Objective
The objective of improving enforcement of existing laws and regulations is to reduce the number of unofficial paths leading from private residences over the dunes, reduce trampling and loss of vegetation, reduce erosion, and promote natural dune growth and formation and vegetative succession. Improving existing laws and regulations will also help to ensure that dredgers follow permit requirements.

(D) Performance Monitoring
Performance monitoring will be entailed by the increased efforts of town, state and federal officials to identify strategies to improve enforcement of existing laws and regulations and to ensure dredgers follow permit requirements.

(E) Ecological Response Objective
The desired ecological response to improving enforcement of existing laws and regulations is natural dune growth and formation and the succession of dune vegetative communities.

(F) Response Monitoring
Response monitoring will be entailed by the cooperation of town officials and state agencies to identify and implement strategies for increased enforcement of existing laws and regulations.

(G) Implementation
NHFG and NHDES should work with towns to identify strategies for increasing enforcement of existing laws and regulations. Funding sources need to be identified to support additional law enforcement staff at both the town and state levels.

(H) Feasibility
Local towns and NHFG have the expertise to carry out enforcement of existing laws and regulations. However, both town and state law enforcement are constrained by limited staff and funding.

4.1.3 Create and implement a comprehensive education and outreach plan for residents, day visitors, community and town officials, Education and Outreach.

(A) Direct threats include human disturbance, recreational management, and shoreline/dune modification
(B) Justification

- Implementing a comprehensive education and outreach plan will help to raise awareness and garner support for protecting and maintaining New Hampshire's remaining dunes.
- Raising public awareness will help to protect dunes from human disturbance and thus allow for natural dune formation and growth as well as vegetative succession.
- Education and outreach should be targeted both at beach users and local decision makers as well as at local conservation commissions and public schools.
- An education and outreach plan should be created to raise awareness and garner local support for protecting and reducing further losses and degradation of dunes. Education and outreach efforts should increase during the summer months when recreational use is at its peak.
- Education and outreach efforts can be conducted in a variety of ways depending on the audience, the time of year, and can be adjusted based on feedback received from outreach efforts.

(C) Conservation Performance Objective
The objective of creating a comprehensive education and outreach plan is to increase community support and involvement in the protection and management of this unique habitat. Such a plan would raise awareness by providing information about dune ecosystems, as well as by emphasizing the benefits of healthy dunes to humans and their property.

(D) Performance Monitoring
The performance of education and outreach efforts will be determined by the number of people interested in participating in presentations and other outreach efforts.

(E) Ecological Response Objective
The desired ecological response to creating an education and outreach plan is natural dune formation and growth, which will natural vegetative succession of existing dunes and potential dune restoration areas.

(F) Response Monitoring
Response monitoring will be done by observing increased involvement in the protection and management of dune habitats as well as by observing a decrease in human uses that harm dune habitats.

(G) Implementation

- 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
- Give mini-presentations to day visitors at beaches that include guided walks and information about dune ecosystems
- Create and distribute an informational mailing to all residents who live along beaches/dunes
- Create an educational program to be used in local schools and encourage student involvement in beach management

(H) Feasibility
NHFG has limited funding and staff. Funding sources should be identified, and additional staff should be acquired to develop an education and outreach plan for dune habitats and the piping plover.

4.1.4 Identify and carry out habitat restoration in most suitable areas, Restoration and Management, Habitat Protection.

(A) Direct threats affected include: shoreline/dune modification

(B) Justification:
- Dune restoration along the coast will help to stabilize the New Hampshire shoreline and protect property in a natural and cost effective manner
- Development pressure along the coast is severe and continues rapidly. Work should

begin immediately to identify potential dune restoration sites and to determine the appropriate interventions.
- Dune restoration efforts will take place at those sites determined by a feasibility study to be most suitable.

Conservation Performance Objective
The objective of dune habitat restoration is to restore areas of historical dune occurrence and to increase the amount of dune habitat in the state.

(D) Performance Monitoring
Performance will be measured by the success of restoration efforts in protecting and repairing dune ecosystems

(E) Ecological Response Objective
The desired ecological response to dune habitat restoration is an increase in the amount of healthy dune habitat in the state.

(F) Response Monitoring
Successful dune restoration will be indicated by an increase in the amount of dune habitat in the state.

(G) Implementation
A feasibility study needs to be conducted to determine historical occurrences of dune habitats, ascertain which areas are most suitable for habitat restoration and identify steps necessary to begin restoration.

(H) Feasibility
Funding for a feasibility study and restoration efforts should be pursued by NHFG, NHDES, DRED, and the Parks Division

4.1.5 Require dredge applicants to consult with NHFG Nongame and Endangered Wildlife Program, regarding disposal and placement of dredge material, Regulation and Policy.

(A) Direct threats include: recreational management and shoreline/dune modification.

(B) Justification

- Requiring dredge and fill applicants to consult with NHFG Nongame and Endangered Wildlife Program will help to ensure that existing dune habitat is not degraded and may potentially help to restore dune habitat in historical areas.
- Reviewing dredge and fill permits will help to determine where dredge material should be placed and will promote natural shoreline stabilization and reduce the risk of destroying dune habitat. Only dredge and fill permits pertaining to Hampton/Seabrook harbor and the immediate coast should be reviewed. Dredge and fill permits should be reviewed year round, as necessary. Dredge operations should continue to be conducted only between November and March.
- Reviewing dredge applications and advising on the placement of dredge material may help to maintain existing dune habitat and restore historical dunes.

(C) Conservation Performance Objective
Reviewing dredge applications will provide input on the disposal and placement of dredge material in an effort to promote natural shoreline stabilization, minimize degradation of existing dunes, and conduct habitat restoration.

(D) Performance Monitoring
Performance will be evident by the inclusion of NHFG Nongame and Endangered Wildlife Program in all dredge applications pertaining to Hampton/ Seabrook harbor and the adjacent coast.

(E) Ecological Response Objective
The objective is to promote natural shoreline stabilization, minimize degradation of existing dunes and conduct habitat restoration.

(F) Response Monitoring
Success of dredge application review will be evident in the success of natural shoreline stabilization, natural dune formation and growth, and the successful restoration of dunes in identified areas.

(G) Implementation
NHFG, Nongame and Endangered Wildlife Program has the authority to review dredge applications and provide advisement on the disposal and placement of dredge material. The USFWS has the authority

to change wording in dredge applications to require applicants to consult with NHFG Nongame and Endangered Wildlife Program during planning.
(H) Feasibility
Given the authority of the NHFG and USFWS, it is highly feasible to revise the wording on dredge permit applications.

4.1.6 Coordinate recreational management activities on beaches and dunes, including boardwalk installation and maintenance, beach raking and motorized vehicle use, Habitat Protection.

(A) Direct threats include: recreational management and shoreline/dune modification.

(B) Justification (some justifications sound like recommendations)
Coordinating recreational management activities and managing motorized vehicle use will help to minimize degradation and erosion of dunes. Recreational management activities and motorized vehicle use should be coordinated in areas where dune habitat occurs. Recreational management activities and motorized vehicle use should be coordinated year round to protect dune habitats. Efforts should be increased during the summer months when use of beaches and dunes is at a peak. Coordination of recreational management can be flexible so that town, state and federal groups can work in successful partnerships.

(C) Conservation Performance Objective
The objective of coordinating recreational management activities on beaches and dunes, including boardwalk installation and maintenance, beach raking and motorized vehicle use is to protect dune habitats, promote dune formation, promote natural succession of dune vegetative communities.

(D) Performance Monitoring
Performance monitoring should include monitoring beach management activities and motorized vehicle use on dunes and beaches.

(E) Ecological Response Objective
The desired ecological response of coordinating recreational management activities on beaches and dunes is to promote natural dune growth, promote natural succession of dune vegetative communities, reduce erosion, and minimize harm to dunes from human activities.
(F) Response Monitoring
Successful coordination of recreational management activities on beaches and dunes including boardwalk installation/maintenance, beach raking and motorized vehicle use will be evident in the minimum use of motorized vehicles on beaches/dunes and the effectiveness recreational management activities with minimal impact to dunes.

(G) Implementation
Collaborative between members from the following groups should be established: NHFG, NHDES, DRED, local town officials, local police and emergency respondents and local conservation commissions. This coalition should meet regularly to discuss recreational management activities and motorized vehicle use on beaches and dunes and should work to effectively carry out efforts with minimum impact to dunes.

(H) Feasibility
NHFG Nongame and Endangered Wildlife Program has experience in coordinating recreational management activities and managing motorized vehicle use on beaches and dunes where the state endangered and federally threatened piping plover occurs. However, NHFG is limited in its ability to fund and staff these efforts year round. Funding is needed to support additional personnel who can adequately coordinate recreational management activities and motorized vehicle use on New Hampshire beaches and dunes.

4.2 Conservation Action Research

Significant habitat loss due to development has already occurred along the New Hampshire seacoast, and development pressure continues. All potential sites for dune habitat restoration should be studied for restoration feasibility.

Element 5: References

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HABITAT PROFILE

Floodplain Forests

Associated Species: Jefferson Salamander, northern leopard frog, Wood Turtle, Red Shouldered Hawk, Cerulean Warbler, Eastern Red Bat, Silver Haired Bat

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Alder alluvial shrubland (S3), Alder – dogwood – arrowwood alluvial thicket (S4), Alluvial mixed shrub thicket (S4), Aquatic bed (S4S5), Balsam fir floodplain/silt plain (S2), Basswood – white ash – black maple floodplain forest (S1), Blue-joint – goldenrod – virgin's bower riverbank/floodplain (S3S4), Herbaceous riverbank/floodplain (S2S4), Herbaceous/wooded riverbank/floodplain (S4), Meadowsweet alluvial thicket (S3?), Oxbow buttonbush swamp (S3), Oxbow marsh (S3), Red maple floodplain forest (S2S3), Riverbank/floodplain fern glade (SU), Silver maple – false nettle – sensitive fern floodplain forest (S2), Sugar maple – ironwood – short husk floodplain forest (S1), Sugar maple – silver maple – white ash floodplain forest (S1S2), Swamp white oak floodplain forest (S1), Sycamore floodplain forest (S1)
Author: Peter J. Bowman, New Hampshire Natural Heritage Bureau

Element 1: Distribution and Habitat

1.1 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 2004). 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 2004).

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 and balsam fir are dominant trees, and riparian wetlands such as oxbows and sloughs are uncommon in these high-gradient floodplains.

M*ajor 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 2004).

1.2 Justification

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*), Baltimore oriole (*Icterus galbula*), and chestnut-sided warbler (*Dendroica pensylvanica*) (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 (*Rana pipiens*). These wetlands also provide habitat for reptiles, such as wood turtle (*Glyptemys insculpta*), Blanding's turtle (*Emydoidea blandingi*), and spotted turtle (*Clemmys guttata*).

1.3 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.

1.4 Population and Habitat Distribution

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. M*ajor 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 2004).

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

The majority of floodplain forest element occurrences (NHNHB 2005) encompassed an elevation range of up to 21 feet up the bank away from the river. Thus, all areas within 21 feet of elevation change of a river were mapped, using the most recent state plane grid derived from the digital elevation model (Complex Systems Research Center 1999). Resulting polygons that extended into lakes, the ocean, or unreasonably far from the river were clipped to extend no more than 500m from a river, or 1000m from a river if they also were within 250m of a tributary stream. This resulted in a base floodplain layer. Areas within this floodplain layer that were dominated by forest cover (Complex Systems Research Center 2001) were selected. In addition, floodplain wetlands that were adjacent to a selected forest polygon were also selected. The resulting polygons were merged, creating the floodplain forest layer.

All polygons within 1 km of major rivers (USEPA 1998) were classed as *major river silver maple floodplain systems* (Sperduto 2004). Polygons that did not

fall into this system classification, and which occurred within the 4 northern ecoregion subsections (Connecticut Lakes, Mahoosic-Rangeley, Vermont Piedmont, and White Mountains), and which overlapped coniferous or mixed forest (from the New Hampshire Landcover Assessment 2001) were classed as *montane/near-boreal floodplain systems*. *Montane/near-boreal floodplain systems* often have both a deciduous and coniferous component (Sperduto 2004), so in addition, any non-coniferous floodplain polygons within 1 km of the same river segment as the coniferous floodplain polygons were also classed as *montane/near-boreal floodplain system*. All of the floodplain polygons not falling into one of these 2 systems were assigned to the third system, the *temperate minor river floodplain*. Mapped floodplain forest polygons (see element 1.6) were grouped into complexes of polygons within 500m of each other, and attributes characterizing habitat quality and quantity were assigned using available GIS data layers.

Data limitations: Errors in the elevation data could create some error in the base floodplain layer. In most cases, this creates an over prediction of habitat rather than an under prediction. Potential inaccuracy in landcover classification would also cause some errors in the data. Because of the limitations of the modeling process, some floodplain polygons have been assigned to systems incorrectly. As a result, a single floodplain complex may contain polygons from different systems. Despite some polygons being incorrectly attributed, the predicted area of floodplain forest systems can provide an informative picture of floodplain habitat in the state.

1.7 Sources of Information

NHNHB publications, State and Federal Agency web sites, NatureServe website, textbooks, and peer-reviewed literature.

1.8 Extent and Quality of Data

See section 1.6

1.9 Distribution Research

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

Element 2: Species/Habitat Condition

2.1 Scale

Mapped floodplain forest polygons were assessed within 10 digit watershed units (HUC-10).

2.2 Relative Health of Populations

The average area of floodplain forest in a watershed was 633 ha ± 565 SD and varied from 23 to 2792 ha. The *temperate minor river floodplain* system comprised approximately half of all mapped floodplain hectares in the state. The remaining floodplain polygons were 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* was in the Upper Ammonoosuc River drainage, while the Middle Androscoggin River watershed had 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* was in the Lamprey River watershed, in the seacoast region.

2.3 Population Management Status

Otter, mink, other furbearers, and waterfowl, are managed by NHFG.

2.4 Relative Quality of Habitat Patches

A number of habitat quality attributes were computed through GIS for the mapped floodplain forest polygons, but because of the number of polygons and attributes, they will not be described here. Also, a number of exemplary floodplain forest natural communities have been identified across the state. Many floodplain forests near developed areas (e.g., much of the Merrimack River floodplain) have been invaded

by exotic plants (see element 3.3.3- Invasive Species) or are fragmented by roads or agriculture.

2.5 Habitat Patch Protection Status

Protected floodplain forest habitat (area, percent) was calculated for HUC 10 watersheds (n=72) using the conservation lands data layer (UNH Complex Systems, GRANIT). The mean protected floodplain forest within watersheds was 24 % ± 22 SD (0-92%). Eight watersheds had greater than 50% protection. However, these statistics can be misleading in some cases because of varying hectares of habitat within watersheds. For example, approximately 75% of the floodplain forest habitat in the Lower Pemigewasset River watershed was on protected land (in WMNF), totaling 350 ha. In comparison, only 18% of the habitat in the Lamprey River watershed was on protected land, but this totaled 496 ha. There were 7 watersheds in which none of the mapped habitat was on protected lands (e.g., Upper and Lower Millers River, Littleton Tributaries) or had relatively low amounts of habitat (185 ha, range: 34-655 ha).

There was some variation in the percentage of protected land among the 3 floodplain forest systems: 22% for *temperate minor river floodplain* habitat, 24% for *major river silver maple floodplain* and 34% for *montane/near-boreal floodplain* systems. The higher percentage of *montane/near-boreal floodplain* protected reflected its occurrences on WMNF land and the Second College Grant, owned and managed by Dartmouth College. Although the *temperate minor river floodplain* system had the lowest percentage of protected land of the 3 systems, it had the greatest area of protection.

2.6 Habitat Management Status

In New Hampshire and throughout the country, USACE is working with TNC to develop strategies for managing dams and waterways (USACE 2005). The New Hampshire chapter of TNC is currently working with USACE on management of dams and river flows in the Ashuelot River watershed and may expand this work to other managed river systems.

2.7 Sources of Information

Condition of floodplain habitats was based entirely on available GIS analyses. GIS data layers were attained from various sources (see Metadata for details).

2.8 Extent and Quality of Data

Condition of floodplain habitats was based largely on available GIS analyses (see section 1.6). A portion of predicted floodplain forests has been designated as exemplary natural communities by the NHNHB.

2.9 Condition Assessment Research:

Conduct GIS analyses to categorize quality of floodplain forest complexes (e.g., high, moderate, low). Attributes have been assigned to floodplain forest complexes but these variables need to be weighted. A subset of high quality sites should be field verified. Floodplain forest sampling should include an assessment of habitat availability for at-risk wildlife. This work can be conducted by NHFG with assistance from other wetland and wildlife experts. Ranked floodplain forest complexes should be incorporated into NHDES wetland permit review and mitigation prioritization and selection.

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Fragmentation, Habitat Loss and Conversion)

(A) Exposure Pathway
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.

(B) Evidence
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).

3.1.2 Altered Hydrology, Altered Natural Disturbance

(A) Exposure Pathway
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.

(B) Evidence
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.

3.1.3 Introduced Species

(A) Exposure Pathway
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.

(B) Evidence
In New Hampshire, there are several exotic plants that are particularly problematic in floodplain habitats, including Oriental bittersweet (*Celastrus orbiculatus*), Japanese knotweed (*Polygonum cuspidatum*) and black swallow-wort (*Vincetoxicum nigrum*) (ISI 2005). 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).

3.2 Sources of Information

Literature reviews, state and federal agency websites, fact sheets, and reports were used to assess the exposure pathway and evidence of threats to floodplain forest systems in New Hampshire. GIS data layers were gathered from GRANIT, NHDES, USGS, and NHDOT to assess threats.

Initially, a list of threats was identified by NHFG and sent out for review. A group of wetland and wildlife experts met on 27 January 2005 to rank threats to marsh and shrub systems (participants included Kim Babbitt, Kim Tuttle, Pam Hunt, Carol Foss, Chris Martin, Laura Deming, Heather Hermann, Benjamin Nugent, and Matthew Carpenter), and at this meeting threats to floodplain habitats were ranked and further modified based on expert review and new information.

3.3 Extent and Quality of Data

Some threats to floodplain forest habitats and the associated flora and fauna are well understood (e.g., habitat destruction/fragmentation). Other threats (e.g., invasive plants, alteration of river flows) need further study.

3.4 Threat Assessment Research

- Collect vegetation data along impounded rivers to gauge effects of river flow modification.
- Collect invasive plant data to identify current threat areas and species, and target sites for invasive management, in conjunction with the efforts of the Invasive Plant Atlas of New England (IPANE) project (IPANE 2005).

Element 4: Conservation Actions

Many of the habitat protection strategies described in watershed profiles will benefit floodplain forests. These include managing river impoundments to simulate natural water flows, removing non-functioning dams, strengthening the Shoreland Protection Act (RSA 483-B), and protecting the highest quality sites.

4.1.1 Identification of potential floodplain forest restoration sites, and development of a floodplain forest restoration plan, Restoration and Management

(A) Threats
Development (Fragmentation, Habitat Loss and Conversion, Non-Point Source Pollution (Chemical Contaminants, Runoff and Sedimentation)

(B) Justification

- A successful restoration plan will identify sites that will connect patches of fragmented floodplain forest, preclude the conversion of floodplain agricultural fields to residential or commercial development, and reduce the effects of agricultural runoff by replacing agricultural fields and enhancing riparian buffers to remaining fields.
- Successful restoration will create or restore quantifiable areas of habitat and will enhance connectivity between extant habitat patches.
- Monitoring of the restoration sites will allow managers to assess successional processes at restoration sites and modify management strategies as necessary.

(C) Conservation Performance Objective

The objective of identifying floodplain forest restoration sites and developing a restoration plan is to restore floodplain forest habitat in areas currently used for agriculture. The plan will set goals for the number of restoration sites and the number of restored hectares within the first 5 years of the project. Success will be measured by determining whether these goals were met, and subsequently, by monitoring of the sites to ensure that the restoration sites are developing toward floodplain forest composition and structure, as defined by New Hampshire natural community and natural community system descriptions.

(D) Performance Monitoring

The restoration plan should select sites based upon their ability to connect existing blocks of floodplain forest habitat. Sites will also need to be in areas in which a natural flood regime still exists (i.e., the stretch of river is not influenced by impoundments). Site selection should ensure that sites are distributed among affected watersheds throughout the state.

(E) Ecological Response Objective

The desired ecological response to floodplain forest restoration is to increase and enhance New Hampshire's floodplain forest habitat. Successful habitat restoration would result in the creation of floodplain forest communities and systems as described by the NHNHB. These restored habitats would also support the range of affected wildlife species, where appropriate, as listed in the plan.

(F) Response Monitoring

Once work begins on given sites, monitoring will require annual visits to ensure that floodplain forest vegetation is developing and that invasive species are not threatening to inhibit floodplain habitat development. These monitoring visits will provide the necessary information to determine if succession is proceeding as desired, or if additional management (invasive control, further planting) is needed.

(G) Implementation

Prior to the development of the plan, maps will be created showing existing floodplain forest habitat and agricultural areas within floodplains, to enable the selection of potential restoration sites. The restoration plan, including prioritized sites, will be written in consultation with experts in riparian ecology and ecological restoration, and completed within 1 year. Once the plan is written and sites are identified, the first projects should begin within 3 years.

(H) Feasibility

A restoration project of this sort is large-scale and resource intensive and will require the participation of outside experts and organizations as well as willing landowners. Projects will have to occur on public land, or access will need to be gained on private land, either through cooperation with the landowner, landowner incentive programs, or direct acquisition. Funding for this project will probably need to be procured through federal grant programs.

4.1.2 Develop and implement invasive plant species management plan for floodplain forests, Restoration and Management

(A) Threats
Invasive plants

(B) Justification

- An invasive species management plan will identify high-quality floodplain forest habitat that is threatened by invasive plant species and will develop strategies to control them. Evaluations of habitat quality will include the presence of at-risk wildlife species.
- Controlling invasive plant species will allow for the restoration and enhancement of native vegetation, which will benefit an array of wildlife.
- Management will be targeted to specific sites, because invasive plant control can be time and labor intensive.
- Because the spread of invasive plants is a relatively slow process, management activities can extend over a period of many years.
- Monitoring sites for decreases in the abundance of invasive plants and a subsequent increase in the cover of native vegetation will allow for refinement of management techniques.

(C) Conservation Performance Objective

The objective of developing and implementing an invasive plant species management plan is to alleviate the impact of invasive plant species on floodplain forests, using standardized methods developed by other organizations (IPANE). Success will be indicated by the creation and implementation of the plan within 2 years.

(D) Performance Monitoring

In the first season, invasive species surveys should be conducted on at least 25 floodplain forest sites. Following site evaluation, an invasive species control plan will be developed for selected sites, with an associated site monitoring plan.

(E) Ecological Response Objective

The desired ecological response is a reduction in the abundance of invasive plant species in floodplain forests. Successful invasive control will be indicated by a measurable reduction in the cover of invasives, and a resultant increase in the cover of native vegetation.

(F) Response Monitoring

Management sites will be sampled for cover of invasive plant species and cover of native plant species using standard fixed vegetation plot techniques. The effects of control methods on both native and exotic species will be monitored by regular re-sampling of these fixed plots. The analysis of these plot data will provide an assessment of the efficacy of the control treatments and will direct any alterations of the management plan.

(G) Implementation

Floodplain forest sites will be selected from the habitat map for invasive sampling. Once data have been gathered at the sites, an invasive control plan will be

developed in collaboration with experts in invasive species management. At the sites, fixed vegetation plots will be established to measure the effects of the control techniques. Vegetation data will be collected before and after treatment, with return visits in subsequent years to monitor the site and conduct additional control measures.

(H) Feasibility

The implementation of an invasive species control plan would be very labor intensive and would likely require help from volunteer organizations. Herbicides and mechanical devised could be very expensive. An effective control project is a long-term endeavor which will require an equivalent commitment of resources.

4.2.1 Conservation Action Research

- The development of the restoration plan will require considerable research into the best current methods in ecological restoration. The restoration projects themselves will require extensive monitoring to evaluate their success in restoring floodplain forest habitat.
- Thorough inventories of invasive species in floodplain habitats will need to be conducted prior to developing a management plan. Development of a series of permanent plots will be necessary to monitor changes following management activities.

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HABITAT PROFILE

Grasslands

Associated Species: Northern Harrier (Circus cyaneus), Upland Sandpiper (Bartramia longicauda), Purple Marten (Progne subis), Eastern Meadowlark (Sturnella magna), Horned Lark (Eremophila alpestris), Grasshopper Sparrow (Ammodramus savannarum), Vesper Sparrow (Pooecetes gramineus, northern leopard frog (Rana pipiens), and Wood Turtle (Glyptemys insculpta).

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Authors: James D. Oehler, Ellen Snyder, and Alina J. Pyzikiewic, New Hampshire Fish and Game, Consulting Wildlife Biologist

Element 1: Distribution and Habitat

1.1 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 les 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 (*Aster* 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).

1.2 Justification

Native grasslands were once the most widely distributed vegetative cover in North America (Knopf 1995). A decline in this habitat type in the Northeast has led to a precipitous decline in grassland bird populations, which are disappearing faster than any other group of birds in this region (Sauer et al. 2003). Seven grassland birds are listed as endangered or threatened in at least 1 state in the region (Mitchell et al. 2000). In New Hampshire, grasslands serve as primary breeding and nesting grounds for several avian species of conservation concern including the state endangered northern harrier (*Circus cyaneus*), state endangered upland sandpiper (*Bartramia longicauda*), state threatened grasshopper sparrow (*Ammodramus savannarum*), eastern meadowlark (*Sturnella magna*), horned lark (*Eremophila alpestris*), and vesper sparrow (*Pooecetes gramineus*).

Large (>10 ha) grasslands are important because many grassland birds require large areas. For instance, eastern meadowlarks require at least 6 ha, grasshopper sparrows at least 12 ha, savannah sparrows 8 to 16 ha, and upland sandpipers 40 to 80 ha (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).

1.3 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 Farmland Protection Program through the USDA. The Farmland Protection 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 2005a).

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.

1.4 Population and Habitat Distribution

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.

1.5 Town Distribution Map

At least one grassland complex larger than 10 ha occurs in nearly every town in New Hampshire. The exceptions are 20 towns and territories in Coos County, 3 towns in Carroll County, 4 towns in Grafton County, and 2 towns in each of Cheshire, Hillsborough, and Rockingham Counties (figure 1).

1.6 Habitat Map

The New Hampshire Landcover Assessment (Complex Systems Research Center 2002) was used to map extensive grassland larger than 10 ha. Much habitat for rare grassland birds is classified as disturbed or cleared. Where such areas abutted active agricultural plots, the two were joined. In this way, areas greater than 10 ha were isolated and converted to a separate shape file.

Polygons were then overlaid atop 1998 Digital Orthophotos and the entire state was scanned at a scale of 1:50,000 to identify areas erroneously mapped as grassland. Invalid polygons were deleted from the data layer, and if only a portion of the polygon was misclassified, the polygon boundary was edited. Polygons that were misclassified were often shrub swamps, wet meadow, developed areas, or timber harvest areas reverting to forest. Only those polygons that were significantly misclassified were edited.

1.7 Sources of Information

Sources of information for this element included technical reports, Breeding Bird Survey data, and peer reviewed journal articles. The New Hampshire Landcover Assessment (CSRC 2002) was used to map grassland habitat. 1998 digital orthophotos were used to check the accuracy of the grassland habitat data layer.

1.8 Extent and Quality of Data

Data for mapping grasslands were obtained from the New Hampshire Landcover Assessment (CSRC 2002). The assessment was obtained from interpretation of satellite imagery (pixel size = 30 m) using standard digital image processing techniques. Because the satellites used cannot capture items on the ground less than 30 m in size, many hedgerows and tree lines that

typically separate fields were not delineated. Thus, this data layer really depicts grassland complexes and not individual grassland patches. The coarse scale of the satellite imagery caused some imprecision in the delineation of boundaries, which may be offset when laid over an aerial photograph.

Because the entire state was scanned to identify misclassification errors, errors of commission (classifying an area as grassland when it is really some other land cover type) should be relatively few. Even so, it is possible that some errors were missed during the scanning. Similarly, it is possible that some true grassland areas were omitted.

1.9 Distribution Research

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.

Element 2: Species/Habitat Condition

2.1 Scale

Counties will be used as the conservation-planning units for this habitat. The majority of grassland habitats in New Hampshire are related to agricultural activity. Most technical and financial assistance is provided to farmers on a county-basis by the Farm Services Agency, Natural Resources Conservation Service, University of New Hampshire Cooperative Extension, Conservation Districts, and others.

2.2 Relative Health of Populations:

Although the amount of grassland habitat in New Hampshire has been declining over numerous decades, it is difficult to determine the extent of grasslands in New Hampshire prior to European settlement. The creation and maintenance of grasslands prior to European settlement are ascribed to beavers and Native American use of fire.

Numerous reports, largely based on historic accounts, suggest that Native Americans in coastal regions and river valleys used fire to create and maintain agricultural fields and to improve hunting grounds and travel corridors (Day 1953, Harris 1972, Cronon 1983, Whitney 1994). The resulting mosaic included habitat, including grassland, in different states of succession. However, archaeological data are equivocal, and the effect that Native American fires had on vegetation composition and distribution in the region is unclear.

Beavers likely contributed to the creation of open areas (Askins 1997). After a beaver dam is abandoned, the previously dammed area succeeds to a meadow dominated by sedges, grasses, and forbs. Though no empirical data exist to elucidate the extent of beaver activity in New Hampshire or the region, it is known that beaver activity may influence 20 to 40% of the total length of second- to fifth-order streams (Naiman et al. 1988). Additionally, a study in the Adirondack Mountains found that beaver dams created patches of disturbance that covered, on average, 6.7 to 12 ha (Remillard et al. 1987). Given their habitat requirements, it is plausible that many grassland endemic species could have used beaver meadows during pre-settlement times (e.g., grasshopper sparrow, savannah sparrow).

An analysis of wet flats in New Hampshire (the flat floodplain area adjacent to streams and rivers that would be affected by beavers) shows that nearly 30% (267 out of 961) of the wet flats 7 to12 ha in size are affected by agriculture and likely no longer serve as grassland habitat because of current management practices (e.g., repeated mowing during the breeding season or planting to crops). Another 17% (165 out of 961) are effected by development (CSRC 2001, TNC 2003).

Native sand plain grasslands may have been more common in New Hampshire prior to European settlement, especially in coastal lowlands and along the Merrimack and Connecticut Rivers in southern New Hampshire. However, only small remnants occur within historic and current pitch pine areas (see the Pine Barren habitat profile).

Despite local losses of specific grassland types (e.g., sand plain grassland) the amount of grassland in New Hampshire increased dramatically after European settlement. Much land was cleared for farmland in the eighteenth and nineteenth centuries, and grasslands abounded at that time (Askins 1997). In 1850 there were over 910,000 ha of improved farmland (hayfields and cropland) in New Hampshire (Silver 1957). However, when agricultural practices were abandoned and fields reverted to woodland or became developed during the twentieth century, grasslands and the species associated with them began their slow decline. Currently, there are approximately 101,175 ha of farmland in New Hampshire, and most of it is intensively managed so as not to be suitable for wildlife (Jones and Vickery 1997, USDA 2004).

2.3 Population Management Status

N/A

2.4 Relative Quality of Habitat Patches

Most of New Hampshire's grasslands are cultivated fields and are thus ill suited to most wildlife. Farm fields are either in a row crop (e.g., corn) or are used for hay or pasture. Hayed fields are typically mowed more than once during the breeding bird season, which likely destroys bird nests (Bollinger et al. 1990). Mowing more than once a season also harms grassland reptiles like black racers, smooth green snakes, and eastern garter snakes (Mitchell 2003). Roads and development fragment fields into patches that may not be big enough to sustain grassland-nesting birds. It also introduces more predators (e.g., cats, raccoons, foxes, crows, blue jays, etc.).

In a study of land use change in Rockingham and Strafford Counties, the University of New Hampshire CSRC documented a roughly 50% decline in active agricultural land from 1962 to 1998. Of the increase in developed land in Strafford County from 15,155 acres (1962) to 33,616 acres (1998), 3,487 acres were converted from active agriculture. In Rockingham County, of the increase in developed land from 36,519 acres (1962) to 98,417 acres (1998), 11,685 acres were converted from active agriculture (Fay Rubin, Complex Systems Research Center, unpublished report). In northern Coos County, where northern harriers breed in large grasslands, the amount of hayfield declined from 54% to 44% from 1982 to 1993 (Serrentino 1988).

2.5 Habitat Patch Protection Status

Only 8% of the grasslands larger than 10 ha are conserved in New Hampshire. The percentage of conserved grasslands by county ranges from 4 to 11% with the most area conserved in Merrimack and Strafford counties (11% each) and the least in Belknap county (4%).

2.6 Habitat Management Status

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 Conservation Reserve Program (CRP), Environmental Quality Incentive Program (EQIP), and Wildlife Habitat Incentives Program (WHIP), 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.

The Conservation Reserve Program provides financial incentives to landowners in the form of annual rent payments to encourage them to take highly erodible cropland out of production (FSA 2005). Financial assistance may also be provided to help establish a suitable cover crop or to restore habitats that were lost during agriculture conversion (e.g., floodplain forest).

The Conservation Research Program is not much used in New Hampshire. On average, only 85.5 ha were enrolled under this program between 2001 and 2003 (FSA 2002, FSA 2003a, FSA 2004). A major reason for this is that the rental rates paid to farmers are based on soil productivity and local dry land cash rates, and priority is given to projects with low costs (FSA 2003b). Since, on a nationwide scale, soil pro-

ductivity is relatively low and the local cash rates are high in New Hampshire and the northeast in general, CRP projects in this region are not often chosen for funding (figure 2). The Conservation Research Program would perhaps become a more viable option for farmers in this state if CRP acreage enrollment goals were established by region (e.g., Midwest, Northeast, etc.) (Oehler 2003).

The Environmental Quality Incentives Program offers financial and technical assistance to help agricultural producers install or implement structural and management practices on eligible agricultural land (NRCS 2005b). 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 2005, New Hampshire received nearly $8 million for EQIP.

The Wildlife Habitat Incentives Program encourages the creation of quality wildlife habitat on private land through technical and financial assistance (NRCS 2005c). Like EQIP, a WHIP Technical Committee in each state sets eligible habitat improvement practices. Like many states in the northeast, New Hampshire's list of eligible practices includes such things as brush management, prescribed burning, grass planting, and other practices applicable to grasslands (New Hampshire NRCS 2005b). Statistics are currently unavailable to determine how many ha have been treated with each of these practices. In 2005, New Hampshire received over $1,000,000 for WHIP.

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 (USFWS 2001). Since its inception, the Partners Program has restored over 40.5 ha of upland habitat (USFWS 2001).

New Hampshire Fish and Game administers the Small Grants Program that was established to fund all or part of the cost of small-scale habitat restoration and enhancement projects on privately owned lands. Up to $50,000 per year is committed to the Small Grants Program. The funds are obtained via a $2.50 habitat fee required of all who purchase a New Hampshire hunting license. Twelve habitat management practices are eligible for funding, of which three are relevant to grasslands. These include mowing to maintain grasslands and shrublands, establishment and maintenance of cool season grasses and clovers, and establishment and maintenance of warm season grasses (NHFG undated). Since 2000, 400 ha have been mowed, 31 ha have been planted to cool season grasses or maintained via soil amendments, and 3.5 ha have been planted to warm-season grasses or maintained via soil amendments (NHFG unpublished data).

Management on State Lands

The NHFG owns in fee-simple or under conservation easement just over 334 ha of fields (NHFG unpublished data). One-hundred-and-seventy-three ha are maintained in active agriculture (either hay or cropland), and the remainder is maintained via brush hog mower with mowing occurring every 1 to 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 not maintained. 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.

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.

2.7 Sources of Information

Sources of information for element 2 include journal articles, websites, GIS data, and white papers.

2.8 Extent and Quality of Data

It is difficult to ascertain how suitable the mapped grassland complexes are for grassland-related wildlife species. The minimum mapping unit for the New Hampshire Landcover Assessment was 30 square meters (CRSC 2001). This resolution is often too coarse to pick up hedgerows and tree lines that may separate fields and render them useless to area-dependent grassland birds. Higher resolution satellite imagery would be needed to adequately map and evaluate grassland complexes in an efficient manner. The alternative would be field ground truthing of mapped complexes to determine their suitability, but that would be extremely time consuming. Concentrating on larger complexes, especially those on state land, would be more manageable. Although Farm Bill and other financial assistance programs are used in New Hampshire and elsewhere in the country, little has been done to evaluate wildlife species' response to the management.

2.9 Condition Assessment Research

- Assess the availability of higher resolution satellite imagery to use to better map grassland complexes and their condition
- Assess the number of farmers currently more than once per season from the highest priority grasslands. Such an assessment could be used as an indicator of grassland health and could be monitored to track grassland health through time.
- 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

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Element 6: List of Figures

HABITAT PROFILE

Hemlock Hardwood Pine Forest

Associated Species: Timber rattlesnake, Northern Goshawk, Veery, Cerulaean Warbler, Eastern Pipistrelle, Eastern red bat, Northern myotis, Silver haired bat, black bear, bobcat

Global Rank: Not ranked
State Rank: Not ranked
Author: Carol R. Foss, Audubon Society of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

Hemlock hardwood pine forests are a transitional forest regions or "tension zones" in New Hampshire. In latitude and elevation, they occur between hardwood conifer forests to the north (mostly above 1,400 ft) and oak pine (Appalachian or central hardwood) forests to the north (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 *Pinus strobus* (white pine) and *Tsuga canadensis* (hemlock). Many of the other species of this system are common throughout eastern United States. Hemlock hardwood pine forests are found throughout the state from the White Mountains south below about 1,500 feet. 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 beech are the primary late-successional trees in this community, with maximum ages of about 500 and 300 years, respectively. *Quercus rubra* (red oak) and *Pinus strobus* (white pine) are also typically abundant, in contrast to their absence or low abundance in northern hardwood conifer forest systems. Most of the old-field white pine stands in central New Hampshire are successional examples of this system. *Acer saccharum* (sugar maple) and *Betula alleghaniensis* (yellow birch) 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 *Fraxinus americana* (white ash) is frequent, or locally abundant in patches of semi-rich sugar maple forests. *Picea rubens* (red spruce) and *Abies balsamea* (balsam fir) 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.), oaks (*Quercus* spp.) other than red oak, dogwoods, and southern herbs (see oak – pine forest description). These more southern species appear in occasional outposts in the south, where oak pine forests dominate.

Numerous herbs are ubiquitous in both the northern hardwood conifer and hemlock hardwood pine forest regions, including *Trientalis borealis* (starflower), *Aralia nudicaulis* (wild sarsaparilla), and *Maianthemum canadense* (Canada mayflower). Plants more prominent in hemlock hardwood pine forests than in northern hardwood conifer forests include *Hamamelis virginiana* (witch hazel), *Betula lenta* (black birch), *Prunus serotina* (black cherry), *Ostrya virginiana* (ironwood), *Viburnum acerifolium* (maple-leaved viburnum), *Gaultheria procumbens* (wintergreen), and *Gaylussacia baccata* (black huckleberry).

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 beech 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.

1.2 Justification

Hemlock hardwood pine forest is the most widely distributed forest type in New Hampshire, covering nearly 50% of the state's land area. Available data indicate that approximately 15% 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, Cooper's hawk, timber rattlesnake, and eastern hognose snake. Intense development in New Hampshire has reduced the area of this forest type 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.

1.3 Protection and Regulatory Status

Approximately 15% 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" (Cullen 1996) and "Good Forestry in the Granite State" (FSSWT 1996) provide recommended management practices for sustainable forestry in New Hampshire.

1.4 Distribution

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. Counties supporting less than 10% of this type include Merrimack, Carroll, Cheshire, Grafton, and Hillsborough.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

To develop a map of hemlock hardwood pine forest in New Hampshire a model was developed for each ecoregion subsection of the state based on the 2001 NH Land Cover Assessment, elevation, landform, and soils. The model was developed by experts from The Nature Conservancy (TNC) and the New Hampshire Natural Heritage Bureau (NHNHB).

First, relevant forested 2001 New Hampshire Land Cover Assessment grid values were combined with elevation ranges from sea level to 2,000 feet (CSRC 2001, USGS 2003). Ecological Land Units, created by The Nature Conservancy's Conservation Science Support, were then added to capture additional areas likely to have geo-physical conditions favorable to hemlock hardwood pine, or remove areas likely to have geo-physical conditions unfavorable to hemlock hardwood pine (TNC 2003). Specifically, north-facing side slopes and north-facing coves were removed from some land cover/elevation classes, and some land cover/elevation classes were restricted to only north-facing side slopes and north-facing coves. South-facing side slopes and south-facing coves were removed from some land cover/elevation classes, and some land cover/elevation classes were restricted to only south-facing side slopes and south-facing coves.

To further refine the model, soil types associated with hemlock-hardwood-pine were identified by Natural Resource Conservation Service scientists and selected from digitized county soil data, where available (e.g., Merrimack county soils have not been digitized) (NRCS 2002, Homer 2005). The soils were selected, and then clipped to only include forested areas based on the New Hampshire Landcover Assessment, and added to the existing model information. The same was done for Appalachian oak-pine, and then Appalachian oak-pine was used to erase areas from hemlock-hardwood-pine where there was overlap, so that Appalachian oak-pine takes precedence over hemlock-hardwood-pine. NHFG then applied a filter

to determine the majority forest type between neighboring polygons in the TNC model, and smoothed the boundaries to generalize the transition between matrix forest types. This process is expected to somewhat over-predict locations of Appalachian oak-pine, but to better capture broad patterns of Appalachian oak-pine.

Model results were reviewed by experts from TNC, NHFG, and NHNHB, who agreed that the broad patterns depicted by the model align with reasonable expectations. No ground truthing was conducted.

1.7 Sources of Information

The hemlock hardwood pine map was developed based on expert input from scientists from the NHNHB and the New Hampshire Chapter of The Nature Conservancy. The results were reviewed by additional scientists from the NHFG and the Audubon Society of New Hampshire. A variety of GIS data was used to generate the map including elevation data from the United States Geological Survey, landform data from The Nature Conservancy's eastern regional office, land cover data from the New Hampshire Landcover Assessment, and soils as outlined by Natural Resource Conservation Service scientists.

1.8 Extent and Quality of Data

The hemlock-hardwood-pine habitat map depicts broad landscape patterns but has limited fine-scale accuracy. Additional refinements will likely be necessary based on ground truthing of the existing map. The Natural Resource Conservation Service provided a table of soil series that were believed to be strongly correlated with hemlock-hardwood-pine and other forest types (Homer 2005). Soil series were provided by ecoregional subsection and elevation ranges. There was considerable overlap between series outlined for hemlock-hardwood-pine and some of the other forest types, especially Appalachian oak pine. However, the transition between Appalachian oak pine and hemlock hardwood pine was especially difficult to delineate. As such, the soil series that were thought to be most strongly correlated with hemlock hardwood pine but did not overlap with Appalachian oak pine were used in the mapping of hemlock hardwood pine. Additional review and refinement of the soils information is necessary for future iterations.

1.9 Distribution Research

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.

Element 2: Species/Habitat Condition

2.1 Scale

County

2.2 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 occurs. An additional approximately 3% decrease is projected to occur between 2001 and 2025 (calculated from data in SPNHF 2005).

2.4 Relative Quality of Habitat Patches

Analysis pending

2.5 Habitat Patch Protection Status

Approximately 15% of the potential hemlock hardwood pine forest area in the 9-county area where nearly 100% of this forest type occurs is in conservation ownership (calculated from TNC data).

2.6 Habitat Management Status

Approximately 10% of the 9-county area where nearly 100% of potential hemlock hardwood pine forest occurs is in certified Tree Farms (calculated from data in Thorne and Sundquist 2001).

2.7 Sources of Information
See 1.7

2.8 Extent and Quality of Data

See 1.8 regarding extent and quality of data associated with the TNC matrix forest map. Tree farm data from Thorne and Sundquist 2001 is based on a New Hampshire Tree Farm program database issued in August 2000. Data regarding changes in forest area from SPNHF 2005 include information from the New Hampshire Land Cover Assessment, 2001 and results of predictive modeling.

2.9 Condition Assessment Research

- Research is needed to determine the extent of this forest type that occurs in large unfragmented blocks
- Research is needed to determine the age class distribution of this forest type on the landscape

Element 3: Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
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.

(B) Direct Evidence
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). See also tables 2.2 and 3.1.

3.1.2 Development (Land Use Planning)

(A) Exposure Pathway
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.

(B) Direct Evidence
A Growth Management Advisory Committee convened by the NH 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 forest lands and wildlife habitat
- Communities seldom evaluate the potential impacts of their zoning ordinance or land use regulations (NHOSP 2000)

3.1.3 Introduced Species (Forest pathogens)

(A) Exposure Pathway
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 2004, infestations occurred throughout southern New England and in New Hampshire's Rockingham County. The adelgid is predicted to spread north and west throughout the southern half of New Hampshire by 2025 (Souto et al. 1996). 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).

(B) Direct Evidence
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 (USDA Forest Service1994). Infestations were detected in Portsmouth in 2000, Peterborough in 2001, Bedford and Epsom in 2002, Jaffrey in 2003, and Nashua and Hollis in 2004 (UNH Cooperative Extension 2004).

3.2 Sources of Information

Threat information was derived from a work session with forestry professionals and stakeholders, available data, published literature, and personal experience.

3.3 Extent and Quality of Data

Threats to hemlock-hardwood-pine forests resulting from the Hemlock Wooly Adelgid and resulting directly or indirectly from land conversion and development are well documented.

3.4 Threat Assessment Research

The major threats are adequately documented. Research should be directed to condition assessment and conservation actions.

Element 4: Conservation Actions

4.1.1 Incorporate Habitat Conservation into Local Land Use Planning
See Strategies: Local Regulation and Policy

4.1.2 Advise Conservation Commissions and Open Space Committees
See Strategies: Local Regulation and Policy, Education and Outreach

4.1.3 Promote Role of the Regional Planning Commissions in Landscape-Scale Conservation
See Strategies: Local Regulation and Policy

4.1.4 Protect unfragmented blocks and other key wildlife habitats
See Strategies: Land Protection

4.1.5 Develop a comprehensive land protection support program
See Strategies: Land Protection

4.1.6 Advocate adoption of sustainable forestry
See Strategies: Education and Outreach

4.1.7 Establish IRAT for Invasive Species
See Strategies: Interagency Regulation and Policy

4.1.8 Homeowner/landowner education series
See Strategies: Education and Outreach

4.1.9. Foster supply of native plants
See Strategies: Education and Outreach

4.2 Conservation Action Research

Research is needed to provide a sound scientific basis for new tools to help municipalities maintain large forest blocks and significant wildlife habitat in the face of development. Such research could include:

- Road noise effects on forest bird distribution and breeding status
- Behavior and land use of mesocarnivores in relation to development and road densities
- Bear use of mast stands relative to proximity of development
- Effects of residential lot sizes on habitat suitability and landscape permeability for selected wildlife species

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High Elevation Spruce-Fir Forest

Associated Species: Spruce Grouse, Bay-Breasted Warbler, Bicknell's Thrush, American Marten, Canadian Lynx, Northern Bog Lemming

Global Rank: NA
State Rank: High-elevation spruce-fir, S4; High-elevation balsam fir, S3S4; Montane black spruce-red spruce, S1; Northern hardwood-spruce-fir, S4

Authors: Jillian R Kelly, New Hampshire Fish and Game; Carol R. Foss, Audubon Society of New Hampshire

Element 1: Distribution and Habitat

1.1 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 in per 1000 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) and have been separated into 4 primary natural communities: high elevation spruce fir (S4), high elevation balsam fir (S3S4), montane black spruce-red spruce (S1), and northern hardwood-spruce fir (S4) (Sperduto and Nichols 2004).

High elevation spruce-fir forests can be found between 2,500 and 3,500 ft. in elevation on upper mountain slopes and ridge tops (Sperduto and Nichols 2004). According to Sperduto and Nichols (2004), forest composition has been influenced by disturbance history, soils, and elevation. High elevation soils are generally very nutrient-poor, with a deep, slowly decomposing humus layer and therefore can impact species composition and growth (Sperduto and Nichols 2004). Characteristic vegetation includes red spruce (*Picea rubens*), balsam fir (A*bies balsamea*) and heartleaf, paper and yellow birches (*Betula spp.;* Sperduto and Nichols 2004).

High elevation balsam fir forests are found within the spruce-fir zone (3,500 to 4,500 ft) and can be considered the transition zone to black spruce (*Picea mariana*)/balsam fir krummholz or heath/krummholz which was categorized with the alpine zone for this process (Sperduto and Nichols 2004, J. Oehler personal comm.). Fir waves are often found within this zone and are characterized as linear patches of blow down or standing dead trees, oriented perpendicular to the prevailing wind, and arranged in a progression of waves of different age regeneration (Sperduto and Nichols 2004). Characteristic vegetation includes balsam fir (dominant;), birch, and red spruce (occasional; Sperduto and Nichols 2004).

Montane black spruce-red spruce forests are uncommon to rare in New Hampshire and are found at mid to high-elevation valley bottoms (2,500 to 3,000 ft.) in the White Mountains (Sperduto and Nichols 2004). Characteristic vegetation includes black spruce, and red spruce, mixing in with balsam fir (Sperduto and Nichols 2004).

Northern hardwood-spruce-fir forests are a transitional forest type found at intermediate elevations (2,100 to 2,800 ft). This forest type generally has lower productivity, increased moisture availability, and a higher percent cover of herbaceous species compared to lower elevation forests (Sperduto and Nichols 2004).

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

1.2 Justification

High elevation spruce-fir forest has a very limited distribution in New Hampshire, covering approximately 4% of the state's land area. 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 Canadian 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 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 and 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.

1.3 Protection and Regulatory Status

Approximately 87% 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.

1.4 Habitat Distribution

High elevation spruce-fir habitat occurs in the White Mountain, Mahoosuc-Rangeley, and Connecticut Lake ecological subsections. High elevation spruce-fir can also occurs 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.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

High elevation spruce-fir habitat was mapped using the Vermont Institute of Natural Science (VINS) elevation threshold that was dominated by spruce-fir, developed as part of a model to predict Bicknell's thrush presence/absence in and around New Hampshire. The threshold descends with an increase in latitude and reflects climatic effects on forest composition and structure. The New Hampshire Land Cover Assessment dataset was also used in this mapping process to identify spruce-fir cover above the elevation threshold in New Hampshire (CSRC 2001). The result was then combined with Hale's (in press) Bicknell's thrush probability surface. Hale developed the model for the White Mountain National Forest using image-derived data layers of dominant vegetation height and distance to nearest fir sapling cover type, a digital elevation model, and point count data to parameterize a multivariate logistic habitat model. Areas identified by Hale's probability surface and fir

sapling land cover, were included even if they fell below the VINS elevation threshold.

1.7 Sources of Information

High elevation spruce-fir habitat was identified using models developed by Hale (in press), Vermont Institute of Natural Science (VINS: Lambert et al. in press) combined with the New Hampshire Land cover analysis (CSRC 2001) and New Hampshire Natural Heritage Natural Communities of New Hampshire publication (Sperduto and Nichols 2004). Literature review and meetings with field experts also were used in the process.

1.8 Extent and Quality of Data

Information on high elevation spruce-fir distribution was derived primarily from the NHNHB description of Natural Communities in New Hampshire, and a literature search.

1.9 Distribution Research

Distribution research should concentrate on the historical distribution and abundance of high elevation spruce-fir, 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.

Element 2: Species/Habitat Condition

2.1 Scale

Conservation-planning units for the high elevation spruce-fir habitat were based on watershed, land ownership, and proximity of multiple patches of high elevation habitat to one another (figure 2). Patches of habitat smaller than 5 acres were excluded from this analysis. Some analysis was also performed at the county scale.

2.2 Relative Health of Habitat

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.

An approximately 3% decrease in forest area occurred between 1992 and 1993 and 2001 in the two-county area where approximately 95% of New Hampshire's potential High Elevation Spruce-Fir forest occurs. An additional approximately 1% decrease is projected to occur between 2001 and 2025 (Calculated from data in SPNHF 2005).

2.3 Population Management Status

N/A

2.4 Relative Quality of Habitat Patches

Habitat units mapped at the scale defined for this process that would provide key ecological attributes include all the large patches, virtually all the medium patches and most of the small patches. Habitat patches that may not provide key ecological attributes include smaller (less than 50 acres) patches, which are isolated from larger patches.

The largest habitat patches can be found in the WMNF. Smaller patches include ridgelines moving north toward the Canadian border (figure 2). Trends or viability of key habitat for conservation actions include conservation of critical Bicknell's thrush habitat in WMNF, and recent conservation initiative to conserve the northern most high elevation spruce-fir crucial to more northern boreal species that will aid in linkages between high and low elevation spruce-fir forests.

2.5 Habitat Patch Protection Status

All of the large patches are currently in conservation ownership (WMNF). Ownership of medium-sized patches is distributed between the state, WMNF, and large private landowners. Of the 13 medium patches, five are preserved, two are conserved, and six are regulated under the High Elevation MOU. Of the six regulated patches, four also have zoning as PD6 zones part of an unincorporated town. Of the five small patches, one is preserved, two are unknown, and two are regulated under the High Elevation MOU and zoning for unincorporated towns.

Habitat management and restoration of high elevation spruce-fir has been highly effective. 92.1% of the high elevation habitat in New Hampshire is currently conservation land, or under guidance of a conservation easement. Virtually all of the remaining 7.8% falls under unincorporated town restrictions as PD6 zones, and/or have agreed to the State's high elevation MOU. The remaining (less than 1%) is unprotected by the high elevation MOU, conservation, easement, or unincorporated town zoning.

2.6 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.

2.7 Sources of Information

Guide to the natural communities of New Hampshire (2004), Master Plan for the Unincorporated Places in Coos County (1989), Zoning Ordinances for Coos County unincorporated places (1991), New Hampshire High Elevation MOU (1996) were used as sources regarding habitat and distribution of high elevation habitat.

2.8 Extent and Quality of Data

See 1.8 regarding extent and quality of data associated with the TNC matrix forest map. Data regarding changes in forest area from SPNHF 2005 includes information from the New Hampshire Land Cover Assessment, 2001 and results of predictive modeling.

2.9 Condition Assessment Research

- Research is needed to determine the age class distribution of this forest type on the landscape.
- Research is needed to determine the proportions and distributions of live and dead/dying stands of this forest type.

Element 3: Habitat Threat Assessment

3.1.1 Acid Deposition

(A) Exposure Pathway
Combustion in vehicle engines, power plants, and other industrial processes generates nitrogen oxides and sulfur oxides, which enter the atmosphere and are transformed into acids. These chemicals can travel for hundreds of miles in the upper atmosphere before returning to earth as acid precipitation or dry deposition. In New Hampshire, vehicles generate 51% of nitrogen oxide emissions, while power plants generate 90% of sulfur oxide emissions and 39% of nitrogen emissions (NHDES 1989). However, much of the acidic deposition in the state comes from heavily industrialized areas in the mid-western and southwestern United States (New Hampshire Comparative Risk Project 1997). Acid deposition resulting from the emission of sulphur dioxide and nitrogen oxides leaches calcium from forest soils, thus making trees, especially high elevation spruce-fir, susceptible to stress. Sulphur and nitrogen oxides occur naturally, but more than 90% of the sulphur and 95% of the nitrogen in eastern North America originate from human sources, including emissions from the use of coal to produce electricity, base metal smelting, and fuel combustion in vehicles (www.atl.ec.gc.ca/msc/as/acidfaq.html).

(B) Direct Evidence
Northern New Hampshire, where most of the State's high elevation spruce-fir forest is located lies within an area of particularly low pH precipitation and high nitrate and excess sulfate deposition (Freedman 1995). Long-term data from the Hubbard Brook Experimental Forest document a long history of severe acid deposition (Likens et al. 1984).

Evidence of the severity, urgency, and underlying mechanisms of the threats associated with acid deposition in high elevation spruce/fir includes: Brynne Lazarus et al. (2004), Fermandez et al. (2003), Johnson et al (1986), Craig and Friedland (1991), Dehayes et al. (1999).

According to Lazarus et al. (2004), acid deposition is a significant factor contributing to the loss of spruce due to winter injury. Winter injury has been linked to the overall widespread decline of red spruce, particularly in the northeast (1960-1980). Johnson et

al. (1986) found that acidic compounds and heavy metals are approximately 3 to 8 times higher in high elevation coniferous forests than in adjacent low elevation hardwood forests. High deposition rates are likely the result of interception of compounds from cloud water.

3.1.2 Energy and Communication Infrastructure

(A) Exposure Pathway
Federal legislation and tax incentives have resulted in a rapid increase in wind energy development proposals. Currently, regulating state agencies and local governments have little information on the long-term local impacts and cost effectiveness of wind farms. Therefore, the ability to respond to proposals and mitigate impacts is limited. The direct threat is to the unique and fragile habitats of wind farm sites, as well as to the wildlife species associated with high elevation spruce-fir habitats. The development of wind farms results in a direct loss of habitat through road and facility construction and maintenance. Species such as spruce grouse, bay-breasted warbler, marten, Canada lynx, and Bicknell's thrush experience a direct loss of habitat as well as habitat fragmentation.

(B) Direct Evidence: Evidence that can be used to evaluate the severity, urgency, and underlying mechanisms of the threats associated with wind farm development on high elevation spruce-fir includes: USFWS (2003), Watefield (2003), PIF, VINS, Windpower Monthly (2003), Wind Power Development in Vermont and Bicknell's Thrush: A Primer

3.2 Sources of Information

Threat information was derived from a work session with forestry professionals and stakeholders, available data, published literature, and personal experience.

3.3 Extent and Quality of Data

Documentation on the impacts of wind farm development is limited to short-term studies. Evidence of timber harvesting impacts is based primarily on local expertise, as well as some research. Evidence on climate change and acid deposition is extensive and is concentrated primarily on extreme conditions, such as those found at higher elevations.

3.4 Threat Assessment Research

Information on presence, abundance, and population trends of species characteristic of high elevation spruce-fir should be of priority to collect. Impacts of climate change, forestry operations, acid deposition, and succession will be important as threats shift in impact and severity.

Element 4: Conservation Actions

4.1.1 Advise Integrated Interagency Wind Energy Risk Assessment Team, Regulation, and Policy

(A) Wind Farm Development

(B) Justification

- 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
- A measurable ecological response will be the amount of habitat that can be maintained or saved due to the complete documentation on wind farm impacts
- The spatial scale of the action is appropriate for the scale of the threat (regional)
- The timeframe for the action is immediate
- The action can be adapted based on new information

(C) Conservation Performance Objective
There is a need to understand the potential long and short-term implications of wind farm development, specifically on high elevation spruce-fir and the associated wildlife species in the Northeast.

(D) Performance Monitoring
Examining implications on other wind farm projects and identifying projects that have been approved should aid in performance monitoring.

(E) Ecological Response Objective
The ecological response objective is no net loss or impact on high elevation spruce-fir.

(F) Response Monitoring
To monitor the response the overall amount of high elevation spruce-fir should be tracked, especially as new data become available. Examining potential impacts of projects on habitat and associated species within the Northeast will also be important if wind towers are built in a specific area.

(G) Implementation
Implementation should occur through the NHFG, USFWS, and research through UNH.

(H) Feasibility: 1.25

4.1.2 Review of Master Plan for the Unincorporated Places in Coos County, Regulation and Policy

(A) Direct threats affected: Energy and Communication Infrastructure, Unsustainable Harvest (Forestry Operations and Management), Recreation, and Development

(B) Justification:

- Revision of the Master Plan for Unincorporated Towns, specifically dealing with development associated with wind farms, communication towers, ski areas and residential will lessen the relevant threats at specific locations.
- The beneficial ecological response will be no net loss or fragmentation of high elevation spruce-fir outside of protected areas.
- The spatial scale of the action is appropriate because of the 7.9% of the high elevation spruce-fir outside of conservation, only 0.3% is outside of the unincorporated towns.
- The timeframe is appropriate because the unincorporated towns planning board is currently dealing with proposals listed as threats.
- The conservation action can be adapted based on new information collected pertaining to the threats.

(C) Conservation Performance Objective
The conservation performance objective is to have more permanent regulation for high elevation spruce-fir habitat, specifically to deal with wind farm and communication tower proposals. Coordinate with the county commissioners in reviewing the unincorporated places master plan and zoning ordinances. For example, examine the guidelines of timber harvesting at high elevations as they relate to development proposals.

(D) Performance Monitoring
Performance monitoring can be done by examining the extent of fluctuation in high elevation spruce-fir area in the unincorporated towns. Actual changes to unincorporated town zoning can also provide an indication of performance.

(E) Ecological Response Objective
The desired ecological response is a decrease or stabilization in the loss of high elevation spruce-fir. Wildlife habitat in current and potential high elevation spruce-fir will be enhanced by minimizing the number of proposals that are approved without sufficient knowledge.

(F) Response Monitoring
Response monitoring can be done by mapping and monitoring habitat as new data become available (e.g., GIS data).

(G) Implementation
Implementation can be done through NHFG as data become available.

(H) Feasibility: 3.28

4.1.3 Protection and easements on remaining high elevation spruce-fir habitat, Habitat Protection

(A) Direct threats affected: Energy and Communication Infrastructure, Unsustainable Harvest (Forestry Operations and Management), Recreation, Development

(B) Justification

- The conservation action will address the threats by assessing protection based on the percentage of land with specific protection or

conservation status.

- The protection, conservation, and easements can concentrate on the most ecologically significant habitats, or on those in need of the most protection based on threats.
- The time frame is appropriate for the immediate threat to portions of the high elevation spruce-fir habitat.

(C) Conservation Performance Objective
To increase the amount of habitat protected or managed.

(D) Performance Monitoring
Assess the amount of high elevation spruce-fir (with GIS) with no conservation easements and or regulation to minimize loss and impacts.

(E) Ecological Response Objective
The stabilization or gain of high elevation spruce-fir habitat and associated species

(F) Response Monitoring
Response monitoring can be done by mapping habitat and monitoring associated high elevation wildlife species.

(G) Implementation
Implementation can be done through continued use of the High Elevation MOU, and through evaluation and expansion of unincorporated town zoning.

(H) Feasibility: 1.75

4.1.4 Education and outreach on causes, effects, and potential reduction of acid deposition

(A) Direct threats affected: Climate Change, Acid Deposition

(B) Justification

- The spatial scale of the threat is global, yet can be addressed statewide.
- The threats are current, and should be addressed as soon as possible.
- The conservation action can be adapted to new information.

(C) Conservation Performance Objective
The conservation performance objective is to decrease the loss of spruce-fir due to climate change and acid deposition.

(D) Performance Monitoring
Identifying the amount and quality of high elevation spruce-fir habitat can be the performance-monitoring objective.

(E) Ecological Response Objective
The ecological response objective is to increase or stabilize the amount of high elevation spruce-fir.

(F) Response Monitoring
Response monitoring can be done by identifying long-term changes in high elevation spruce-fir. Remapping the habitat when new data is available can do this.

(G) Implementation
NHFG can do the mapping using GIS. Education should occur at the state or national level.

(H) Feasibility: 1.25

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HABITAT PROFILE

Coastal Transitional Watersheds

Associated Species: American Eel (Anguilla rostrata), Atlantic Salmon (Salmo salar), Bridle Shiner (Notropis bifrenatus), Burbot (Lota lota), Brook Trout (Salvelinus fontinalis), Lake Trout (Salvelinus namaycush), Lake Whitefish (Coregonus clupeaformis), Rainbow Smelt (Osmerus mordax), Round Whitefish (Prosopium cylindraceum), Slimy Sculpin (Cottus cognatus), Sunapee trout (Salvelinus aureolus), Tessellated Darter (Etheostoma olmstedi).

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Author: New Hampshire Fish and Game and The Nature Conservancy

Element 1: Distribution and Habitat

1.1 Habitat Description

Coastal transitional watersheds encompass watersheds with low elevation and some areas of moderate elevation between 800-1,700 ft. These watersheds include major tributaries to the Merrimack River and those watersheds dominated by large lakes and their tributaries in New Hampshire's Lakes Region. Acidic bedrock and sandy outwash plains are dominant. Several watersheds extending into Maine have a much higher percentage of calcareous bedrock, but these enriched sections do not influence the New Hampshire headwaters. The larger rivers in this watershed group are low gradient and meandering. There are greater percentages of moderate and high gradient tributaries in this watershed group than in the low tidal and low non-tidal groups, although low and very low gradient tributaries still dominate and very high gradient tributaries are nonexistent.

Habitats in this group are dominated by riffle-pool systems. There are some habitats with step-pool systems in high gradient areas and some with dune-ripple systems in areas of very low gradient, high sinuosity, and deep sands. Fish communities are dominated by warmwater species, although some coldwater communities may be found in areas with high groundwater input and/or higher elevation. The large lakes found in this watershed group provide unique habitats for a variety of lake-associated plant and animal species.

Low-Moderate Fine Scale Systems 10 and 14

Due to its proximity to the lower Merrimack River mainstem, fine scale system 10 is very similar to fine scale systems 11 and 12, although system 10 has substantial areas of moderate elevation, steeper landforms, and higher gradient tributaries. Fine scale systems 10 and 14 have nearly identical elevation profiles. Both are acidic in geology, but system 14 is more acidic-granitic and is dominated by very large lakes and/or streams feeding into these large lakes.

1.2 Justification

The most compelling and unique habitats in this watershed group are the large lakes in the Lakes Region and the sandy, meandering, and large tributaries to the Merrimack River in south-central New Hampshire. The Lakes Region is unique due to its large, deep, warmwater and coldwater fisheries and the watersheds that support them. The large Merrimack River tributaries include rivers that are larger, flatter, lower in elevation, and likely warmer than the large tributaries to the north. For example, these watersheds average over 348 km^2 (86,000 acres) compared to 188 km^2 (46,500 acres) for the Pemigewasset tributary watersheds just to the north. These large

Merrimack River tributaries are crucial for supporting numerous native and diadromous fishes.

1.4 Habitat Distribution

Low-moderate major watersheds occur in 14 watersheds in New Hampshire's larger tributary streams and rivers of the Merrimack River basin. They include watersheds that range from as far south as the Souhegan River watershed, to watersheds encompassing the drainages of the Lakes Region and the Ossipee River. Other major rivers in this habitat group include the main stems of the Piscataquog and Lower Contoocook Rivers to the west, and the Suncook, Soucook, Winnipesaukee Rivers to the east. Watersheds in this habitat group also surround Lakes Winnipesaukee, Winnisquam, Squam, Wentworth, and Ossipee. The easternmost watersheds are primarily in Maine, with the New Hampshire portions encompassing the acidic sandy outwash plains of the Ossipee and Little Ossipee headwaters.

This watershed group sits entirely within the Merrimack-Saco-Charles River Ecological Drainage Unit (EDU). This group primarily overlaps with the Southern New England Coastal Hills and Plains and the New Hampshire-Vermont Upland subsections of TNC's Lower New England-Northern Piedmont Ecoregion.

1.8 Extent and quality of data

Like all other major and fine scale habitat groups, elevation is the primary parameter defining low-moderate watersheds. Gentle side slopes and hill slopes are associated with the low to moderate elevations. Similar to other major watershed groups across New Hampshire, this watershed group has acidic bedrock. The rivers in these watersheds are acidic, moderately sloped rivers dominated by the sandy and cobble substrates characteristic of the Merrimack River drainage. While some watersheds and rivers in the moderate elevation-south major watershed group (fine scale system 9) share characteristics with this group, cold headwater streams at higher elevations are more dominant.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the large land area covered by the major watershed groups (Figure 3), a fine scale classification (Figure 4) was used, when possible, to assess the relative condition of aquatic habitats across the state. The types and sources of information were extremely variable and covered many different scales, and so the following sections refer to both the major and fine scale systems. The actual scale at which the natural conditions and processes lead to differences in aquatic communities is unknown.

Low-moderate major watersheds (Figure 3) include major tributaries to the Merrimack River and watersheds dominated by large lakes in New Hampshire's Lakes Region. They are divided into two conservation planning units. Fine scale system 10 contains 6 watersheds of the major tributaries to the Merrimack River. Fine scale system 14 includes 8 watersheds that contain large lakes and their adjacent tributaries (Figure 4).

2.2 Relative Quality of Habitat Patches

Fine scale system 10 encompasses 3,017 km^2 (745,406 acres). Headwater streams (watershed area <48.28 km^2) dominate, comprising 85% of the total river/stream area. Small rivers (watershed area of 77.7-518.0 km^2) and medium rivers (watershed area of 518-2590 km^2) comprise 8% and 7% of the total river/stream area, respectively.

Fine scale system 14 encompasses 1,686 km^2 (416,611 acres). Headwater streams dominate, comprising 73% of the total river/stream area. Small rivers and medium rivers comprise 20% and 7% of the total river/stream area, respectively.

The Contoocook and North Branch Rivers provide several significant habitats and resources. The rivers and adjacent areas provide habitat for 117 bird species, including the pied-billed grebe (*Podilymbus podiceps*), bald eagle (*Haliaeetus leucocephalus*), common loon (*Gavia immer*), osprey (*Pandion haliaetus*), northern harrier (*Circus cyaneus*), common nighthawk (*Chordeiles minor*), eastern bluebird (*Sialia sialis*), purple martin (*Progne subis*), and great blue heron (*Ardea herodias*). There are 48 mammals and several endangered plant species present. The Contoocook

River provides both warm and coldwater fish habitat with its variety of surface waters, including rapids, impoundments, and slow waters. The Contoocook River is also an important area for the recovery of anadromous fish in the Merrimack River watershed. The Contoocook and North Branch Rivers have 25 and 5 impoundments, respectively, that are used for hydroelectricity, water storage, and flood control. The 7 major water withdrawals from the Contoocook River are used for town water supplies, sewage treatment, and industrial operations and account for more than 75,708L (20,000 gal) of water per day. There are 26 permits to discharge water from hydroelectric, wastewater treatment, and industrial facilities in the Contoocook River (NHDES 1991).

The three branches of the Piscataquog River (middle, north, and south) have excellent water quality and provide adequate habitat for several species of concern. Despite increased trends in development throughout the watershed, the river maintains pristine characteristics. A total of 4,407 ha (10,890 ac) of land along the river are protected. The watershed supports several bird species, including pied-billed grebe, peregrine falcon (*Falco peregrinus*), common loon, osprey, northern harrier, Cooper's hawk (*Accipiter cooperii*), and common nighthawk. There are amphibians and reptiles such as eastern hognose snake (*Heterodon platirhinos*), Blanding's turtle (*Emys blandingii*), eastern box turtle (*Terrapene carolina*), wood turtle (*Clemmys insculpta*), and spotted turtle (*Clemmys guttata*), and an exceptional abundance of the brook floater mussel (*Alasmidonta varicosa*). The diverse riffle-pool habitats of this 95.7% free-flowing system support both warm and coldwater fish species. The Piscataquog River is one of the most important Atlantic salmon nursery tributaries to the Merrimack River in southern New Hampshire. The watershed supports an exceptionally rare orchid and the small whorled pogonia (*Isotria medeoloides*). Impoundments along the Piscataquog River are used for hydroelectricity production and water storage. There are no permits for water discharge and only one permitted water withdrawal site for irrigation (NHDES 1993).

The Souhegan River in south-central New Hampshire also faces increased pressure from development. While local populations have continued to grow, there are still large areas of undeveloped land along the river. Land use is typically rural, with forests broken up by scattered residential housing. The river flows through more developed village centers. Several towns have produced plans for land use and other regulatory controls. In many towns, there are conservation areas for floodplains, wetlands, and aquifers. The Souhegan River provides a travel corridor for wildlife through areas with high population densities. The eastern hognose snake, blue spotted salamander (*Ambystoma laterale*), Blanding's turtle, spotted turtle, marbled salamander (*Ambystoma opacum*), great blue heron, Long's bitter cress (*Cardamine longii*), wild lupine (*Lupinus perennis*), bird's foot violet (*Viola pedata*), Siberian chives (*Allium schoenoprasum* var. *sibiricum*), skydrop aster (*Symphyotrichum patens* var. *patens*), goat's rue (*Tephrosia virginiana*), stiff tick-trefoil (*Desmodium obtusum*), and giant rhododendron (*Rhododendron maximum*) are examples of the 28 threatened or endangered species observed within the river corridor (NHDES 2000, Souhegan Watershed Association (SWA) 2003).

There is habitat for both warm and coldwater fish species. The Souhegan River is a productive Atlantic salmon nursery with adequate water temperatures, dissolved oxygen levels, food sources, and downstream fish passages on all impoundments, although there are no upstream fish passages. The Souhegan River is largely free flowing. Hydroelectric facilities operate by run-of-the-river methods. There are 9 registered water withdrawals for agricultural, industrial, irrigation, and municipal water supplies. There are 5 permitted discharge sites from municipal and industrial wastewater treatment facilities. Nonpoint source pollution is the greatest threat to water quality of the Souhegan River. Runoff from fertilizers, pesticides, herbicides, stormwater, and faulty septic systems can lead to excessive nutrients in the river system (SWA 2003).

Lakes and ponds throughout the watersheds of the Lakes Region and outer Merrimack River in New Hampshire were examined using GIS analysis. Lakes and ponds with surface areas less than 4.05 ha (10 ac) comprise 90% of the total number of lakes and ponds. There is a high concentration of large lakes in this area. Seven lakes are greater than 405 ha (1,000 ac) (Merrymeeting Lake (499 ha), Ossipee Lake (1,628 ha), Paugus Bay (497 ha), Squam Lake (2,748 ha), Wentworth Lake (1,253 ha), Winnipesaukee Lake (17,982 ha), and Winnisquam Lake (1,705 ha). There is an average density of 5.79 lakes/ponds greater than 4.05 ha per 100 km^2 in this unit. Most lakes

and ponds (81%) are at elevations of 6.10-243.84 m (20-800 ft), and 19% are at elevations of 243.84-518.16 m (800-1,700 ft).

2.3 Population Management Status

N/A

2.4 Relative Health of Populations

Land Use

Compared to other areas of New Hampshire, road density is high in this watershed group. Within fine scale system 10, the density of roads maintained by NHDOT is 1.15 km/km^2 (km of road/km^2 of land area) and the density of private/gravel roads is 0.82 km/km^2. Of the total land area of fine scale system 10, unfragmented land comprises 69%, developed land 5.8%, and agricultural land 6.9%. When compared to other systems in the state, both the percentage of agricultural land and the estimated population for 2005 (199,214 people or 65.5 people/km^2) are relatively high.

The high rate of population increase in the Lakes Region of New Hampshire has been well documented (Lakes Region Planning Commission (LRPC) 2004, SPNHF 2005). Since the completion of Interstate 93 in the 1960s, the population in the Lakes Region has doubled (LRPC 2004). In fine scale system 14, the estimated population for 2005 is 47,124 people (25.0 people/km^2). As a result of this population boom, there have been several negative impacts to the natural landscape, such as increased densities of fragmented land, roads, industrial activity, and residential development (LRPC 2004). The construction of impervious surfaces (e.g., roads, parking lots, and structures) can lead to increased stormwater runoff that carries non-point source pollutants. Within fine scale system 14, the density of roads maintained by NHDOT is 0.88 km/km^2 and the density of private/gravel roads is 0.92 km/km^2, which is the highest density of private/gravel roads in this area of New Hampshire. Of the total land area of fine scale system 14, 67% is unfragmented, 5.8% is developed, and 2.5% is agricultural land.

Estimated increases in census blocks adjacent to lakes and ponds were analyzed using 1990 and projected 2020 values (see Lake Type Classification for methods). The changes in housing density in rural (<0.063 housing units/ha), exurban (0.063-0.25 housing units/ha), and suburban (0.25-2.5 housing units/ha) areas could indicate increases in shoreline development, impervious surfaces, and nonpoint source pollution. Population estimates for 2005 census blocks predict that housing densities adjacent to lakes will change from suburban to urban at one lake/pond, exurban to suburban at 233 lakes and ponds, and rural to exurban around 198 lakes and ponds.

Water Quality

The LRPC (2004) identified the primary threats to lakes and rivers of the Lakes Region. Several pathways contribute to non-point source pollution. Pollutants in stormwater runoff can be amplified by increased impervious surfaces, malfunctioning septic systems, erosion and sedimentation, and improper drainage systems. The lack of surface water quality data is also a concern (LRPC 2004).

The New Hampshire Lakes Lay Monitoring Program (LLMP) conducts water quality surveys in Lake Winnipesaukee and Squam Lake. Overall, surveys indicate excellent to pristine-like water quality with high transparency, suitable dissolved oxygen, low nutrients (phosphorus), and low algal plant levels (chlorophyll *a*). Some areas within both lakes have slight algal blooms with the intensity varying from year to year (Lake Winnipesauke Watershed Association (LWWA) 2002, Squam Lakes Association (SLA) 2004). Mercury from airborne pollution is identified as a chronic problem to all lakes in the Lakes Region (LRPC 2004).

The surface water quality of 12 tributaries to Lake Winnipesaukee was studied in 2004 as part of the New Hampshire Department of Environmental Services (NHDES) Volunteer Rivers Assessment Program (VRAP). The only tributary that failed to meet state water quality standards for dissolved oxygen and turbidity was Hawkins Brook in Meredith. Five of eight dissolved oxygen measurements and one turbidity measurement from Hawkins Brook failed to meet state standards for class B waters. The range of pH values (pH 6.13-7.40) fell below state water quality standards for class B waters (pH 6.50-8.0) and 32% of pH samples were below state water quality standards. Acid precipitation and natural environmental conditions (e.g. soils, geology, wetland drainage) can lower pH values (NHDES 2004).

Surface water quality of the Piscataquog River was studied in 2002, 2003, and 2004 as part of the

NHDES VRAP (NHDES 2002, NHDES 2003, NHDES 2004). Turbidity levels consistently met state requirements for class B waters. Most samples (97%) met state standards for class B waters (6.50-8.0 mg/L). The range of pH values (pH 5.38-7.15) from 2002-2004 was below state water quality standards for class B waters (pH 6.50-8.0). Acidic precipitation and natural environmental conditions (e.g. soils, geology, wetland drainage) can lower pH values.

Surface water quality of the Soucook River was studied in 1999 and 2003 as part of the NHDES VRAP (NHDES 1999, NHDES 2003). Turbidity levels exceeded state minimum standards for class B waters. Three percent of dissolved oxygen samples were below state water quality standards in 1999 (range 3.12-11.16 mg/L) and samples exceeded state water quality standards in 2003. In 1999, 33% of water pH samples (pH 5.43-7.31) and in 2003 27% of water pH samples (pH 5.57-7.57) were below state water quality standards.

The number of point source pollutant sites regulated through NHDES is relatively low in these areas. The number of National Pollutant Discharge Elimination System (NPDES) permits for fine scale system 10 and fine scale system 14 are 0.012 and 0.006 NPDES permits/river km, respectively.

Invasive Species

The two fine scale systems within this area have the highest occurrences of exotic aquatic plants in New Hampshire. Variable milfoil (*Myriophyllum heterophyllum*) has been documented in at least 28 water bodies in fine scale system 10 and fine scale system 14. Examples of water bodies with documented infestations of variable milfoil include Crescent Lake (1980), Gorham Pond (2000), Hopkinton Lake (2000), Jones Pond (2003), Little Suncook River (2000), Northwood Lake (1990), Ossipee Lake (1995), Silver Lake (1995), Squam River (2000), Squam Lakes (2000), Waukewan Lake (1980), Winnipesaukee Lake (1970), Winnipesuakee River (2000), and Winnisquam Lake (1995) (Smagula 2004).

To assess the likelihood that recreation or stocking contribute to invasive fish and aquatic plants, the degree of remoteness of lakes and ponds was analyzed through GIS. The results indicate that 2,956 lakes and ponds (95.8%) are within 500 m of a trail or road, 103 lakes and ponds (3.3%) are enclosed by a protective buffer of 500-805 m without a mapped road or trail, and 26 lakes and ponds (0.8%) are enclosed by a protective buffer of 805-1609 m without a mapped road or trail. Only one pond has a buffer greater than 1609 m (1 mile).

The LRPC (2004) identified invasive plants that are carried on boats or sold commercially as the primary threat to lakes and rivers of the Lakes Region. The rivers and lakes in this system are increasing in popularity for recreation. There were 100,935 boats registered in New Hampshire in 2003 (LWWA 2004), many of which will be used in the lakes region, and the number of hours spent by anglers in bass tournaments increased from 8,304 to 23,084 hrs in just four years from 1996-2000 (LWWA 2004). The increase in recreation could lead to an increased risk of invasive species infestations. The LWWA estimates that 10% of the 2100 boats inspected by lake hosts in 2003 were carrying plants (LWWA 2004). The Lake Host program has prevented the spread of fanwort in 2003 and stopped variable milfoil from entering or leaving Lake Winnipesuakee in 2004 (New Hampshire Lakes Association (NHLA) 2004).

Several non-native fish populations have become naturalized within the watersheds of the Lakes Region and Merrimack River. Increased water temperatures and altered habitats from large impoundments facilitate proliferation of these species. Several of these fish provide sport-fishing opportunities. Illegal stocking by fishermen is a major source of non-native fish introductions. Largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), rock bass (*Ambloplites rupestris*), bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), landlocked Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*), and rainbow trout (*Oncorhynchus mykiss*) are examples of species that have naturalized populations in New Hampshire (New Hampshire Fish and Game Department (NHFGD) 2004, Estuarine and Freshwater Working Group 2005). Landlocked Atlantic salmon, brown trout, and rainbow trout are annually stocked by NHFGD.

Hydrology

There are approximately 579 active dams/impoundments in fine scale system 10 and 157 in fine scale system 14. The number of impoundments in fine scale system 10 and fine scale system 14 is 0.077/river km and 0.039/river km, respectively. Fine

scale system 10 has a very high concentration of impoundments per river kilometer when compared to other areas of New Hampshire.

Culverts at stream crossings likely create additional habitat fragmentation. Because road density is relatively high in this area, there may be an increased number of road and stream intersections. Each crossing is a potential cause of fragmentation and a point of entry for stormwater runoff containing petrochemicals and road sands and salts.

An excessive amount of drinking water withdrawals is identified as a concern for lakes and rivers of the Lakes Region (LRPC 2004). Water withdrawals can lower water levels and reduce instream habitat. Aquatic species that are limited to thermal refuges in the summer may be further impacted from water withdrawals, which are often greatest during this time.

2.5 Habitat Patch Protection Status

Within fine scale system 10, conserved land comprises 13.3% of total land area and unfragmented land comprises 16%. Within fine scale system 14, conserved land comprises 14.7% of total land area and unfragmented land comprises 19%.

The Contoocook, Pemigewasset, Piscataquog, and Souhegan Rivers are each designated in the New Hampshire Rivers Management and Protection Program (RMPP) (NHDES 2004). The RMPP regulates dam construction, instream water flow levels, channel modification, water quality, solid and hazardous waste storage/treatment facilities, and motorized boat traffic.

2.6 Habitat Management Status

It is difficult to assess the efforts to restore and manage habitats at such a broad level. A database of conservation groups may enhance cooperative efforts and eliminate redundancy and repetition. There are conservation and management plans for the upper Merrimack, Piscataquog, and Souhegan Rivers. These plans identify ecologically significant areas and guide human use and management of these areas. Public outreach and education are identified as useful tools for conserving and restoring these watersheds. Because these plans provide highly detailed information at local levels, they should be used to help identify sensitive areas, local impacts, and management actions.

The NHLA is a statewide organization committed to the preservation and protection of lakes and ponds in New Hampshire. Through collaboration with lake associations, state agencies, and educators, the NHLA is enhancing shoreline and watershed protection, water quality, boating safety, lake environment education, and fish and wildlife preservation (NHLA 2001).

Several agencies are actively involved in habitat restoration projects and identifying potential areas of habitat enhancement or improvement. Ongoing or recently completed projects include the mapping of ecologically significant areas, reviews of environmental impacts and dam relicensing, riparian buffer and stream bank stabilization, developing conservation easements, invasive plant and water quality monitoring, creating a task force for dam removal, NHDES fish biomonitoring, landowner education, and annual river clean ups. Restoration efforts include the restoration of Atlantic salmon and brook trout populations and warmwater fish passage.

The NHDES Weed Watcher program trains volunteers to collect plant data and detect infestations of invasive plant species in the early stages when eradication may still be possible (NHDES 2002). In 2005, 110 lakes throughout New Hampshire have Weed Watcher programs (Amy Smagula, NHDES, personal communication).

There are two pilot projects being conducted by NHDES on the Souhegan and Lamprey Rivers to determine the instream flows needed to retain the ecological integrity of the river and supply water for various users. The studies will be used to inform future studies on other designated rivers in the state.

2.8 Extent and Quality of Data

The information on current habitat quality and restoration efforts gathered from literature reviews was highly concentrated on larger rivers of this habitat group. The smaller rivers within this habitat group were not well represented. Information obtained from GIS analyses may not accurately represent all physical features.

2.9 Condition Assessment Research

Increasing sampling of aquatic communities and water quality will provide more conclusive long-term trend data. Additional monitoring is needed to identify impacts of water flow alterations (e.g. erosion, changes in dissolved oxygen, and impacts on plants, fish and other aquatic wildlife). Increased sampling of fish tissue throughout these watersheds may identify areas affected by contaminants. Habitat assessments, water quality monitoring, and aquatic community data are needed for the headwater streams and small tributaries of these systems. The pilot projects initiated by The Nature Conservancy in the Ashuelot River watershed should be expanded to other watersheds in this habitat group to identify and protect additional areas of significance.

Element 3: Species and Habitat Threat Assessment

Existing river management plans, local watershed associations, and GIS analyses indicate that non-point source pollution (especially sedimentation and runoff from stormwater and agriculture), invasive species, recreation, habitat fragmentation, and development/sprawl are the primary threats to this area.

Refer to the general threats section for: Transportation Infrastructure, Development (Fragmentation and indirect effects), Non-Point Source Pollution (Runoff and Sedimentation), Acid Deposition, Introduced Species, Altered Hydrology, Recreation, Unsustainable Harvest (Forestry Operations and Management), and Agriculture.

Element 4: Conservation Actions

Conservation actions in this watershed group should focus on controlling the negative effects of development and reducing the impacts of recreational activities, especially the intentional or accidental spread of invasive species. Setting long-term goals for removing inactive dams and improving road/stream crossings will help restore the connectivity of these watersheds.

There are several strategies for conservation action in the RMPP management plans for the Merrimack, Piscataquoag, and Souhegan Rivers. Plans developed by the LRPC, SLA, and LWWA offer strategies to control growth and protect shoreline.

Refer to the general strategies for: Transportation Infrastructure, Development (indirect effects), Fragmentation, Pollutants (Acid Deposition), Invasive Species, Altered Hydrology, Sedimentation, Recreation, Forestry, Pollutants (Stormwater runoff), and Agriculture.

Element 5: References

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HABITAT PROFILE

Non-Tidal Coastal Watersheds

Associated Species: Alewife (Alosa pseudoharengus), American Brook Lamprey (Lampetra appendix), American Shad (Alosa sapidissima), Atlantic Sturgeon (Acipenser oxyrhynchus), Banded Sunfish (Enneacanthus obesus), Blueback Herring (Alosa aestivalis), Bridle Shiner (Notropis bifrenatus), Burbot (Lota lota), Brook Trout (Salvelinus fontinalis), Rainbow Smelt (Osmerus mordax), Redfin Pickerel (Esox americanus americanus), Sea Lamprey (Petromyzon marinus), Shortnose Sturgeon (Acipenser brevirostrum), Slimy Sculpin (Cottus cognatus), Swamp Darter (Etheostoma fusiforme), Tesselated Darter (Etheostoma olmstedi)

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Author: New Hampshire Fish and Game and The Nature Conservancy

Element 1: Distribution and Habitat

1.1 Habitat Description

Non-tidal coastal watersheds contain river systems that are similar to low tidal watersheds except they are above the tidal extent and many are connected to the deep and large Merrimack River mainstem. Low non-tidal watersheds contain extensive, deep, and coarse sediment deposits, although this watershed group contains a large swath of moderately calcareous metasedimentary bedrock and less fine marine clay than low tidal watersheds. Despite having less fine marine clay, low non-tidal watersheds may still have more buffering capacity than other parts of the state due to the influence of the moderately calcareous metasedimentary bedrock.

Low non-tidal watersheds have a relatively high percentage of low to mid-elevation landforms with gentle sloping hills and abundant wet and flat landforms. The lower Merrimack River mainstem, south of the Winnipesaukee River confluence in Franklin, dominates much of this watershed group, which has more miles and a greater percentage of large river habitats than any system other than the Connecticut River watershed.

Low to moderate gradient streams dominate the tributaries of this system. They are generally composed of riffle-pool habitats with occasional dune-ripple habitats in areas of deep and extensive coarse sediment. There is no strictly tidal marsh community of plants and animals as in low tidal systems. Depending on fish stocking, habitat quality, and the ability of fish to move upstream past barriers in the Merrimack River, diadromous fish (such as American shad (*Alosa sapidissima*), alewife (*Alosa pseudoharengus*), American eel (*Anguilla rostrata*), Atlantic salmon (*Salmo salar*), or blueback herring (*Alosa aestivalis*)) may spawn or rear their young in these low non-tidal rivers. Some fish that are more characteristic of large and deep lakes may occur in these watersheds as the Merrimack River deepens and slows throughout sections of the mainstem.

Low non-tidal watersheds primarily include the larger watersheds directly adjacent to the Merrimack River mainstem, although the smaller brooks draining into the mainstem provide unique habitats. The mouths of small streams along large river mainstems may provide refuges and breeding habitats for both local and wide-ranging fish species. However, most of these smaller streams are dammed at our near their confluence with the Merrimack River, which prevents natural connectivity to upstream habitats.

Low Non-Tidal Fine Scale Systems: 11, 12
Fine scale systems 11 and 12 are fairly similar. Both

watershed types are nearly entirely low elevation, composed of more gentle landforms, have a high degree of coarse sediment, and are highly influenced by the large Merrimack River mainstem and lower slow-flowing sections of large tributaries. There are a few key differences between these systems, the primary being that the southern fine scale system 11 overlaps with a large swath of moderately calcareous bedrock (Berwick Formation), which may provide significant buffering capacity to those streams. This bedrock is characterized by multiple metasedimentary and metavolcanic geologic units with up to 15% calcareous rock, some of the "richest" in the state. Fine scale system 12 watersheds are more directly adjacent to the Merrimack River mainstem, whereas fine scale system 11 also includes watersheds of larger tributary rivers flowing south across the Massachusetts border.

1.2 Justification

The large mainstem of the Merrimack River and associated small and medium tributaries are critical habitats for diadromous and other wide-ranging migratory fish. There are few large river habitats in the state (or in the region) that support this suite of species and ecological processes, and so all large rivers are a high priority for conservation. Large river habitats require representation across wide geographies.

1.4 Habitat Distribution

Low non-tidal watersheds occur in nine watersheds in New Hampshire's south-central Merrimack Valley region, including small tributaries to the Merrimack River south of the town of Franklin. These watersheds extend north from the Massachusetts state line to the confluence with the Winnipesaukee River. The rivers in this system are not tidally influenced.

Low non-tidal watersheds sit entirely within the Merrimack-Saco-Charles River Ecological Drainage Unit (EDU) and the Southern New England Coastal Hills and Plains subsections of TNC's Lower New England-Northern Piedmont Ecoregion. The southernmost watersheds cross into Massachusetts, including small tributaries to the Merrimack River such as the Nashua River, Beaver Brook, Salmon Brook, Nesenkeag Brook, Chase Brook, and portions of the Squannacook River watershed in Massachusetts.

1.8 Extent and quality of data

While low non-tidal watersheds are distinct from other major watershed groups, the fine scale systems embedded within this group are less clear. The major landscape parameter defining the difference is the abundant calcareous bedrock in the southern watersheds. It is unclear whether this difference has a significant effect on the composition of aquatic species. This difference may have a stronger influence on current and long-term water chemistry and water quality, such as the ability to buffer the effects of acid deposition.

Both fine scale systems are important from a statewide perspective. The enriched bedrock of fine scale system 11 may provide unique and long-term buffering capacity, and fine scale system 12 has unique small stream connectivity with the Merrimack River mainstem. Additional research and data would help further determine the relative importance of these fine scale systems compared to other watersheds in the state. For example, the Connecticut River and low tidal watersheds also have enriched bedrock, and the Connecticut River systems also have small tributary connections with a large river mainstem. A regional analysis comparing these habitats with those in Massachusetts might help focus conservation actions depending on adequate fish passage for diadromous species and whether watersheds with enriched geologic features have a detectable influence on assemblages of aquatic species.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the large land area covered by the major watershed groups (Figure 3), a fine scale classification (Figure 4) was used, when possible, to assess the relative condition of aquatic habitats across the state. The types and sources of information were extremely variable and covered many different scales, and so the following sections refer to both the major and fine scale systems. The actual scale at which the natural conditions and processes lead to differences in aquatic communities is unknown.

The low non-tidal watershed group can be divided into two smaller units, the upper Merrimack inner basin (fine scale system 12) and the lower Merrimack drainages (fine scale system 11) (Figure 4).

2.2 Relative Quality

The upper Merrimack inner basin (fine scale system 12) encompasses 899.9 km^2. It consists of 81% small headwater streams (watershed area <48.28 km^2), 8% small rivers (watershed area of 77.70-518.00 km^2) that drain into the large mainstem of the Merrimack River, and 11% large rivers (watershed area >2590 km^2). This system lacks the full range of river sizes typical of most other watershed groups. The lower Merrimack group (fine scale system 11) encompasses 1,422 km^2 and contains a greater variety of river sizes, with 8% small rivers, 4% medium-sized rivers (watershed area of 518.00-2590 km^2), and 4% large rivers.

There are 429 lakes and ponds with a surface area greater than 1 acre in the low non-tidal watershed group. Of these water bodies, 137 are greater than 4.05 ha (10 ac). The group has a relatively high density of lakes greater than 4.05 ha (5.4/100 km^2), behind the low-moderate and moderate south watershed groups (Figure 3).

Deep, coarse sediment left by retreating glaciers creates a number of unique communities, including pine barrens, floodplain forests, and inland sand dunes along the banks of the upper Merrimack River (fine scale system 12). The river corridor is used by bald eagles (*Haliaeetus leucocephalus*) during winter and as a migration route for songbirds in the spring and fall. The Merrimack River is important habitat for freshwater mussels, including the state endangered brook floater (*Alasmidonta varicosa*). The river also provides important spawning habitat for anadromous fish such as alewives, American shad, blueback herring, Atlantic salmon, and sea lamprey (*Petromyzon marinus*) (USFWS 2000).

In addition to the mainstem of the Merrimack River, fine scale system 11 contains a number of low gradient, meandering streams and small rivers that join the Merrimack River in Massachusetts. The vegetated shorelines of the lakes, rivers, and ponds in these watersheds provide important habitat for many uncommon or rare native fish such as the banded sunfish (*Enneacanthus obesus*), redfin pickerel (*Esox americanus americanus*), and bridle shiner (*Notropis bifrenatus*). These three fish species commonly use the abundant wetlands in this system, which often grade into pond or stream habitats. The connections between open water, wetland, and upland habitats is critical to the many species of fish, amphibians, waterfowl, and turtles that use multiple habitat types throughout their life cycles. Beyond the urban areas of Manchester and Nashua, much of the headwaters of the lower tributaries to the Merrimack River, such as the Squanacook and Nissitissit Rivers, remain forested.

2.3 Population Management Status

N/A

2.4 Relative Health

Land Use

The lower Merrimack River and its surrounding watersheds (fine scale system 11) are in the fastest growing part of New Hampshire (SPNHF 2005). The population grew by an average of 12,498 people per year between 1990 and 2000. Road density is the highest in the state at 2.77 km of road/km^2 of land area. The upper Merrimack River corridor (fine scale system 12) is close behind with the second highest road density (2.39 km/km^2). The population is increasing the fastest along Interstate 93, which parallels the mainstem of the Merrimack River (SPNHF 2005). A proposed expansion of this highway will put increasing development pressure on these systems. The well-drained, sandy soils of these watersheds are highly suitable for development. Developed land currently makes up 17.5% of fine scale system 11 and 15% of fine scale system 12. These proportions of developed land are twice that of the next closest system (the low tidal fine scale system 13 at 8%). Lake shorelines are a high priority for developers. Census blocks around 76 of the 470 lakes greater than 4.05 ha in low non-tidal watersheds are predicted to increase in density class by the year 2020 (TNC 2005).

The amount of agricultural land is also relatively high in fine scale systems 11 and 12 (5.9% and 6.6%, respectively). Chemicals, excess nutrients, and sediments that run off agricultural fields can degrade adjacent water bodies. Forested buffers around headwater streams can reduce the impacts of runoff from developed and agricultural land. The amount of forested land within 250 ft (76.2 m) of headwater streams in fine scale systems 11 and 12 is the lowest in the state at 63.06% and 63.64%, respectively. Further loss of forested buffers adjacent to headwaters will be detrimental to aquatic habitats throughout low non-tidal watersheds.

Water Quality

The Merrimack River was once listed as one of America's ten dirtiest rivers (NHDES 2000). The Clean Water Act has led to great improvements in water quality by regulating industrial sources of pollution. The upper Merrimack River has excellent water quality for a large river, although water quality monitoring does reveal some issues. While the river passes NHDES class B water quality standards during dry weather, the river exceeds standard levels of fecal coliform after heavy rains (Landry and Tremblay 2000). Volunteer sampling of invertebrates at sites along the river reveals a decline in the number of species from upstream to downstream (Landry and Tremblay 2000). The decrease in water quality after heavy rains and the decline in species richness downstream are signs of non-point source pollution. Although non-point source pollution is the major contributor of pollutants to the Merrimack River watershed, wastewater treatment facilities are also a significant source of phosphorous, nitrogen, and *E. coli* (USACE 2004). Although none of New Hampshire's waters meet water quality standards for mercury, the lower Merrimack and coastal watersheds of southeastern New Hampshire have been specifically identified as "mercury hotspots" (Evers 2005).

The mainstem of the lower Merrimack River has relatively poor water quality. Manchester and Nashua are the major sources of pollution through combined sewer outflows (CSOs), which occur when wastewater treatment facilities are bypassed during heavy rainfall. The cities are currently working with NHDES to reduce pollution from CSOs. There is less information about the watersheds of the tributaries that join the Merrimack River in Massachusetts. While the New Hampshire portions of these watersheds lack the point sources of the urban areas downstream, rapid development will likely have an increasing impact on water quality (Dunn 2002).

Hydrology

New Hampshire's aquatic ecosystems are fragmented by a history of small-scale industrialization, which resulted in a high density of small dams throughout the southern watersheds (NHDES 1999). There are 367 active dams in the lower Merrimack River watershed. The number of dams for every 10 km of river in fine scale systems 11 and 12 is 2.49 and 1.92, respectively. The proportion of free-flowing river reaches in fine scale systems 12 and 11 are the second and third lowest in the state, behind the lower Connecticut River. Only the Amoskeag Dam in Manchester has a fishway for upstream fish passage, which provides access to just 8 km (5 mi) of river upstream. The fishway is designed to allow anadromous fish to pass upstream during spring spawning runs. Design elements that regulate flow and a short operating season limit the effectiveness of the fishway for most freshwater fish species.

Culverts and stream crossings add to the aquatic habitat fragmentation caused by dams (Warren and Pardew 1999). With the highest road density in the state, these watersheds are extremely fragmented. The relatively high density of roads, parking lots, roofs, and driveways contribute to stormwater runoff from impervious surfaces. Not only does this runoff inject sediment and contaminants into water bodies, but it also alters local hydrological patterns (NHDES 1999), which can lead to significant alterations in stream geomorphology and aquatic habitats.

The Amoskeag Dam in Manchester, Garvin Falls Dam in Bow, and the Hooksett Dam in Hooksett are the 3 major hydroelectric dams on the Merrimack River. The operation of these facilities creates large impoundments, causes unnatural water level fluctuations above the dams, and alters flows below the dams. The three dams are currently undergoing relicensing, which presents an opportunity to improve fish passage at the Amoskeag fishway and install fish passage at the other two dams.

An estimated 1.2 billion L (320 million gallons) of water are withdrawn from the Merrimack River watershed per day for municipal drinking water, irrigation, and industrial uses (MRWC 2001). The NHDES has identified the lower Merrimack River as potentially impacted by water withdrawals. A local resident reported that the operation of the Methuen Falls hydropower project on the Spickett River repeatedly drained the river dry over the summer of 2002 and affected river flows well into New Hampshire (Low Flow Inventory 2004). North of Manchester, the upper Merrimack River watersheds (fine scale system 12) have a much lower rate of water withdrawals.

Invasive Species

There are 12 known invasive aquatic plant infesta-

tions in fine scale system 11 and 7 infestations in fine scale system 12. Not only do these systems have a relatively high number of infestations, but they also have the widest variety of invasive species, including variable milfoil (*Myriophyllum heterophyllum*), Carolina fanwort (*Cabomba caroliniana*), water chestnut (*Trapa natans*), and Brazilian elodea (*Egeria densa*).

Many non-native fish species, such as the common carp (*Cyprinus carpio*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides)*, and black crappie (*Pomoxis nigromaculatus*), have become naturalized in water bodies throughout low non-tidal watersheds. The long-term effects of these species on native populations are poorly understood. Most non-native fish introductions result from illegal private stocking of sport fish (Estuarine and Freshwater Working Group 2005).

The state of New Hampshire is working on a comprehensive plan for the management of aquatic nuisance species (Estuarine and Freshwater Working Group 2005). The plan lists a number of species of exotic fish, including species from the snakehead family (Channidae), which have not yet established populations in New Hampshire. Exotic species are more often introduced when people release private aquarium fish into a lake or river. Urban areas tend to have higher incidences of exotic species introductions. The urban communities of Concord and Manchester on the mainstem of the Merrimack River, and Nashua on the Nashua River, present a great risk for the introduction of exotic species.

2.5 Habitat Patch Protection Status

The lower Merrimack River watersheds (fine scale system 11) and upper Merrimack River corridor (fine scale system 12) have the lowest percentages of unfragmented blocks of land (46.0% and 57.5%, respectively) compared to the other 13 systems. Of the total amount of unfragmented blocks of land, 13.6% are protected in fine scale system 11 and 18.6% in fine scale system 12. Public conservation land comprises 8.2 % of the total land area in fine scale system 11 (the lowest in the state) and 13.7% of fine scale system 12.

Both the upper sections of the Merrimack River (from the confluence of the Winnipesaukee and Pemigewasset Rivers in Franklin to Garvins Falls in Bow) and the lower sections (from the Bedford/Merrimack town line to the New Hampshire/Massachusetts state line) are designated river reaches in the Rivers Management and Protection Program (RSA 483).

2.6 Habitat Management Status

Management activities for aquatic habitats in low non-tidal watersheds include water quality monitoring, hydrological research and management, and anadromous fish restoration. The Merrimack River Watershed Council (MRWC) coordinates over 30 volunteer water quality monitoring groups through the Volunteer Environmental Water Quality Network (VEMN). The MRWC has also funded a number of studies, including an assessment of the Powwow River watershed and an analysis of water use throughout the Merrimack River watershed (Monnelly and Strauss 2001, MRCW 2001). Management plans have been developed for the upper and lower sections of the Merrimack River designated under the Rivers Management and Protection Act (RSA 483). While the mainstem of the Merrimack River receives considerable attention, there has been less focus on the smaller Merrimack River tributaries, such as the Spickett River and Beaver Brook, which join the main stem of the Merrimack River in Massachusetts.

There is an ongoing effort to restore anadromous fish populations in the Merrimack River watershed. Recent work has focused on improving downstream fish passage at hydroelectric dams (Jon Greenwood, NHFG Fisheries Biologist, personal communication). Returns of adult anadromous fish to the Merrimack River watershed in New Hampshire are limited by the effectiveness of upstream fish passages in Massachusetts. Relicensing of the Amoskeag, Hooksett, and Garvin Falls Dams, owned by Public Service of New Hampshire, provide opportunities to install or improve fishways. A fishway on the Hooksett Dam would provide access to excellent habitats in the Soucook and Suncook Rivers.

2.7 Sources of Information

Data from NHFG, volunteer water quality reports (VRAP reports coordinated through NHDES), watershed management plans (under the Rivers Management and Protection Program, RSA 483), and conversations with local watershed organizations were used to assess the status and relative quality of watershed groups.

2.8 Extent and Quality of Data

An evaluation of the Upper Merrimack Monitoring Program data validates the work of the volunteers who monitor water quality in the upper Merrimack River watershed (Landry and Tremblay 2002). Most monitoring has occurred along the mainstem of the Merrimack River. There is very little information about the smaller tributaries that feed into the Merrimack River.

2.9 Condition Assessment Research

While the New Hampshire Natural Heritage Bureau has identified rare and exemplary shoreline plant communities, there has been little work to identify rare or unique aquatic communities. Future surveys should attempt to identify aquatic communities indigenous to the low non-tidal watersheds, document the current ranges of invasive species, and assess the extent of habitat degradation in these watersheds.

Element 3: Species and Habitat Threat Assessment

Threats to aquatic habitats in low non-tidal watersheds are related to the rapidly increasing population density. Nonpoint source pollution will worsen with further increases in impervious surface area. The risk of invasive species introductions will increase with the number of people using and living near the water bodies in these drainages. Dams and poorly designed culverts are restricting the amount of habitat available to some species. Many other species are impacted by unnatural fluctuations in water level. Refer to the general threats section for: Transportation Infrastructure, Development (Fragmentation and indirect effects), Non-Point Source Pollution (Runoff and Sedimentation), Acid Deposition, Introduced Species, Altered Hydrology, Recreation, Unsustainable Harvest (Forestry Operations and Management), and Agriculture.

Element 4: Conservation Action

While land protection can help prevent further aquatic habitat degradation in low non-tidal watersheds, many heavily impacted areas will require restoration. A coordinated effort is needed to reduce fragmentation and impervious surface area in these watersheds. Setting limits on water withdrawals or water level fluctuations will have long-term benefits for fish and wildlife.

Refer to the general strategies section for: Transportation Infrastructure, Development (indirect effects), Fragmentation, Pollutants (Acid Deposition), Invasive Species, Altered Hydrology, Sedimentation, Recreation, Forestry, Pollutants (Stormwater runoff), and Agriculture.

Element 5: References

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HABITAT PROFILE

Pine Barrens

Associated Species: frosted elfin butterfly (Callophyrus [Incisalia] irus), Karner blue butterfly (Lycaeides melissa samuelis), Persius duskywing (Erynnis persius persius), Sleepy duskywing (Erynnis brizo brizo), wild indigo duskywing (Erynnis baptisiae), barrens xylotype (Xylotype capex), broad-lined catophyrra (Catopyrrha coloraria), cora moth (Cerma cora), Phyllira tiger moth (Grammia phyllira), pine barrens itame (Itame sp 1), pine barrens zanclognatha moth (Zanclognatha martha), pine pinion moth (Lithophane lipida lipida), black racer (Coluber constrictor), eastern hognose snake (Heterodon platirhinos), smooth green snake (Liochlorophis vernalis), eastern box turtle (Terrapene carolina), Fowler's toad (Bufo fowleri), common nighthawk (Chordeiles minor), eastern towhee (Pipilo erythrophthalmus), whip-poor-will (Caprimulgus vociferus), New England cottontail (Sylvilagus transitionalis).
Global Rank: Globally Not Ranked
State Rank: Pitch pine-scrub oak woodland (S1S2)
Author: Goulet, Celine
Affiliation: New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 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 2004). 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 2004). 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 2004). This variant is characterized by a high diversity of both common and rare vascular plants, including blue lupine (Lupinus perennis), blunt-leaved milkweed (Asclepias amplexicaulis), and New Jersey tea (Ceanothus americanus) (Sperduto and Nichols 2004). The Ossipee variant occurs in the Ossipee pine barrens, occupying deep outwash deposits between Ossipee and Silver Lake (Sperduto and Nichols 2004). Less diverse than the southern variant, the Ossipee variant is instead associated with more northern plant species such as bearberry (Arctostaphylos uva-ursi), three-toothed cinquefoil (Potentilla tridentata), and savin-leaved clubmoss (Diphasiastrum sabinifolium) (Sperduto and Nichols 2004).

1.2 Justification

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 2004). A large proportion of these Lepidopteran fauna are exclusively dependent on blue lupine and other plants restricted to pine barrens (Sperduto and Nichols 2004). 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), pink-edged sulphur (Colias interior), and the noctuoid moth Xylena thoracica (Sperduto and Nichols 2004).

Pine barren communities also serve a role in the life histories of a number of vertebrates as well, a relationship based on edaphic and structural features, not host plant specificity as attributed to Lepidopteran endemism (Howard et al 2005). Such 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 was 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 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).

3.3 Protection and Regulatory Status:

Federal

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

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.

1.4 Population and Habitat Distribution

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 2004). 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) remain today (VanLuven 1994).

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

Potential pine barrens habitat was mapped using known pine barrens occurrences (New Hampshire Natural Heritage Bureau 2005). Six variables were measured for pixels within known occurrences: elevation, slope, landcover, drainage, texture, and a composite index of drainage and texture indicating the location of the pixel relative to large, contiguous areas of appropriate soils conducive to fire spread. For each variable, the range of values that encompassed 85-93% (depending on the variable) of the pixels was selected. Throughout the state, pixels that fell within these value ranges for all six variables were selected as potential pine barrens habitat. Known habitat patches as well as historically known patches were then added to the map.

Limitations of Data

The pine barrens map was heavily dependent on the accuracy of soils data and elevation data. While there are some errors in the elevation data, there are likely to be more errors in the soils data. County soil surveys often do not show small inclusions of different soil types within larger polygons. In addition, digital county soil surveys are not available for Belknap and Merrimack Counties or the White Mountains, and drainage and texture data is absent from some polygons of Coos County. For these areas, the STATSGO data set was used (Natural Resources Conservation Service 1994). STATSGO is a map of soil data at a much coarser scale than county soil surveys, and thus is much more prone to error at the fine scales required for accurate habitat maps. Thus, the pine barrens map will be most inaccurate in these areas.

1.7 Sources of Information

Information on pine barrens distribution and status was collected from habitat management plans, technical field reports, agency data, and scientific journals.

1.8 Extent and Quality of Data

The pine barrens habitat and associated fauna have been studied extensively in New Hampshire and adjacent states. Although life history data on certain species could be improved, general habitat associations, particularly of Lepidoptera, are well known. See limitations in section 1.6 above.

1.9 Distribution Research

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.

Element 2: Species/Habitat Condition

2.1 Scale

2.2 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, (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.

3.3 Population Management Status

Not required for habitat profiles.

2.4 Relative Quality of Habitat Patches

The Concord pine barrens are extremely fragmented. Mean patch size of existing pine barrens in the Concord area is 10.2ha, and of predicted patches is 2.9ha. Patches in the Ossipee area are much larger; current pine barrens patches average 44.2ha, while predicted patches are still small, averaging 2.4ha. Predicted patches elsewhere in the state are similarly quite small. The pine barrens at the Concord airport are surrounded by less than 40% unaltered land within 250m. In contrast, the pine barrens in the Ossipee

region have from 67-93% unaltered land within 250m. Road density, however, is higher in the Ossipee barrens.

Although the Concord pine barrens are more fragmented and developed, they have the highest known density of rare plants and animals relative to other pine barrens in New Hampshire. Thus, the landscape context of the Ossipee barrens is more favorable, but the biodiversity of the Concord barrens is of critical importance.

2.5 Habitat Patch Protection Status

Approximately 227 ha (560 ac) of the remnant Concord pine barrens is protected through the Concord Municipal Airport Development and Conservation Management Agreement (2000). The majority of the land (210 ha) occurs on the Concord Municipal Airport and is owned by the city of Concord. Eight conservation zones made up of 57 management units have been established on this land, with management working towards enhancing and restoring the pitch pine-scrub oak woodland community, a critical habitat for the Karner blue butterfly as well as a suite of other rare species. Of the remaining land, 11 ha (27 ac) is held as a conservation easement granted to the United States Fish and Wildlife Service. The easement is open to the public but wheeled vehicles are forbidden. The 4 ha (10 ac) of the historic main site, located along a powerline right-of-way, is privately owned and maintained by Public Service of New Hampshire.

Thirty percent of the existing Ossipee pine barrens are in fee ownership protection. Tweve hundred acres of pitch pine is on protected land, within a larger contiguous area of 5000 acres, owned by the Nature Conservancy. Additional small parcels are owned by the towns of Freedom and Madison.

2.6 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. These techniques are used to create sandy and herbaceous openings within a matrix of heath, scrub-shrublands, and woodlands. 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).

Similarly, The Nature Conservancy is currently exploring various management options to implement within the Ossipee pine barrens, including mechanical treatments to create firebreaks and remove unwanted vegetation, as well as some level of prescribed burning (Howard 2003). 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).

2.7 Sources of Information

Pitch pine-scrub oak woodland habitat protection and management information was obtained from habitat management plans, agency agreements, and personal communication.

2.8 Extent and Quality of Data

The GIS data used to create the predicted pine barrens map does contain some errors, primarily in the soil data. The map is less accurate in Belknap and Merrimack Counties, the White Mountains, and small portions of Coos County, due to a lack of fine scale soil data. The delineation of known pine barrens and the conservation data are fairly accurate.

2.9 Condition Assessment Research

Predicted pine barrens patches need to be verified on the ground as existing pine barrens or potential patches for restoration. Evaluation of the suitability and feasibility of restoration in these patches is necessary.

Element 3: Species and Habitat Threat Assessment

1.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway:

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 perme-

ability, 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).

(B) Evidence
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).

3.1.2 Altered Natural Disturbance (Fire Suppression)

(A) Exposure Pathway
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). Additionally, without a regular fire regime, fuels have accumulated, increasing the risk of high intensity wildfires inappropriate to pine barrens regeneration

(B) Evidence
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).

3.1.3 Development (Fragmentation)

(A) Exposure Pathway
Continuity of pine barren communities has been severely interrupted by infrastructure and road development. Currently, most communities are fragmented into relatively small habitat patches (Howard et al 2005). Such fragmentation serves to alter both microclimatic conditions and biogeographical distribution of pine barrens (Saunders et al 1991). As a result, total available habitat is reduced, ecological processes are disrupted, edge effects are increased, and the intrusion of invasive species is promoted, all of which serve to jeopardize overall community composition and structure (Saunders et al 1991, VanLuven 1994, Howard et al 2005).

(B) Evidence
Fragmentation of pine barrens on the modern landscape has had far reaching effects, altering both this community's ecological function and its physical environment. Of the affected ecological processes, the interference with a natural fire regime has had the greatest impact. Without large, continuous areas of unfragmented habitat, the occurrence of natural fires of sufficient frequency, intensity, and extent is reduced (Wagner et al 2003). Such reduction hinders pitch pine-scrub oak woodland vegetation recruitment, thereby affording the introduction of new, unnatural elements into the biota (Webb 2000, Howard et al 2005). Additionally, fragmentation creates artificial edges which have been shown to alter microclimate by elevating light, decreasing humidity, increasing wind exposure, and introducing airborne materials such as dust, further disrupting natural eco-

logical processes and facilitating the establishment of invasive species (Saunders et al 1991, Webb 2000).

3.1.4 Light Pollution

(A) Exposure Pathway:
Light pollution has adverse effects on much of the insect fauna associated with pine barrens (Frank 1988). Lepidopterists have long attributed population declines to light pollution, especially in moths (Frank 1988). Artificial lighting disturbs flight, navigation, vision, migration, dispersal, oviposition, mating, feeding, and crypsis in some moths (Frank 1988). It also increases their susceptibility to predation by birds, bats, and spiders (Frank 1988). The result may be either changes to behavioral patterns or an alteration in species composition of moths inhabiting illuminated environments (Frank 1988).

(B) Evidence:
Outdoor lighting has sharply increased over the last half century (Frank 1988). It has been suggested that declines in North American moth populations, especially northeastern Saturniids, is a direct result of light pollution (Frank 1988). The impacts of light pollution are amplified in small populations threatened by other disturbances, particularly in habitats fragmented by urban development (Frank 1988).

3.2 Sources of Information

Information on threats affecting pine barrens was acquired from the Concord Pine Barrens Habitat Management Plan, scientific journal articles, and personal communications and observations.

3.3 Extent and Quality of Data

Much study has been conducted regarding threats impacting pine barrens habitat. This information is documented in management and conservation plans as well as scientific journals.

3.4 Threat Assessment Research

Community-level effects of fire suppression and fragmentation should be further investigated. Research should focus on vegetation responses to fire suppression based on specific land-use and ecological histories, effects of microclimatic alterations on community composition, and habitat patch isolation. In addition, research should be conducted regarding the long-term effects light pollution has on insect populations and species composition, especially in reference to species inhabiting fragmented communities. Further research on invertebrate – host plant relationships and life cycles will aid in determining the influence of these threats on various species.

Element 4: Conservation Actions

4.1.1 Habitat Management

Category: Restoration and Management

(A) List of Direct Threats Affected
Habitat Loss, Habitat Fragmentation, Succession

(B) Justification:
1) Habitat management will increase the distribution and abundance of pine barrens within their existing and historical range by reverting closed-canopy stands to an early-successional structure. Standard habitat management techniques including forestry, fire, and herbicide have well-documented efficacy in reducing the cover of canopy-forming, shade-tolerant, and fire-sensitive species.
2) 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, 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.
3) Habitat management is necessary to prevent the loss of protected habitat to succession, but is not adequate to secure unprotected remnants and buffer existing conservation land from development.

4) Restorative management intensity is high in the short-term, but can be reduced to a sustainable maintenance level in the long-term. Depending upon the intensity of management, beneficial responses can be observed in 0-3 years, and maintained with management on a 5-10 year rotation.
5) Pine barren vegetation can be controlled and maximized by adjusting the frequency and intensity of habitat management to modify current densities of canopy species and scrub oak. The prescription may be adapted to guide management in new areas.

(C) Conservation Performance Objective

The habitat management performance objective is to create a matrix of interconnected grasslands, shrublands, and woodlands by manipulating the densities of woody species in key vegetative strata. Progress toward target levels (i.e., reduction in canopy and shrub strata) will indicate the performance of habitat management.

(D) Performance Monitoring

Densities of woody species will be monitored as prescribed in Fuller et al. (2003) prior to implementation of management and in subsequent years.

(E) Ecological Response Objective

The habitat management response objective is to increase the densities of pitch pine-scrub oak woodland plant species in proportion to their associated early successional vegetative strata. Target levels for management units by strata and species are described in Fuller et al. (2003). Progress toward target levels (i.e., increase in density of pitch pine-scrub oak woodland plant species in proportion to sand, herbaceous, and heath strata) will indicate a beneficial response to habitat management.

(F) Response Monitoring

The density of key habitat plants will be monitored as prescribed in existing management plans such as Fuller et al. (2003) prior to implementation of management and in subsequent years.

(G) Implementation:

The New Hampshire Fish and Game Department, the New Hampshire Department of Resources and Economic Development, the New Hampshire Army National Guard, the United States Fish and Wildlife Service, the Federal Aviation Administration, and the city of Concord will cooperate to implement habitat management as per the Concord Municipal Airport Development and Conservation Management Agreement (2000) and the Management Plan (Fuller et al., 2003) under the guidance of the management team.

The Nature Conservancy has also developed a management plan for the Ossipee pine barrens which mechanical thinning, constructing fire breaks, and some prescribed burns (Jeff Lougee, personal communication).

Most management of pine barrens to this point has focused on Karner blue butterflies. Management procedures for other rare species should also be developed.

(H) Feasibility:

These restoration plans have successfully been implemented in the Concord pine barrens, and have begun to be implemented in the Ossipee pine barrens. Future feasibility is limited only by funding, which for the Concord site is secure through 2012.

4.1.2 Backyard Habitat Program

Category: Education and Outreach

(A) List of Direct Threats Affected

Habitat loss, Fragmentation, Succession, Isolation

(B) Justification:

1) Engaging the public to propagate pine barrens habitat plants on public and private land, and encouraging landscape professionals to adopt native plant landscaping will increase the availability of native plants for pine barrens-dependent species and provide stepping-stone habitat in highly fragmented areas.
2) Karner blue butterflies have been documented ovipositing and feeding on blue lupine planted by schoolchildren. Studies have shown that Karner blue butterflies use commercial and residential landscape plants to augment 'natural' habitat. Other species may also have similar responses to cultivated

host plants.

3) Habitat restoration efforts are currently restricted to Concord, New Hampshire. Similar strategies could be implemented in other pine barrens throughout the state. Efforts will be targeted towards decision-makers, professionals, landowners, and school children.
4) Habitat restoration is an ongoing process and the importance of this work needs to be addressed in both the short and long term. Students that plant blue lupine today will provide an immediate benefit, and may support recovery efforts as adults.
5) Education and outreach can be molded to meet different target audiences (landowners vs. school children) or habitat areas (private land vs. public land), and evolve as new techniques are developed. Content of educational materials can be geared towards specific threats to pine barren habitat.

(C) Conservation Performance Objectives:
In the Concord pine barrens, increase the number of blue lupine plants planted by schoolchildren and other volunteers to more than 500 plants per year for the next 5 years. Within 5 years, increase the proportion of landowners adopting pine barrens-friendly management and landscaping practices within the Concord pine barrens area to more than one-half for new developments and existing buildings within the potential habitat area. Increase volunteer participation in restoration activities to more than 20 per year for the next 5 years.

(D) Performance Monitoring:
Performance may be monitored via: documentation of the number of blue lupine plants planted each year by school children and other volunteers; random surveys of landowners to determine current land management practices; documenting the number of approved development plans that adopt pine barrens-friendly landscaping and management practices; and documenting the number of competent and reliable volunteers.

(E) Ecological Response Objective:
The desired ecological response is to increase the availability of blue lupine and nectar plants within and between habitat restoration areas. Successful education and outreach will be indicated by pine barrens lepidoptera using plants propagated by school children and using developed landscapes managed under pine barrens-friendly programs.

(F) Response Monitoring:
The use of plants propagated by school children will be documented during structured pine barrens population monitoring as described in the Concord pine barrens management plan (Fuller et al. 2003). As suitable plants are cultivated in the landscape surrounding restoration areas, monitoring will be adapted (with landowner permission) to document the movement of Karner blue butterfly and other pine barrens species through habitat between restoration areas.

(G) Implementation:
Hire education and outreach staff to:

Target nursery operators, landscape professionals and contractors to raise awareness of native plants, receive training on propagation, develop a supply of native plants, and advocate native plant landscaping in the community. Identify a training structure and present information at landscaping association meetings. Implement green landscaping certification.

Target landowners to disseminate educational materials, raise awareness, cultivate a demand for native plants, and implement landowner incentives. Train landowners to preserve existing native plant resources and adopt native plant landscaping. Encourage land managers to adopt Best Management Practices that incorporate native plant restoration.

Give presentations to the community and create informational materials such as kiosks, brochures, demonstration sites, etc.

(H) Feasibility
The limiting factor to educational implementation is funding and personnel resources. The New Hampshire Fish and Game Department is limited in staff and funding to carry out restoration and recovery work. More integration with the Public Affairs Division is needed to focus on education and outreach. Resources must be made available for developing education materials and training. The National Wildlife

Federation has assisted with blue lupine planting by school children and will continue to do so.

4.1.3 Artificial Light Reduction

Category: Education and Outreach

(A) List of Direct Threats Affected
Light Pollution

(B) Justification:

1) Reducing the amount of light pollution in pine barrens habitat will remove external artificial light that can compromise the behavior of nocturnal Lepidoptera.

2) Nocturnal pine barrens Lepidoptera will be better able to continue their life cycles in natural conditions without light pollution.

3) Light reduction would only be implemented in areas where nocturnal Lepidoptera are demonstrated to occur.

4) Light reduction would only be implemented during those times of the year when target Lepidoptera are active.

5) If new occurrences of nocturnal Lepidoptera are found, light reduction can be implemented in those areas as well.

(C) Conservation Performance Objective
The performance objective will be a reduction in artificial light to levels that do not affect nocturnal Lepidoptera, as demonstrated in available literature.

(D) Performance Monitoring
Reduction in light will be monitored by periodic site visits. Residences and commercial establishments that do not conform to acceptable light levels will be noted.

(E) Ecological Response Objective
Nocturnal activity of target Lepidoptera will be uninterrupted and behavior will not change from expected levels based on available literature. Populations of target species will not decline.

(F) Response Monitoring
Visits to known nocturnal Lepidoptera sites in areas of restricted artificial light will be made. Samples of target species will be taken and populations monitored. Nondeclining populations will indicate an effective ecological response. Observations of activity in target species will be used to determine if normal behavior is occurring.

(G) Implementation
Artificial light-free reserves will be established, such as sheltered hollows shielded from lighting (Frank 1988). To reduce lighting impact in habitats already exposed to lamps, low-pressure sodium lamps may replace other lamps when illumination is essential (Frank 1988). Filters to block ultraviolet light may be installed over mercury vapor lamps, and shields may be placed around lamps to block stray light (Frank 1988). Landowners will be presented with information and encouraged to use alternative lighting as outlined in Frank 1988.

(H) Feasibility
Staff time and funding will be necessary to implement this strategy. Effective light reduction will depend on the willingness of landowners to adopt light reduction practices.

4.1.4 Habitat Restoration

Category: Habitat Management

(A) List of Direct Threats Affected
Habitat loss, Fragmentation, Succession, Isolation

(B) Justification:

1) Restoring habitats that are no longer pine barrens to a pine barrens state will increase the amount of pine barrens habitat available, thus increasing connectivity between patches, reducing fragmentation, and mitigating habitat loss.
2) Increasing the amount and connectivity of pine barrens communities will provide more suitable habitat for pine barrens species and more opportunity for fire spread and seed dispersal, thus ensuring the continuity of pine barrens.
3) Pine barrens habitats are rare in the northeast; thus, any restoration of habitat to a pine barrens state will increase the spatial distribution of this habitat throughout the region.
4) Pine barrens habitats are becoming increasingly rare. Immediate restoration of potential habitat is needed to prevent extinction of local popula-

tions of pine barrens species.

5) As new potential sites become available, restoration can be implemented and adapted to those sites. Restoration measures can be changed to include the most effective methods as more information is gained.

(C) Conservation Performance Objective:
The objective is to increase the amount of pine barrens vegetation throughout its historical range.

(D) Performance Monitoring:
Performance will be monitored by site visits before restoration and at intervals afterwards to determine if pine barrens vegetation is increasing and surviving at restored sites.

(E) Ecological Response Objective:
The objective is to create habitat suitable for pine barrens fauna.

(F) Response Monitoring:
Response will be monitored by site visits to survey for pine barrens fauna. The use of restored sites by pine barrens fauna, as well as the existence of pine barrens vegetation, will indicate successful restoration.

(G) Implementation:
Potential sites for restoration will be selected, with a focus on historical sites where remnant patches may occur. Emphasis will be primarily on open, bare sites and secondarily on sites occupied by white pine. Open sites will be seeded with pine barrens vegetation and monitored. Upon successful generation and growth of these species, typical pine barrens management will be implemented. Sites occupied by white pine will be cut and an appropriate fire regime and other pine barrens management strategies will be implemented. Sites will be monitored for the growth of pine barrens vegetation.

(H) Feasibility:
Site restoration will require staff and funding. Existing management plans could be adapted to incorporate restoration. Cooperation with willing landowners will be necessary for restoration on privately owned sites.

4.2 Conservation Action Research

Because each geographically isolated pitch pine-scrub oak woodland community has been subject to a unique combination of ecological and anthropogenic influences, knowledge of such factors is critical to the design of management plans (Howard et al 2005). In addition, research should be conducted regarding vegetational responses to the various management techniques, intensities, and frequencies. Focus should be specifically on key pitch pine-scrub oak woodland species.

Element 5: References

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Element 5.2 Data Sources

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HABITAT PROFILE

Tidal Coastal Watersheds

Associated Species: Alewife (Alosa pseudoharengus), American Brook Lamprey (Lampetra appendix), American Eel (Anguilla rostrata), American Shad (Alosa sapidissima), Atlantic Salmon (Salmo salar), Atlantic Sturgeon (Acipenser oxyrhynchus), Banded Sunfish (Enneacanthus obesus), Blueback Herring (Alosa aestivalis), Bridle Shiner (Notropis bifrenatus), Burbot (Lota lota), Brook Trout (Salvelinus fontinalis), Rainbow Smelt (Osmerus mordax), Redfin Pickerel (Esox americanus americanus), Sea Lamprey (Petromyzon marinus), Shortnose Sturgeon (Acipenser brevirostrum), Swamp Darter (Etheostoma fusiforme)

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Author: New Hampshire Fish and Game and The Nature Conservancy

Element 1: Distribution and Habitat

1.1 Habitat Description

Tidal coastal watersheds include tidal rivers and their watersheds. These rivers support runs of diadromous fish, such as American shad, alewife, American eel, Atlantic salmon, and blueback herring. These basins are dominated by abundant tributaries that are at low and very low elevations, are connected to larger meandering mainstem rivers, flow over acidic bedrock, and have extensive areas of deep and coarse sediment. There are a few moderate gradient tributaries in the upper headwaters of some of these watersheds, but the majority are low-gradient rivers. Most of these low-gradient tributaries have warmwater fish communities. Colder, groundwater-fed systems rarely occur. Instream habitats are dominated by riffle-pool habitats in the low gradient and unconfined valleys. In the low or very low gradient and highly sinuous channels with coarse sediments and sands, dune-ripple habitats may also occur. Dune-ripple habitats are dominated by sand-sized substrates and lack riffle-pool structure (Kline 2005).

The tributaries and mainstems in the lowest portions of these watersheds occur in areas of deep and extensive fine marine clay, which provides additional buffering capacity. Finer streambed substrates and connected wetland and floodplain communities are common in these areas of deep, fine surficial geological deposits. Low tidal watersheds are unique with tidal marsh/estuary ecosystems and small tidal tributaries at their mouth, in addition to the abundant freshwater stream and river habitats.

Fine scale system 13 was the only fine scale system in this analysis that was so ecologically distinct as to merit its own major watershed group. Although low gradient streams and mainstem tidal rivers dominate this watershed group, there is some variation with the two northernmost watersheds encompassing more moderate elevations and substantial amounts of moderate and a few high gradient streams along side slopes and summits.

1.2 Justification

Tidal aquatic ecosystems and their tributaries offer unique habitats for New Hampshire's wildlife. They are relatively uncommon in New Hampshire, and the rivers and estuary system at Great Bay are unique in the Northeast. Many rare species congregate in these coastal areas and may occur nowhere else in New Hampshire. In addition to the estuarine and diadromous fish species listed in section 1.1, species such as bald eagle, osprey, common tern, American black duck, saltmarsh specialist songbirds (e.g. saltmarsh

sparrow, marsh wren, Nelson's sharp-tailed sparrow), and congregatory species groups such as waterfowl, wading birds, and shorebirds use Great Bay and other coastal waters throughout the breeding and migratory seasons.

The gradients between salt, brackish, and fresh water occur uniquely within this watershed group. Restoring or enhancing marine and aquatic connectivity is paramount to ensuring stable and viable populations of riverine, estuarine, diadromous, and many marine species.

1.3 Protection and Regulatory Status

1.4 Habitat Distribution

Low tidal watersheds occur in seven watersheds in New Hampshire's coastal region, including all of the watersheds draining into Great Bay Estuary and New Hampshire's Atlantic Ocean coastline. They extend west of TNC's North Atlantic Coast Ecoregion, and into the Southern New England Coastal Hills and Plains subsections of southeastern and south-central New Hampshire. They sit entirely within the Merrimack-Saco-Charles River Ecological Drainage Unit (EDUs)[1]. The southeastern-most watershed contains rivers draining into the mouth of the Merrimack River, including the Powwow River. The rivers in this watershed are not tidally influenced, but represent the headwaters of these southern Merrimack River tributaries.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

1.7 Sources of Information

1.8 Extent and quality of data

This pattern sometimes caused these watersheds to group with fine scale system 14 in some of the underlying TWINSPAN runs. Although the critical tidal connection and low gradient systems of their lower mainstems were felt to be overriding factors to keep these watersheds ultimately included in this Group, future research could examine whether certain watersheds should group with more northern system Groups (such as Salmon Falls River, for example). Overall, this system has one of the strongest ecological signatures of any in this analysis. TWINSPAN identified this area early in the splitting as a unique type, no matter what combination of variables were used. The strength of this type is further supported by its overlap with other regional land and water classifications (e.g. Ecoregions, EDUs, etc.).

Element 2: Species/Habitat Condition

2.1 Scale

Due to the large land area covered by the major watershed groups (Figure 3), a fine scale classification (Figure 4) was used, when possible, to assess the relative condition of aquatic habitats across the state. The low tidal watershed group is fine scale system 13 for this comparison.

2.2 Relative Quality

The total area of the low tidal watershed group is 2918.9 km^2. Approximately 103.5 km^2 of this area is surface water. Headwater streams (watershed area <48.28 km^2) are the most dominant stream/river type, comprising 84% of the total riverine habitat. Small rivers (watershed area of 77.70-518.00 km^2), medium rivers (watershed area of 518.00-2589.99 km^2), and large rivers (watershed area >2589.99 km^2) comprise 12%, 1%, and 2%, respectively, of riverine habitats.

There are 137 lakes greater than 10 acres in the low tidal watershed group. Most of these lakes (109 lakes) are less than 100 acres in size. Only two lakes, Pawtuckaway Lake and Bow Lake, are greater than 1000 acres, and the size of both of these lakes was increased by the creation of dams. There are over 2,455 small ponds less than 10 acres, ranging from shallow wetland systems with less than one acre of open water to relatively deep ponds with rocky or sandy shorelines. Where the coastal watersheds meet the Atlantic Ocean, New Hampshire contains approximately 354 km of tidal shoreline and 46 km^2 of estuary at high tide (Jones 2000).

The coastline of New Hampshire, though small, has a surprising diversity of habitats. Various combinations of rock, sand, and mud substrates along the coast support different communities of marine spe-

cies. Salt marshes, tidal flats, shellfish beds, and submerged aquatic vegetation in the estuaries of Great Bay and Hampton Harbor are essential to countless species of fish, birds, and invertebrates.

Freshwater habitats in the coastal watersheds are equally diverse. The Lamprey River watershed is perhaps the best example, with at least 25 different habitat characteristics required by New Hampshire wildlife species of concern (SPNHF 2002). A survey by the National Park Service found the Lamprey River contains 6 of 9 mussel species known to New Hampshire, including the state-endangered brook floater (*Alasmidonta varicosa*) (LRAC 1990).

Although freshwater and marine ecosystems are often considered separately, coastal watersheds are better viewed as a complex network of interdependent habitats. Many species move between marine, estuarine, and freshwater ecosystems at different stages of their life cycles. Submerged aquatic vegetation, such as the eelgrass beds (*Zostera marina*) in the Great Bay estuary, is an important nursery habitat for many species of invertebrates and juvenile fish (ASMFC 1997). Some of these species, such as Atlantic menhaden (*Brevoortia tyrannus*) and American lobster (*Homarus americanus*), will spend most of their adult lives in coastal waters, while others, such as alewives (*Alosa pseudoharengus*) and juvenile American eels (*Anguilla rostrata*), will migrate upriver and contribute nutrients to freshwater rivers (MacAvoy et al. 2000). The water quality of these rivers is critical to the health of shellfish beds and submerged aquatic vegetation in the estuaries. Protecting wildlife in the coastal watersheds will require maintaining and restoring continuity between freshwater, estuarine, and marine habitats.

2.3 Population Management Status

N/A

2.4 Relative Health

Land Use

Despite a rapidly increasing population, much of the land in low tidal watersheds remains natural. Approximately 69% of the land cover is unfragmented natural land, 5% is agricultural land, and 8% has been developed. In 2001, there were 282 blocks of unfragmented land greater than 250 acres, although only 15 of these blocks were greater than 2,500 acres (New Hampshire Estuaries Project (NHEP) 2003). Impervious surfaces are increasing rapidly in southeastern New Hampshire. In 43 towns in the coastal watersheds, impervious surface area increased from 4.3% to 6.3% between 1990 and 2000 (Justice and Rubin 2002). During this period, the average amount of impervious surface area per person increased from 1.5 acres to 2 acres, which suggests a growth pattern typical of urban sprawl (NHEP 2003).

Hydrology and Connectivity

There are approximately 514 active dams in the coastal watersheds. Dams range from hydroelectric facilities to small earthen dams used to create wildlife habitat. The number of dams per total river length in the low tidal watershed group is 0.065 dams/km, which is the third highest in the state.

There are 8 fishways (one on the Salmon Falls, Cocheco, Oyster, Lamprey, Winnicut, and Taylor Rivers and two on the Squamscott River) designed to provide access to spawning habitats used by anadromous fish in coastal rivers. While these fishways have helped restore populations of river herring and sea lampreys, they have been less effective for other species (Trowbridge 2003a). The coastal fishways are typically open only during spring spawning runs. For most of the year, dams at the head of tide act as barriers between freshwater and estuarine systems. Restoring connectivity by removing dams and installing more effective fishways will benefit many species.

Poorly designed culverts and stream crossings result in the fragmentation of freshwater ecosystems (Warren and Pardew 1999). The density of maintained and unmaintained roads (1.67 and 0.67 km/km^2, respectively) is second only to low non-tidal watersheds where Interstate 93 crosses into New Hampshire.

Invasive Species

The Piscataqua River and Great Bay are at a high risk of invasive species invasion from the release of ballast water by foreign ships transporting oil, coal, and other commercial goods to the shipping ports along the Piscataqua River (Buck 2004). Invasive species have caused a number of major community shifts in the coastal ecosystem (Harris and Tyrell 2001). The green crab (*Carcinus maenas*), the common periwinkle (*Littorina littorea*), and, most recently, the Japanese shore crab (*Hemigrapsis sanguineus*), are just a few examples

of non-native species that have become abundant in coastal waters.

There are 4 infestations of freshwater invasive aquatic plants in low tidal watersheds, a number that is surprisingly low compared to other watersheds with high population density. This number does not include wetland and shoreline species such as purple loosestrife (*Lythrum salicaria*) and common reed (*Phragmites australis*), which may have an indirect effect on aquatic ecosystems. There are many non-native fish species that have become naturalized in the rivers, lakes, and streams of low tidal watersheds, including black crappie (*Pomoxis nigromaculatus*) and smallmouth bass (*Micropterus dolomieu*). The impact of these species on native freshwater communities is poorly understood.

Water Quality

Water quality data collected by Great Bay Watch from 1990 to 2000 indicate good overall water quality in Great Bay and its tributaries (Konisky et al. 2000). Fecal coliform levels show a decreasing trend at most sites and dissolved oxygen levels generally exceed class B standards of 75% saturation (Konisky et al. 2000, NHDES 2000). Stormwater runoff remains a problem as elevated fecal coliform levels are correlated to rainfall (Konisky et al. 2000). The elevated levels of bacteria in shellfish following heavy rains provide further evidence for nonpoint source pollution (Konisky et al. 2000). Approximately 63% of shellfish beds in New Hampshire are permanently closed due to bacterial contamination (Jones 2000). An overall increase in water quality between 1990 and 2000 suggests a decrease in point source pollution from industrial sources and wastewater treatment facilities (Konisky et al. 2000). However, an increase in polyaromatic hydrocarbons (PAH) in shellfish tissue is evidence that oil and gasoline is entering coastal waters through stormwater runoff and/or boat spills (NHEP 2003).

2.5 Habitat Patch Protection Status

Only 9.7% of the total land in low tidal watersheds is conserved. Of the 355,406 acres of unfragmented land in these watersheds, 12.7% is protected. A greater proportion of tidal shorelines is protected (21%) compared to freshwater shorelines (14%), but tidal shorelines are more developed (Trowbridge 2003a). It is difficult to purchase large pieces of property in the coastal watersheds because of rapidly increasing property values.

2.6 Habitat Management Status

There is an incredible amount of funding for the restoration of coastal ecosystems, yet there is surprisingly little monitoring to determine whether restoration projects have achieved their goals (Cornelison 1998). Most work in New Hampshire has focused on marine and estuarine habitats. Over 176 acres of salt marsh have been restored since 2000 (NHEP 2003). The University of New Hampshire's Seagrass Ecology Group has been mapping eelgrass beds in the Great Bay since 1986. There are at least 35 ongoing coastal water quality and biological monitoring programs in New Hampshire (NHEP 2003).

Land protection is the main strategy for conserving coastal watersheds. The Great Bay Resource Protection Partnership has protected 4,100 acres of land as of 2003 (NHEP 2003). Restoration efforts on coastal rivers have recently focused on dam removal. A timber crib dam was removed on the Bellamy River in 2004, providing access to more freshwater spawning habitat for anadromous fish. A nature-like fishway has been proposed to improve fish passage at the Wiswall Dam on the Lamprey River. An inactive dam on the Winnicut River is also under review for removal. Comparatively little work has been done to identify and restore degraded headwater streams.

2.7 Sources of Information

The relative quality of watershed groups was assessed using GIS data from various sources, including NHDES, TNC, and The New Hampshire Geographically Referenced Analysis and Information Transfer System (NH GRANIT), as well as reports and management plans from both private and government organizations.

2.8 Extent and Quality of Data

While useful for assessing general trends, GIS data may not be completely accurate at finer scales. Much detail is lost with such a broad scale approach. Information on long-term trends is scarce. Most of the indicator data used in the status reports produced by

NHEP has only been collected in the last 10 to 20 years (NHEP 2003).

2.9 Condition Assessment Research

The NHEP developed a number of indicators for ecosystem health in coastal watersheds. Their work has developed a baseline upon which to compare the future health of low tidal watersheds in New Hampshire. Refining and expanding the data used as environmental indicators will allow for a better assessment of future trends. Additional indicators should incorporate data on the status of headwaters and other underrepresented areas in coastal watersheds.

There should also be an effort to identify natural processes needed by the species in coastal watersheds. Certain variations in seasonal flows, nutrient concentrations, or sediment transport may be critical for these species. Understanding these connections will help preserve the natural processes needed by many species, rather than taking a reactive approach to the declines of individual species.

Element 3: Species and Habitat Threat Assessment

The effects of rapid development, including habitat conversion, non-point source pollution, and altered hydrology, are the most pressing threats to coastal watersheds. Fragmentation due to dams and stream crossings restricts the amount of habitat available to many species and could have a negative impact on their genetic integrity. Restoring connectivity between marine, estuarine, and freshwater habitats will have a positive, long-term effect on the health of the coastal ecosystem. While the entire coastal watershed is at risk of future invasive species introductions, the greatest risk is from foreign ships that enter the Piscataqua River. Heavy ship traffic in the Piscataqua River also puts the Great Bay and coastal areas at risk from oil spills. In 1979 an oil spill from the tanker *New Concord* during an incoming tide contaminated sites in the Piscataqua River, the Bellamy River, and the Great Bay (NHFG 1979). Oil and toxic chemical spills will continue to threaten the coastal ecosystem, although oil containment technology has improved significantly over the past 10 years (UNH 2004).
Refer to the general threats section for: Transportation Infrastructure, Development (Fragmentation and indirect effects), Non-Point Source Pollution (Runoff and Sedimentation), Acid Deposition, Introduced Species, Altered Hydrology, Recreation, Unsustainable Harvest (Forestry Operations and Management), Oil Spills, and Agriculture.

Element 4: Conservation Actions

Salt marsh and river restoration will largely continue through a cooperative process with the New Hampshire Natural Resource Conservation Service (NHNRCS), which coordinates efforts to restore coastal salt marshes, and the NHDES, which has a River Restoration Coordinator (focused largely on removing dams).
The NHFG purchases property and assists with conservation easements throughout the state as opportunities arise. The NHFG is also part of the CORD review process, and thus can acquire land for little or no fee. Much of the land obtained through the CORD process was originally acquired by the New Hampshire Department of Transportation for road or road infrastructure projects.
Refer to general strategies for: Transportation Infrastructure, Development (indirect effects), Fragmentation, Pollutants (Acid Deposition), Invasive Species, Altered Hydrology, Sedimentation, Recreation, Forestry, Pollutants (Stormwater runoff and oil spills), and Agriculture.

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[1] EDUs in New England were qualitatively delineated by the TNC Freshwater Initiative program in 1999 using USFS Fish Zoogeographic Subregions, USFS Ecoregions and Subsections, and major drainage divisions (Bryer and Smith 2001). The EDUs were defined by grouping 8-digit US Geological Survey Hydrologic Units watersheds into units that were thought to contain aquatic systems with similar patterns of physiography, drainage density, hydrologic characteristics, connectivity, and zoogeography (Bryer and Smith 2001).

HABITAT PROFILE

Marsh and Shrub Wetlands

Associated Species: American Black Duck, American Bittern, American Woodcock, Blanding's Turtle, Common Moorhen, Eastern Red Bat, Great Blue Heron, Least Bittern, New England Cottontail, Northern Harrier, Osprey, Pied-Billed Grebe, Ringed Boghaunter, Rusty Blackbird, Sedge Wren, Silver Haired Bat, Spotted Turtle

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Tall graminoid emergent marsh (S4), Northern medium sedge meadow marsh (S3), Peaty marsh (S4), Short graminoid – forb emergent marsh/mud flat (S4), Medium-depth emergent marsh (S4), Deep emergent marsh aquatic bed (S4S5), Cattail marsh (S4), Aquatic bed (S4S5), Herbaceous seepage marsh (S3), Mixed tall graminoid- scrub- shrub marsh (S4S5), Highbush blueberry – winterberry shrub thicket (S4), Buttonbush basin swamp (S4), Alder alluvial shrubland (S3), Alder - dogwood arrowwood alluvial thicket (S4), Meadowsweet alluvial thicket (S3), Alluvial mixed shrub thicket (S4), Seasonally flooded red maple swamp (S4S5), Seasonally flooded boreal swamp (SU), Meadowsweet - robust graminoid sand plain marsh (S3S4), Meadow beauty sand plain marsh (S1), Three-way sedge - manna-grass mud flat marsh (S2S3), Spike-rush- floating- leaved aquatic mud flat (S1), Sharp-flowered manna-grass shallow peat marsh (S1), Montane sandy basin marsh (S1)
Author: Michael N. Marchand, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

The marsh and shrub wetland habitat described here corresponds to the emergent marsh-shrub swamp and sand plain basin marsh ecological systems described by NHNHB (NHNHB, Sperduto 2004). Emergent marsh and shrub swamp systems have a broad flood regime gradient that is often affected by the presence or abandonment of beaver (*Castor canadensis*) activity (Sperduto 2004). 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 2004).

The emergent marsh-shrub system is often grouped into three broad habitat categories: wet meadows, emergent marshes, and scrub-shrub wetlands. Wet meadows often are 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 wet meadows 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 wet meadow communities (Sperduto 2004, Sperduto and Nichols 2004). Examples of 'wet meadow' natural communities in New Hampshire may include tall graminoid emergent marsh, northern medium sedge meadow marsh, and short graminoid-forb emergent marsh/mud flat (Sperduto and Nichols 2004). Representative wildlife that use wet meadows include ribbon snake (*Thamnophis sauritus sauritus*), sedge wren (*Cistothorus platensis*), northern harrier (*Circus cyaneus*), northern leopard frog (*Rana pipiens*), king rail (*Rallus elegans*), common moorhen (*Callinula*

chloropus), and spotted turtle (*Clemmys guttata*; Benyus 1989).

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 deep-emergent marsh-aquatic beds (Sperduto and Nichols 2004). 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*), king rail (*Rallus elegans*), Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), least bittern (*Ixobrychus exilis*), common moorhen (*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 basin swamp, 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 (see ringed boghaunter profile under Peatlands habitat), 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.

1.2 Justification

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 rich 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. New Hampshire's population grew by 17% between 1990 and 2004, double the rate of all other states in New England, and growth is projected to continue at a rapid rate (Society for the Protection of New Hampshire Forests 2005). 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).

1.3 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.

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 Treaty Act (1918)
- 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).

1.4 Population and Habitat Distribution

Emergent marsh-shrub swamp systems are widespread throughout New Hampshire (Sperduto 2004), 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 2004). For the distribution of natural communities in each Ecoregion subsection, see Sperduto and Nichols (2004).

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

Marsh and Shrub Wetland maps were completed by the NHNHB as part of the CWCS. Wetlands from the National Wetlands Inventory (NWI) layer were selected based on comparing vegetation classes and subclasses as well as water regimes with descriptions for the natural communities within the marsh and shrub habitat (Sperduto and Nichols 2004), as well as expert review (D. Sperduto, NHNHB, personal communication). Wetlands on tidal flat organic or peat soils, and those described as acidic, excavated, and partially drained or ditched were excluded. Individual wetlands were assigned to natural communities based on their proximity to streams, isolation, elevation, ecoregion subsections, vegetation and hydrology. Wetlands that overlapped known peatlands from NHNHB surveys were eliminated from the layer (see Peatlands Profile-Element 1.6). Various attributes (e.g., quality, protection status, size, etc.) were assigned to the completed habitat map by NHFG and NHNHB.

Limitations: NWI classifications may be erroneous, particularly in underestimating peatlands; this would result in some peatlands included in the Marsh and Shrub Wetlands map. Also, incorrect water regime classifications in the NWI layer would result in incorrect natural community predictions. Mapped wetlands need some field survey to assess the quality of natural community predictions. Digital soil data were only available for part of the state, excluding Merrimack and Belknap counties as well as the White Mountains. Thus, any elimination of wetlands using soil data did not occur in these regions, so the habitat may be overpredicted in these regions.

1.7 Sources of Information

NHNHB publications, State and Federal agency web sites, NatureServe website, textbooks and peer-reviewed literature, and GIS layers from various sources (e.g., GRANIT, Complex Systems at UNH) were used for habitat mapping.

1.8 Extent and Quality of Data

Marsh and Shrub wetlands are distributed statewide. Natural communities that make up this system often have a more refined distribution. See mapping limitations in section 1.6.

1.9 Distribution Research

- Field-verify the prediction of mapped wetlands, especially for high priority sites and where rare natural communities may occur (e.g., meadow beauty sand plain marsh (S1), spike-rush - floating-leaved aquatic mud flat (S1), sharp-flowered manna-grass shallow peat marsh (S1), montane sandy basin marsh (S1)). 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.
- Beaver impoundments are of particular value for a variety of wildlife species. Although these habitats may be included in the mapped Marsh and Shrub wetlands, they also may be found in forested wetlands and open water habitats. Because these habitats are extremely valuable and existing layers such as NWI maps are probably insufficient, a specific effort to assess these habitats is worthwhile. Satellite imagery, color infrared aerial photographs, and other existing GIS data layers could be used to assess the current and potential (based on landscape modeling) distribution and abundance of beaver flowages in New Hampshire.

Element 2: Species/Habitat Condition

2.1 Scale

Mapped Marsh and Shrub Wetland polygons (see section 1.6) were combined into 'marsh complexes'. Individual marsh polygons were included in a complex if they were less than 250 m from an adjacent marsh. Marshes that were bisected by a major road (e.g., interstate, state route) were not considered part of the same complex. The condition and quality of Marsh and Shrub wetlands were assessed within these complexes based on available GIS data.

Marsh and Shrub wetlands have a statewide distribution and are relatively abundant, making it impossible to discuss each marsh complex separately. Therefore, the abundance of these habitats was summarized at a larger scale (e.g., Ecoregion subsections).

2.2 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 (figure 2).

2.3 Population Management Status

Waterfowl, beaver, muskrat, and other furbearers are managed by the NHFG.

2.4 Relative Quality of Habitat Patches

Because of the number and complexity of Marshes found in New Hampshire, complexes were assessed based entirely on available or easily created GIS data layers. For example, wetland size may be important for some area-sensitive birds (Hunt 2005). For amphibians, hydroperiod is an important factor influencing both species richness and abundance (Babbitt et al. 2003). Therefore, we grouped wetland complexes that had ephemeral wetlands, semipermanent and permanent wetlands, or both ephemeral and semipermanent wetlands. Because of the number of attributes assigned to polygons, individual variables will not be discussed here.

Southeastern New Hampshire is part of the middle-upper Atlantic coast waterfowl area, which stretches from South Carolina north along the Atlantic coast through Nova Scotia (North American Waterfowl Management Plan 1986). The Atlantic Coast Joint Venture, a subgroup of the North American Waterfowl Management Plan, has identified 3 waterfowl focus areas for New Hampshire: Lake Umbagog region, Great Bay area, and a 5 km area adjacent to and including the Connecticut River (North American Waterfowl Management Plan 1986). These areas are likely to be significant habitat areas for many other species as well. Wetlands associated with the Merrimack River and its tributaries are important areas for wildlife and priority areas for future protection efforts.

2.5 Habitat Patch Protection Status

Protection status was calculated for areas within 250 m of each marsh complex statewide and summarized for each Ecoregion subsection. The total mean area protected in the buffered complexes was 13 percent ± 27 SD (range 0-100%); mean fee ownership was 10 percent ± 13 SD (0-100%) and land in easement was 3 percent ± 13 SD (0-100%). Only 30 % of individual buffered complexes had greater than 5 % land area protected, 11% of complexes had greater than 50 % protected, and 8% of complexes had greater than 70% land protected statewide.

The percent protection among buffered complexes varied among ecoregion subsections (figure 3). The White Mountains subsection had the greatest percentage of buffered complex land in protection (58%); however, this subsection has the lowest percentage of overall marsh complex area (9%). Conversely, the Gulf of Maine Coastal Plain Lowland had the greatest percent of overall land consisting of marsh buffered complex (55%), but the percent in protection was low (14%).

2.6 Habitat Management Status

From 1997 to 2004, 121 ha of wetlands were created, restored, or enhanced as part of mitigation for 397 ha of wetlands impacts (S. Crystall, NHDES, personal communication). Restoration of freshwater wetlands in New Hampshire has been largely a result of wetland violation enforcements (L. Sommer, NHDES, personal communication). Most mitigation resulted from protection of uplands and wetlands through conservation easements (S. Crystall, NHDES, personal communication).

The NHFG owns and manages 19 waterfowl impoundments, and manages an additional 12 impoundments on other properties. Water control structures on each of these impoundments allow for aquatic vegetation manipulation. Most management consists of moist soil management where water is removed every 7-10 years, from approximately 20 June through mid-September with the goal to enhance the growth of aquatic plants (E. Robinson, NHFG, personal communication). In addition, some forest

management has occurred to encourage beaver occupation on state-owned properties (B. Lemire, NHFG, personal communication).

According to RSA 210:9, no person shall destroy or disturb or interfere in any manner with the dams or houses of beaver, without first obtaining a special permit from the executive director of the NHFG; an exception is allowed for the protection of property from damage or submersion. For several years, the NHFG provided technical assistance to landowners in order to maintain beaver flowages and reduce concerns over property damage, but funding for this assistance has not been available recently. A handout describing beaver control techniques (e.g., install beaver piping) is available at NHFG and the UNH Cooperative Extension.

In the coastal watershed, a management plan was completed that identified action plans for water quality, land use, habitat protection and restoration, and public outreach and education (New Hampshire Estuaries Project 2000). This management plan has set the groundwork for many of the actions that will be addressed for other habitats and areas of New Hampshire. Also, the Great Bay Resource Protection Partnership has protected 84 properties and 2,628 ha (6,494 acres) in the coastal watershed (R. Stevens, Great Bay National Estuarine Research Reserve, personal communication). Many of these protected properties provide habitat for at-risk wildlife species including Blanding's and spotted turtle and American black duck. Management plans are being developed for each of the properties.

2.7 Sources of Information

Condition of wetlands was based largely on available GIS analyses.

2.8 Extent and Quality of Data

Condition of wetlands was based largely on available GIS analyses.

2.9 Condition Assessment Research

- Conduct GIS analysis to identify quality of marsh complexes (e.g., high, moderate, low). Attributes have been assigned to marsh complexes but weighting of these variables needs to be completed as a next step. A subset of sites that are identified as high quality should be field verified. Marsh sampling should include an assessment of habitat availability for at-risk wildlife. This work can be conducted by NHFG with assistance from other wetland and wildlife experts. Ranked marsh complexes should be incorporated into NHDES wetland permit review and mitigation prioritization and selection.
- Develop and implement a bioassessment program for freshwater wetlands in New Hampshire (e.g., King et al. 2000, D. Neils, NHDES, personal communication).

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
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.

(B) Evidence
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).

More than 50% of original wetland acreage in the United States has been lost (Dahl 1990). In New Hampshire, Dahl (1990) estimated 9% (8,000 ha) of wetlands were lost between 1780 and 1980, the lowest percent of any state in the conterminous United States. In the conterminous United States between 1986 and 1997, urban and rural development accounted for 51% of freshwater wetland losses, followed by agriculture (26%), and silviculture (23%) (Dahl 2000). For freshwater emergent wetlands

converted to uplands during 1986-1997, 51% were on agricultural lands, 22 % were lost to development, 25 % to unidentified land use manipulations, and 2 % to silviculture (Dahl 2000). Freshwater emergent wetlands declined by 4.6 % during that time (Dahl 2000). Freshwater shrub wetlands, in contrast had a 6.6 % increase in acreage over this time period, largely because of emergent marsh and forested wetland conversion (Dahl 2000). However, the interaction between emergent marsh and shrub wetlands should not be misinterpreted. There was a net loss to freshwater wetlands, and 79,600 ha of shrub wetland were converted to uplands (Dahl 2000).

NHDES currently has regulations that limit the amount of wetland filling (RSA 482-A). Wetlands impacts averaged 50 ha per year from 1997 to 2004 in New Hampshire, with a low of 22 ha in 1997 and highs of 65 (2000) and 64 ha (2004) (S. Crystall, NHDES, personal communication). 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). New Hampshire is the fastest growing state in the northeast, and future rates of development and associated wetland impacts are likely to continue (Sundquist and Stevens 1999).

Several exemptions in state regulations allow wetland habitats and associated wildlife to be disturbed. For example, NHDES does not require a permit for the "removal of a beaver dam by hand or machine provided machinery does not enter the water or create any disturbance by filling or dredging to the adjacent waters, wetlands, or their banks; all dredged materials are placed out of department jurisdiction; and removal of the dam is done in a gradual manner that does not allow a sudden release of impounded water to cause erosion or siltation." (NHDES Wt 303.05). Also, a reduced application (Minimum impact agricultural projects) may be filed for agricultural 'improvements' up to 1.2 ha (3 ac) of wet meadow (NHDES Wetlands Bureau Fact Sheet WB-6). Lake drawdowns are conducted in the fall and these drawdowns leave adjacent wetlands shallow or dry during the winter months (e.g., Northwood Lake).

3.1.2 Development (Fragmentation)

(A) Exposure Pathway
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.

(B) Evidence
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, upland habitats are given little consideration. NHDES site-specific permits are required when 9,290 m^2 (100,000 ft^2) of terrain are altered, but there is currently no review for wildlife impacts, including rare or endangered species, during this process. 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.

3.1.3 Introduced Species (Introduced Plants)

(A) Exposure Pathway
Invasive plants are introduced to a wetland habitat, often following disturbance or soils being exposed (Weatherbee et al. 1999). Invasive plants compete with native vegetation, often dominating areas of wetlands by forming monotypic stands. Invasive plants often are less valuable to wildlife as habitat and may decrease the aesthetic, recreational, and monetary value of New Hampshire waterbodies (Pimentel et al. 2004, NHDES Environmental Fact Sheet BB-40). Harm to native flora and fauna may vary depending on the invasive species and needs further research.

(B) Evidence
Approximately 42% of federal threatened or endangered species primarily are at risk from alien-invasive species (Pimentel et al. 2004). Examples of invasive wetland plants known to occur in New Hampshire include purple loosestrife (*Lythrum salicaria*), common reed (*Phragmites australis*), Japanese knotweed (*Polygonum cuspidatum*), shining buckthorn (*Rhamnus frangula*), water chestnut (*Trapa natans*), variable milfoil (*Myriophyllum heterophyllum*), Eurasian milfoil (*Myriophyllum spicatum*), and fanwort (*Cabomba carolinina*). Over 40 surface waters (not including wetlands) in New Hampshire are affected by various species of exotic aquatic plants (NHDES Watershed Bureau). Numerous additional wetlands have been invaded by purple loosestrife or Phragmites. The exotic species program within the NHDES Watershed Management Bureau has largely focused on controlling or eliminating invasive plants from surface waters. Herbicides are currently used to treat some species (e.g., milfoil) that have been in lakes and ponds. Attempts to eradicate extensive areas using chemicals are rarely effective (NHDES Watershed Bureau). However, there is considerable interest in documenting new or established invasive species among terrestrial and aquatic habitats (e.g., Invasive Plant Atlas of New England, National Invasive Species Council)

Phragmites is native to coastal marshes in New England; however, it has expanded its range and benefited from salt applications along roadways (Weatherbee et al. 1999, Richburg et al. 2001). Purple loosestrife has been introduced to 48 states, including New Hampshire, and is tolerant of a range of environmental conditions. It forms dense stands and has no natural enemies in North America (Pimentel et al. 2004, NHDES Fact Sheet BB-45). Individual purple loosestrife plants can produce millions of long-lived and easily dispersed seeds annually, and can re-sprout from broken stems or roots (NHDES Environmental Fact Sheet BB-45). The reported ecological effects of purple loosestrife have varied (Farnsworth and Ellis 2001). For example, an experimental removal of purple loosestrife in New York resulted in reduced purple loosestrife density, but a corresponding increase in native species richness did not occur (Morrison 2002). Therefore, removal programs should clearly identify goals before initiation (Morrison 2002). Recommended criteria for physical control of purple loosestrife have been described by the NHDES Exotic Species Program (NHDES Fact Sheet BB-45). Biological control of purple loosestrife by introduced beetles (e.g., *Galerucella* spp.) has shown some promise (Malecki et al. 1993, Katovich et al. 2001, Blossey 2003). The ecological effect of non-native invertebrates introductions on wetland flora and fauna is not well known but biological control appears to have some support in New Hampshire as a substitute for chemical control (Lionel Chute, NHNHB, personal communication).

3.2 Sources of Information

Literature reviews, state and federal agency websites, fact sheets, and reports were used to assess the exposure pathway and evidence of threats to marsh and shrub wetlands in New Hampshire. GIS data layers were gathered from the Complex Systems Research Center at UNH (GRANIT), NHDES, and NH Division of Transportation to assess threats.

Initially, a list of threats was identified by NHFG and sent out for review. A group of wetland and wildlife experts met on 27 January 2005 to rank threats to Marsh and Shrub Wetlands (participants included Kim Babbitt, Kim Tuttle, Pam Hunt, Carol Foss, Chris Martin, Laura Deming, Heather Hermann, Benjamin Nugent, and Matthew Carpenter). Ranked threats were sent out for further review, comments were incorporated and ranks were adjusted based on further expert input.

3.3 Extent and Quality of Data

Some threats to marsh and shrub wetlands and the associated flora and fauna are well established (e.g., wetland filling). Other threats need further study (See Element 3.4) or regional coordination (e.g., contaminants).

3.4 Threat Assessment Research

- Support a regionally coordinated effort to assess impacts of various contaminants (including sodium chloride) on wetland habitats
- Support research that identifies effects of invasive species (e.g., purple loosestrife) on native freshwater wetland fauna and flora and monitor new invasions through coordinated efforts with local (e.g., garden clubs) and regional efforts (e.g., Invasive Plant Atlas of New England).

Element 4: Conservation Actions

Protecting Marsh and Shrub Wetland habitat and surrounding uplands will be the most important effort to maintain marsh dependent organisms in New Hampshire. Marsh protection strategies (e.g., land acquisition, prime wetland designation, zoning ordinances, etc.) are incorporated into the discussion of Habitat Protection under General Strategies

4.1.1 Maintain natural establishment, occupancy, and abandonment of beaver flowages in the landscape, Regulation, Habitat Protection

(A) List of Direct Threats Affected: Wetland loss

(B) Justification

- There is presently no regulation or monitoring of beaver dam removals. Any action will be an improvement over existing conditions.
- Beaver flowages are critical habitat for a number of wildlife species. Natural flood regimes have been limited by increasing development that restricts beaver activity. Existing beaver dams that maintain impoundments may be removed if on private property with no regulatory review, including if rare species are present, because NHFG is not necessarily notified.
- Beaver flowages should be maintained at a landscape level so natural abandonment and establishment can occur. Otherwise, existing beaver impoundments will need to be maintained by human-created dams as wetlands are abandoned by beavers. Otherwise, local populations of wildlife with poor dispersing abilities may be extirpated when embedded in a developed landscape. Development must be restricted in areas with future potential to become beaver flowages.
- Wetland filling is regulated by the NHDES for developers but large wetland complexes can be drained legally with little if any review. With the rapid loss of upland habitat in southern New Hampshire, landscapes that currently have the ability to maintain beaver flowages will be fragmented or lost. Therefore, regulations pertaining to managing and regulating beaver impoundments should be reviewed within 1 year of the completion of the New Hampshire Comprehensive Wildlife Strategy.
- Most regulations can be changed, although not easily, if determined to be ineffective.

(C) Conservation Performance Objective
To reduce or eliminate the loss of wetlands resulting from beaver dam removal and to maintain landscapes where potential flooding exists for the future.

(D) Performance Monitoring
Estimate the number and area of wetlands that are lost annually from removal of beaver dams and compare to the area of wetland filled because of NHDES Wetlands Bureau Dredge and Fill permitting. Assess the number of wetlands that are maintained through beaver piping or other water control structures.

(E) Ecological Response Objective
Maintain naturally functioning wetlands and connectivity for wildlife dispersal in the landscape.

(F) Response Monitoring
It is well established that beaver impoundments are important habitats for numerous wildlife spe-

cies. Therefore, monitoring individual wetlands is not necessary. However, species-specific monitoring (e.g., Blanding's turtle, pied-billed grebe), connectivity analyses, and satellite imagery wetland change detection analyses may indicate the importance and effectiveness of actions.

(G) Implementation

- Maintaining functional beaver flowages in the New Hampshire landscape will require several more specific actions.
- Identify staff and funding needed to coordinate the following actions.
- Use landowner incentive programs (e.g., LIP) to maintain water levels (e.g., beaver piping) on existing beaver impoundments where additional flooding may cause property damage.
- Educate public about the importance of beaver impoundments for wildlife and the risk of flooding if structures are built in areas with potential to become impounded.
- Model existing and potential beaver flowages and incorporate into environmental reviews and landscape level planning done by towns and regional planners.
- Evaluate NHFG and NHDES regulations to require a review process prior to any beaver dam removal. Work with Wildlife Control Officers to ensure that maintenance of beaver impoundments is a preferred option over removal.

(H) Feasibility
Wetlands are very expensive to create and ecological success is often not obtained. Maintaining landscapes with naturally fluctuating beaver impoundments will be a cost-effective way at maintaining high-quality wetlands in New Hampshire long-term. Changing existing regulations may be somewhat challenging because of concern over landowner rights.

4.1.2 Create a list of wetland restoration sites and implement high priority projects, Restoration and Management

(A) List of Direct Threats Affected: All threats listed under Element 3

(B) Justification
Creating a list of restoration sites is the first step in prioritizing wetland restoration actions.

- Restoration sites are those that are impacted by a threat listed on the Marsh and Shrub Wetland Threat Ranking Form. Creating a list of restoration sites will not in itself reverse the threat but will provide a mechanism to select and prioritize sites for limited restoration funding. Freshwater emergent wetlands can reestablish quickly under wet conditions and can be restored with some success (Dahl 2000), especially when compared to other wetlands types such as peatlands and forested wetlands.
- Restoration will be focused on specific impaired wetlands but selection and prioritization may be embedded within 10-digit watersheds that are classified as in need of restoration (NHDES Watershed analysis).
- Restoration can address any number of threats (e.g., roads as dispersal barrier, altered hydrology, invasive plant removal). State and federal wetlands permitting currently allows and encourages wetland restoration as part of mitigation for impacts. Selecting restoration sites can be difficult and time consuming for permit applicants and actions may not result in the best ecological project.
- Restoration sites should only be considered if removal of the threat likely would result in a positive ecological response. Lists of potential restoration sites can be updated on annual or continual basis.

(C) Conservation Performance Objective
To create and prioritize a list of impaired wetlands in New Hampshire in which ecological integrity will be improved.

(D) Performance Monitoring
The number of potential restoration sites submitted per town or watershed unit will be compiled. Each potential restoration site should clearly describe how the system is being impacted and what measures can be taken to improve ecological integrity. Sites will be prioritized and a portion will receive funding. The number of restoration projects that receive funding

will be summarized per town and watershed on an annual basis.

(E) Ecological Response Objective
To improve the functioning of wetland systems by restoring impaired wetlands. Improved wetland function will vary depending on the reason a wetland is impaired or not fully functioning. Successful ecological response thresholds will be developed for each group of threat (e.g., invasive species removal, restore hydrology, etc.)

(F) Response Monitoring
Response monitoring will be site-specific and relevant to meeting the objectives. Success will be determined by monitoring positive changes to the described impairment. Funding should include a monitoring component to ensure limited funds are effectively allocated.

(G) Implementation
(See Action RST-4, RST-5, RST-6 from the 2000 NHEP Management Plan)
Compiling a list of potential wetland restoration sites will likely involve several phases. Standardized information can be gathered from locations across the state through GIS analyses, many of which will result from New Hampshire's Comprehensive Wildlife Strategy mapping. Some of these mapping efforts may involve field visits as verification (e.g., ineffective road culverts for migratory wildlife). Inventory methodology was developed in the coastal watershed (NHEP 2003). Other regional and statewide monitoring efforts should be quarried for information. For example, the Invasive Plant Atlas of New England database can be searched for invasive species locations in New Hampshire and these sites can be assessed based on degree of infestation, significance of the habitat for wildlife, and likelihood of improving ecological integrity. A second phase may involve quarrying locals for their knowledge of potential restoration sites (town conservation commissions and planning boards, land trusts, conservation groups). A list that includes both sites predicted to need some restoration activity and those identified by locals must be compiled and prioritized. Types of impaired wetlands worthy of considering restoration might include: filled, excavated, graded, ditched, and drained wetlands, reduced water quality as result of runoff or pollutants, altered hydrology, barriers to wildlife dispersal (e.g., ineffective road culverts), and invasive species presence. Criteria for prioritizing potential sites need to be developed. If mitigation funds become available for this purpose (i.e., In-lieu wetlands mitigation, NHDES), a selection board that includes members from state agencies (e.g., NHFG, NHDES, NHNHB, NHDOT) and conservation groups (e.g., The Nature Conservancy, New Hampshire Audubon) would convene as needed. Top priority restoration projects would be funded and monitored for success. This list would also be available for towns or regional conservation groups to implement local restoration.

(H) Feasibility
A list of potential restoration sites was compiled for the coastal watershed as part of the NHEP management plan (NHEP 2000, 2003). Towns with more developed and active conservation commissions and planning boards are more likely to participate than some other towns with limited personnel or experience.

4.1.3 Assess the impacts of lake, pond, and wetland water level drawdowns on at-risk wildlife and plant assemblages in New Hampshire and implement any necessary changes to procedures, Restoration and Management.

(A) List of Direct Threats Affected: Wetland loss and alteration

(B) Justification

- Threats may vary depending on species and type of drawdown. Recommended procedure changes will be designed to reduce threats.
- Recommended procedure changes will occur when ecological responses are expected and can be measured.
- Water withdrawal procedures may be adjusted in specific areas where at-risk species are known or likely to occur. General recommendations can be incorporated into withdrawals statewide.
- With the loss of rapid rate of development in southern New Hampshire and the associated loss of wetlands as wildlife habitat, it is increasingly important to incorporate at-risk

species in managed systems.

- At-risk species and specific threats can be monitored and adjusted as appropriate.

(C) Conservation Performance Objective
To improve wetland ecosystem function and viability of at-risk species by implementing appropriate changes to current water withdrawal procedures.

(D) Performance Monitoring
Identify specific locations where hydrological alterations may impact at-risk wildlife. The number of wetland and lake drawdowns can be easily tracked, as well as the number of procedure changes that occur as a result of improved coordination among agencies and interested parties.

(E) Ecological Response Objective
Maintain or enhance marsh habitat for a diversity of species, especially at-risk wildlife.

(F) Response Monitoring
Wildlife surveys could be conducted before and after drawdown activities to determine potential impacts of current procedures and monitor long-term response of wildlife or communities to changing procedures. Specific monitoring (e.g., species presence, habitat use, productivity, survivorship, behavioral response) could occur for those species of the highest conservation concern (e.g., pied-billed grebe, Blanding's turtle) or those easily surveyed. Research may be encouraged in locations where the effects of existing procedures are not known.

(G) Implementation
Review procedures for wetland and lake drawdowns and identify sites where at-risk species may occur. Existing impoundments managed by NHFG are known and species maps can be used to identify wildlife that may occur on each area. Identify existing areas where management for at-risk wildlife can be improved. Future proposed impoundments should be reviewed by the NHFG Nongame and Endangered Species Program and incorporate at-risk species management. Lake and pond annual drawdowns are identified by NHDES. The effect of these drawdowns on adjacent marsh wildlife is expected to be detrimental. Use GIS to compare known lake drawdowns and rare species occurrences. Review procedures and justifications for drawdowns and identify areas for enhanced wildlife habitat.

Specific recommendations to consider might include: avoiding late fall drawdowns to prevent mortality of hibernating amphibians and reptiles, conducting drawdowns gradually to allow wildlife to disperse, maintain channels to adjacent wetlands to facilitate safe dispersal of threatened turtles and other wildlife (Hall and Cuthbert 2004), and ensure that water levels and timing are sufficient for at-risk birds that may be nesting at specific sites (e.g., pied-billed grebe).

(H) Feasibility
Altering existing drawdown schedules for lakes and ponds may be challenging in some cases due to local support for the action. Incorporating biodiversity considerations into state- managed impoundments should be possible in most cases, especially where waterfowl considerations are maintained. Future proposed drawdowns should be carefully evaluated by NHDES and NHFG for potential impacts to at-risk wildlife or system functions.

4.2 Conservation Action Research

- Restoration efforts will be prioritized according to likelihood of success. Degree of success will be incorporated in Ecological Response Monitoring.
- Model existing and landscapes where beaver flowages are likely in the future.

Element 5: References

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Element 6: List of Figures

Figure 1. Marsh & Shrub Wetlands are distributed throughout New Hampshire. For the distribution of natural communities in each Ecoregion subsection, see Sperduto and Nichols (2004).

Figure 2. Area (ha) of marsh, shrub, and mixed (marsh and shrub) wetland habitats in each Ecoregion subsection of New Hampshire, USA.

Figure 3. Percent of each ecoregion subsection area in New Hampshire that was mapped as a marsh or 250 m marsh buffer (hatched bars) and the percent of each buffered marsh complex that was protected by fee acquisition or easement for each ecoregion subsection (solid bars).

HABITAT PROFILE

Northern Upland Watersheds

Associated Species: American Eel (Anguilla rostrata), Atlantic Salmon (Salmo salar), Burbot (Lota lota), Brook Trout (Salvelinus fontinalis), Finescale Dace (Phoxinus neogaeus), Lake trout (Salvelinus namaycush), Northern Redbelly Dace (Phoxinus eos), Rainbow Smelt (Osmerus mordax), Round Whitefish (Prosopium cylindraceum), Slimy Sculpin (Cottus cognatus), Tesselated Darter (Etheostoma olmstedi)

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Author: New Hampshire Fish and Game and The Nature Conservancy

Element 1: Distribution and Habitat

1.1 Habitat Description

The landforms, elevations, and geology of northern upland watersheds watersheds are similar to moderate-south watersheds (Figure 3), but moderate-north watersheds are distinct because of their northern terrestrial communities, higher elevations, and separation from watersheds south of the White Mountains. Both the higher elevation and the northern climate result in rivers that support more coldwater fisheries compared to similar southern rivers.

Higher gradient, coldwater stream communities likely dominate this watershed group. Where there are wetlands, there may be some sinuous stream habitats with more stable water flows and warmer waters. There are few long reaches of mature rivers, which would tend to have slower water, deeper pools, and habitats within meanders and laterally varied substrates. The mainstem of the Androscoggin River may have some characteristics of slow and deep rivers, but it is still fairly high up in the watershed and even the wide sections in New Hampshire have characteristics of faster and colder streams.

Moderate-north watersheds contain the headwater networks that support coldwater ecosystems and fisheries in the New Hampshire portions of the Androscoggin and Connecticut River basins. In addition, this watershed group contains some of the largest impounded reservoirs in New Hampshire. Both the dammed sections of the Ammonoosuc and Connecticut River Lakes provide artificial but unique lake-like habitats.

Moderate-north fine scale systems: 5, 7
Like moderate-south watersheds, the distinction between fine scale systems is subtle. Both fine scale systems 5 and 7 have similar geology, landforms, and elevations, but fine scale system 5 has a greater area above 762 m. Fine scale system 7 has a higher percentage of “big water” features, including large reservoirs, Lake Umbagog, more wetlands, and the large mainstem sections of the Androscoggin River. Fine scale system 5, by contrast, contains more of the highest headwaters and river tributaries.

1.2 Justification

Like northern terrestrial ecosystems, the aquatic systems of the North Country may provide unique ecological and evolutionary contexts for species assemblages. Potentially remote native trout streams, remote lakes and ponds, Lake Umbagog, and the unusually large reservoir systems, managed for industry (hydropower and timber) and recreation, provide settings found nowhere else in New Hampshire. There are slow streams meandering through lowland spruce fir flats and coldwater streams cascading down steep slopes.

1.4 Habitat Distribution

Moderate-north watersheds occupy the northern tier of New Hampshire, north of the major White Mountains drainages. Large tributaries to the upper reaches of the Connecticut and Androscoggin Rivers include the Perry, Nash, Indian Stream, Mohawk, Israel, and Upper Ammonoosuc Rivers to the west, and the Dead Diamond, Swift Diamond, and Magalloway Rivers to the east. Smaller native brook trout streams, such as Gore, Cone, and Smarts Mill Brook (among others) also flow directly into the Connecticut River mainstem in and around Colebrook. This watershed group straddles the Penobscot-Kennebec-Androscoggin and Upper Connecticut Ecological Drainage Units (EDUs). This watershed group is entirely within TNC's Northern Appalachians Ecoregion.

1.8 Extent and quality of data

Moderate-north watersheds are unique and clearly distinguishable from New Hampshire's other major watershed groups based on aquatic connectivity and geography. The difference between the fine scale systems is more subtle. There are differences in elevation, geology, and landform, but these may not control or influence biological communities. Nevertheless, representing both fine scale systems 5 and 7 in conservation plans will ensure a broader array of environmental settings.

2.1 Scale

Due to the large land area covered by the major watershed groups (Figure 3), a fine scale classification (Figure 4) was used, when possible, to assess the relative condition of aquatic habitats across the state. The types and sources of information were extremely variable and covered many different scales, and so the following sections refer to both the major and fine scale systems. The actual scale at which the natural conditions and processes lead to differences in aquatic communities is uncertain.

Moderate-north watersheds are divided into two conservation planning units (Figure 4). Fine scale system 5 includes 5 watersheds of the Androscoggin and Connecticut Rivers in northern New Hampshire with greater amounts of high elevation features. Fine scale system 7 includes 6 watersheds, also of the Androscoggin and Connecticut Rivers, but with more flat landforms and large lakes.

2.4 Relative Quality of Habitat Patches

Fine scale system 5 encompasses 1,709 km^2 (422,314 ac). Headwater streams (watershed area <77.7 km^2) are the most common stream/river type within this system, comprising 75% of the total stream area. Small rivers (watershed area of 77.7-518.0 km^2), medium rivers (watershed area of 518.0-2590.0 km^2), and large rivers (watershed area >2590.0 km^2) comprise 16%, 9%, and 1%, respectively. Moderate elevations (244-518 m) and high elevations (518-762 m) are most dominant, at 44.8% and 42.7%. Very high elevations (762-1371.6 m) comprise 12.5% of this system.

In fine scale system 5, the Connecticut, Mohawk (Colebrook), and Upper Ammonoosuc Rivers provide habitat for several life stages (e.g. spawning, nursery, rearing) of Atlantic salmon (Connecticut River Salmon Commission 1998, USFWS 2005). There is quality wild brook trout habitat in Pond (Stratford/Odell), Long Mountain (Stratford/Odell), Alder (Second College Grant), Lamb Valley (Second College Grant), and Lomis Valley (Second College Grant) Brooks, as well as in the west branch of the Mohawk River and Little Greenough Pond (Wentworths Location) (NHFG, unpublished data).

Fine scale system 7 encompasses 1,611 km^2 (398,047 ac). Headwater streams are the most common stream or river, comprising 64% of the total stream area. Small rivers, medium rivers, and large rivers comprise 18%, 11%, and 7%. High elevations and moderate elevations dominate at 49.5% and 45.8%. Very high elevations comprise 4.7% of this system.

An Androscoggin River basin study identified Umbagog Lake in Errol as having significant habitat value for waterfowl (USACE 1980). Lake Umbagog provides diverse habitats with relatively low disturbance, making it an important breeding ground for common loons (*Gavia immer*). Lake Umbagog and the adjacent wetland complex also provides ideal habitat for American black ducks (*Anas rubripes*), great blue herons (*Ardea herodias*), ospreys (*Pandion haliaetus*), bald eagles (*Haliaeetus leucocephalus*), and ring-billed gulls (*Larus delawarensis*) (USACE 1980). The lake provides fisheries for warm and coldwater

fish species. Smallmouth bass were illegally introduced into the system in the 1980s (Noon 1999) and expanding populations threaten salmonid populations in tributaries to the lake (Rapid, Magalloway, and Diamond Rivers) (Reardon and Zinc 2004). Clear and Chickwolnepy Streams (tributaries to the Androscoggin River) have ideal spawning and nursery habitat for Atlantic salmon (DeRoche 1967). However, spawning runs by anadromous fish in the Androscoggin River are blocked downstream of the New Hampshire boarder in Maine (USACE 1980).

Most lakes and ponds in the northern section of New Hampshire have a surface area less than 4.05 ha (10 ac) (94% of the total number). There are relatively few larger lakes and ponds. There is an average of 1.37 lakes/ponds greater than 4.05 ha per 100 km^2. The 4 lakes greater than 405 ha (1,000 ac) are First Connecticut Lake (1,243 ha or 3,071 ac), Lake Francis (783 ha or 1,934 ac), Second Connecticut Lake (446 ha or 1,102 ac), and Umbagog Lake (2,456 ha or 6,068 ac). Sixty percent of lakes and ponds are at elevations between 243.84-518.16 m (800-1,700 ft) and 38% are at elevations between 518.16-762 m (1,700-2,500 ft). Only 2% of lakes and ponds have elevations greater than 762 m (2,500 ft).

2.2 Relative Health of Populations

Land Use

Fine scale system 5 has the highest percentage of unfragmented land (94%) and the lowest percentage of developed land (0.8%) in New Hampshire. Low percentages of developed land correspond with the lowest road density in New Hampshire. The density of roads maintained by NHDOT is 0.17 km/km^2 and the density of private/gravel roads is 0.19 km/km^2. The estimated population for 2005 is 13,249 people, with a relatively low population density of 6.8 people/km^2.

Fine scale system 7 also contains large areas of unfragmented land (92%). The amount of developed land is very low compared to other units in New Hampshire (1.1% of total land). The density of NHDOT roads is 0.21 km/km^2 and the density of private/gravel roads is 0.25 km/km^2, which are both low. The estimated population for 2005 is 9,677 people, or 3.8 people/km^2, the lowest population density in the state.

Land uses along the upper Connecticut River are rural and agricultural, with large areas of forested and undeveloped lands (NHDES 1991). The higher elevations of these areas may inhibit agricultural use. The total area of agricultural land is small compared to other parts of New Hampshire. Agricultural lands in fine scale system 5 and fine scale system 7 comprise 1.9% and 1.2% of the total land area.

Silviculture in northern New Hampshire can be intensive with various levels of regard for significant wildlife habitats and post-harvest effects to stream systems. Forestry management in the Second College Grant is implemented with the "highest standards of forestry practice" with goals of broad wildlife species and age class distributions (Dartmouth Outing Club 2005). Concern is growing as private companies purchase large tracts of land with the intent of heavy logging followed by reselling, without consideration for the subsequent effects on wildlife habitat. Current forestry policies in New Hampshire may encourage out-of-state logging companies to purchase land. Logging regulations in New Hampshire are less stringent than neighboring states, which have more regulations on clear cutting and the sale of woodlots post-cutting (Webster 2005).

Housing increases for census blocks adjacent to lakes and ponds in moderate-north watersheds were estimated using 1990 values and projected 2020 values (see Lake Type Classification for methods). Changes between rural (<0.063 housing units/ha), exurban (0.063 to 0.25 units/ha), and suburban (0.25 to 2.5 units/ha) housing densities could indicate increases in shoreline development, impervious surfaces, and nonpoint source pollution. Housing densities adjacent to lakes are not expected to change in this area by 2020.

Water Quality

The NHDES Volunteer Rivers Assessment Program (VRAP) reported on surface water quality of the Androscoggin River (NHDES 2004). Dissolved oxygen and turbidity levels at all sample sites met state requirements for class B waters. Turbidity levels increased near urban areas. The range of pH values (pH 6.37-6.79) was below state water quality standards for class B waters (standard is pH 6.50-8.0). Acidic precipitation and natural environmental conditions (e.g. soils, geology, wetland drainage) can lower pH values (NHDES 2004). Within the Androscoggin River watershed, there is mercury seepage from contaminated

groundwater and nonpoint source pollution caused by agriculture, stormwater runoff, and poorly managed timber harvests (C. Knox, Androscoggin River Watershed Council, personal communication).

On the upper Connecticut River, there are adequate amounts of dissolved oxygen, low levels of fine particles or organic matter embedded in sediments, and a variety of fish habitats (Francis and Mulligan 1997). The upper Connecticut River system provides a highly prized coldwater fishery. Sedimentation and turbidity are the two highest threats to this area (Francis and Mulligan 1997). Silviculture practices have catalyzed the rates of bank erosion, which introduces sediments and nutrients into the system (Francis and Mulligan 1997). High water temperatures in the summer, coupled with excessive nutrient levels, can significantly lower dissolved oxygen rates (Francis and Mulligan 1997).

Water discharges registered through NHDES are moderate in this area when compared to registered discharges throughout New Hampshire. The number of National Pollution Discharge Elimination System (NPDES) permits issued per river kilometer is 0.013 NPDES permits/river km for fine scale system 5 and 0.027 NPDES permits/river km for fine scale system 7.

Upstream forestry operations that cause sedimentation and increased turbidity can damage downstream fisheries. Siltation from timber harvesting in 1972 covered smelt eggs and decimated the smelt population in First Connecticut Lake (Francis and Mulligan 1997).

Invasive Species

There are no documented infestations of exotic aquatic invasive plants in either fine scale system 5 or fine scale system 7 (Smagula 2004). Several non-native fish populations have become naturalized within the watersheds of the Connecticut and Androscoggin Rivers. Increased water temperatures and altered habitats from the creation of large impoundments facilitate the proliferation of these species. Several non-native species provide sport-fishing opportunities. Largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), northern pike (*Esox lucius*), landlocked Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*), and rainbow trout (*Oncorhynchus mykiss*) are examples of species that have naturalized populations (NHFG 2004, Estuarine and Freshwater Working Group 2005). Landlocked Atlantic salmon, brown trout, and rainbow trout are annually stocked by NHFG. The population of smallmouth bass in Umbagog Lake is perhaps the most infamous naturalized non-native fish population in New Hampshire. The well-established population is expanding into the inlets of the lake and displacing native brook trout populations (Maine Department of Inland Fisheries and Wildlife (MDIFW) 2005).

To assess the likelihood of intentional or accidental introductions of invasive fish and aquatic plants, the degree of remoteness of lakes and ponds was analyzed through GIS. The highest percent of remote lakes and ponds occurs in this area. There are 850 lakes and ponds (69%) within 500 m of a trail or road, 154 lakes and ponds (13%) enclosed by a protective buffer of 500-805 m without a mapped road or trail, 151 lakes and ponds (12%) with a buffer of 805-1609 m, and 74 lakes or ponds (6%) with a buffer greater than 1609 m.

Hydrology

There are approximately 71 active dams/impoundments within fine scale system 5. There are no active impoundments in the mainstem of the Connecticut River in this area. From West Stewartstown to Dalton, there is a 112.65 km stretch of the Connecticut River mainstem that is free flowing (Francis and Mulligan 1997).

There are approximately 51 active dams/impoundments within fine scale system 7, which vary from large river impoundments for hydroelectricity production to small stream impoundments for wildlife habitats. There are five active impoundments along the Connecticut River in this area (Francis and Mulligan 1997). Impoundments in Berlin have a high degree of adjacent industrial development and little natural habitat (USACE 1980). Impassable dams downstream of the New Hampshire border in Maine block spawning runs of anadromous fish in the Androscoggin River (USACE 1980).

The loss of food supplies and spawning or rearing habitat for fish in the upper Connecticut River can occur during low flow periods or after seasonal drawdowns of the Connecticut Lakes and Lake Francis. Modified flow rates further impact limited wintering habitat by influencing ice formation and dissolved oxygen levels (Francis and Mulligan 1997).

2.3 Population Management Status

N/A

2.5 Habitat Patch Protection Status

In fine scale system 5, 35.4% of the total land area is conserved and 37% of unfragmented land is protected through conservation. In fine scale system 7, 11.8% of total land area is conserved. Unfragmented land comprises a significant proportion of this system, but only 12% is protected through land conservation.

The Connecticut River is designated in the New Hampshire River Management and Protection Program (RMPP)(NHDES 2004). The RMPP regulates dam construction, instream water flow levels, channel modification, water quality, solid waste and hazardous waste storage/treatment facilities, and motorized boating traffic.

2.6 Habitat Management Status

It is difficult to assess efforts to restore and manage habitats at such a broad level. A database of conservation groups may enhance cooperative efforts and eliminate repetitive or redundant projects.

There is a conservation and management plan for the Connecticut River. The plan identifies ecologically significant areas and guides the human use and management (Francis and Mulligan 1997). Public outreach and education are identified as useful tools for conserving and restoring this watershed. The plan provides highly detailed information at local levels and should be used to help identify sensitive areas, local impacts, and management actions. The Connecticut River Management Plan (1997) is currently being revised. The Coldwater Fisheries Coalition has created a management plan for coldwater fisheries in the upper Connecticut River (Coldwater Fisheries Coalition 1998).

Several agencies are actively involved in habitat restoration and identifying potential areas of habitat enhancement or improvement. Ongoing or recently completed projects include riparian buffer stabilization, stream bank erosion inventories, creating a task force for dam removal, landowner education, annual river clean ups, NHDES fish biomonitoring, and other studies. There are targeted restoration efforts for Atlantic salmon and brook trout.

The United States Forest Service (USFS) has initiated several watershed restoration projects to address the negative effects of historical silviculture practices on riverine habitats. Two segments along the west branch of the Upper Ammonosuc River in Berlin now have improved bank stability, channel depth, fish and invertebrate habitat, and habitat structure with large woody debris (Jay Milot, United States Forest Service, personal communication).

In Lake Umbagog, the MDIFW is working to minimize the effects of an increasing smallmouth bass population that is expanding and displacing native brook trout populations. The MDIFW is continuing research on the habitats, movements, and foraging of smallmouth bass, brook trout, and landlocked salmon. Passage barriers have been repaired and smallmouth bass fishing regulations have been amended to provide further protection to brook trout populations (MDIFW 2005).

2.7 Sources of Information

A watershed classification based on geological, topographical, climactic, and connectivity attributes, developed by TNC, was used to define scale and habitat condition. Watershed management plans, GIS analyses, and anadromous fish restoration plans were used to identify significant habitats, relative condition, quality, and ongoing management and restoration efforts.

2.8 Extent and Quality of Data

Information on current habitat quality and restoration efforts was highly concentrated on larger rivers. Smaller rivers within this habitat were not well represented. Information obtained from GIS analyses may not accurately represent all physical features.

2.9 Condition Assessment Research

Surveys in moderate-north watersheds should focus on identifying high quality areas or unique aquatic habitats representative of the region. Sites with degraded habitats, such as eroded banks or poor water quality, should be identified and monitored to help target future restoration work.

Element 3: Species and Habitat Threat Assessment

Existing river management plans, local watershed associations, and GIS analyses indicate that the primary threats to this area are fragmentation, development, sprawl, and non-point source pollution, especially sedimentation and runoff from poorly managed logging operations, agricultural fields, and impervious surfaces in population centers like Berlin. Refer to the general threats section for: Transportation Infrastructure, Development (Fragmentation and indirect effects), Non-Point Source Pollution (Runoff and Sedimentation, Nutrients (Eutrophication)), Acid Deposition, Introduced Species, Altered Hydrology, Recreation, Unsustainable Harvest (Forestry Operations and Management), and Agriculture.

Element 4: Conservation Actions

Watersheds within high percentages of unfragmented land are unique to northern New Hampshire. Strategies to preserve connectivity must be developed to protect these large unfragmented land tracts. Fortunately, there is an opportunity for protection rather than restoration in this area. Several strategies for conservation action for this area can be found in the Connecticut River Management Plan. Refer to the general strategies for Transportation Infrastructure, Development (indirect effects), Fragmentation, Population Isolation, Pollutants (Pesticides/Fertilizers), Pollutants (stormwater runoff), Pollution (acid deposition), Sedimentation, Forestry, and Agriculture.

5.1 Literature

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HABITAT PROFILE

Southern Upland Watersheds

Associated Species: Atlantic Salmon (Salmo salar), Burbot (Lota lota), Brook Trout (Salvelinus fontinalis), Lake Trout (Salvelinus namaycush), Northern Redbelly Dace (Phoxinus eos), Rainbow Smelt (Osmerus mordax), Round Whitefish (Prosopium cylindraceum), Slimy Sculpin (Cottus cognatus), Sunapee Trout (Salvelinus aureolus), Tessellated Darter (Etheostoma olmstedi)

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Author: New Hampshire Fish and Game and The Nature Conservancy

Element 1: Distribution and Habitat

1.1 Habitat Description

Southern upland watersheds are similar to northern upland waterhseds. They both have cold water, moderate to high gradient, confined valley streams, and medium to large rivers, although they differ in landscape setting. The rivers in moderate-south watersheds are typical, medium-sized tributaries of the southern New Hampshire. They represent the middle range of most attributes, lacking the extremes of elevation or gradient in other watershed groups. Moderate-south watersheds have features with considerably lower elevation than those of moderate-north and high elevation watersheds, but they have features with relatively high elevation when compared to the rest of New Hampshire. With the lowest average of enriched bedrock of all watershed groups in New Hampshire, the rivers in moderate-south watersheds likely have the lowest buffering capacity and highest natural acidities. As with other moderate and high elevation watersheds, moderate-south watersheds have a higher percentage of hills and side slopes and a relatively high percentage and mileage of medium-sized rivers.

Step-pool and riffle-pool habitats likely dominate the moderate to high gradient tributaries, with step-pool habitats occurring in the more confined river sections and riffle-pool habitats occurring in the more sinuous and unconfined river sections. In the higher elevations, aquatic ecosystems are subject to colder seasonal temperatures, relatively large daily variations in temperature, and relatively unstable hydrologic regimes due to snow melt or precipitation flowing over shallow soils.

The lower, warmer rivers in this watershed group share fisheries characteristics with the low-moderate watershed group. In the moderately sized streams and small rivers at mid-elevation, there may be transitional warm to coldwater communities dominated by blacknose dace, longnose dace, white sucker, creek chub, and common shiner. Moderate-south watersheds also contain the headwater networks that support coldwater ecosystems and fisheries for New Hampshire portions of the Merrimack and Connecticut River basins. Lake Sunapee and Newfound Lake occur in this watershed group. These two large lakes are similar to those in the Lakes Region (fine scale system 14), but are situated in watersheds with higher elevations and more acidic geology.

Moderate-south fine scale systems: 3, 9: These two fine scale systems are very similar in terms of moderate elevation and landform, but fine scale system 3 is slightly higher and steeper than fine scale system 9. Fine scale system 3 has larger areas of intermediate granitic bedrock and some small areas of moderately calcareous bedrock, both of which may contribute to a greater buffering capacity in its waters.

1.2 Justification

Moderate-south watersheds support many of the most

important headwater tributary habitats, ecosystems, and fisheries of the Connecticut and Merrimack Rivers. These rivers and their tributaries provide habitat for a full range of local and migratory species.

1.4 Habitat Distribution

Moderate-south watersheds contain the southern rivers and headwaters that drain east into the Merrimack River and west into the Connecticut River. The north-south trending highlands roughly define the ridge running from Cardigan to Monadnock Mountain and divide the Merrimack and Connecticut River basins. Rivers in the moderate-south watershed group include major tributaries to the Merrimack River, such as the Contoocook headwaters and its tributaries (the Warner and Blackwater Rivers, and the Smith and Baker Rivers), and major tributaries to the Connecticut River, including the lower reach of the Ammonoosuc, Mascoma, Sugar, and Cold Rivers, and the upper reaches of the Ashuelot River.

This watershed group straddles the Merrimack-Saco-Charles River and Upper Connecticut Ecological Drainage Unit (EDU). It primarily overlaps the New Hampshire-Vermont Upland subsections of TNC's Lower New England-Northern Piedmont Ecoregion.

1.8 Extent and quality of data

Moderate-south watersheds are unique and clearly distinguishable from New Hampshire's other major watersheds groups. The differences between fine scale systems 3 and 9 are more subtly based on aquatic connectivity and geography. The differences in elevation, geology, and landform are recognizable between these fine scale systems, but may not control or influence biological communities. Nevertheless, representing both fine scale systems 3 and 9 in conservation plans will ensure a broader array of environmental settings.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the large land area covered by the major watershed groups (figure 3), a fine scale classification (figure 4) was used, when possible, to assess the relative condition of aquatic habitats across the state. The types and sources of information were extremely variable and covered many different scales, and so the following sections refer to both the major and fine scale systems. The actual scale at which the natural conditions and processes lead to differences in aquatic communities is uncertain.

The watersheds in the moderate elevation mountains and foothills of western New Hampshire are divided into two fine scale systems. Fine scale system 3 includes 4 watersheds of the Connecticut and Pemigewasset Rivers (figure 4). Fine scale system 9 includes 11 watersheds of the Connecticut, Merrimack, and Pemigewasset Rivers (figure 4).

2.4 Relative Quality of Habitat Patches

Fine scale system 3 encompasses 2,201.8 km^2. Headwater streams are the most dominant stream/river type, comprising 87% of the total area of riverine habitats .Small rivers and medium-sized rivers comprise 10% and 3%, respectively. Fine scale system 9 encompasses 3,463.9 km^2. Headwater streams and small rivers comprise 87% and 12% of the riverine habitats .

In moderate-south watersheds, lakes and ponds with surface areas less than 10 acres are the most abundant (94% of the total number of lakes and ponds). There are 3 lakes greater than 1000 acres, Mascoma Lake (1,161 ac), Newfound Lake (4,451 ac), and Sunapee Lake (4,136 ac). Twenty-five percent of lakes and ponds are at elevations of 6.096-243.84 m (200-800 ft) and 72% occur at elevations of 243.84-518.16 m (800-1,700 ft). Less than 3% of lakes and ponds have elevations greater than 518.16m (1,700 ft).

The Cold River watershed is recognized for its variety of natural resources (NHDES 1999). Along the mainstem of the Cold River, shorelines consist of undeveloped forests, wetlands, and agriculture. Peregrine falcons, bald eagles, osprey, Cooper's hawk, and sedge wrens have been observed within the watershed. The coldwater fishery provides suitable rearing habitat for juvenile Atlantic salmon. The resources, values, and characteristics of this mostly free-flowing river (99.3% free flowing), provided the grounds for its protection in New Hampshire's Rivers Management Protection Program (RMPP) (NHDES 1999).

The variety of resources of the Ashuelot River is also recognized through New Hampshire's RMPP.

The upstream reaches of the river are forested with minimal development. As the river progresses, shorelines consist of mixed forests, farmlands, wetlands, and development (commercial, residential, and industrial). The Ashuelot River provides essential habitat for a variety of wildlife. The United States Fish and Wildlife Service has designated the river as one of the top four refuges for the federally endangered dwarf wedge mussel. The north-south trajectory of the river provides a migration route for several raptors, waterfowl, and songbirds. Bald eagles (Haliaeetus leucocephalus), northern harriers (Circus cyaneus), blue-gray gnatcatchers (Polioptila caerulea), common loons (Gavia immer), common nighthawks (Chordeiles minor), and great blue herons (Ardea herodias) have been documented throughout the Ashuelot River. Water temperatures provide fisheries for warm and coldwater fish species (NHDES 1993).

2.2 Relative Health of Populations

Land Use

In fine scale system 3, the density of roads (expressed as km of road/km^2 of total land area) maintained by NHDOT is 0.68 km/km^2 and the density of private/gravel roads is 0.59 km/km^2 .Developed land comprises 3.3% of the total land area. The density of roads and developed land is low compared to the southeastern part of the state, but higher than in watersheds to the north. Over 78% of the total land area remains unfragmented , but despite the relatively low population density (25 people/km^2), unregulated growth is becoming a threat in some areas (Dan Lambert, Mascoma Watershed Association, personal communication). When compared to other systems in the state, fine scale system 3 has a relatively high percentage of agricultural land (5.1%) .

In fine scale system 9, the density of roads maintained by NHDOT is 0.79 km/km^2 and the density of private/gravel roads is 0.64 km/km^2 .Developed land comprises 3.7% of the total land area. Road density is slightly higher than in fine scale system 3. The amount of developed land remains relatively low, although the population is increasing rapidly along the Interstate 89 corridor (SPNF 2005). Over 75% of the total land area remains unfragmented .When compared to other systems in the state, fine scale system 9 also has a relatively high percentage of agricultural land (4.5%) .

Housing increases for census blocks adjacent to lakes and ponds in moderate-south watersheds were estimated using 1990 values and projected 2020 values (see Lake Type Classification for methods). Changes between rural (<0.063 housing units/ha), exurban (0.063 to 0.25 units/ha), and suburban (0.25 to 2.5 units/ha) housing density categories could indicate increases in shoreline development, impervious surfaces, and nonpoint source pollution. Census blocks are expected to change from exurban to suburban densities around 37 lakes and ponds, and from rural to exurban densities around 734 lakes and ponds. Moderate-south watersheds are predicted to have the greatest number of changes in housing densities adjacent to lakes and ponds.

Water Quality

Historical evidence of poor water quality illustrates the need for clean waters. Pollutants from point and nonpoint sources caused fish kills in the Mascoma River in 1966 and 1977, with mortality estimates as high as 5000 fish (NHFG, unpublished data). In 1977, a release of sulfuric acid (H_2S0_4) in the Sugar River lowered pH levels to a value of 1.6 and caused a documented fish kill (NHFG, unpublished data). Since that time, water quality has gradually improved from the implementation of the Clean Water Act. Water treatment facilities, lined landfills, septic systems approved by the Environmental Protection Agency, and continued monitoring have improved water quality for aquatic organisms.

Surface water quality reports from the NHDES Volunteer Rivers Assessment Program (VRAP) provide a general illustration of water quality in moderate-south watersheds. The Sugar River flows through a variety of areas from natural to somewhat urban. Reports on the Sugar River from 2000-2002 show that dissolved oxygen and turbidity levels met state requirements for class B waters during all three sampling years. The range of pH levels annually fell below state water quality standards for class B waters (state standard is pH 6.5-8.0). Fifty-five percent of pH samples were below state standards in 2000 (pH 4.04-7.36), 43% were below state standards in 2001 (pH 4.70-7.70), and 33% were below state standards in 2002 (pH 4.09-9.25) (NHDES 2000, NHDES 2001, NHDES 2002). There is no information on

specific sources that would explain the low pH values, although acidic precipitation and natural environmental conditions (e.g. soils, geology, and wetland drainage) can lower pH values.

Dissolved oxygen levels in the Cold River met state requirements for Class B waters in 2003 and 2004. Turbidity levels in 2003 also fell within state standards (NHDES 2003). In 2004, some turbidity levels (8%) exceeded state standards. Precipitation likely contributed to increased turbidity (NHDES 2004). The range in pH levels for 2003 and 2004 were below state water quality standards for class B waters (state standard is pH 6.50-8.0). Thirty-one percent of pH samples exceeded state standards in 2003 (pH 5.57-7.22) and 78% of pH samples were below state standards in 2004 (pH 5.31-7.09) (NHDES 2003, NHDES 2004).

In the Gridley River between 2002-2004, there were low dissolved oxygen and pH values in this Contoocook River tributary. Specific sampling sites exhibited very low dissolved oxygen levels in all three sampling years. Forty-two percent of dissolved oxygen samples were below state water quality standards for Class B waters (>5.0 mg/L) for all 3 years. Levels of dissolved oxygen ranged from 2.00 to 9.83 mg/L. Large, adjacent wetlands and slow moving water in some sampling locations are believed to contribute to low dissolved oxygen levels (NHDES 2002, NHDES 2003, NHDES 2004). Turbidity levels met state requirements for Class B waters during all three sampling years (NHDES 2002, NHDES 2003, NHDES 2004). The range in pH levels annually fell below state water quality standards for class B waters. All pH samples during all sample years were below state standards (pH 4.76-6.45). Moderate-south watersheds may be more vulnerable to the effects of acid deposition due to naturally acidic bedrock.

Fine scale system 9 has the lowest number of National Pollution Discharge Elimination System (NPDES) permits issued per river kilometer in New Hampshire (0.004 permits/river km). The number of NPDES permits issued by NHDES for fine scale system 3 is also low at 0.008 permits/river km .

Invasive Species

In fine scale system 3, Eurasian milfoil (Myriophyllum spicatum) was introduced at Mascoma Lake in 2000 and variable milfoil (Myriophyllum heterophyllum) was introduced at Sunapee Lake in 2001 (Smagula 2004). There are 8 documented infestations of exotic aquatic plants in fine scale system 9. Variable milfoil has been detected in Pearly Pond (1975), Contoocook Lake (1990), Cheshire Pond (1995), Massasecum Lake (1995), Monomonac Lake (2000), Powder Mill Pond (2000), the Contoocook River (2001), and Dublin Lake (2001) (Smagula 2004).

Several nonnative fish populations have become naturalized in the Connecticut River. Increased water temperatures and enhanced habitat from large impoundments facilitate proliferation of these species. Several of these fish provide sport-fishing opportunities. Largemouth bass (Micropterus salmoides), smallmouth bass (Micropterus dolomieu), black crappie (Pomoxis nigromaculatus), bluegill (Lepomis macrochirus), walleye (Sander vitreus), northern pike (Esox lucius), white perch (Morone americana), landlocked Atlantic salmon (Salmo salar), brown trout (Salmo trutta), and rainbow trout (Oncorhynchus mykiss) are examples of species that have naturalized populations (NHFG 2004, Estuarine and Freshwater Working Group 2005). Landlocked Atlantic salmon, brown trout, and rainbow trout are annually stocked by NHFG.

To assess the likelihood of intentional or accidental introductions of invasive fish and aquatic plants, the degree of remoteness of lakes and ponds was analyzed through GIS. The results indicate that 4,025 lakes and ponds (92%) are within 500 m of a trail or road, 225 lakes and ponds (6%) are enclosed by a protective buffer of 500-805 m without a mapped road or trail, and 110 lakes and ponds (3%) are enclosed by a protective buffer of 805-1609 m without a mapped road or trail. No lakes or ponds have a buffer greater than 1609 m (1 mile).

Hydrology

The primary stressors to the Ashuelot River are impacts from altered natural flows (Zankel 2004). Population growth in this area of New Hampshire could reduce the continuity of riverine habitats and lead to the isolation of aquatic species. Additional road/stream crossings from future development may further limit migration and dispersal of fish and amphibians (Zankel 2004). The presence of impassable dams has already significantly impacted diadromous species, such as Atlantic salmon, river herring (Alosa pseudo-

harengus and Alosa aestivalis), American shad (Alosa sapidissima), and sea lamprey (Petromyzon marinus).

There are approximately 290 active dams or impoundments in fine scale system 3 and 485 in fine scale system 9, varying from large river impoundments for hydroelectric production to small stream impoundments for wildlife ponds (NHDES 1999). The numbers of impoundments/river km in fine scale system 3 and fine scale system 9 are 0.046 and 0.055, respectively .

2.3 Population Management Status

N/A

2.5 Habitat Patch Protection Status

In fine scale system 3, conserved land comprises 19.0% of the total land area, and 23% of unfragmented land is protected through conservation. In fine scale system 9, conserved land comprises 17.7% of the total land area, and 20.7% of unfragmented land is protected through conservation .

The Ashuelot and Cold Rivers are designated in the New Hampshire River Management and Protection Program (RMPP) (NHDES 1993, NHDES 1999). The RMPP regulates dam construction, instream water flow levels, channel modification, water quality, solid and hazardous waste storage/treatment facilities, and motorized boating traffic.

2.6 Habitat Management Status

It is difficult to assess the efforts to restore and manage habitats at such a broad level. A database of conservation groups may enhance cooperative efforts and eliminate conflicting or redundant projects.

The Ashuelot River watershed has abundant natural resources in need of further protection. A watershed management plan for the Ashuelot River was completed in conjunction with TNC, the Society for the Protection of New Hampshire Forests, Monadnock Conservancy, and the Southwest Regional Planning Commission. The management plan identifies several ecologically significant communities and suggests conservation strategies to reduce threats to these communities (Zankel 2004).

Several organizations (both governmental and non-governmental) are actively involved in either habitat restoration projects or identifying potential areas of habitat improvement. Ongoing or recently completed projects include riparian buffer stabilization, stream bank erosion inventories, identifying impassable culverts, public outreach and education, shoreline development monitoring, exotic aquatic plant monitoring, creating a task force for dam removal, landowner education, NHDES biomonitoring, constructing sediment control devices, and annual river clean ups. Efforts that target individual species include the restoration of Atlantic salmon and brook trout habitat.

2.7 Sources of Information

A watershed classification based on geological, topographical, climactic, and connectivity attributes, developed by TNC, was used to define scale and habitat condition. Watershed management plans, GIS analyses, and anadromous fish restoration plans were used to identify significant habitats, relative condition, quality, and ongoing management and restoration efforts.

2.8 Extent and Quality of Data

Information on current habitat quality and restoration efforts was highly concentrated on the larger rivers and lakes of this watershed group. Smaller rivers, streams, and ponds were not well represented. Information from GIS analyses may not accurately represent all physical features.

2.9 Condition Assessment Research

Increased sampling of aquatic communities and water quality will provide more conclusive, long-term trend data. Additional monitoring would help identify the impacts of water flow alterations (e.g. erosion, changes in dissolved oxygen, and impoundments) on plants, fish, and other aquatic wildlife. Increased sampling of fish tissue throughout these watersheds may recognize areas affected by contaminants. Habitat assessments, water quality monitoring, and aquatic community data are needed for the headwater streams and small tributaries of these systems. The pilot projects initiated by The Nature Conservancy in the Ashuelot River watershed should be expanded to other watersheds in this group to identify and protect additional areas of significant habitat.

Element 3: Species and Habitat Threat Assessment

Existing river management plans and GIS analyses indicate that altered natural flow regimes, nonpoint source pollution (especially sedimentation and stormwater runoff), and invasive species are the primary threats to habitats in moderate-south watersheds.

Refer to the general threats section for: Transportation Infrastructure, Development (Fragmentation and indirect effects), Non-Point Source Pollution (Runoff and Sedimentation, Nutrients (Eutrophication)), Acid Deposition, Introduced Species, Altered Hydrology, Recreation, Unsustainable Harvest (Forestry Operations and Management), and Agriculture.

Element 4: Conservation Actions

Moderate-south watersheds are in a relatively natural state compared to watersheds in the southeastern part of the state. Conservation actions should focus on land protection, although restoration projects may be necessary in certain areas. Identifying and protecting high quality aquatic habitats should be a priority. Preventing the spread of invasive species will be important for maintaining the integrity of this watershed group. Several conservation strategies can be found in the Ashuelot River Management Plan and the Ammonoosuc Watershed Region Conservation Plan.

Refer to the general threats section for Transportation Infrastructure, Development (indirect effects), Fragmentation, Pollutants (Acid Deposition), Invasive Species, Altered Hydrology, Sedimentation, Recreation, Forestry, Pollutants (Stormwater runoff), and Agriculture.

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HABITAT PROFILE

Montane Watersheds

Associated Species: Atlantic Salmon (Salmo salar), Brook Trout (Salvelinus fontinalis), Rainbow Smelt (Osmerus mordax), Slimy Sculpin (Cottus cognatus)

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Author: New Hampshire Fish and Game and The Nature Conservancy

Element 1: Distribution and Habitat

1.1 Habitat Description

Montane watersheds are characterized by high elevation and steep or very steep acidic streams that flow over granite bedrock in and around the White Mountains. This watershed group has a high percentage of the two highest elevation zones and the highest percentage of steep slopes, cliffs, ridge tops, slope crests, and small cove headwater streams. Tributaries flow off the White Mountains in all directions, draining into the Connecticut, Pemigewasset/Merrimack, Saco, and Androscoggin River watersheds. The bedrock is mostly acidic, with little buffering capacity.

These headwaters are primarily cold mountain streams with cascade and step-pool habitats. Stream channels are narrowly confined by valley walls, and streambeds consist of bedrock, boulders, and cobbles. Very shallow soils and geologic materials create streams with variable flow that responds to runoff events. In some cases, as the stream size increases, the main stems flow through areas of deep, coarse-grained sediments and become more sinuous within wider valleys. However, high watersheds also contain plane bed systems, where the stream runs directly on resistant bedrock, which creates long, featureless runs and the absence of discrete pools, riffles, and point bars.

High watersheds have multiple examples of pristine, coldwater fisheries. The very smallest high elevation coldwater streams often contain only brook trout (*Salvelinus frontinalis*). Slightly further downstream, slimy sculpin (*Cottus cognatus*) is found with brook trout, sometimes with the addition of blacknose dace (*Rhinichthys atratulus*). The above two stream types have cold, fast-moving water and rocky substrates.

High fine scale systems: 4, 6, 8
The relative extremes of elevation and landforms are the primary justification for splitting high watersheds into 3 fine scale systems. Fine scale system 6 is the most mountainous and steep in the state, followed by fine scale system 4, then fine scale system 8. Fine scale systems 6 and 4 are the only watersheds with landforms and streams above the elevation of 1,219 m (4,000 feet). All three fine scale systems also have relatively high percentages of steep slopes, ridge crests, and headwater streams, roughly in the same order as elevation (fine scale system 6 > fine scale system 4 > fine scale system 8).

Fine scale system 4 is transitional to the north, and fine scale system 8 is transitional to the south, although both contain substantial areas of high and very high elevation. Fine scale system 8 is quite mountainous, although at more moderate elevations because it includes the southern foothills of the White Mountains and some large coarse sediment deposits along the larger mainstems of the Pemigewasset and Saco Rivers. Fine scale system 4 is more acidic granitic than fine scale systems 6 and 8. It has a smaller extent of very steep landforms, more wet flats and wetlands, and larger meandering rivers that ultimately connect to the Connecticut River.

1.2 Justification

High watersheds are unique in New Hampshire and region-wide. The fisheries in these high mountain streams are not necessarily unique, but the environmental settings provide ecological and evolutionary contexts for fish and other aquatic species (particularly insects) that may only occur at these high elevations.

1.4 Habitat Distribution

The predominant defining feature of high watersheds is the granite of the White Mountain massif. The medium-sized tributaries and the upper reaches of the Connecticut (Ammonoosuc, Israel, and Johns Rivers), Pemigewasset (East Branch and Mad Rivers), Androscoggin (Peabody and Wild Rivers), Saco (East Branch, Ellis, and Swift Rivers), and Bearcamp River watersheds flow in a radiating pattern toward all points of the compass. High watersheds straddle the Upper Connecticut, Merrimack-Saco-Charles, and Penobscot-Kennebec-Androscoggin River Ecological Drainage Units (EDUs). This watershed group is entirely within TNC's Northern Appalachians Ecoregion.

1.8 Extent and quality of data

High watersheds are a clearly defined watershed group, but the differences between the three fine scale systems are more subtle. Specifically, fine scale systems 4 and 8 are transitional with their northern and southern watershed groups, but the majority of the watersheds in these systems have clear similarity with the high elevation watersheds in fine scale system 6. Representing the three fine scale systems in conservation plans will capture environmental settings across directional (north-south and east-west), topographic, and geographic gradients.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the large land area covered by the major watershed groups (Figure 3), a fine scale classification (Figure 4) was used, when possible, to assess the relative condition of aquatic habitats across the state. The types and sources of information were extremely variable and covered many different scales, and so the following sections refer to both the major and fine scale systems. The actual scale at which the natural conditions and processes lead to differences in aquatic communities is uncertain.

High watersheds are divided into three fine scale systems (Figure 4). Fine scale system 4 includes 4 watersheds of the Connecticut River. All of these watersheds have elevations that are transitional from mountainous and steep to more moderate and low altitudes. As a result, streams consist of less confined headwater streams that flow down into foothills and eventually into larger rivers.

Fine scale system 6 includes 6 watersheds of the Androscoggin, Pemigewasset, and Saco Rivers. These watersheds contain extensive areas of moderate, high, and very high elevations and are the most mountainous and steep in New Hampshire. Streams are confined and high gradient.

Fine scale system 8 includes 4 watersheds of the Pemigewasset and Saco Rivers. All watersheds have low to moderate elevations with small areas of high elevations. These watersheds contain mountain and foothill streams or rivers with lower gradients and levels of confinement.

2.4 Relative Quality of Habitat Patches

Typical headwater streams within the WMNF are highly energetic with bedrock substrates and few fine sediments. There are low turbidity levels during most high flows, but tannins from the adjacent forest can create a yellow color in the water. As streams progress downstream, there are greater amounts of boulders and cobbles. Streams with lower gradients have bedrock, boulder, cobble and coarse gravel substrates. As stream size increases toward valley floors, there are sand and gravel bars mixed with the boulder and cobble substrates. During high flows, sediments move downstream and streams are scoured. Even during floods, turbidity is still considered low. Most fine sediments have already been washed downstream or deposited on adjacent stream banks (Spear et al. 2000).

Streams and rivers of the WMNF have low levels of dissolved nutrients and low abundances of aquatic organisms. Shifting sediments and granite bedrock cause streams to be sterile. The size of fish in these

systems reflects these sterile conditions. A study of wild brook trout in the Swift River (fine scale system 8) showed only 151 of 3,742 wild brook trout (4%) were longer than 6 inches (Spear et al. 2000).

There are some streams within the WMNF that are unaffected by historical logging, but these streams are not well documented. Streams in old growth forests contain high concentrations of large woody debris (LWD). Large woody debris creates pools, which attract organic matter, increase stream depths, and attracts aquatic organisms. Wonalancet Brook in fine scale system 8 was identified as an unaltered system within an old growth forest. Determining the LWD ratios of streams in old growth forests will help identify other non-impacted streams and facilitate restoration to natural conditions. There are also streams within old second growth forests in these watersheds, although it is difficult to differentiate between old growth and old second growth forests. Wilderness designations within the WMNF help restore stream habitat by naturally increasing LWD concentrations (Spear et al. 2000).

Fine scale system 4 encompasses 961 km^2 (237,516 ac). Headwater streams (watershed area <77.70 km^2) and small rivers (watershed area from 77.70-518.00 km^2) comprise 82% and 18% of all streams and rivers. Medium rivers (watershed area from 518.00-2589.99 km^2) and large rivers (watershed area >2589.99 km^2) are not present in this system .Moderate elevations (243.84-518.16 m) and high elevations (518.16-762 m) dominate, at 62.0% and 20.8% of total land area, respectively. Very high elevations (762-1371.6 m), alpine elevations (>1371.6 m), and low elevations (6.10-243.84m) comprise 15.2%, 1.6%, and 0.5% .

Fine scale system 6 encompasses 1,968 km^2 (486,249 ac). Headwater streams and small rivers comprise 82% and 11% of streams and rivers. Medium and large rivers are less prevalent, comprising 2% and 5% of streams and rivers .The Saco River is the only major river basin in New Hampshire that is currently meeting standards for the federal Clean Water Act (NHDES 1990). Land adjacent to the Saco River is undeveloped or in agriculture, with some clusters of residential housing. In the WMNF, large riparian buffers and continuous forest surround the upstream reaches and tributaries of the Saco River. In a 1983 study, there were 55 mammal, 165 bird, 32 amphibian and reptile, and 36 fish species present. There is spawning substrate for anadromous fish species, but these fish are blocked from this area by impassable downstream dams in Maine (NHDES 1990). The Swift River, a tributary to the Saco River, is free flowing and almost entirely within the WMNF. Its water quality is good to excellent (NHDES 1990).

Fine scale system 8 encompasses 1,304 km^2 (322,199 ac). Headwater streams are prevalent, comprising 82% of streams and rivers. Small and medium rivers comprise 11% and 7% .The Pemigewasset River is recognized for large areas of adjacent undeveloped land and high water quality (NHDES 1991). There are concentrations of developed land in Plymouth. There is adequate feeding and nesting habitat for a variety of bird species, including upland sandpipers (*Bartramia longicauda*), peregrine falcons (*Falco peregrinus*), sedge wrens (*Cistothorus platensis*), bald eagles (*Haliaeetus leucocephalus*), ospreys (*Pandion haliaetus*), northern harriers (*Circus cyaneus*), common loons (*Gavia immer*), common nighthawks (*Chordeiles minor*), Cooper's hawks (*Accipiter cooperii*), and purple martins (*Progne subis*). Red spotted newts (*Notophthalmus viridescens viridescens*), snapping turtles (*Chelydra serpentine*), and northern water snakes (*Nerodia sipedon*) are examples of the 19 amphibian and reptile species found along the river (NHDES 1991).

High watersheds contain the lowest number of lakes and ponds in the state. Lakes and ponds with surface areas less than 4.05 ha (10 ac) are the most abundant (93% of the total number of lakes and ponds). There is an average of 1.27 lakes/ponds greater than 4.05 ha per 100 km^2 of land. Conway Lake, at 1,316 ac, is the only lake greater than 1,000 ac. Forty-two percent of the lakes and ponds are at low elevations, 46% are at moderate elevations, 8% are at high elevations, and 4% are at very high elevations. This watershed group contains all lakes and ponds with elevations greater than 1,219.2 m (4,500 ft), which comprise less than 1% of the total number of lakes and ponds in high watersheds.

2.2 Relative Health of Populations

Land Use

Large portions of the WMNF are contained within these three fine scale systems. Road density, development, and the amount of unfragmented land are highly influenced by the presence of the WMNF and

high elevations. In fine scale system 4, the density of roads maintained by the New Hampshire Department of Transportation (NHDOT) is 0.50 km/km^2 (expressed as road km/km^2 of total land area) and the density of private/gravel roads is 0.30 km/km^2. In fine scale system 6, the densities of NHDOT roads and private/gravel roads are 0.29 km/km^2 and 0.21 km/km^2. In fine scale system 8, the densities of NHDOT roads and private/gravel roads are 0.54 km/km^2 and 0.50 km/km^2 .Developed land in fine scale systems 4, 6, and 8 comprises 2.3%, 1.4%, and 2.5% of total land area .Unfragmented land in fine scale systems 4, 6, and 8 comprises 86%, 93%, and 83% of the total land area .The population in high watersheds is very low compared to other watershed groups in New Hampshire. Estimated populations for 2005 in fine scale systems 4, 6, and 8 are 9,985 people (10.4 people/km^2), 11,451 people (5.5 people/km^2), and 22,577 people (13.9 people/km^2) .

The mountainous terrain inhibits agriculture within much of the high watersheds. Floodplains of larger rivers may provide the best areas for farming. Agricultural land in fine scale systems 4, 6, and 8 comprises 2.7%, 0.5%, and 2.1% of total land area .Because of the very high elevations in fine scale system 6, this system has the lowest percentage of agricultural land in the state.

Housing increases for census blocks adjacent to lakes and ponds in high watersheds were estimated using 1990 values and projected 2020 values (see Lake Type Classification for methods). Changes between rural (<0.063 housing units/ha), exurban (0.063 to 0.25 units/ha), and suburban (0.25 to 2.5 units/ha) housing densities could indicate increases in shoreline development, impervious surfaces, and nonpoint source pollution. Housing densities adjacent to 62 lakes and ponds are expected to change from exurban to suburban and from rural to exurban at 128 lakes and ponds.

Water Quality

In 2003, the NHDES Volunteer Rivers Assessment Program (VRAP) conducted surface water quality studies of Great Brook, Wildcat Brook, and the Ellis River. Dissolved oxygen and turbidity levels at all sites met state requirements for class B waters, which are adequate to support aquatic wildlife. The range of pH values (pH 5.67-7.05) was below state water quality standards for class B waters (standard is pH 6.50-8.0) and 85% of pH samples were below state water quality standards. Acid precipitation and natural environmental conditions (e.g. soils, geology, wetland drainage) can lower pH values (NHDES 2003). In 2004, water samples from Wildcat Brook and Ellis River were comparable to 2003, with dissolved oxygen and turbidity levels meeting water quality standards, but pH levels for 14 out of 15 samples (93%) below state water quality standards for class B waters (NHDES 2004).

The Androscoggin River was once considered one of the most polluted rivers in North America. Since the implementation of the Clean Water Act (1977), river water quality has dramatically improved with temperature and dissolved oxygen levels adequate for salmonids (Danner and Young 2002). For the Androscoggin River, dissolved oxygen and turbidity levels met state requirements for class B waters, which are adequate to support aquatic wildlife. Turbidity levels increased near urban areas. The range of pH values (pH 6.48-7.09) essentially met state water quality standards for class B waters. Acid precipitation and natural environmental conditions (e.g. soils, geology, wetland drainage) can lower pH values (NHDES 2004).

Water discharges registered through NHDES are relatively low when compared to the rest of New Hampshire. The number of National Pollution Discharge Elimination System (NPDES) permits issued per river kilometer for fine scale systems 4, 6, and 8 are 0.011, 0.007 and 0.005 NPDES permits/river km, respectively .

Invasive Species

There are no exotic aquatic plants in waterbodies in this area (Smagula 2004). Largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), landlocked Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*), and rainbow trout (*Oncorhynchus mykiss*) are examples of fish species that have naturalized populations (NHFG 2004, Estuarine and Freshwater Working Group 2005). Landlocked Atlantic salmon, brown trout and rainbow trout are annually stocked by NHFG.

To assess the likelihood of recreation or stocking contributing to introductions of invasive fish and aquatic plants, the degree of remoteness of lakes and ponds was analyzed through GIS. There

are 953 lakes and ponds (89%) within 500 m of a trail or road, 60 lakes and ponds (6%) enclosed by a protective buffer of 500-805 m without a mapped road or trail, 40 lakes and ponds (4%) with a buffer of 805-1609 m, and 8 lakes or ponds (1%) with a buffer greater than 1609 m.

Hydrology
There are approximately 96, 77, and 88 active dams or impoundments in fine scale systems 4, 6, and 8 .Fine scale system 8 has the lowest number of impoundments per river km in New Hampshire (0.016 impoundments/river km). The number of impoundments/river km is 0.049 and 0.026 in fine scale systems 4 and 6.

2.3 Population Management Status

N/A

2.5 Habitat Patch Protection Status

The fine scale systems of high watersheds have the highest percentage of conservation land within the state. Conservation land comprises 52.3%, 82.3%, and 48.4% of the total land area in fine scale systems 4, 6, and 8 .The densities of unfragmented land with conservation status are also the greatest in New Hampshire. The amount of unfragmented land with conservation status is 58.4%, 86.5%, and 56% for fine scale systems 4, 6, and 8 .Designated wilderness areas within the WMNF further protect aquatic systems from the effects of roads and logging.

The Pemigewasset, Saco, and Swift Rivers are designated in the New Hampshire River Management and Protection Program (RMPP) (NHDES 2004). The RMPP regulates dam construction, in stream water flow levels, channel modification, water quality, solid waste and hazardous waste storage/ treatment facilities, and motorized boating traffic.

2.6 Habitat Management Status

It is difficult to assess the efforts to restore and manage habitats at such a broad level. A database of conservation groups may enhance cooperative efforts and eliminate repetitive or redundant projects.

There are conservation and management plans for the WMNF and Ammonoosuc River watershed. These plans identify ecologically significant areas and guide human use and management. Public outreach and education are identified as useful tools for conserving and restoring these watersheds. Because these plans provide highly detailed information at local levels, they should be used to help identify sensitive areas, local impacts, and management actions (Ammonoosuc Conservation Trust 2004, WMNF 2005).

Several agencies are actively involved in habitat restoration and identifying potential areas of habitat enhancement or improvement. Ongoing or recently completed projects include riparian buffer stabilization, stream bank erosion inventories, creating a task force for dam removal, landowner education, NHDES fish biomonitoring, and annual river clean ups. There are targeted restoration efforts for Atlantic salmon and brook trout.

Long-term data from the Hubbard Brook Ecosystem Study at the Hubbard Brook Experimental Forest in West Thornton provide information on several aquatic topics. Instantaneous stream flow, precipitation, temperature, chemistry, and limnology are examples of long-term data that are available. Trend data can help to form models and hypothesis and to provide information on ecosystem function and rare or severe events (Hubbard Brook Experimental Forest 2001). Studies of salamander occurrences in first order streams are being carried out at the Bartlett Experimental Forest (Stone 2004).

2.7 Sources of Information

A watershed classification based on geological, topographical, climactic, and connectivity attributes, developed by TNC, was used to define scale and habitat condition. Watershed management plans, GIS analyses, and anadromous fish restoration plans were used to identify significant habitats, relative condition, quality, and ongoing management and restoration efforts.

2.8 Extent and Quality of Data

Information on current habitat quality and restoration efforts was highly concentrated on larger rivers. Smaller rivers within this habitat were not well represented. Information obtained from GIS analyses may not accurately represent all physical features.

2.9 Condition Assessment Research

Increased sampling of aquatic communities and water quality will provide more conclusive, long-term trend data. Additional monitoring would help identify the impacts of water flow alterations (e.g. erosion, changes in dissolved oxygen, and impoundments) on plants, fish, and other aquatic wildlife. Increased sampling of fish tissue throughout these watersheds may recognize areas affected by contaminants. Habitat assessments, water quality monitoring, and aquatic community data are needed for the headwater streams and small tributaries of these systems. The pilot projects initiated by The Nature Conservancy in the Ashuelot River watershed should be expanded to other watersheds to identify and protect additional areas of significant habitat.

Element 3: Species and Habitat Threat Assessment

Existing river management plans, local watershed associations, and GIS analyses indicate non-point source pollution (especially sedimentation and runoff from poorly managed forestry operations and agricultural fields), acid deposition, development, sprawl, and fragmentation are the primary threats to habitats in high watersheds. Refer to the general threats section for Transportation Infrastructure, Development (Fragmentation and indirect effects), Non-Point Source Pollution (Runoff and Sedimentation), Acid Deposition, , Introduced Species, Altered Hydrology, Recreation, Unsustainable Harvest (Forestry Operations and Management), and Agriculture.

Element 4: Conservation Actions

Watersheds within high percentages of unfragmented land are unique to northern New Hampshire. Strategies to preserve connectivity must be developed to protect these large unfragmented land tracts. Fortunately, there is an opportunity for protection rather than restoration in this area. Several strategies for conservation action can be found in management and conservation plans for the WMNF and Ammonoosuc River watershed. Refer to the general strategies for Roads/Transportation Infrastructure, Development/Urban Sprawl, Fragmentation/Population Isolation, Pollutants, Acid Deposition, Water level Management, Nutrient and Sediment Loading, Forest Management, and Agriculture.

Element 5: References

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HABITAT PROFILE

Peatlands

Associated Species: Ringed Bog Haunter (Williamsonia lintneri), Palm Warbler (Dendroica palmarum), Mink Frog (Rana septentrionalis), Northern Bog Lemming (Synaptomys borealis)

Global Rank: Not ranked
State Rank: Atlantic white cedar – giant rhododendron swamp (S1), Atlantic white cedar – leather-leaf swamp (S1), Acidic northern white cedar swamp (S1), Atlantic white cedar – yellow birch – pepperbush swamp (S2), Black gum – red maple basin swamp (S1S2), Black spruce – larch swamp (S3), Bog rosemary – sweet gale – sedge fen (S3), Calcareous sedge – moss fen (S2), Circumneutral – calcareous flark (S1), Hairy-fruited sedge – sweet gale fen (S3), Highbush blueberry – sweet gale – meadowsweet shrub thicket (S4), Highbush blueberry – mountain holly wooded fen (S3S4), Highbush blueberry – winterberry shrub thicket (S4), Inland Atlantic white cedar swamp (S1), Large cranberry – short sedge moss lawn (S3), Leather-leaf – black spruce bog (S3), Leather-leaf – sheep laurel dwarf shrub bog (S1S3), Liverwort/horned bladderwort mud-bottom (S3), Marshy moat (S4), Montane alder – heath shrub thicket (S1?), Montane heath woodland (S2), Montane sloping fen (S1), Northern white cedar – balsam fir swamp (S2), Northern white cedar circumneutral string (S1), Northern white cedar – hemlock swamp (S2), Northern white cedar seepage forest (S2), Pitch pine – heath swamp (S1S2), Red maple – Sphagnum basin swamp (S4), Red spruce swamp (S3), Seasonally flooded Atlantic white cedar swamp (S2), Speckled alder wooded fen (S3S4), Sphagnum rubellum – small cranberry moss carpet (S3), Subalpine sliding fen (S1), Swamp white oak basin swamp (S1), Sweet gale – meadowsweet – tussock sedge fen (S4), Sweet pepperbush wooded fen (S2), Wet alpine/subalpine bog (S1), Winterberry – cinnamon fern wooded fen (S4), Wooded subalpine bog/heath snowbank (S1S2)
Federal Listing: Not listed
State Listing: Not listed
Author: Heather L. Herrmann, New Hampshire Natural Heritage Bureau

Element 1: Distribution and Habitat

Habitat Description

The peatland habitat described here includes 11 different natural communities as described by Sperduto (2004). Peatlands are defined by limited inputs of groundwater and surface runoff that result in low nutrient content and acidic water. A lack of nutrients causes slower decomposition of organic materials, resulting in the accumulation of peat. Some plant species are specifically adapted to low-nutrient, acidic conditions found in peatlands.

Open Peatlands

Open peatlands are dominated by *Sphagnum* mosses, sedges, and shrubs. Several open peatland systems are found in New Hampshire. Alpine/subalpine bogs and montane sloping fens are found at higher elevations, generally above 760 meters (2500 feet). Alpine bilberry (*Vaccinium uliginosum*) and black crowberry (*Empetrum nigrum*) are dominant plants in alpine/subalpine bogs, whereas sedges are dominant plants in montane sloping fens (Sperduto and Nichols 2004). These peatlands are small and can sometimes be found interspersed with dry subalpine heath/krummholtz systems or at the heads of old beaver drainages.

Calcareous sloping fens and patterned fens are two open peatland systems found in northern New Hampshire. Calcareous sloping fens are influenced by

groundwater seepage from bedrock high in calcium and other base cations. The diverse plant communities of calcareous fens include sedges, brown mosses, willow (*Salix* sp.) and dogwoods (*Cornus* sp.) (Sperduto 2004). Patterned fens are more common in northern regions and only three examples are known in New Hampshire. Also influenced by groundwater, patterned fens form a series of strings (linear, raised areas) and flarks (low, wet areas) that run perpendicular to the direction of groundwater flow. Strings have a typical bog species such as leather-leaf (*Chamaedaphne calyculata*), sheep laurel (*Kalmia angustifolia*), stunted black spruce (*Picea mariana*), and eastern larch (*Larix laricina*). Flarks have open pools and *Sphagnum* carpets (Sperduto and Nichols 2004). Poor level fen/bog systems and medium level fen systems are widespread and can be quite expansive. Poor level fen/bog systems have very little drainage and no input from groundwater, lakes or streams. Medium level fens can have stream and groundwater input, and therefore tend to be less acidic and more nutrient-rich than poor level fens/bogs. These two systems can often be found adjacent to each other. Vegetation in each includes open *Sphagnum*, tall or medium shrubs, and sparse black spruce (*Picea mariana*) or eastern larch (*Larix laricina*) (Sperduto 2004).

The kettlehole bog is an open peatland usually found in central and southern New Hampshire. These bogs are small patches where pieces of glacial ice melted, leaving holes that subsequently filled in from the edges with peat. Kettlehole bogs typically have a marshy border surrounding a tall shrub or black spruce (*Picea mariana*) swamp, within which is a boggy area of black spruce and leather-leaf (*Chamaedaphne calyculata*), and often an open *Sphagnum* carpet, sometimes with a pool of water, in the middle (Sperduto 2004).

Forested Peatlands

Several forested peatland systems are found in New Hampshire. The black spruce peat swamp is dominated by black spruce (*Picea mariana*) and eastern larch (*Larix laricina*). It often forms a border around more open peatlands such as the poor level fen/bog system or kettlehole bog system. Temperate peat swamps, found in central and southern New Hampshire, are dominated by red maple (*Acer rubrum*), red spruce (*Picea rubens*), eastern hemlock (*Tsuga canadensis*), and other hardwoods. This system is not as acidic as many other peatlands. Northern white cedar minerotrophic swamps, found in northern New Hampshire, contain more nutrients than other peatlands and are dominated by northern white cedar (*Thuja occidentalis*) and other conifers including balsam fir (*Abies balsamea*) and various spruces (*Picea* spp.). Coastal conifer peat swamps—dominated by Atlantic white cedar—are located in coastal New Hampshire with a few examples farther inland (Sperduto 2004).

1.2 Justification

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.

1.3 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.

1.4 Population and Habitat Distribution

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.

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. Several peatland Odonata and Lepidoptera reach their range limit in adjacent states or the province of Quebec but have not yet been found in New Hampshire (Herrmann et al. 2003, Paul Brunelle, personal communication), or have historic ranges extending into New Hampshire but have not recently been found (i.e., Hessel's hairstreak, *Callophrys hesseli*) (NatureServe 2005).

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

Potential peatlands were mapped beginning with the National Wetlands Inventory (NWI) GIS layer (Complex Systems Research Center 2001). Wetlands with broad-leaf evergreen (generally ericaceous), needle-leaf evergreen (conifer) or needle-leaf deciduous (larch) vegetation were selected initially. Water regimes were restricted based on expert review (Dan Sperduto, NHNHB). Any groups of wetlands adjacent to a river or lake were omitted. NWI classes were further classed as individual peatland systems, and landscape context (i.e., elevation, isolation from other wetlands, presence of inlets and outlets) was used to assign each polygon to a potential peatland system. Polygons of known rare or exemplary peatlands (NHNHB 2005) were then added to the map.

Limitations of Data

The model was designed to be inclusive. NWI maps can underpredict peatlands (Dan Sperduto, NHNHB, personal communication). To counter this tendency to underpredict, other non-peatland NWI classes adjacent to peatland classes were included. Combined with the inclusion of many coniferous and deciduous wetlands (as black spruce peat swamp and temperate peat swamp systems), this may have led to overprediction. Because many coniferous or deciduous forested wetlands in southern New Hampshire (Gulf of Maine Coastal Plain and Gulf of Maine Coastal Lowland ecoregion subsections) could be eastern hemlock (*Tsuga canadensis*) or red maple (*Acer rubrum*) swamps without a peatland component, it is likely that many of the predicted forested peatlands are not actually peatlands. Any interpretations or actions based on the map should consider this overprediction. Classification of wetlands into specific systems could also contain error based on the general nature of NWI categories and the lack of more detailed information to aid in the classification.

1.7 Sources of Information

Information was gathered from literature review, GIS data, NHNHB data (2005), and expert review.

1.8 Extent and Quality of Data

Peatlands have been surveyed more extensively in New Hampshire than have many other natural community groups. An extensive landscape analysis and field inventory of peatlands was conducted in 2000

(Sperduto et al. 2000). See limitations of predicted peatlands in element 1.5 above.

1.9 Distribution Research

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, Hessel's hairstreak, bog elfin (*Callophrys lanoraieensis*), and a number of peatland odonates. Habitat records need to be field-verified, especially forested peatlands in southern New Hampshire and rare peatland communities in northern New Hampshire.

Element 2: Species/Habitat Condition

2.1 Scale

Wetlands within 250 m of each other were grouped into complexes of wetlands, except that wetlands separated by a major road (interstate, US or state route) were assigned to different complexes. Wetland complexes numbered in the thousands, and so rather than identify or analyze each complex individually, they were summarized statewide and by ecoregion (TNC 1998).

2.2 Relative Health of Populations

There are 4,113 ha of peatlands known in New Hampshire, and 18,996 ha of predicted peatlands. 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). Predicted peatlands generally follow the same pattern of distribution (Figure 1), except that a sixth ecoregion (Hillsboro Inland Hills and Plain) was also predicted to have a large peatland area.

Of the known peatland in New Hampshire, approximately 57% is open peatland and 43% is forested peatland. Forested peatlands are most common in coastal areas and northern New Hampshire. For example, 85% of the peatlands in the Connecticut Lakes subsection are forested. Elsewhere in the state, open peatlands are more abundant. It should be noted, however, that known peatlands are those that include rare or exemplary peatland communities and may not reflect the true distribution of peatlands across the state. At least 75% of the total predicted peatland area was forested (Figure 1). This is likely an overestimate (see element 1.6); however, because forested peatlands may be less obvious on the ground than open peatlands, these areas should all be considered potential peatlands until field verification shows otherwise.

2.3 Population Management Status

N/A

2.4 Relative Quality of Habitat Patches

The largest peatland complexes occurred in the Connecticut Lakes, Mahoosuc-Rangeley Lakes, and Gulf of Maine Coastal Lowland ecoregion subsections (however, note the potential for overprediction of peatlands in southern New Hampshire discussed in element 1.5). Within each ecoregion, an average of at least 75% of the area within a 250m radius of the complexes was undisturbed landscape (forest, wetland, or open water) . Twenty percent of all peatland complexes were surrounded by undisturbed landscape. However, the majority (62%) of these undisturbed complexes were small (less than 1 ha). Peatlands in northern New Hampshire averaged lower densities of roads within 250 m than did peatlands in the southern part of the state, with coastal peatlands having more than 1 km of road per km^2 of land area.

2.5 Habitat Patch Protection Status

Protection status was calculated for all the land area within 250m of each peatland complex, and summarized by ecoregion subsection (figure 2) using the Conservation Lands data layer (Complex Systems Research Center 2005). Total peatland buffer conservation land in fee ownership throughout the state was 34,605 ha, while total peatland buffer conservation land in easements was 8,896 ha. With the exception of the Northern Connecticut River Valley ecoregion, fee ownership conservation area was greater than easement conservation area throughout the state.

The highest level of protection is in the White Mountains, where 72% of total peatland buffer area

is protected. In other ecoregion subsections, protection was less than 30% of peatland buffer area (figure 2). Within the White Mountains subsection, 62% of peatland complexes were entirely protected within 250m of the peatland, and 72% of complexes had at least 50% protection. However, this subsection had the smallest total peatland area of all subsections. The second highest level of protection was in the Connecticut Lakes ecoregion subsection, where only 23% of complexes had at least 50% protection. The two ecoregion subsections with the highest predicted peatland area—the Gulf of Maine Coastal Lowlands and Gulf of Maine Coastal Plain—also had the lowest level of protection, with less than 1% of complexes having at least 50% protection.

2.6 Habitat Management Status

Habitat management of peatlands is generally limited to land protection (see element 1.3). 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.

2.7 Sources of Information

Information was gathered from databases, GIS analysis, and expert review.

2.8 Extent and Quality of Data

The GIS data used to assess habitat condition are relatively detailed, coming primarily from satellite imagery, topographic maps, and well-defined conservation boundaries. The primary errors in assessing condition are in the predicted habitat itself, which depends partly on NWI maps, which can lead to errors in wetland classification.

2.9 Condition Assessment Research

- Aerial photo analysis and field surveys of predicted peatlands (particularly in the 2 southeastern and 2 northern subsections) to facilitate better boundaries and landscape analyses
- Evaluate effects of current wildlife management strategies (i.e., those focused on waterfowl or fish) on peatlands in wildlife management areas and national wildlife refuges

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Fragmentation, Habitat Loss and Conversion)

(A) Exposure Pathway
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.

(B) Evidence
In 2004, NHNHB reviewed 655 proposals requiring a permit for impacts to wetlands (NHNHB, unpublished data). Although projects with impacts to "bogs" are considered major impact projects in New Hampshire (NHDES 2004) and thus are reviewed more critically, some forested peatlands may not be recognized as such. 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.

3.1.2 Altered Hydrology

(A) Exposure Pathway
Impoundments downstream from peatlands can raise the peatland water level to the point that nutrients previously transported past the peatland, via groundwater or a stream channel, are now in contact with the peatland. This increase in nutrients can alter the plant communities and the rate of peat decomposition. With more decomposition, the peat structure will change, affecting the topography of the peatland surface. The resulting wetland may no longer be suitable for peatland-dependent plants and animals.

(B) Evidence
Peatlands typically develop in places where the vegetation is not (or is minimally) in contact with groundwater or upland runoff (Damman and French 1987). As a result, they are very nutrient-poor compared to other wetlands and decomposition occurs at a very slow rate. Peat is the partially decomposed vegetative matter that accumulates beneath the surface vegetation and further separates plants from the underlying groundwater. In some cases, peatlands lie on either side of a deep-cut stream channel through which nutrient-carrying water flows and bypasses the peatland. Downstream impoundments may raise the water level and cause water that had previously bypassed the peatland to flow across the peatland surface, bringing more nutrients into contact with the vegetation and peat (Dan Sperduto, NHNHB, personal communication). Peat decomposes quickly under higher nutrient conditions (Aerts et al. 2001), and non-peatland vegetation will begin to grow under these conditions. Several non-peatland natural communities in New Hampshire are documented to occur on former peatlands that have been flooded by beavers (Sperduto and Nichols 2004).

3.1.3 Non-Point Source Pollution (Nutrients (Eutrophication))

(A) Exposure Pathway
Increased nutrient input through runoff, decaying woody debris, or hydrologic alterations changes the nutrient content of the water in peatlands. This increases the rate of peat decomposition, which in turn affects water transport through the peat and nutrient availability. All of these factors contribute to changes in the structure of the peat surface and the composition of the plant community. Generally, increases in nutrient levels change the peatland to a non-peat wetland that may not be suitable for peatland plants and animals.

(B) Evidence
Peatlands are nutrient poor systems where organic decomposition is very slow and organic matter (peat) accumulates over time. Peat accumulates as long as the rate of plant growth exceeds the rate of decay (Johnson 1985, Damman and French 1987). Peatlands are inhabited by a suite of plants adapted to nutrient-poor conditions (Sperduto and Nichols 2004). Increases in nutrient concentrations will change the plant community and the rate of organic decomposition (Aerts et al. 2001), resulting in a loss of peatland habitat. Land conversion and other human activities near peatlands 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).

3.1.4 Unsustainable Harvest (Forestry Operations and Management)

(A) Exposure Pathway
Timber harvesting in forested peatlands changes the vegetation structure and the amount of decaying

woody debris in the peatland. It can also increase compaction of the peat and nearby soil, leading to increased runoff and nutrient inputs. In addition, forestry activities too close to peatlands could disturb peatland wildlife, leading to decreased nesting success of birds and other changes to wildlife populations.

(B) Evidence
In New Hampshire, any activity that involves dredging material from or adding material to a wetland requires a permit (NHDES 2004). However, forestry activities can occur in peatlands 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. Although peatland 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 peatlands. 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 peatland can alter the structure and density, and thus the water transport abilities, of the peat (Damman and French 1987).

3.1.5 Recreation (Off Road Vehicles)

(A) Exposure Pathway
The use of off-road vehicles in peatlands could cause severe destruction of vegetation and peat, and possibly erosion and channelization that would alter the flow of water and nutrients through the peatland.

(B) Evidence
Off-road vehicle use is increasing rapidly in the Northeast. 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). Even though it is illegal to ride off-road-vehicles in any wetland in New Hampshire (NHFG 2005), individuals may leave trails and ride in peatlands or other wetlands if a trail passes within sight of one.

3.2 Sources of Information

Information was gathered from literature review, expert consultation, and databases.

3.3 Extent and Quality of Data

- There is a wide body of research on the ecology, hydrology, nutrient processes, and restoration of peatlands in northern Europe and Canada. Less research has been conducted in the northeastern United States, where peatlands are less abundant. The rarity of many peatland types in New Hampshire is well documented.
- The effects of habitat fragmentation on wetland-dependent wildlife have also been widely studied, but not as much research has been done on peatland-specific taxa. However, the high rate of human development and fragmentation in New Hampshire is well documented.
- The effects of forestry on soils, wetlands, hydrology, and nutrient dynamics are fairly well known for other regions, but this information is not as well known for New Hampshire peatlands.
- There is a good body of research indicating the severe impacts of off-road vehicles on ecosystems. There is also substantial anecdotal evidence (through newspaper articles) of off-road vehicle users violating laws and regulations. Thus, concern that New Hampshire off-road vehicle users may be violating wetland regulations is justified.

3.4 Threat Assessment Research

- Assess the level of timber harvesting in peatlands occurring during the winter. Assess the influence of forestry on coarse woody debris, soil compaction, nutrient cycles, and peatland habitat structure at various distances from peatland borders.
- Monitor use of off-road vehicle trails near wetlands to determine to what extent users are leaving trails and riding in wetlands. Monitor erosion, sediment, and nutrient inputs in peatlands near off-road vehicle trails.

Element 4: Conservation Actions

4.1.1 Conservation Action: Establish buffers around peatlands

Category: Regulation

(A) List of Direct Threats Affected
Development (Fragmentation, Habitat Loss and Conversion), Non-Point Source Pollution (Nutrients (Eutrophication)), Recreation (Off Road Vehicles), Unsustainable Harvest (Forestry Operations and Management)

(B) Justification

- Creating buffers will prevent some of the upland fragmentation surrounding peatlands, and will protect peatlands from increased nutrient input from forestry activities, erosion through off-road vehicles, or other land uses, through allowing surface water to infiltrate the ground rather than running directly into the peatland.
- Reducing these threats will facilitate maintenance of the water chemistry levels needed by peatland plants and provide suitable migration habitat for wildlife.
- Habitat fragmentation occurs primarily in the southern part of New Hampshire, while forestry and off-road vehicle impacts can occur throughout the state. Thus, the implementation of peatland buffers needs to occur statewide.
- The current rate of development in New Hampshire, as well as the growing use of off-road vehicles, suggests that the upland surrounding peatlands needs to be protected immediately to prevent further impacts.
- Buffer distances can be increased as necessary if data shows that peatland water chemistry or wildlife populations are still negatively affected by surrounding land uses.

(C) Conservation Performance Objective:
Establishing permanent buffers around peatlands will eliminate development, timber harvest, and off-road vehicle use, and will reduce increases in runoff from these activities within the buffer. Success will be measured by monitoring compliance with the buffer restrictions.

(D) Performance Monitoring
Projects occurring near the designated peatland buffer area will be monitored. Any project that involves land conversion (timber harvest, road or off-road trail building, construction) within a peatland buffer will be considered non-compliant with buffer restrictions.

(E) Ecological Response Objective
The desired ecological response to buffers around peatlands is no change in the water chemistry or vegetation composition of any peatland, and no decline in populations (averaged over time) of peatland-dependent wildlife or plant species.

(F) Response Monitoring
Populations of peatland-dependent plants and wildlife will be monitored, including ongoing monitoring of rare species. Water chemistry (pH and nutrient levels) will be periodically monitored (at intervals to be determined) in a random set of peatlands throughout the state. If water chemistry, vegetation, or wildlife population changes occur when land conversion activities occur immediately outside the buffer, increases in the buffer distance should be considered.

(G) Implementation

- An appropriate buffer distance will be determined, based on hydrology research and wildlife migration distances. Included in the buffer requirements will be the stipulation that off-road vehicle trails will be located at least 100 feet from any peatland to reduce visibility of the peatland and deter drivers from entering them.
- Delineate peatlands throughout the state (preferably all peatlands, but if not, then a significant number of important peatlands distributed throughout the state and across community classifications).
- Establish through regulation either a required buffer distance or strong incentives to include buffers in place (e.g., project restrictions or a high fee for non-compliance) during construction, road, and off-road vehicle

trail building, and other land conversion activities. Compliance with the buffer may be overseen by the New Hampshire Department of Environmental Services (NHDES) as part of the wetland review process.

(H) Feasibility
Enacting a regulation for a peatland buffer will require the agreement of various state agencies including NHDES, NHFG, and the New Hampshire Department of Resources and Economic Development (NHDRED) as well as legislators, which could slow the process. Buffering selected peatlands may be more feasible initially than buffering all peatlands. Once a peatland buffer is in place, enacting the buffer will be a regular part of the ongoing wetland review process of NHDES. If incentives are used rather than a strict buffer requirement, monitoring and enforcing buffers will require more time and effort.

4.1.2 Conservation Action: Delineate forested peatlands in northern New Hampshire and notify large landowners

Category: Education and Outreach

(A) List of Direct Threats Affected
Forestry activities in/near peatlands, Increased nutrient input

(B) Justification

- Mapping and notifying large landowners of the locations of forested peatlands on their properties will reduce winter harvesting in or near peatlands that are not properly mapped in existing GIS layers.
- Reducing harvesting in or near peatlands will protect the vegetation structure, reduce nutrient changes due to forestry activities, eliminate soil compaction, and increases woody debris around peatlands.
- Most large-scale timber harvesting occurs in northern New Hampshire; thus, delineation of peatlands in this region would be the most efficient way to target the highest number of unprotected peatlands affected by forestry practices. Prompt delineation of peatlands in northern New Hampshire will protect them before they are inadvertently damaged.
- Peatland delineations can be changed as beaver activities alter the landscape or if new peatlands are discovered. Landowners can be updated when any changes are made.

(C) Conservation Performance Objective
Delineating and notifying landowners about forested peatlands in northern New Hampshire will reduce the harvesting of timber in and near peatlands. Success will be measured by the number of delineated peatlands in northern New Hampshire that are harvested.

(D) Performance Monitoring
Opportunistic field checks and updated aerial photo analysis will allow for assessment of whether delineated peatlands have been cut. Peatland delineations will also be given to NHDES, who will process permit requests wetland impacts and can determine if harvest activities are likely to occur near a peatland.

(E) Ecological Response Objective
The ecological response objective is to eliminate changes to peatland structure, vegetation, and ecological processes from cutting.

(F) Response Monitoring
Opportunistic field checks of peatlands in northern New Hampshire will determine if vegetation and structure have changed.

(G) Implementation
Through color infrared aerial photo interpretation supplemented by field surveys, the predicted peatland map (element 1.6) will be refined in the Connecticut Lakes and Mahoosic-Rangeley Lakes ecoregion subsections, to create a detailed map of forested peatlands by community or system. Portions of the peatland 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. In the event that GIS ownership data cannot be obtained, tax maps or other ownership maps will need to be used with care due to their lack of spatial accuracy. The entire map will be given to the NHDES Wetlands Bureau for use in the environmental review process.

(H) Feasibility
Finalizing the peatland map in northern New Hampshire through aerial photo analysis and field checking will require 1-2 people several months to complete, and landowner permission will be required for field visits. Obtaining accurate spatial data about ownerships will depend on the availability of this data, and if accurate digital data is not available, more time will be required to either digitize ownerships or select peatlands based on hardcopy maps.

4.2 Conservation Action Research

Determine an appropriate buffer distance for maintaining ecological functions of peatlands

Element 5: References

5.1 Literature

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HABITAT PROFILE

Salt Marshes

Associated Species: American Bittern, American Black Duck, Common Tern, Nelson's Sharp Tailed Sparrow, Salt Marsh Sharp Tailed Sparrow, Seaside Sparrow, Semipalmated Sandpiper, Willet

State Ranks: Salt marsh system: Low salt marsh (S3), High salt marsh (S3), Salt pannes and pools (S3), Brackish marsh (S2S3), Coastal salt pond marsh (S1); Brackish tidal riverbank marsh system: Low brackish tidal riverbank marsh (S1S2), High brackish tidal riverbank marsh (S1S2), Brackish marsh (S2S3); Sparsely vegetated intertidal system: Coastal shoreline strand/swale (S2), Intertidal rocky shore (S3), Saline/brackish intertidal flat (S3).

Authors: Megan J. McElroy and Kimberly J. Babbitt, University of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

Salt marshes are grass-dominated tidal wetlands existing in the transition zone between ocean and upland (Niering and Warren 1980). These marshes are among the most productive ecosystems in the world and are dominated by detritus-based food chains (Mitsch and Gosselink 2000).

Salt marsh plants are salt-tolerant and adapted to fluctuating water levels. Salt marshes are composed of 3 distinct vegetative zones in response to tidal regime: low marsh, high marsh, and marsh border. The low marsh, occurring as a narrow band along the seaward edge of the marsh, and along creeks and ditches, becomes flooded during most tides, but is exposed during low tide. Tall-form smooth cordgrass (*Spartina alterniflora*) is the predominant plant species found in the low marsh and can grow up to 2 meters.

The high marsh occurs between the low marsh and the marsh border. The high marsh becomes flooded usually only during extreme high tides, such as the new-moon and full-moon tides. Throughout the high marsh, grasses and rushes dominate. Species such as salt hay grass (*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 salt marsh 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 marsh border is located at the upland edge of a salt marsh but can also be found in pockets of the marsh 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 following dominant species: marsh elder (*Iva frutescens*), sweet gale (*Myrica gale*), seaside goldenrod (*Solidago sempervirens*), and switchgrass (*Panicum virgatum*).

Frequency and duration of tidal flooding are key environmental factors that create and influence salt marsh vegetative patterns (Niering and Warren 1980, Mitsch and Gosselink 2000). In addition, salinity, substrate, 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. Over time, organic matter accumulates on the marsh and forms peat. By building up more peat, salt marsh elevation can keep apace with rising sea level, unless the rate of sea-level rise becomes too great.

1.2 Justification

More than 50% of coastal and estuarine marshes in the United States have been lost, 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). An estimated 30-50% of New Hampshire's original salt marsh habitat has been lost to development (New Hampshire Coastal Program (NHCP). Therefore, protecting and restoring remaining salt marsh habitat has become a high priority for New Hampshire.

Salt marsh habitat is an important conservation concern because it has many important 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 provide habitat and food for small fish, crustaceans, and insects, as well as larger fish that are important to the New England fishing industry. Moreover, salt marshes provide breeding, foraging, and migratory stopover habitat for many species of birds (Mitsch and Gosselink 2000), including several species of special concern in New Hampshire, such as saltmarsh sharp-tailed sparrow, Nelson's sharp-tailed sparrow, and willet.

1.3 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).

1.4 Population and Habitat Distribution

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 (NHCP).

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

Salt marsh habitat was mapped using National Wetlands Inventory (NWI) data (USFWS 2001). Specifically, those wetlands classified as emergent intertidal estuarine wetlands (code = E2EM) were extracted from the NWI data to represent salt marshes in New Hampshire. Salt marsh habitats were not restricted by size, vegetative structure, or other attributes. Therefore, habitat quality for different species varies among salt marsh polygons. Potential habitat maps for salt marsh species (e.g., salt marsh birds) can be created by querying for specific attributes (e.g., marshes larger than 20 ha).

1.7 Sources of Information

Information on salt marsh habitat ecology, research, management, and restoration was obtained from a literature review. National Wetland Inventory maps were used to identify salt marsh habitat in the state. The New Hampshire Coastal Program's website was used to gather information on salt marsh distribution and abundance in the state, management and restoration projects, and research and conservation issues in the state. Sperduto (2004) was used to crosswalk salt marsh habitat with the New Hampshire Natural Heritage Bureau natural communities and ecological systems (see State Ranks above).

1.8 Extent and Quality of Data

The extent and quality of data on the distribution of salt marsh habitat in New Hampshire are quite good. NHCP monitors habitat changes by regular sampling of soil, fish, vegetation, and birds at select sites that are natural or undisturbed, degraded or restricted, and restored or mitigated. Therefore, any changes in habitat quality or type (e.g., a tidally restricted salt marsh becoming brackish or dominated by invasive species) are well documented and handled by NHCP.

1.9 Distribution Research

Continuation of NHCP's long-term monitoring and surveying efforts of salt marsh habitat is needed so

that information on distribution and loss due to tidal restrictions or degradation is kept current.

Element 2: Species/Habitat Condition

2.1 Scale

The New Hampshire conservation units for salt marsh habitat are Great Bay and Portsmouth and Coast (including Rye, Hampton, and Seabrook).

2.2 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 (Burdick et al. 1997). 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 about 2509 ha (6,200 ac) of salt marsh habitat (NHCP). An estimated 30-50% of New Hampshire's original salt marsh habitat has been lost to development. Tidal restrictions and filling have caused most of this historic marsh loss and degradation (NHCP). Residential and commercial development along the entire length of the coast, and the presence of Route 1A, have disrupted and restricted the connection between ocean and the marshes (NHCP).

2.3 Population 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 the 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. Currently, researchers at UNH are attempting to answer some of these questions surrounding habitat suitability and effects of restoration practices.

2.4 Relative Quality of Habitat Patches

Salt marsh habitat within New Hampshire's coastal zone can be identified in a geographical information system by using National Wetland Inventory data (NWI code = E2EM1P). Although these habitat patches are all considered salt marsh, they are vastly different in status (i.e., tidally restricted, undisturbed, or restored), size, shape, regime, vegetative structure, location on the landscape relative to human disturbance, elevation, presence of ditches, pools, and pannes, among many other characteristics. Their ability to provide key ecological attributes varies between sites and also depends on the target wildlife species or communities. For example, saltmarsh sharp-tailed sparrow, a salt marsh obligate, typically breeds in large, unrestricted, *Spartina*-dominated marshes with the presence of pannes, pools, and creeks for foraging. However, this is not always the case. Sparrows may occupy marshes that do not fit the above criteria, while marshes that appear to meet all the critical habitat attributes may have an absence of sparrows. Therefore, all New Hampshire's salt marshes potentially have key ecological attributes, but more research is needed to fully understand habitat quality in relation to rare or endangered salt marsh obligates.

2.5 Habitat Patch Protection Status

All salt marshes, regardless of ownership, are protected and regulated by the NHDES through a permitting process. Some marshes are protected further through conservation easements, such as Bay Road marsh in Newmarket, Squamscott River in Newfields, and Chapman's Landing in Stratham. In addition, areas of the Hampton marsh complex are protected through conservation easements held by ASNH, NHFG, and SPNHF.

2.6 Habitat Management Status

The Coastal Zone Management Act of 1972 created the federally consistent formal review process for any federal activities affecting New Hampshire's coastal zone. NHCP, part of the Department of Environmental Services, gained federal approval in 1982 and oversees all protection, mitigation, and restoration efforts surrounding salt marsh habitat in the state. With assistance from the Natural Resource Conservation Service (NRCS), and other partnerships and non-government organizations, NHCP identifies degraded salt marshes, prioritizes sites for restoration, and develops ways to measure the effectiveness of restoration techniques. NHCP is currently forming a comprehensive restoration program that will help coordinate, inventory, and monitor restoration projects in the state.

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). In New Hampshire, restriction removal, fill removal, and open marsh water management are techniques used for restoration. Between 1990 and 2000, removing tidal restrictions restored 236 ha (582 ac), 3 ha (8 ac) of marsh have been restored by fill removal at 2 sites, and the New Hampshire Coastal Program estimates 40 ha (98 ac) have been restored through open marsh water management.

2.7 Sources of Information

Information on salt marsh habitat ecology, research, management, and restoration was obtained from a literature review. The NHCP website was used to gather information on salt marsh condition, health, current management, and restoration efforts.

2.8 Extent and Quality of Data

The extent and quality of data on the condition and management efforts of salt marsh habitat in New Hampshire are quite good. NHCP monitors habitat changes by regular sampling of soil, fish, vegetation, and birds at select sites that are natural or undisturbed, degraded or restricted, and restored or mitigated. Therefore, any changes in habitat quality or type (e.g., a tidally restricted salt marsh becoming brackish or dominated by invasive species) are well documented and handled by NHCP.

2.9 Condition Assessment Research

Continuation of NHCP's long-term monitoring and surveying efforts of salt marsh habitat is needed. This information provides evidence of marsh health at specific sites and can be used to compare different sites. NHCP efforts focus on restricted and restored marshes, but many of New Hampshire's marshes are not monitored. Therefore, extending this effort to unmonitored marshes on an annual basis is recommended.

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Historically, human activities, such as dredging, filling, and the construction of roads, dikes, bridges, and impoundments, have reduced the amount of salt marsh habitat along the Atlantic coast (Roman et al. 1984). The coastal zone of New Hampshire is a popular location for residential and commercial development because of its flat landscape and proximity to the ocean.

(B) Evidence
More than 50% of coastal and estuarine marshes in the United States have been lost, with the Northeast region being one of the four "hotspots" for the most significant loss (Benoit and Askins 1999). In New England, 80% of the marshes have been lost to human development (Shriver et al. 2004). Habitat loss is a significant factor in the decline of wetland birds, especially species that depend on salt marshes for nesting, such as the saltmarsh sharp-tailed sparrow (Greenlaw and Rising 1994, Benoit and Askins 1999).

3.1.2 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Coastal development also results in the loss of marsh

border habitat and upland habitat surrounding the marsh, both of which act together as an important buffer zone (NHCP). Many species of birds and mammals use this buffer habitat for breeding, feeding, and other activities (NHCP).

(B) Evidence
The loss of upland buffer habitat and an increase in development surrounding a marsh system may negatively influence the behavior of salt marsh obligate wildlife species. For example, salt marsh nesting birds may nest greater distances from the edge due to the loss of the upland buffer and an increase in noise pollution and therefore be forced to occupy less space (NHCP).

Coastal development combined with an accelerated rate of sea-level rise and loss of upland buffer habitat threatens marsh growth. As sea level rises, marshes will not be able to keep pace with the rising ocean in places where the upland buffer has been lost to development. The result will be smaller and narrower fringe marshes bordering the ocean.

3.1.3 Development (Fragmentation)

(A) Exposure Pathway
Residential and commercial development has fragmented the landscape and created isolated patches of marsh habitat. Historically, the flat, open, and expansive qualities of salt marshes made them ideal locations for the construction of roads and railroads. Ultimately, construction of these transportation systems has left smaller and smaller patches of marsh that consist of more edge habitat and less interior habitat.

(B) Evidence
Fragmented habitats are usually associated with an increase in edge habitat and a decrease in available interior habitat. Area-sensitive species, such as saltmarsh sharp-tailed sparrows (Benoit and Askins 2002), could be negatively impacted by fragmentation and decreasing patch size. In Connecticut, saltmarsh sharp-tailed sparrow densities exhibited a significant positive relationship with marsh area (Benoit and Askins 2002). Moreover, an increase in the amount of edge in many different habitat types can be associated with higher densities of nest predators (Niehaus et al. 2003). Thus, salt marsh nesting birds may be impacted by increased nest predation in fragmented patches. Fragmentation also reduces the amount of suitable nesting habitat. With increasing edge and development pressures surrounding a marsh, many salt marsh nesting birds could lose quality nesting habitat and be forced to move further from the marsh edge or exist at lower densities.

3.1.4 Altered Hydrology (Tidal Restriction), Transportation Infrastructure

(A) Exposure Pathway
Transportation routes (roads and railroads) that have been built on salt marshes since the late 1800s sever the vital connection between the marsh and ocean (NHCP, Roman et al. 1984). Roads built on the marsh often have tide gates or inadequately sized culverts that reduce or eliminate tidal flooding of the marsh system.

(B) Evidence
Without tidal influence, typical salt marsh grasses of tidally restricted marshes are replaced with brackish species and invasive plants (Niering and Warren 1980, Sinicrope et al. 1990, Burdick et al. 1997, Brawley et al. 1998, Benoit and Askins 1999). Tidal restrictions also result in a decrease in salt and sediment exchange and an increase in fresh water from rain and snowmelt (Burdick et al. 1997). Further, tidally restricted marshes are less productive than unrestricted marshes (Roman et al. 1984). Burdick et al. (1997) found that tidal restrictions negatively affect the entire salt marsh ecosystem. Historical degradation of salt marsh habitat quality along the Atlantic coast has contributed to regional declines in the saltmarsh sharp-tailed sparrow population (Greenlaw and Rising 1994, Benoit and Askins 1999) and other salt marsh nesting birds.

3.2 Sources of Information

Information on salt marsh threats was obtained from a literature review and the New Hampshire Coastal Program.

3.3 Extent and Quality of Data

The above threats to salt marsh habitat are well documented and are the focus of many scientific studies in New England.

3.4 Threat Assessment Research

Because past human activities such as road construction continue to negatively affect salt marshes, habitat restoration is a high priority. Pre- and post-restoration research and monitoring of salt marsh structure and function are essential for accurate evaluation of restoration success. For example, open marsh water management for mosquito control may negatively affect the salt marsh ecosystem, but more research is needed (NHCP).

Research is needed to determine the effects of methylmercury on the salt marsh ecosystem in New Hampshire. Methylmercury has become an important regional ecological and human health concern. The Biodiversity Research Institute has started to investigate the effects of mercury on salt marsh birds in New England, but research is needed in New Hampshire. Salt marsh birds are already a regional conservation priority due to habitat loss and degradation, but mercury could pose an increasing threat to these and other salt marsh species. As scientific research assesses mercury's effects, conservation actions can better address the issue.

Element 4: Conservation Actions

4.1.1 Protecting remaining salt marsh habitat and surrounding upland buffer habitat, Habitat Protection

(A) Salt Marsh Loss, Upland Habitat Loss, Habitat Fragmentation, Increased Human and Noise Disturbance, Invasive Plant Species, Increased Deposition of Pollutants, Tidal Restriction, Dredge and Fill, Sea Level Rise

(B) Justification

1) Most of New England's historical salt marsh habitat has been lost to development and other human activities. Therefore, preserving the remaining habitat patches will ensure that no more salt marsh is lost or fragmented in New Hampshire. Protecting quality habitat and the upland buffer will reduce or lessen the threats listed in (A) in measurable ways and benefit the salt marsh community. For example, maintaining the upland buffer surrounding a marsh and protecting it from development will reduce or prevent human and noise disturbance at that site.
2) Many salt marsh nesting birds, such as willet, are area-sensitive and require large, contiguous patches of habitat on a landscape for population colonization and growth. Protecting existing patches will ensure that these and other populations will not decline or become locally extinct due to habitat loss and fragmentation. Protecting existing marshes and upland buffers will benefit New Hampshire's current salt marsh bird populations and allow them to stabilize, grow, or disperse into new protected areas.
3) Habitat protection across the landscape is necessary to maintain current population numbers because salt marshes are threatened by development everywhere.
4) Protection of existing salt marsh habitat structure, function, and value is achievable immediately. Habitat protection has the advantage of being a preventative approach, rather than a reconstructive or restorative approach. For example, sites currently used by salt marsh nesting sparrows likely would continue to be used if the habitat were protected.

(C) Conservation Performance Objective
The performance objective for salt marsh and upland buffer protection is to maintain a tidally influenced, *Spartina*-dominated system with low marsh, high marsh, pannes, pools, and a border of upland habitat. The objective for each conservation unit is to maintain known salt marsh structure, function, and value that can be measured through frequent monitoring. The ultimate goal is to maintain habitat quality within every conservation unit that potentially could support breeding populations of salt marsh obligate birds, which can be used as indicators of habitat health.

(D) Performance Monitoring
Performance monitoring should be conducted at as many salt marshes as possible, or at sites of high priority or concern, on a regular basis (depending on priority, available personnel, funding, and time). Monitoring includes regular sampling of soil salinity, tidal elevations, vegetation structure, and fish and bird communities.

(E) Ecological Response Objective
The desired ecological response to salt marsh protection is persistence of a tidally influenced, *Spartina*-dominated system that could support salt marsh fish populations and potentially support obligate bird populations. This response should be immediate at natural, undisturbed sites that are monitored and protected from further human disturbance and development. For salt marsh protection to be deemed successful, long-term monitoring and research should indicate that fish and bird use stabilizes or increases.

(F) Response Monitoring
Response monitoring should be conducted at as many salt marshes as possible, or at sites of high priority or conservation concern, on a regular basis (depending on priority, available personnel, funding, and time). The response indicator for successful marsh protection is a measured quality of marsh structure and function, in terms of soil salinity, vegetative structure, tidal elevations, and fish and bird communities.

(G) Implementation
NHCP oversees all protection and management of salt marsh habitat within New Hampshire and works with local partners and conservation commissions to ensure protection.

(H) Feasibility:
Although NHCP has successfully protected many hectares of salt marsh habitat in New Hampshire, the pressures of development within the coastal zone are significant. Any impact to wetlands must go through a permitting process before implementation. However, even legally permitted impacts can result in habitat loss. Therefore, reducing or eliminating future disturbance and development is crucial to protecting existing salt marsh systems and communities. The feasibility of intense long-term monitoring at natural sites is limited by personnel and funding.

4.1.2 Restoring degraded salt marshes back to Spartina-dominated systems, Restoration and Management

(A) Salt Marsh Loss, Upland Habitat Loss, Habitat Fragmentation, Invasive Plant Species, Tidal Restriction, Dredge and Fill, Mosquito Ditching

(B) Justification
1) Pre- and post-restoration environmental monitoring has shown that restoring degraded marshes by reintroducing tidal influence can be successful (see Warren et al. 2002, NHCP). Removing or reducing tidal restrictions decreases or eliminates invasive plant species and creates a functioning *Spartina*-dominated system over several years (Niering and Warren 1980, Roman et al. 1984, Warren et al. 2002).
2) Salt marsh restoration has produced a positive ecological response in degraded salt marsh ecosystems (Burdick et al. 1997, Warren et al. 2002). Although more research is needed, restoration is expected to benefit salt marsh obligate bird populations over the long-term. In a 20-year study of salt marsh restoration in Connecticut, abundance and nesting activity of salt marsh specialists were low following restoration, but were comparable to breeding populations of the same species in reference marshes after 15 years (Warren et al. 2002). Restoration may have a near-term negative effect on salt marsh nesting sparrows due to increased flooding, but over time it is possible for restoration to increase bird activity and reproductive success due to an increase in the amount of quality habitat.
3) Salt marsh restoration is critical across the landscape to conserve salt marsh habitat in New Hampshire. Without it, tidal restrictions would continue to degrade and alter these marshes into brackish or freshwater marshes and uplands dominated by common reed and other invasive species. Salt marsh habitat would continue to be lost in the state.
4) Warren et al. (2002) suggest restoration response times for certain ecological parameters to be between 5 and 21 years. Burdick et al. (1997) found significant positive changes to vegetative structure only a few years after restoration, and Warren et al. (2002) found typical salt marsh fish communities present at restoration sites 5 years after restoration. Limited research has been conducted on the timeframe of restoration success in terms of bird use. However, Warren et al. (2002) found salt marsh sharp-tailed sparrow activity at a restored site was similar to activity at reference sites 15 years after restoration.
5) There are many different techniques for restoring

salt marshes, including seeding and replanting *Spartina* grasses, reintroducing tidal flooding to restricted areas by constructing larger culverts under roads, installing self-regulating tide gates to permit water passage, and plugging ditches (see Broome et al. 1988, Sinicrope et al. 1990, Warren et al. 2002). These techniques can be tailored to obtain the desired ecological response depending on a site's specific needs. Ongoing monitoring of salt marsh functions at restored sites provides the necessary ecological information about the outcomes of restoration activities. These data can be used to guide restoration management goals and plans (i.e., adaptive management).

(C) Conservation Performance Objective
The salt marsh restoration performance objective is to create a tidally influenced, *Spartina*-dominated system with low marsh, high marsh, pannes, pools, and a border of upland habitat. The objective for an individual site is to establish marsh structure and function comparable to that of natural, undisturbed systems. Warren et al. (2002) suggests that full restoration of ecological functions, including salt marsh sparrow breeding activity, can occur within 2 decades. Therefore, the ultimate goal for the performance objective is to create habitat with salt marsh structure, function, and value relative to the conservation unit within 20 years of restoration.

(D) Performance Monitoring
Annual performance monitoring should be conducted at all restoration sites, including pre-restoration monitoring, if feasible. If pre-restoration monitoring is not possible due to time constraints and severity of marsh degradation, then monitoring of reference sites is acceptable. All monitoring and research activities should be conducted at reference sites and restoration sites to enable assessment of restoration success. Monitoring should be performed until at least 15-20 years after restoration to determine if desired effects are realized. Restoration is a long-term process and needs to be monitored over a long timeframe. Monitoring should include regular sampling of soil salinity, vegetation structure, tidal elevations, and fish and bird communities.

(E) Ecological Response Objective
The desired ecological response to salt marsh restoration is creating a tidally influenced, *Spartina*-dominated system that could support salt marsh fish populations and potentially support obligate bird populations. This response should be realized approximately 5-20 years after restoration (e.g., 5 years for fish colonization and 20 years for bird colonization) (Warren et al. 2002). For restoration to be deemed successful, long-term monitoring should indicate that soil salinity, vegetative structure, tidal elevations, and fish and bird use at restored sites are comparable to that of similar reference sites.

(F) Response Monitoring
Response monitoring should be conducted at all restoration sites on a regular basis (depending on priority, available personnel, funding, and time). The response indicator for successful marsh restoration is the quality of marsh structure and function measured in terms of soil salinity, vegetative structure, tidal elevations, and fish and bird communities.

(G) Implementation
NHCP oversees all protection, management, and restoration of salt marsh habitat within New Hampshire, often with partners such as Ducks Unlimited, U.S. Fish and Wildlife Service, University of New Hampshire, National Oceanic and Atmospheric Administration, and many local partners, such as town conservation commissions and businesses. Restoration sites are chosen based on degree of degradation, feasibility of proposed restoration activities, and available monetary resources for the project. Once technical support and funding are established for each project, a timeline is created for restoration activities and post-restoration monitoring of habitat functions.

(H) Feasibility
NHCP has successfully implemented salt marsh restoration projects throughout New Hampshire's coastal zone and is planning future restorations. In addition to planning, collaborating with partners, obtaining funding for each project, and carrying out the restoration, NHCP and its partners annually conduct biotic and abiotic sampling to monitor restoration success. The feasibility of intense long-term monitoring of restoration success is limited by personnel and funding.

4.2 Conservation Action Research

More research is needed in New Hampshire to determine the long-term effects of restoration on populations of salt marsh nesting birds, such as saltmarsh sharp-tailed sparrow, Nelson's sharp-tailed sparrow, seaside sparrow, and willet. Salt marsh obligate birds are of special concern in New Hampshire and the impact of restoration on these populations is not well documented. Because these birds may be faithful to breeding sites or territories (see Lowther et al. 2001, Benoit and Askins 2002) and their nests are sensitive to fluctuations in water level, restoration might cause high nest failure rates at a site for several years after restoration. The effects on the small and localized populations of these birds are unknown.

Element 5: References

5.1 Literature

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HABITAT PROFILE

Shrublands

Federal Listing: Not listed
State Listing: Not listed
Associated Species: Golden-Winged Warbler (Vermivora chrysoptera), American Woodcock (Scolopax minor), New England Cottontail (Sylvilagus transitionalis), Smooth Green Snake (Opheodrys vernalis), Black Racer (Coluber constrictor), Wood Turtle (Glyptemys insculpta).
Global Rank: N/A
State Rank: N/A
Author: James D. Oehler and Ellen Snyder, New Hampshire Fish and Game, Consulting Wildlife Biologist

Element 1: Distribution and Habitat

1.1 Habitat Description

Shrubland habitat (hereafter referred to as shrubland) refers to shrub-dominated areas with scattered forbs and grasses. These habitats are typically the result of some disturbance and include dry shrublands, utility rights-of-way, old agriculture fields, and reverting gravel pits.

1.2 Justification

Shrublands and other woody early-successional habitats are declining in New Hampshire and throughout the Northeast (Trani et al. 2001, Brooks 2003), as are the associated wildlife species (Hunter et al. 2001, Litvaitis 2001, Dettmers 2003, Wagner et al. 2003). For example, nearly half of the 33 shrubland birds covered by Breeding Bird Survey routes in the Northeast have significantly declined in the last 35 years (Dettmers 2003). Partners in Flight (PIF), a cooperative bird conservation organization seeking to maintain populations of North American land birds, has identified the Northeast as being particularly important for maintaining source populations of shrubland birds (Dettmers 2003a, Dettmers 2003b). Since 1960, the distribution and abundance of New England cottontail has declined substantially throughout New England (Johnston 1972, Jackson 1973, Litvaitis 1993) and are being considered for listing under the federal Endangered Species Act (USFWS 2004). Additionally, 139 species of reptiles, amphibians, birds, and mammals either prefer (17 species) or utilize (122 species) shrub and old-field habitats (Scanlon 1992).

1.3 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.

1.4 Population and Habitat Distribution

It is difficult to determine the distribution of shrublands in New Hampshire because of limitations of remote sensing data (see section 1.8 for details). United States Forest Service's (USFS) Forest Inventory and Analysis (FIA) data indicate that from 1973 to 2002, the amount seedling/sapling forest declined 63% from nearly 449,000 hectares to just over 167,000 hectares. Seven counties experienced a 70 to 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 .

1.5 Town Distribution Map

See attached.

1.6 Habitat Map
Not completed for this habitat.

1.7 Sources of Information

Sources of information include journal articles, USFS FIA data, New Hampshire Landcover Assessment, 1998 aerial photos, and discussions with previous data users.

1.8 Extent and Quality of Data

Existing data sources are inadequate to map shrubland habitat to assess abundance and distribution in New Hampshire. FIA data include a series of nearly 400,000 field points on stand age, size, composition, ownership, etc. This information is useful in assessing wildlife habitat, assessing the sustainability of ecosystem management practices, and in making forest-planning decisions (USFS 2005). FIA data is more relevant to young forests than to shrubland habitats.

FIA plots classified as "non-stocked" (stocking of less than 10% of live trees) would ideally provide the best information on shrublands in New Hampshire (Frieswyk and Widman 2000). However, due to the sporadic and incomplete nature of data collection for this classification, the "non-stocked" classification was deemed unreliable (Carol Alerich, USFS-FIA program, personal communication) . The next best indicator of the decline of shrubland habitats in New Hampshire is the trend in the amount of forestland dominated by seedlings and saplings (these stand size classes are typically lumped together in the FIA data). Data for seedling/sapling forest is not available for 1948 or 1963 (Carol Alerich, USFS-FIA program, personal communication).

Even if satellite imagery were more current, satellites are typically poor at detecting differences in vegetation structure (i.e., height and size of vegetation) (Bergen et al. 2002). Aerial photographs can be used, but would be time consuming and cost prohibitive if done for a large area (Dan Sundquist, SPNHF, personal communication).

1.9 Distribution Research

A better means of mapping shrubland habitats is needed to assess the abundance and distribution of New Hampshire's shrublands. Two options are radar and lidar sensors that can measure vegetation height and can directly estimate other variables related to vegetation structure (Bergen et al. 1997, Bergen and Dobson 1999).

Element 2: Species/Habitat Condition

2.1 Scale

Counties will be used as the conservation-planning unit for this habitat because that is the scale at which most information exists and because most technical and financial assistance (from the USDA NRCS, UNH Cooperative Extension, and others) is provided to private landowners by county.

2.2 Relative Health of Populations

Data on the distribution and health of shrublands are severely lacking (see section 1.8). 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 .

It is difficult to ascertain the historic extent of shrublands in New Hampshire. Native Americans in coastal and inland river valleys used fire to create and maintain agricultural fields, improve hunting grounds, and maintain travel corridors, among other purposes (Day 1953, Harris 1972, Cronon 1983, Whitney 1994). Settlements often occurred on sandy, glacial outwash deposits of major river valleys where food was plentiful (Whitney 1994). Pitch pine-scrub oak barrens occur in these areas (Howard et al. 2005). The result of Native American burning was a mosaic of habitat types in different states of succession, likely including native scrub oak shrublands and heathlands.

Fire regimes may have greatly influenced vegetation patterns (Patterson and Sassaman 1988), though some researchers determined that the use of fire was location-specific and not as extensive as some suggest (Clark and Royall 1996, Parshall and Foster 2002). Parshall and Foster (2002) found that fires were more common over the last 300 years than in the preceding 1,500 years with a great portion of these fires occur-

ring during the early settlement period.

Historic accounts summarized in Askins (1997) indicate that beaver (*Castor canadensis*) activity also created open areas. After an abandoned beaver dam degrades and becomes breeched, the previously ponded area succeeds to a meadow dominated by sedges, grasses, and forbs and without further disturbance will succeed to shrubland. Beaver activity may influence 20-40 percent of the total length of second- to fifth-order streams (Naiman et al. 1988). One study in the Adirondack Mountains of New York found that beaver dams created patches of disturbance up to 12 ha in size (Remillard et al. 1987). Interestingly, an analysis of the current status of wet flats in New Hampshire (the flat floodplain area adjacent to streams and rivers that would be impacted by beavers) shows that nearly 30% (267 out of 961) of the wet flats 7 – 12 ha in size are impacted by agriculture and likely no longer serve as shrubland habitat. Another 17% (165 out of 961) are impacted by development (CSRC 2001, TNC 2003).

Weather-related disturbances such as wind and ice storms may infrequently create early-successional habitats. Hurricanes capable of causing extensive blowdown occur every 150 years on average in southeastern New Hampshire, every 380 years in central New Hampshire, and less than once every 380 years in northern New Hampshire (Boose et al. 2001). The January 1998 ice storm was a major weather event in New Hampshire's history causing significant damage to the forests of central and northern New Hampshire.

The amount of early-successional habitat increased dramatically after European settlement. Much land was cleared for farmland in the eighteenth and nineteenth 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 industrial 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, causing shrubland species to decline (Litvaitis 1993). Today, given the lack of fires and the reduction in areas potentially impacted by beavers, coupled with effect of habitat fragmentation caused by development, the future health of shrubland wildlife depends on active management.

2.3 Population Management Status

2.4 Relative Quality of Habitat Patches

It is difficult to assess the quality of habitat patches without a suitable habitat map. In general, habitat patch quality depends on a number of factors including vegetation structure (e.g., stem density), habitat patch size, and degree of habitat fragmentation in the surrounding landscape.

Vegetation Structure: Vegetation structure is a key component of shrubland habitats. Vegetation structure requirements can differ among wildlife species. For instance, New England cottontails require stem densities approaching 10,000 stems/hectare (Litvaitis and Tash 2005). American woodcock are found in areas with an overstory canopy cover of 53-64% in diurnal sites and a shrub canopy cover of 75-87% (Dunford and Owen 1973, Morgenweck 1977). The vegetation structure requirements are not clear for the other species covered under this profile.

Habitat Patch Size: Habitat patch size is also an important component to consider when evaluating habitat patch quality. Golden-winged warblers occupy patches that are at least 10 hectares in size (Confer 1992). Litvaitis (1993) found that New England cottontail occupied patches in southeastern New Hampshire ranging from 0.2 to > 15 ha, but very small patches were inherently volatile (Barbour and Litvaitis 1993, Villafuerte et al. 1997). Volatility of small patches is largely related to the relative abundance of generalist predators (e.g., coyotes, foxes, raccoons, skunks) within the surrounding landscape that, in turn, depends on the degree of habitat fragmentation expressed in the landscape (Barbour and Litvaitis 1993, Brown and Litvaitis 1995, Oehler and Litvaitis 1996).

Habitat Fragmentation: Southeastern New Hampshire is undergoing rapid development (Sundquist and Stevens 1999). Generalist predator populations in fragmented landscapes tend to increase because of the readily available food sources (e.g., trash, crops, pet food, etc.) (Oehler and Litvaitis 1996). As suit-

able habitat patches become increasingly smaller, wildlife species attempting to utilize those patches become increasingly vulnerable to predation (Brown and Litvaitis 1995). As such, shrubland patches in the southern part of the state should be at least 5 hectares in size if managing for New England cottontails and at least 10 hectares if managing for golden-winged warblers.

2.5 Habitat Patch Protection Status

Since habitat patches were not identifiable, no information on habitat patch protection status can be generated.

2.6 Habitat Management Status

Financial & Technical Assistance Programs

The USDA's Environmental Quality Incentive Program (EQIP) offers financial and technical help to agricultural producers to install or implement structural and management practices on eligible agricultural land (NRCS 2005b). 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 and 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, hedgerow planting, prescribed grazing, restoration and management of declining habitats, and tree/shrub establishment, among others (New Hampshire NRCS 2005a). Statistics are currently unavailable to determine how many hectares have been treated with each of these practices. In 2005, New Hampshire received nearly $8 million for EQIP.

The USDA's Wildlife Habitat Incentives Program (WHIP) encourages the creation of high quality wildlife habitat on private land through technical and financial assistance (NRCS 2005c). Like EQIP, a WHIP Technical Committee in each state sets eligible habitat improvement practices. Like many states in the Northeast, New Hampshire's list of eligible practices include such things as brush management, early-successional habitat management/development, prescribed burning, tree/shrub planting, upland wildlife habitat management, and other practices applicable to shrubland habitats (New Hampshire NRCS 2005b). Statistics are currently unavailable to determine how many hectares have been treated with each of these practices. In 2005, New Hampshire received over $1,000,000 for WHIP.

Since 1990, the USFWS' Partners Program has provided technical and financial assistance to landowners, state agencies, organizations, and individuals to restore fish and wildlife habitat such as coastal wetlands, riparian habitats, and grasslands (USFWS 2001). Since its inception, the Partners Program has restored over 40.5 hectares of upland habitat in New Hampshire (USFWS 2001). It is unknown how many hectares specifically pertain to shrubland habitats.

NHFG administers the Small Grants Program, which was established to fund small-scale habitat restoration and enhancement projects on privately owned lands. Up to $50,000 per year is committed to the Small Grants Program. The funds are obtained via a $2.50 habitat fee required of all who purchase a New Hampshire hunting license. A number of Small Grant practices apply to shrubland habitats. These include release of apple trees, release of fruiting shrubs, mowing to maintain grasslands and shrublands, regeneration or restoration of alder or aspen/birch, and brush clearing/sapling removal to maintain old fields and shrublands. Since 2000, nearly 2,500 apple trees have been released, 14 hectares of fruiting shrubs have been released, 400 ha of grasslands or shrublands have been mowed, 20 ha have had alder or aspen/birch regenerated, and 438 ha of old fields have been maintained, (NHFG unpublished data).

UNH Cooperative Extension specialists and county-based educators in the Forestry and Wildlife Program also provide technical assistance to landowners on wildlife habitat management issues.

Management on State Lands

The NHFG owns in fee-simple or under conservation easement just over 334 ha of fields (NHFG unpublished data). Of these, 173 ha are maintained in active agriculture (either hay or cropland). The remainder is maintained by mowing occurring every 1-3 years after the bird nesting season. All of the fields under NHFG management should be evaluated to determine which ones would be more suited for shrubland habitat management rather than grassland management.

DRED owns in fee-simple or under conserva-

tion easement approximately 543 ha of fields and shrubland openings (DRED unpublished data). Forty hectares are maintained in active agriculture (either hay or cropland), 137 ha are maintained via mowing by State Parks or NHFG personnel, and 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 management strategy.

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

2.7 Sources of Information

Sources of information for element 2 include journal articles, websites, GIS data, and white papers.

2.8 Extent and Quality of Data

It is difficult to assess the distribution and condition of shrublands without an adequate habitat map. The habitat requirements of some shrubland dependent wildlife are lacking.

2.9 Condition Assessment Research

- Determine specific habitat needs of shrubland dependent wildlife (e.g., vegetation structure and habitat patch size).
- Develop an adequate early-successional habitat map to identify and prioritize habitat management opportunities.

Element 3: Species and Habitat Threat Assessment

3.1.1 Altered Natural Disturbance (Natural Succession)

(A) Exposure Pathway
Shrubland-dependent vertebrate wildlife species require dense understory cover; their occurrence is influenced more by the height and density of vegetation than by specific plant communities (Litvaitis 2003). New England cottontail, woodcock, ruffed grouse, eastern towhee, and other shrubland species shift in space and time in response to natural succession, disturbance, and human land uses (Litvaitis 2005). 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.

(B) Evidence
Although over 80% of New Hampshire is reforested, second growth forests lack the structural diversity present in virgin forests. Forest maturation, coupled with suppression of natural disturbance (e.g., fire) has reduced the amount of early successional conditions (Litvaitis 2003). Concurrently, shrublands are being developed for residential and commercial purposes. Thus, early successional habitat is at or below historical levels (Brooks 2003). 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 tend to be ephemeral and require natural or human disturbance to retain their characteristics (Brooks 2003).

3.1.2 Development (Fragmentation, Habitat Loss and Conversion)

(A) Exposure Pathway
Direct loss of shrubland habitat occurs through the conversion of these lands for residential, industrial, and commercial purposes. Development patterns lead to fragmentation of remaining undeveloped habitats, creating smaller patches that may not sustain wildlife populations and promoting generalist predators that prey on shrub-dependent wildlife (Barbour and Litvaitis 1993, Litvaitis 2005).

(B) Evidence
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 2005). New Hampshire's population grew by 17.2% from 1990 to 2004--the fastest growing state in the Northeast for the past four decades. New Hampshire has lost more than 17,000 acres of open space to development each year in the past five years (Society for the Protection of New Hampshire Forests, unpublished report).

The amount of shrubland habitat of functional quality for wildlife may now be falling below historic levels as current landscape conditions are strikingly different than in pre-settlement times (Brooks 2003). Habitat loss and fragmentation of remaining habitat is causing shrubland species to decline (Litvaitis 2005), especially New England cottontail, American woodcock, eastern towhee, golden-winged warbler, black racer, and smooth green snake since their populations are embedded in a rapidly developing landscape (Society for the Protection of New Hampshire Forests, unpublished report). Increases in generalist predators may reduce or even eliminate small populations of prey species like New England cottontails and some songbirds.

3.1.3 Recreation (Off Road Vehicles)

(A) Exposure Pathway
Two and four wheeled all-terrain vehicles (ATVs) can have direct and indirect impacts on shrubland habitat and associated wildlife. Although by state law ATVs are not allowed on private land without permission or public roads, there is overwhelming anecdotal evidence of ATVs crossing lands without permission. Direct impacts include trampling vegetation by riding through and over shrubs. Indirect effects include the introduction of invasive species (carried inadvertently on the vehicle), excessive noise disturbance, and compaction and rutting of soil. These direct and indirect effects can degrade habitat quality for shrub dependent wildlife.

(B) Evidence
ATVs are registered through NHFG, which reported that ATV registrations doubled from 1998 to 2001 (from 9,452 to 18,001 ATVs). This increase follows a national trend with a concomitant increase in concerns about negative impacts to soils, water, wildlife, and habitats. In April 2003, the USFS Chief Dale Bosworth identified unmanaged off-road vehicle use as one of the four greatest threats to the National Forests, along with fire, the spread of invasive species, and habitat fragmentation. Bosworth particularly noted the unplanned ATV tracks crisscrossing many forests. In New Hampshire, conflicts have arisen around ATV use at Pisgah State Park, Nash Stream, and on other public lands. Private landowners, including tree farmers, are raising concerns about detrimental effects by ATV riders on their lands. A report by the Montana Chapter of The Wildlife Society documents the direct and indirect effects of recreation, including off-highway vehicles, on wildlife and their habitats (Joslin and Youmanns 1999).

3.2 Sources of Information

Sources of information on threats to shrub-dominated early successional habitat included peer-reviewed scientific papers, GIS-analysis in reports by New Hampshire organizations, agricultural statistics from the USDA website, and gray literature.

3.3 Extent and Quality of Data

The decline in shrubland and other early successional habitats and their associated wildlife species is well documented. The effects of development that lead to fragmentation and the increase in generalist predators (e.g., coyote, fox, raccoon) are well documented. The impacts of ATV's on shrublands needs further study.

3.4 Threat Assessment Research

Studies are needed to determine the impacts of ATVs on wildlife and their habitats in New Hampshire.

Element 4: Conservation Actions

4.1.1 Habitat Conservation, Habitat Protection Direct Threats: Development

(B) Justification
The loss of open space in New Hampshire is a major threat to shrubland habitats. Permanently protecting shrublands that harbor species of concern (e.g., New England cottontail) through fee simple acquisitions

or conservation easements may be required to protect and manage species. Land conservation measures will provide an opportunity to manage ephemeral shrublands. Given the pace of development and loss of open space in New Hampshire, this conservation action should receive priority. Once lands are permanently protected the decision cannot be reversed, however management decisions to benefit priority wildlife species can be adapted to changing information and site conditions.

(C) Conservation Performance Objective
The conservation objective is to permanently protect, through fee simple acquisition or conservation easements, shrub-dominated early successional habitat that support populations of declining species including New England cottontail, American woodcock, and eastern towhee.

(D) Performance Monitoring
The measurable component is the acres of shrubland that support priority wildlife species that are permanently protected.

(E) Ecological Response Objective
The ecological objective is to ensure that populations of New England cottontails and other priority wildlife successfully reproduce in these permanently protected shrublands.

(F) Response Monitoring
Populations of New England cottontails and other key species in the protected shrublands should be monitored to determine their reproductive success and to determine if additional shrublands need permanent protection to sustain the populations statewide.

(G) Implementation
This conservation action requires the development of an adequate statewide habitat map to determine which shrublands are most significant for New England cottontail and other wildlife and that would benefit from permanent protection. This should include an assessment of which shrublands are best protected through fee simple acquisition and which shrublands can be adequately protected through conservation easements. The latter approach requires a conservation easement that incorporates the management strategies for maintaining shrubland conditions such as mowing, cutting, prescribed fire, or grazing. These actions may be more easily incorporated into conservation easements for lands owned by conservation organizations rather than individual private landowners.

(H) Feasibility
The ephemeral nature of shrubland habitats makes it more difficult to identify priorities for permanent protection. The best approach may be to identify known areas of importance to New England cottontail, American woodcock, and other priority species and focus on conserving these core areas. Land conservation partners (e.g., land trusts) can be engaged to contact landowners with priority shrublands to assess their interest in selling their land or placing a conservation easement on their land. The Farmland Protection Program and North American Wetlands Conservation Act (NAWCA) may be more applicable for grassland conservation. The New Hampshire Land and Community Heritage Investment Program is a critical resource (if new funds become available). Permanent land conservation is typically more expensive than other conservation measures (such as encouraging shrubland management among private landowners).

4.1.2 Vegetation Management, Restoration, and Management

Direct Threat: Altered Natural Disturbance (Natural Succession)

(B) Justification
Since shrubland habitats are relatively short lived, periodic management is needed to maintain the dense habitat structure. Relatively stable shrublands require monitoring and selective removal 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. Once shrublands become well established, they may require only periodic mowing or cutting, every 5 to 10 years or more (Tefft 2005).

Creating small patches of shrub-dominated early-successional habitats in New Hampshire's highly developed landscapes may not prove effective since predation pressure is often intense in small patches and surrounding land uses may create migration barriers.

Therefore, positioning managed habitats near existing patches of shrubland, wetland, or a beaver flowage would create larger patches of suitable habitat. The establishment and maintenance of some moderate (>10 acres) to large-size (>25 acres) patches of early-successional habitat can serve as core habitats within human-dominated landscapes (Litvaitis 2005).

Utility rights-of-way (e.g., power line corridors), offer another opportunity to create a larger mosaic of shrub-dominated early successional habitat. Recent research in southern New York has shown that power line corridors can be very productive habitat for a number of songbirds that nest in shrubby habitats. However, these linear habitats may not be suitable for other species affiliated with shrublands. New England cottontails, for example, are not found along corridors, possibly because raptors perched on utility poles are very efficient predators. Therefore, positioning several acres of managed early-successional habitat near a power line corridor could improve the suitability of corridors for cottontails and other species that may be vulnerable to predation. Placing managed habitats near utility corridors may also increase the ability of animals to move across a landscape by using the utility corridor as a dispersal route (Litvaitis 2005).

(C) Conservation Performance Objective
The conservation objective is to identify core areas of shrubland habitats in the state and apply vegetation management to maintain these habitats in a shrub-dominated early successional condition.

(D) Performance Monitoring
The measurable component is the number and acreage of core areas managed as shrub-dominated early successional habitat.

(E) Ecological Response Objective
The ecological objective is to increase the amount of functional shrub-dominated early successional habitat that supports reproducing populations of New England cottontails, woodcock, and other habitat associates.

(F) Response Monitoring
A suggested monitoring approach is to monitor the populations of key species (e.g., New England cottontail, American woodcock, eastern towhee) within the core shrubland habitats.

(G) Implementation
The core shrub-dominated early successional areas in the State need to be identified. If in public ownership, then land managers can manage the habitat. If core areas are on private lands, then an outreach program is needed to interest landowners in managing shrubland habitats. The NHFG Small Grants Program is important in reimbursing landowners for this type of management since there is typically no economic return from shrubland management. Relevant Farm Bill conservation programs should also take into consideration priority species and focus areas for shrubland habitat management. UNH Cooperative Extension and the NH Coverts Program have an extensive network of landowners interested in wildlife and could be valuable partners in identifying and maintaining core shrubland habitats as well as connectivity between habitat patches.

(H) Feasibility
NHFG can work with its state and federal partners to identify the most important shrub-dominated early successional habitats on state and federally owned lands. These shrubland habitats may be near extensive grassland habitats and could be managed collectively. Private landowners may be unwilling or unable (because of cost) to manage large shrubland areas so cost-share and grant programs are extremely important to achieving this conservation objective. The WHIP program and NHFG small grants program could support landowner involvement in managing shrubland habitats.

ATV Rider Education and Enforcement
Refer to the general recreation strategy.

4.2 Conservation Action Research

An important step in maintaining shrub-dominated early successional habitat is to identify the known core areas of this habitat type on public land. If public lands lack sufficient shrubland habitat to sustain the associated wildlife species of concern than analysis of private lands is needed to identify additional potential core areas. This includes an analysis of which lands may require permanent protection through fee simple or conservation easements assuming landowners are interested.

Element 5: References

5.1 Literature

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Talus Slopes and Rocky Ridges

Associated Species: Melissa arctic (*Oeneis melissa*), Timber Rattlesnake (*Crotalus horridus*), Peregrine Falcon (*Falco peregrinus*), and Bobcat (*Lynx rufus*).
Global Rank: Not ranked
State Rank: (affected natural communities)
TALUS SLOPES: Rich Appalachian oak rocky woods (S1), Subalpine cold-air talus barren (S1), Red oak - hickory wooded talus (S1S2), Red oak - ironwood - Pennsylvania sedge woodland (S2), Rich red oak rocky woods (S2S3), Semi-rich Appalachian oak - sugar maple forest (S2S3), Temperate lichen talus barren (S2S3), Montane lichen talus barren (S3), Spruce - birch - mountain maple wooded talus (S3), Montane landslide (S3S4), Red oak - black birch wooded talus (S3S4)
ROCKY RIDGES: Circumneutral rocky ridge (S1), Chestnut oak forest/woodland (S1S2), Montane heath woodland (S2), Jack pine rocky ridge woodland (S1), Red pine rocky ridge (S2), Red oak - ironwood - Pennsylvania sedge woodland (S2), Appalachian oak - pine rocky ridge (S3), Red oak - pine rocky ridge (S3S4), Red spruce - heath - cinquefoil rocky ridge (S3S4)
Authors: Benjamin D. Kimball and Steven G. Fuller, Natural Heritage Inventory and New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

This profile covers two related but distinct habitats: talus slopes and rocky ridges. Talus slopes range from open, lichen covered talus "barrens" to closed-canopy forested talus communities (Sperduto and Nichols 2004). Rocky ridges generally occur on outcrops and shallow-to-bedrock ridge and summit settings (Sperduto and Nichols 2004). While it is opportune to lump them together for the purposes of habitat modeling, each is treated separately in certain text portions of this profile.

Talus Slopes

Both forested and unforested 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. Some plant species and natural communities are associated with the conditions of talus slopes (Kruckberg 2002). Four talus slope natural community systems occur in New Hampshire: montane acidic talus, temperate acidic talus, rich north-temperate talus/rocky woods, and rich Appalachian oak rocky woods (Sperduto 2004). These systems are distinguished from each other primarily by climate, elevation, and level of enrichment (nutrient availability).

Montane acidic 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 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 670 m (2,200 ft) in elevation, but occasionally down to about 450 m (1,500 ft). This system includes a few low-elevation "talus gorges" such as Ice Gulch and Devil's Hopyard. Montane acidic talus slopes are often found below montane cliff systems, and surrounded by either northern hardwood or high-elevation spruce–fir forests.

Temperate acidic talus slopes are found at low

elevations (below 550 m [1,800 ft] elevation) in central and southern New Hampshire characterized by oaks (*Quercus* spp.), black birch (*Betula lenta*), and other temperate species. This system tends to have an open woodland character, with frequent canopy gaps and occasional lichen-dominated talus barren openings. Soil development is variable on these slopes, and moisture conditions range from dry to mesic. Most examples are smaller than montane acidic talus systems. A few temperate acidic talus slopes in the state have giant talus blocks with late-melting ice that produces a relatively cold, moist microclimate compared to the rest of the talus slope. These areas support patches of montane species such as red spruce (*Picea rubens*) and American mountain ash (*Sorbus americana*) within the larger temperate mosaic. This system transitions to forested talus or forested till areas characterized by hemlock–hardwood–pine forest or oak–pine forest systems. Temperate cliff systems, and sometimes, Appalachian oak rocky ridges, are often associated upslope.

Rich north-temperate talus/rocky woods system is found on enriched talus and other rocky slopes in central New Hampshire from about 150–365 m (500 - 1,200 ft) in elevation, and occasionally up to about 600 m (2,000 ft) in the low elevation valleys in the White Mountain region. The larger talus slopes often have patches of temperate lichen talus barren, and occasionally patches of rich mesic or semi-rich mesic sugar maple forest communities in mesic, colluvial areas at the base of the talus slopes. A few examples at intermediate elevations in the White Mountains (around 450 m [1,500 ft]) include patches of spruce-birch-mountain maple wooded talus, which is otherwise indicative of montane acidic talus systems. Tree canopy dominants usually include sugar maple (*Acer saccharum*) and red oak (*Quercus rubra*), with lesser amounts of basswood (*Tilia americana*), white ash (*Fraxinus americana*), ironwood (*Carpinus caroliniana*), black birch (*Betula lenta*), red maple (*Acer rubrum*), and occasionally yellow birch (*Betula allegheniensis*) and paper birch (*Betula papyrifera*). Softwoods are sparse or absent. This system often transitions to montane rocky ridge and montane cliff systems upslope and northern hardwood–conifer forest or hemlock–hardwood–pine forest systems downslope.

Rich Appalachian oak rocky woods system is the southern equivalent of rich north-temperate talus/rocky woods system (see above). It occurs on rocky to shallow till hillsides mostly below 150 m (500 ft) within 48 km [30 mi] of the coast or Massachusetts border. It is indicated by a host of southern plants that do not occur further north or at higher elevations. There are 2 primary natural communities, rich Appalachian oak rocky woods, and red oak-ironwood-Pennsylvania sedge woodland. Temperate lichen talus barrens are small and rare in this system, as are patches of rich mesic forest. This system typically transitions to more nutrient-poor, rocky conditions on the ridge tops classified as Appalachian oak rocky ridge system, but occasionally they occupy the ridge top settings as well where the red oak-ironwood-Pennsylvania sedge woodland community dominates. The hillsides on which this system occurs includes talus, other unconsolidated, loose rocky slopes, and relatively shallow till soils with occasional outcrops.

Rocky Ridges

Rocky ridges occur on outcrops and shallow-to-bedrock ridge and summit settings below those that are classified as alpine habitat (Sperduto and Nichols 2004). There are two major rocky ridge natural community systems in New Hampshire: montane rocky ridge system and Appalachian oak rocky ridge system. The primary differences between these 2 systems are climate and elevation, and because of this, they have distinctly different geographic distributions in New Hampshire (D. D. Sperduto, NHNHB, personal communication).

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° slope. This system includes nearly all the rocky ridges in the White Mountain region and other rocky exposure between 400-900 m (1300–3000 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 thin forest cover > 65%), much open bedrock exposure, and one or more of the three primary diagnostic communities that overlap in their elevation ranges. Small cliffs are found in some examples of this system. Downslope, this system sometimes transitions to montane cliff, montane acidic talus,

or rich north-temperate talus/rocky slope systems. Upslope (when it exists), this system becomes subalpine heath–krummholz/rocky bald, northern hardwood–conifer, or high-elevation spruce–fir–northern hardwood forest systems.

Appalachian oak rocky ridges occur on outcrops and shallow-to-bedrock ridges and summits below 356 m [1,200 ft]) in southern New Hampshire. They are dominated by southern oaks and pines with little if any red spruce, red pine, and other northern plants diagnostic of montane rocky ridge and slab systems. Outcrops include small cliff slabs, which are steep bedrock exposures of < 65° slope. This system includes nearly all the rocky ridges in southern New Hampshire and most other ledges below 300m (1,000 ft) in elevation. These ridges, summits, and slabs typically have a woodland to sparse woodland canopy (ranging from completely open patches to thin forest cover >65%) and much open bedrock exposure. Red oak is typically present, but the presence of other oaks is the key diagnostic feature of this system (in combination with the absence of red spruce and red pine and other northern plants in any abundance). This system typically transitions to oak–pine forest systems, though rich Appalachian oak rocky woods are occasionally found below it on mid- to lower-slope positions.

1.2 Justification

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.

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 deserve separate treatment in conservation plans. Talus slopes and rocky ridges provide crucial habitat for several rare wildlife species in New Hampshire, including timber rattlesnake and bobcat.

1.3 Protection and Regulatory Status

Very little of New Hampshire's talus slope and rocky ridge 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 talus slopes and rocky ridges 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.

1.4 Population and Habitat Distribution

In New Hampshire, known and predicted (within the limitations of Geographic Information Systems [GIS] modeling) talus slope and rocky ridge habitat occupies 0.47% (11,269 ha [27,826 ac]) 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.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

The definition of talus slope and rocky ridge habitat used in this analysis was a combination of areas occurring on outcrops and shallow-to-bedrock ridge and summit settings, and slopes with large, often lichen covered rocks with little or no soil accumulation. Talus slope and rocky ridge habitat areas were identified by modeling shallow-to-bedrock polygons from soils data layers as well as the NHNHB data depicting exemplary natural communities and systems for this habitat type. At its upper elevation limits, around 1,160-1,220 m (3,800-4,000 ft), this habitat transitions to alpine habitat. Smaller occurrences at this elevation may be considered inclusions within high-elevation spruce–fir forest.

1.7 Sources of Information

Current distribution, historic distribution, and status information of talus slope and rocky ridge habitat is primarily found in records of rare plant and exemplary natural community and system locations in the NHNHB database (Biotics). Habitat maps were generated using State Soil Geographic (STATSGO) soil layers and NHNHB exemplary talus slope and rocky ridge natural community and system occurrences. Other data sources consulted include state and federal agency web sites, information from the NHNHB database, consultations with experts, and textbooks and peer-reviewed literature.

1.8 Extent and Quality of Data

Lack of soils data for portions of the WMNF, Belknap and Merrimack Counties, and eastern Hillsboro County present a significant challenge in predicting talus slope and rocky ridge habitat occurrences in New Hampshire. Several known examples of this habitat that are not included in the model as a result of this limitation include the summit of Mount Kearsarge in Warner, Ragged Mountain in Danbury, and summits in the Belknap Range in Gilford and Alton.

The vegetation and biota of New Hampshire's talus slopes and rocky ridges has received relatively little research attention in comparison to alpine habitats. Very little is known about fauna and their distribution in these habitats.

1.9 Distribution Research

Habitat mapping could be improved by further refining the habitat definition and separating talus slopes from rocky ridges and treating the two as distinct and unique habitat types. This could happen as new and updated GIS layers (e.g., new county soils layers and new exemplary natural community/system polygons) become available. In addition, NHNHB continues to add and refine exemplary natural community and system polygons for this habitat, and these updates should be included in future iterations of the model. Lastly, the elevation boundary between alpine habitat and talus slope and rocky ridge habitat could be further investigated and improved upon in the model. This could result in areas such as the boulder fields in several ravines in the Presidential Range to be predicted polygons for this habitat type (these are too low for alpine and too large to be considered an inclusion in the surrounding forest).

Field verification of predicted polygons for this habitat type would help refine attribute parameters of the model. As noted in the metadata for this habitat's coverage, limitations of the soils data layer lend to errors of omission or commission, and field truthing will need to take place to better ascertain levels of error. This is especially recommended in the southeastern part of the state, where, for example, the town of Windham seems to contain an abnormally large concentration of predicted polygons for this habitat.

Inventory studies are needed to better understand the makeup and distributions of plant and animal populations on talus slopes and rocky ridges in New Hampshire. Research should include inventories of rare wildlife in these habitats.

Element 2: Species/Habitat Condition

2.1 Scale

To facilitate conservation planning, talus slope and rocky ridge habitat polygons (both known and predicted) derived from the mapping process were clustered by major ridgelines, mountain ranges, and, occasionally, general geographic proximity regardless of intervening landform. Clustering in this fashion resulted in 70 conservation planning units being defined. Known sites missed by the model are not yet accounted for.

2.2 Relative Health of Populations

The largest known talus slope in the state (below Cannon Cliff) was not mapped. The largest known rocky ridge occurrence, Grantham Mountain, is 409 ha (1,011 ac). The largest predicted habitat polygon, at Smarts Mountain, is almost 809 ha (2,000 ac). The average size for both known and potential talus slope and rocky ridge polygons is about 28 ha (70 ac) each.

2.3 Population Management Status

N/A

2.4 Relative Quality of Habitat Patches

For known exemplary occurrences as mapped and recorded in the NHNHB database, relative quality of this habitat is high. For known sites, habitat patches mapped as >40 ha (100 ac) and assigned an Element Occurrence Rank of "A" in the NHNHB database, are as follows: red pine rocky ridge at Green Hills in Conway, red spruce–heath–cinquefoil rocky ridge at Grantham Mountain, red pine rocky ridge at Owls Head in Benton, and red oak–pine rocky ridge at Rattlesnake Mountain in Rumney. The largest mapped, A-ranked talus habitat is a spruce–birch–mountain maple wooded talus community in Zealand Notch. While some recreational threats and impacts have been noted at certain sites, many remain in good condition. Habitat quality at predicted sites is unknown.

2.5 Habitat Patch Protection Status

Of the 11,345 ha (28,035 ac) mapped for this habitat, 57% (6,457 ha [15,957 ac]) occur on conservation lands as mapped by the Geographically Referenced Analysis and Information Transfer (GRANIT) System. Of these protected sites, 293 ha (723 ac [0.03% of the total]) are protected by conservation easements while the majority (6,165 ha [15, 234 ac]; 54% of the total mapped acres) are fee ownership parcels, 2,332 ha (5,763 ac) of which are in the WMNF (21% of the total).

2.6 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. See also Cliffs habitat profile.

2.7 Sources of Information

Information regarding the management and protection of talus slope and rocky ridge habitat was obtained from the 2004 Proposed Land and Resource Management Plan for the WMNF, Appalachian National Scenic Trail comprehensive management plans, as well documents delineating the Wilderness Act. Habitat patch identification and quality were determined utilizing the STATSGO database for New Hampshire (Natural Resources Conservation Service 1994), and NHNHB natural community and natural

community system polygon delineations (NHNHB 2005). A full literature review of the habitat was conducted, and field researchers familiar with the habitat were consulted.

2.8 Extent and Quality of Data

See Species/Habitat Condition Technical Assessment. See also sections 1.8 and 1.9.

2.9 Condition Ranking

See Species/Habitat Condition Technical Assessment

2.10 Condition Assessment Research

Possible measurable parameters for evaluating relative condition of talus slope and rocky ridge habitat, including extent of recreational impacts and rare natural communities, could include the following: extent of trampling, disappearance of or decline in known rare species occurrences at sites, succession to forest without advent of fire, extent of visitation at sites, and number of trails at sites.

Element 3: Habitat Threat Assessment

3.1.1 Recreation

(A) Exposure Pathway
Recreational use of rocky ridge habitat is high (much less so for talus slopes). 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. 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.

(B) Evidence
Rocky ridges in New Hampshire are highly recreated, enduring high levels of foot traffic and motorized vehicle use (NHNHB 2005). 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). Magnitude of response is strongly correlated with trampling intensity (Cole 1995, US Forest Service 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 both vegetation cover and height, as well as soil erosion, results 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).

3.1.2 Climate Change

(A) Exposure Pathway
The composition of the earth's atmosphere is changing, altering temperature, precipitation, air quality, and extreme weather frequency. All of these factors, along with fire and other natural disturbance, play roles in the persistence of the open character of some of New Hampshire's rocky ridge habitats. As such, climate change could significantly affect the phenology and distribution of this habitat in the state.

(B) Evidence:
Climate change has been extensively demonstrated regionally and locally (Climate Change Research Center 1998, Harvey 2003), and could significantly alter the phenology and distribution of vegetation on rocky ridges (Kimball and Weihrauch 2000). In New Hampshire, temperatures have increased by 0.7°F, 2-3 times the regional average (NERA 2001, Harvey 2003). Walther et al. (2002) has documented poleward and upward shifts of species ranges including: treeline advancement towards higher altitudes, elevation shift of alpine plants, as well as northward range shifts of 39 butterfly species, each of which are linked to global warming (Grabherr et al. 1994, Pauli et al. 1996, Harvey 2003). Changing climatic regimes will ultimately alter species distributions and composition, disrupting community structure as well as overall function (Walther et al. 2002).

3.1.3 Acid Deposition

(A) Exposure Pathway
Acid deposition may cause the following reactions in

alpine communities: changes in community structure, changes in spatial distribution of ecosystems, changes in soil properties, and changes in soil fauna (Rusek 1993). While talus slope and rocky ridge habitat, occurring at slightly lower or lower elevations, may not experience this threat to the same degree, the similarities between the habitats would suggest cause for concern.

(B) Evidence
Exposure to acid deposition is high at high elevation and in areas with frequent direct exposure to clouds. Many rocky ridge and talus slope occurrences meet these criteria. Extensive studies have demonstrated the detrimental consequences of acid deposition in alpine communities. Data provided by such research have attributed decreases soil pH, the increased range of acidophilic species, the disappearance of calciphilic species, and changes plant community distribution to acid deposition (Rusek 1993). While similar studies have not been conducted specifically in talus slope and rocky ridge habitat, the two habitat types share many of the same characteristics (e.g., thin soils, frequently open canopy structure, ridge top settings, etc.) and therefore the same concern is likely warranted for this habitat.

3.1.4 Altered Natural Disturbance (Fire Suppression)

(A) Exposure Pathway
Fire may play an important role in the persistence of this habitat at some sites. Many of the component species are adapted to the open, exposed conditions, and would suffer under a more shaded canopy. Suppression of wildfires could negatively impact the ability of some species to reproduce and alter the open woodland character of the natural communities and systems, resulting in different species compositions and succession to a more forested structure.

(B) Evidence
Open rocky ridge habitats persist for a variety of reasons, including exposure, wind disturbance, soil depth, drought, and periodic fire (Whitney and Moeller 1982, Ruffner and Abrams 1998, Sperduto and Nichols 1999). Fire in particular may play an important role in the continued existence of this habitat and its component species at some sites (Sperduto and Nichols 1999, Sperduto and Nichols 2004). Fires may play an important role in maintaining the relatively depauperate soils, open lighting, and xeric conditions of these sites (P. Bowman, NHNHB, personal communication). Control and suppression of wildfires may affect the ability of some rocky ridge species to germinate seed (e.g. jack pine [*Pinus banksiana*]) and cause community succession of the surrounding forest (Baldwin 1979, USFS 1990). It should be noted that in the early 1900s, New Hampshire experienced tremendous human-induced fires because of the logging industry and settlement activities (Baldwin 1974, Belcher 1980, Leonard 1885). It is unclear how much of a role those fires played in the existence of today's subalpine exposures, and, ironically, there may be some examples of sites where a more natural fire regime would lead to smaller habitat extents than at present (Nichols 2002).

3.1.5 Energy and Communication Infrastructure
See Threats, Energy and Communication Infrastructure)

3.2 Sources of Information

Information regarding talus slope and rocky ridge threats was compiled from expert review and consultation, management plans, technical field reports, and peer reviewed scientific journals.

3.3 Extent and Quality of Data

Threats affecting talus slope and rocky ridge habitat are poorly documented throughout the scientific literature. However, extensive research has been conducted in alpine zones, which share some similar habitat characteristics. Such research has been concentrated on recreation impacts, global warming, and increasing atmospheric pollution.

3.4 Threat Assessment Research

Further research should be focused on range shifts of talus slope and rocky ridge flora and fauna, history and significance of fire on rocky ridges, and pollution-induced wildlife stress/mortality. Measuring the effects of recreational impacts to the habitat (hiker trampling as well as all-terrain vehicle and snowmobile use) is a high priority. Investigation into the importance of fire is also a high priority.

Element 4: Conservation Actions

(See also: Cliffs habitat profile)

4.1.1 Advise Trail Managers on Mitigation for Habitat Impacts, Regulation, and Policy

(see also Strategies, Recreational Management)

(A) Recreation

(B) Justification

- Restricting trail use, placement, and width in sensitive areas will reduce the area of exposure.
- Trail advisories will be designated for high-use trails through delineated sensitive areas.
- Advisories will be provided immediately upon entry into trail management agreements (see below, Implementation).
- Trail use and design will be modified based on habitat response indicators.

(C) Conservation Performance Objective
Eliminate the co-occurrence of adverse trail impacts with delineated S1-ranked natural communities and rare plant populations in talus slope and rocky ridge habitat. Performance will be indicated by entry into trail management agreements, modification of trails, and adoption of trail advisories.

(D) Performance Monitoring
Advisories will include trail use and design modification reporting protocols.

(E) Ecological Response Objective
Restore S1-ranked natural communities and protect rare plant and animal populations in delineated areas. Advisories will include restoration, protection, and monitoring recommendations.

(F) Response Monitoring
Cover of rocky ridge vegetation and soils will be measured in delineated areas prior to implementation of advisories and in subsequent years. Responses will be used to revise advisories.

(G) Implementation
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.

4.1.2 Advise the International Association of Fish and Wildlife Agencies Regional Coordination Team on Climate Change and Acid Deposition Impacts, Regulation and Policy

(see Strategies, Regional Coordination)

4.1.3 Engage in Inter-Agency Risk Assessments for Climate Change and Acid Deposition, Regulation and Policy

(see Strategies, Inter-Agency Regulation and Policy)

4.1.4 Identify High Risk Areas, Conservation Planning

(see Strategies, Conservation Planning)

4.1.5 Monitor Indicator Species for Climate Change and Acid Deposition, Monitoring

(see Strategies, Monitoring)

4.2 Conservation Action Research

Baseline surveys need to be conducted to better identify diagnostic species for sensitive talus slope and rocky ridge habitat areas and indicators of climate change and acid deposition. A permanent monitoring scheme needs developed and implemented in order to assess habitat changes across space and time.

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HABITAT PROFILE

Vernal Pools

Associated Species: Marbled Salamander, Jefferson Salamander, Blue-Spotted Salamander, Spotted Turtle, Blanding's Turtle, Ribbon Snake
Global Rank: Not ranked
State Rank: Vernal woodland pool (S3), vernal floodplain pool (S2)
Author: Kimberly J. Babbitt and Jessica S. Veysey, University of New Hampshire

Element 1: Distribution and Habitat

1.1 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*, 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 2004).

1.2 Justification

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 (*Rana 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).

1.3 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.

1.4 Population and Habitat Distribution

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, Jenkens and Babbitt 2003, Mattfeldt 2004, Hermann et al. 2005, Tarr et al. In Press), natural resource inventories, and citizens documenting vernal pools using the Identification and Documentation of Vernal Pools in New Hampshire manual (Tappan and Marchand 2004). However, these data have not been compiled into one database.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

1.7 Sources of Information

Sources of information include a literature review, the NHDES website, and NHFG.

1.8 Extent and Quality of Data

Vernal pool habitat is well documented in the scientific literature. Specific knowledge about the distribution and abundance of vernal pools in different areas of the state is lacking and is needed.

1.9 Distribution Research

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.

Element 2: Species/Habitat Condition

There is a general lack of data relevant to section 2. 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 in press). 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.

Element 3 Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
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.

(B) Evidence
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.

Even strict wetland regulations and oversight may not protect vernal pool habitat suitability if upland habitat is not also protected. Maintenance of appropriate terrestrial habitat, through buffers (e.g., Semlitsch 1998, Calhoun and deMaynadier 2001, Calhoun and Klemens 2002, Semlitsch and Bodie 2003) or other means will offer some protection, although more research is needed determine both the utility and consequences of guiding development or logging practices via this mechanism. Further, because some species range widely (e.g., Blanding's turtle), a landscape-level approach to conservation and planning will be required to ensure long term persistence of the full range of species associated with vernal pools.

In the last few decades, commercial and residential development in New Hampshire have increased dramatically, in conjunction with accelerated human population growth and immigration (Sundquist and Stevens 1999). Similar urbanization has eliminated the marbled salamander from large portions of its former range on Long Island and mainland New York (Klemens 1993). Petranka (1998) noted that thousands of local populations of marbled salamanders have already been eliminated due to habitat loss. Windmiller (1996) noted that increasing urbanization likely reduces mole salamander abundance and excludes salamanders from otherwise suitable habitat. Gibbs (1998a) suggested that ambystomatids are predisposed to local extinction caused by habitat fragmentation.

3.1.2 Transportation Infrastructure (Mortality, Fragmentation, Dispersal Barriers)

(A) Exposure Pathway
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.

(B) Evidence
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 (Rana 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).

3.1.3 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
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.

(B) Evidence
Wetland loss in the United States from historic draining and filling is well documented (e.g., Dahl 1990, 2000); see Marsh and Shrub Wetlands profile for details. Lack of reliable data for vernal pools creates difficulty in accurately determining historic losses. An important aspect of wetland loss is not simply the continued loss of habitat, but the continued undervaluing of vernal pool habitat as well. Size has traditionally been used an important criterion for assessing wetland value. Further, recent Supreme Court ruling (SWANCC 2001) decreases protection for wetlands that are "isolated" from waters of the United States, under the federal regulation of dredge and fill as per Section 404 of the Clean Water Act. Although the consequences of this decision are still being debated, it likely results in no federal protection under Section 404 for most or all vernal pools. Thus, it falls to the state or local governments to ensure that vernal pools are protected (see section 1.3). New Hampshire has the fasted growing population in New England (Sundquist and Stevens 1999) and consequently faces significant development impacts. Without increased protection priority for vernal pools, it is certain that vernal pool habitat will decrease in the future.

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 functiona or wildlife habitat of the wetlands they are intended to replace (Brown 1999).

3.1.4 Unsustainable Harvest (Forestry Operations and Management)

(A) Exposure Pathway
Forest management practices such as clear cutting and partial cutting.

(B) Evidence
Forest management practices (e.g., clear cutting, partial cutting) may reduce forest canopy cover over or near vernal pools. This often results in warmer ambient temperatures (in soil, water, and air), increased wind, and increased insolation. Higher temperatures and wind can lead to increased desiccation and mor-

tality of dispersing or breeding amphibians. Higher temperatures may increase metabolism, increasing energetic demands and leading to starvation if food is scarce. Greater irradiation of breeding wetlands may increase water temperatures, wetland hydroperiod, and exposure to UV radiation.

Forest cutting might disrupt dispersal corridors, force species into suboptimal habitat, and increase exposure to predation or competition. Logging roads can be barriers to wildlife movement, or alternatively, create areas that attract breeding amphibians but that dry too quickly or are subject to vehicular traffic. Runoff from logging roads can transport silt and other pollutants to breeding wetlands, interfering with breeding, embryonic development, and juvenile survival. Reforestation of commercial forests solely with evergreen species [e.g., red spruce (*Picea rubens*)] is not optimal for species that prefer deciduous/mixed upland areas.

3.2 Sources of Information

Information was obtained from a literature search.

3.3 Extent and Quality of Data

The quality of existing data is relatively good in term of our general understanding of factors that are likely to impact vernal pools and associated fauna. However, we lack information on the abundance and distribution of vernal pools in the landscape in New Hampshire. Further, to be able to make informed decisions about vernal pool protection, we need better data on the terrestrial habitat requirements of obligate (and facultative) users of vernal pools.

3.4 Threat Assessment Research

An accurate map of vernal pools is needed for the state. Because not all vernal pools show up on NWI maps, this is not a trivial task. Wetland filling, as a threat, is driven by developmental pressure and how the state of New Hampshire chooses to regulate wetland filling. NHDES maintains records of legal filling activities and could use a comparative aerial photography approach (i.e., before-after) to document recent (e.g., last 10 years) illegal impacts to vernal pools. Monitoring of vernal pool habitat quality (e.g., water quality, hydroperiod) must be conducted concurrently with research that examines land use attributes (e.g., land use type, roads, impervious surface, etc.) on vernal pool habitat quality and ability to support species dependent on vernal pools.

Element 4: Conservation Actions

This list is not intended to be exhaustive (particularly 4.1.2 – 4.1.13), but rather to provide a list of conservation actions that should have the greatest conservation impact or that are needed to enhance threat assessment activities.

4.1.1 Rewrite Municipal Zoning Codes, Habitat Protection/Regulation and Policy

(A) Development, roads, wetland fill, pollution (toxins, fertilizers, increased soil and water acidity), disease, invasive species, fish stocking, collection, global warming.

(B) Justification
Rewriting local zoning codes to favor open-space and mixed-use development is expected to be the most effective means of reducing the negative effects of development and thereby protecting vernal pool habitat and pool-dependent wildlife. Rewriting local zoning codes should have the following effects, compared to development under conventional zoning codes:

- Development can be clustered more densely, allowing permanent preservation of and connection between larger tracts of undeveloped land, and reduced fragmentation of the landscape.
- Transportation infrastructure can be reduced, since buildings are closer together; and residential, commercial, and industrial buildings are intermixed. Consequently, effects of roads and development (see sections 3.1.1 and 3.1.2) on vernal pools and their wildlife can also be reduced.
- The design process is more flexible so that development can be planned around, instead of through or near, vernal pools, wildlife migration routes, and other valuable natural resources.

This action can be applied at the state or municipal level. This action is most critical in those areas experiencing the greatest population growth (i.e., southern and southeastern New Hampshire). Revised zoning

codes can be implemented quickly if supported by the public. Model zoning codes already exist and can be adapted to local situations. Moreover, state law (i.e., NH RSA 674, RSA 675, RSA 477) already permits municipalities to amend zoning codes such that they allow or promote open-space and mixed use development. Zoning codes can be revised as needed to respond to new information.

(C) Conservation Performance Objective
The objective of rewriting zoning codes is to promote and facilitate open-space/mixed use development, instead of traditional (low-density, large-lot, separated land use) development. Zoning codes should be revised as soon as feasible, and the effect on open-space/mixed use development should be documented within a year of implementation.

(D) Performance Monitoring
Performance will be assessed using the following three parameters:

1. Number of towns that have adopted revised zoning codes (that favor open-space/mixed use development)
2. Numbers of each type of building permit (open-space/mixed use versus conventional)
3. Acreage claimed by each type of development (for all developments, this includes land that is part of the developable parcel but not developed, such as permanently-preserved open space in open-space developments)

These parameters should be measured on a regular basis at the municipal level and will be reported to the agency that is charged with monitoring this conservation action. The municipal scale is most practical since municipal boards will possess this information because of municipal zoning (planning) board activities and the development permitting process. If performance is deemed unsatisfactory, the entity charged with administering this conservation action should consider methods to promote this action, including educating municipal zoning boards and the public.

(E) Ecological Response Objective
The desired ecological results of revising zoning codes are to maintain large mosaics of relatively undisturbed forest and wetland habitats. This habitat-based approach should allow local wildlife populations to persist.

(F) Response Monitoring:
Several ecological responses could be monitored, depending on research or management goals. The following list provides a few examples:

- Survey the distribution and abundance of target vernal pool wildlife (salamanders, turtles)
- Monitor breeding habitat (habitat structure, water chemistry, pollution, etc)
- Monitor populations for growth, mortality, fecundity, migration, and occurrence of disease or deformities
- GIS data layers for vernal pools and target wildlife species should be developed using aerial photographs and/or remote sensing data. Separate data layers could be developed for other measured habitat or population variables
- Develop indicators for breeding habitats (hydroperiod, landscape position, etc), upland landscapes (forest area, forest to edge ratio, and landscape connectivity), and human development (road density, impervious surfaces, etc.)
- Add a zoning code status layer to the GIS map. Then periodically update field and aerial/remote sensing data to compare indicators (above) over time to evaluate the effects of zoning changes (or compared with models).
- If response indicators show that vernal pool habitat or critical upland habitat continues to degraded or fragmented, or vernal pool wildlife are decreasing, then this conservation action should be readdressed.

(G) Implementation
Educate the public, municipal zoning boards, and real estate agents about the benefits of open-space/mixed-use development. Develop a model open-space/mixed use zoning code for each municipality and have it endorsed by the municipal zoning board, town meeting, or otherwise have it approved as outlined in NH RSA 91, RSA 477, RSA 674, and RSA 675). A state agency, consulting group, or non-profit group should coordinate a statewide effort, although towns may also want to delegate responsibilities to volunteers, zoning board or conservation commissioners, or consultants. Efforts should first focus on communities where critical species are known to exist. For example, Winchester is the only municipality where a pure Jefferson salamander has been documented and should

therefore receive special attention.

Incorporate data from habitat surveys, rare species surveys, and GIS datalayers (see section 4.1.1 F) into proposed zoning codes and to revise codes as new information becomes available. Calculate ecological response indicators to assess the success of the conservation action.

4.1.2 Maintain the natural hydroperiod of individual vernal pools. Regulations should not allow for dredging, excavation, drainage, or filling in or adjacent to vernal pools. (Habitat Protection/ Regulation and Policy)

Any changes to wetland hydroperiod can alter habitat suitability, including rendering the pool unsuitable for supporting many vernal pool-dependent species. Vernal pools in which hydroperiods are shortened may not be inundated for a sufficient length of time to allow development of larval amphibians to metamorphosis. Vernal pools that are converted to permanent sites will not support the same assemblage of species if fish populations become established.

4.1.3 Change wetland dredge and fill and set back regulations so that vernal pools are given equal value to other wetland types. When vernal pools are impacted or completely filled in, compensatory mitigation should be required. Use wetlands functions and values assessments when evaluating permit applications, rather than focusing on size of wetland impact (Habitat Protection/Regulation and Policy).

The continued approach of placing higher value on larger wetlands will result in relatively higher loss of vernal pool habitat compared to other wetlands because a large majority of vernal pools are small. There is ample evidence that size is a poor criterion on which to measure wetland value (Gibbs 1993, Semlitsch and Bodie 1998, Snodgrass et al. 2000, Paton and Couch 2002, Babbitt in press).

4.1.4 Establish a mechanism to use mitigation funds for wetland loss to support efforts to conduct applied research on impacts of development and on vernal pools. (Regulation and Policy/Habitat Protection)

As measures are taken to encourage "smart growth" and establish Best Management Practices (BMPs) for vernal pools, it is important to examine whether these approaches are effective. Long-term research would be required, so commitment on the part of developers at the start of development projects would be necessary. Although this conservation action would require significant time and effort, it is an effective and direct way of obtaining critically needed information about how best to manage land in a developed landscape. Given trends in population growth and development, the suburban landscape is the area in which impacts to vernal pools and the species that depend on them is likely to offer both the greatest challenges and the greatest opportunities for conservation.

4.1.5 Establish a GIS data layer for vernal pools. (Habitat Protection)

An accurate map of vernal pools is needed to efficiently and effectively conserve vernal pools, track impacts, assess protection efforts, assess threats, and to document and seek mitigation for legal and illegal filling.

4.1.6 Create a database to store the location and condition of documented vernal pools (Habitat Protection, Regulation and Policy, Education and Outreach)

NHFG published a guide 'Identification and Documentation of Vernal Pools in New Hampshire' (Tappan and Marchand 2004). Landowners, citizens, towns, consultants, and non-profits have used this manual to document vernal pools in New Hampshire and submitted documentation to NHFG. In addition, many vernal pools have been documented and studied as part of research conducted by schools and universities, especially the University of New Hampshire (e.g., Turtle 2000, Jenkens and Babbitt 2003, Mattfeldt 2004, Hermann et al. 2005, Tarr et al. In Press). All documented vernal pools should be acquired and stored in a central database. This information could be used during development site reviews, prioritizing land for protection, creating species habitat models, or identifying locations for research.

4.1.7 Determine location of vernal pool-rich areas of the landscape and permanently protect the land. (Habitat Protection)

The most permanent source of protection for vernal pools and vernal-pool dependent species is through land protection that includes wetlands and critical uplands. Land protection though fee simple purchase or easements should be considered.

4.1.8 Support establishment of BMPs for vernal pools. (Habitat Protection/Regulation and Policy)

Vernal pool BMPs have recently been developed for residential and commercials development (Calhoun and Klemens 2002) and forestry (Calhoun and de-Maynadier 2001). These BMPs are laudable and provide a good first step. However, research to test the efficacy of these BMPs is lacking. It is unclear whether these BMPs, which largely establish terrestrial buffer zones, will result in long-term protection of widely ranging species. Support of BMPs for vernal pools, together with research to examine their utility and need for refinement, should be established.

4.1.9 Support development design standards that keep roads distant from vernal pools and that limit use of road salt in areas where vernal pools are adjacent to roads. (Habitat Protection)

See section 3.1.2 for justification. To the extent possible, roads should not be constructed to run near a vernal pool, through a cluster of vernal pools, or between vernal pools and forested uplands. Alternatives to standard road salt applications should be used on roads adjacent to vernal pools.

4.1.10 Establish standards for the development of criteria for assessing and determining critical locations for tunnel crossings. (Habitat Protection)

The use of tunnels to safely direct wildlife under or over roads has proven effective in many circumstances, including for vernal pool species. Care must be taken to design structures that animals will use (i.e., no behavioral avoidance) and are not likely to experience increased predation (i.e., from predators cuing in on migrating organisms). Tunnel crossings are particularly important in areas where rare, endangered, threatened, or species of special concern still occur (e.g., marbled salamander, Jefferson salamander, Blanding's turtle, spotted turtle). For more details see Jefferson salamander profile.

4.1.11 As part of broader initiative relative to invasive species management, document trends in increasing invasive species in vernal pools. (Habitat Management)

Invasive species are not considered a significant threat to vernal pools now, but should be watched to ensure that this threat does not increase in the future.

4.1.12 Recognize that the spatial relationship among pools of varying hydroperiod, including permanent sites, has a significant influence on local biodiversity. (Habitat Protection)

Efforts should be undertaken to develop watershed-scale conservation management plans. Because we lack historic data on vernal pool abundance, we do not know what we have lost. However, maintaining a similar ratio of wetlands in differing hydroperiod/habitat types, as well as maintaining uplands surrounding these wetlands in a fashion that will support wetland-dependent species, will ensure that the relative densities of vernal pools are not decreased significantly relative to other habitat types. For example, species such as the Blanding's turtle require both permanent pools and vernal pools.

4.1.13 Develop a bioassessment program for vernal pools.

A suitable approach for assessing vernal pool quality is lacking. Because it is not likely that development will abate or that all vernal pools will be protected, it will become increasingly important to assess the value of vernal pools to decrease our chances of "protecting the wrong pools." A bioassessment program should be 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., 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 contaminant levels. 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 that can be obtained through remote sensing (e.g., Tiner 2004).

4.2 Conservation Action Research

In addition to the need for documentation and mapping of vernal pools, it is essential to assess what protection and management activities in the terrestrial landscape will ensure that vernal pools retain habitat quality and continue to support wildlife. Information needs include species-specific requirements, and the quality, amount, and type of habitat required for long-term maintenance of populations. More research on dispersal mechanisms and upland habitat is needed to protect some pool-dependent species.

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HABITAT PROFILE

Lowland Spruce-Fir Forest

Associated Species: spruce grouse, Northern Goshawk, three-toed woodpecker, bay-breasted warbler, purple finch, rusty blackbird, hoary bat, Canadian lynx, American marten, northern bog lemming
Global Rank: Not ranked
State Rank: Not ranked
Author: Carol R. Foss
Affiliation: New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat description

This system is a mosaic of lowland spruce - fir forest and red spruce swamp communities that occur on mineral soils. In northern New Hampshire, these range from well or moderately well drained upland forests to poorly or very poorly drained swamps. Somewhat poorly drained soils are intermediate and very common. The average condition for red spruce swamps is acidic and poorly drained, with shallow, well decomposed organic soils (10 – 40 cm) over sandy to silty mineral soil. When soils are very poorly drained, these systems tend toward black spruce peat swamps. In steeper areas at moderate elevation, such as the White Mountains, swampland may be dominated by red spruce. These areas may border areas of narrow spruce fir, hardwood forest, or high elevation spruce fir. Lowland spruce fir is more minerotrophic than black spruce peat swamps, but less so than northern white cedar or near-boreal hardwood-conifer minerotrophic swamp systems. Diagnostic natural communities:

- Red spruce swamp (S3)
- Lowland spruce - fir forest (S3)
- Montane black spruce - red spruce forest (S1)

Associated natural community systems: Black spruce peat swamp systems occur on adjacent very poorly drained peat soils. In more minerotrophic settings this system can be adjacent and transition into northern white cedar or near-boreal hardwood-conifer minerotrophic swamp systems. Upslope, lowland spruce – fir forest/swamps typically transition to northern hardwood – conifer systems.

1.2 Justification

Lowland spruce-fir forest covers approximately 10% 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 Canadian Lynx, eastern small-footed bat, marten, osprey, Peregrine falcon, Bald Eagle, and three-toed woodpecker. Extensive heavy cutting in recent decades has substantially reduced the distribution of mature spruce-fir forest in New Hampshire. Recent forest inventory data (Miles 2005) suggest that 71% of live spruce and fir trees are in the 2-inch diameter class and less than 1.5% are in diameter classes of 10 inches and above. 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.

2.3 Protection and Regulatory Status

Much of New Hampshire's lowland spruce-fir occurs on private industrial land; approximately 30% 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" (Cullen 1996) and "Good Forestry in the Granite State" (FSSWT 1996) provide recommended management practices for sustainable forestry in New Hampshire.

2.4 Distribution

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

2.5 Town Distribution Map

See attached.

1.6 Habitat Mapping

To develop a map of lowland spruce-fir forest in New Hampshire a model was developed for each ecoregion subsection of the state based on the 2001 New Hampshire Land Cover Assessment, elevation, landform, and soils (Keys and Carpenter 1995, Sperduto and Zankel 2005). The model was developed by experts from TNC and NHNHB.

First, 2001 New Hampshire Land Cover Assessment grid value 422 (spruce-fir) was selected and combined with elevations from 1,000 to 2,500 feet extracted from the USGS National Elevation Dataset. Only spruce-fir occurring in that elevation range was included (CSRC 2001, USGS 2003). Ecological Land Units (ELU), created by TNC's Conservation Science Support, were then added to capture additional areas likely to have geo-physical conditions favorable to lowland spruce-fir, or remove areas likely to have geo-physical conditions unfavorable to lowland spruce-fir (TNC 2003). Specifically, acidic granitic dry flats, acidic sedimentary/metasedimentary dry flats, acidic shale dry flats, mafic/intermediate granitic dry flats, moderately calcareous sedimentary/metasedimentary dry flats, and wet flats were included. Water bodies were used to erase wet flats in the ELU layer that were actually open water.

To further refine the model, soil types associated with lowland spruce-fir were identified by NHNHB scientists and selected from digitized county soil data, where available (NRCS 2002). The soils data added areas that, while not captured as spruce-fir in the New Hampshire Land Cover Assessment, had requisite features for spruce-fir habitat.

NHFG had previously completed a model to map high-elevation spruce fir in New Hampshire, based on a Vermont Institute of Natural Science (VINS: Lambert et al. 2005) elevation threshold, which depicts the lower elevation limit of Bicknell's Thrush habitat, Hale's (in press) Bicknell's Thrush probability surface, and New Hampshire Natural Heritage Bureau (NHB) exemplary high-elevation spruce-fir natural communities. This layer was used to erase features in the lowland spruce-fir layer to ensure that there was no overlap between the two. However, overlap is unlikely because of the different elevation ranges that were used. NHFG then applied a filter to determine the majority forest type between neighboring polygons in TNC's model, and smoothed the boundaries to generalize the transition between matrix forest types.

Model results were reviewed by experts from TNC, NHFG, and NHNHB, who agreed that the broad patterns depicted by the model align with reasonable expectations. No ground truthing was conducted. This is a first version of the model, and further refinements may be developed in the future.

1.7 Sources of Information

The lowland spruce-fir map was developed based on expert input from scientists from NHNHB and the New Hampshire Chapter of TNC. The results were reviewed by additional scientists from NHFG and ASNH. A variety of GIS data was used to generate the map including USGS elevation data, landform data from TNC's eastern regional office, landcover data from the New Hampshire Landcover Assessment, among others, and soils as outlined by NHNHB scientists based on extensive fieldwork in lowland spruce-fir areas.

1.8 Extent and Quality of Data

The habitat map is considered a first version but is thought to provide a useful depiction of broad landscape patterns. Additional refinements will likely be necessary based on ground truthing of the existing map. Soils information gathered during extensive NHNHB fieldwork in spruce-fir areas was used instead of those outlined by the NRCS. NRCS provided a table of soil series that were believed to be strongly correlated with lowland spruce-fir and other forest types (Homer 2005). Soil series were provided by ecoregional subsection and elevation ranges. There was considerable overlap between series outlined for lowland spruce-fir and some of the other forest types. Thus, additional review and refinement are necessary prior to incorporating the NRCS listed soils into a lowland spruce-fir model. This was not possible for this initial version.

1.9 Distribution Research

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.

Element 2: Species/Habitat Condition

2.1 Scale: County

2.2 Relative Health of Populations

An approximately 3% decrease in forest area occurred between 1992 and 1993 and 2001 in the two-county area where approximately 95% of New Hampshire's potential Lowland Spruce-Fir forest occurs. An additional approximately 1% decrease is projected to occur between 2001 and 2025 (Calculated from data in SPNHF 2005).

2.4 Relative Quality of Habitat Patches: Analysis pending.

2.5 Habitat Patch Protection Status

Approximately 30% of potential Lowland Spruce-Fir forest in the two-county area where approximately 80% of this forest type occurs is in conservation ownership (calculated from TNC data).

2.6 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).

2.7 Sources of Information

See 1.7

2.8 Extent and Quality of Data

See 1.8 regarding extent and quality of data associated with the TNC matrix forest map. Tree farm data from Thorne and Sundquist 2001 are based on a New Hampshire Tree Farm program database issued in August 2000. Data regarding changes in forest area from SPNHF 2005 include information from the New Hampshire Land Cover Assessment, 2001 and results of predictive modeling.

2.9 Condition Assessment Research

Research is needed:

- to determine the age class distribution of this forest type on the landscape;
- to determine locations and sizes of remaining mature patches and identify stands that will reach maturity in the near term;
- to determine the extent of this forest type that occurs in large un-fragmented blocks;
- to determine presence and breeding status of spruce-fir dependent species in remaining mature patches;
- to ground-truth Capen et al.'s remote-sensing based habitat models for priority spruce-fir bird species

Element 3: Species and Habitat Threat Assessment

3.1.1. Unsustainable Harvest (Forestry Operations and Management)

(A) Exposure Pathway: Extensive, heavy cutting in recent decades has substantially reduced the distribution of mature spruce-fir forest in New Hampshire. 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. See also 3.1.2.

(B) Direct Evidence: Recent forest inventory data (Miles 2005) suggest that 71% of live spruce and fir trees are in the 2-inch diameter class and less than 1.5% of these trees are in diameter classes of 10 inches and above. Historical harvesting practices in some areas have resulted in conversion of former spruce-fir sites to northern hardwood-conifer forest.

3.1.2. Non-Point Source Pollution

(A) Exposure Pathway: Use of DDT and related pesticides to control forest pests during the mid twentieth century resulted in dramatic population declines of raptors and other wildlife species (Cade et al. 1971, Ogden 1977, Bednarz et al. 1990). More recent pest management strategies have included shorter rotations and pre-salvage harvesting, which may create extensive even-aged stands that are increasingly vulnerable to future outbreaks.

(B) Direct Evidence: The Osprey population in northern New Hampshire included only 3 to 4 known nesting pairs by 1977 (Smith 1979). After DDT was banned in 1976, this population gradually increased to 21 pairs by 1989 (Evans in Foss 1994). Recent forest inventory data (Miles 2005) suggest that 71% of live spruce and fir trees are in the 2-inch diameter class and less than 1.5% of these trees are in diameter classes of 10 inches and above.

3.1.4. Altered Natural Disturbance

(A) Exposure Pathway: Short rotations on managed spruce-fir forests prevent much of the forest from reaching sufficient age for bark beetles and, more recently, spruce budworm, to create natural stand mortality and to provide prey for species that depend heavily on these resources (e.g., three-toed woodpecker, Bay-breasted Warbler, Cape May Warbler).

(B) Direct Evidence: Recent forest inventory data (Miles 2005) suggest that 71% of live spruce and fir trees are in the 2-inch diameter class and less than 1.5% of these trees are in diameter classes of 10 inches and above.

3.2 Sources of Information

Threat information was derived from a work session with forestry professionals and stakeholders, available data, published literature, and personal experience.
3.3 Extent and Quality of Data: Threat pathways are well documented. Spatially explicit data regarding areas affected by threats are inadequate or lacking.

3.4 Threat Assessment Research

Comprehensive analysis of the current age-class distribution of lowland spruce fir forest across the landscape, including patch sizes, is needed.

Identification of areas that historically supported lowland spruce-fir forest but have been converted to northern hardwood-conifer forest as a result of past management practices is needed.

Element 4: Conservation Actions

4.1.1. Protect un-fragmented blocks and other key wildlife habitats.

See Strategies: Land Protection

4.1.2. Develop a comprehensive land protection support program.

See Strategies: Land Protection

4.1.3. Advocate adoption of sustainable forestry.

See Strategies: Education and Outreach

4.1.4. Restore and maintain late successional habitats.

See Strategies: Habitat management

4.1.5. Establish IRAT for Forestry

See Strategies: Interagency Regulation and Policy

4.2 Conservation Action Research

Identify existing unprotected patches of late successional lowland spruce-fir forest. Determine patch sizes of late successional lowland spruce-fir forest needed to support species dependent on that habitat type.

Element 5: References

5.1 Literature

Complex Systems Research Center. 2001. New Hampshire land cover assessment – 2001. 30m raster data. Available from GRANIT, University of New Hampshire.

Homer, J. 2005. Soil types corresponding to the NH Natural Heritage Bureau forest systems classification. U.S. Department of Agriculture, Natural Resource Conservation Service, Lancaster, NH, U.S.A., Unpublished Report to New Hampshire Fish and Game Department.

Keys, J.E. and C.A. Carpenter. 1995. Ecological units of the eastern United States: first approximation. U.S. Department of Agriculture, Forest Service.

Lambert, J. D., K. P. McFarland, C. C. Rimmer, S. D. Faccio, and J. L. Atwood. 2005. A practical model of Bicknell's Thrush distribution in the northeastern United States. Wilson Bulletin 117:1-11.

Natural Resources Conservation Service. Date varies, in progress with last revision in 2002. Soil Units of Rockingham, Sullivan, Cheshire, and Strafford Counties. Automated by and available from GRANIT, University of New Hampshire.

Sperduto, D, and M. Zankel. 2005. Distribution of matrix forest systems in New Hampshire by subsection, elevation, slope, and aspect. NH Department of Resources and Economic Development, Division of Forests and Lands, Natural Heritage Bureau, and The Nature Conservancy, Concord, NH, U.S.A. Unpublished Report to New Hampshire Fish and Game Department.

The Nature Conservancy, Conservation Science Support. 2003. Ecological Land Units. 30m raster data. Available from TNC, Eastern Resource Office, Boston, MA.

United States Geological Survey. Date varies, complete by 2003. National Elevation Dataset. 30m raster data. Projected by Complex Systems Research Center in January 2005, available from GRANIT, University of New Hampshire.Twith most of New Hampshire's potential lowland spruce-fir forest area.

HABITAT PROFILE

Northern Hardwood - Conifer Forest

Associated Species: Ruffed grouse, American woodcock, wood thrush, veery, Canada warbler, cerulean warbler, eastern pipistrelle, eastern red bat, hoary bat, northern long-eared bat, silver-haired bat, gray wolf. Global Rank: Not ranked
State Rank: Not ranked

Author: Carol R. Foss
Affiliation: Audubon Society of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat description

New Hampshire's northern hardwood forests are characterized by Fagus grandifolia (American beech), Acer saccharum (sugar maple), and Betula alleghaniensis (yellow birch). In latitude and elevation, these northern hardwood forests are positioned between the high-elevation spruce - fir forest and hemlock – hardwood – pine forest systems. Northern hardwood forests are generally found between 1,400 and 2,500 ft. in elevation in northern New Hampshire and along the western highlands (Sunapee Uplands subsection), although the tolerance of individual species varies. Some occurrences can be found down to about 1,000 ft. elevation.

The upslope transition to spruce - fir forest is marked by the appearance of Picea rubens (red spruce), Abies balsamea (balsam fir), the increased importance of yellow birch, and the disappearance of sugar maple and beech; the downslope transition to the hemlock – hardwood – pine forest system is marked by the appearance of more Tsuga canadensis (hemlock) along with Quercus rubra (red oak), Pinus strobus (white pine), and occasionally Ostrya virginiana (ironwood) and decreased dominance of yellow birch and sugar maple.

This system is a matrix of sugar maple, beech, and yellow birch forest and mixes with patches of several other communities. Hemlock - beech - northern hardwood forests occur at lower elevations (800 to 2,000 ft.) and are differentiated from the matrix community by a substantial presence of hemlock. It occurs in valley bottoms and lower mountain slopes of the White Mountains, and middle to higher elevations of hills and low mountains of the Sunapee Uplands subsection of western New Hampshire. Hemlock – spruce – northern hardwood forests are also found at elevations below 2,000 ft. This is a conifer to mixed community type with considerable hemlock and spruce mixing with variable amounts of birches, other northern hardwoods, balsam fir, and sometimes white pine. It occurs primarily on river terraces, stream ravines, and compact till settings in the mountains where it transitions to more pure northern hardwoods on better soils (e.g., fine tills). Semi-rich mesic sugar maple forests are a common but relatively small part of the mosaic formed by this system where there is slightly enriched till or fine river terrace sediments. Both beech forest and hemlock forest types are occasional in this and the hemlock – hardwood – pine forest systems, but generally form relatively small patches. Northern hardwood - spruce - fir forests mark the transition to high-elevation spruce-fir forest, 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.

Herbs such as Aralia nudicaulis (wild sarsaparilla) and Trientalis borealis (starflower) are common to both transitional and northern hardwood forests. Species of the northern hardwood forests generally not found in transitional forests include Dryopteris campyloptera (mountain wood fern), Lonicera canadensis (Ca-

nadian honeysuckle), Polystichum braunii (Braun's holly fern), and other northern herbs also found in the spruce - fir forest. Species that tend to be more abundant in northern hardwoods including Oxalis acetosella (northern wood sorrel), Huperzia lucidula (shining clubmoss), Clintonia borealis (blue-bead lily), and Streptopus spp. (twisted stalks).

Diagnostic natural communities:

- Sugar maple - beech - yellow birch forest (S5) – matrix forest type
- Hemlock – spruce – northern hardwood forest (S3S4)
- Hemlock - beech - northern hardwood forest (S4)
- Semi-rich mesic sugar maple forest (S3S4)
- Northern hardwood - spruce - fir forest (S4)

Peripheral or occasional natural communities:

- Beech forest (S4)
- Hemlock forest (S4)

Associated natural community systems: Northern hardwood – conifer forest systems transition upslope to high-elevation spruce - fir forest systems. Downslope they transition to either 1) hemlock – hardwood – pine forest systems, especially in low elevation valleys of White Mountains and further south; or 2) lowland spruce – fir forest/swamp systems in the North Country and some valley bottoms in the White Mountains.

1.2 Justification

Northern hardwood-conifer forest covers approximately 20% of New Hampshire. Available data indicate that approximately 19% of the state's potential 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 osprey, Cooper's hawk, Peregrine falcon, and Bald Eagle. Development pressure is heavy within some parts of the range of Hemlock-Hardwood-Pine forest in New Hampshire, particularly in the Lakes Region and the perimeter of the WMNF. 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.

1.3 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 40% 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. 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" (Cullen 1996) and "Good Forestry in the Granite State" (FSSWT 1996) provide recommended management practices for sustainable forestry in New Hampshire.

1.4 Distribution

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%.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

To develop a map of northern hardwood-conifer forest in New Hampshire a model was developed for each ecoregion subsection of the state based on the 2001 New Hampshire Land Cover Assessment, elevation, and landform (Keys and Carpenter 1995, Sperduto and Zankel 2005). The model was developed by experts from TNC and NHNHB.

First, relevant 2001 New Hampshire Land Cover Assessment grid values were selected and combined with elevations from 500 to 1,400 feet extracted from the USGS National Elevation Dataset (CSRC 2001,

USGS 2003). Appropriate elevation ranges were determined for each of New Hampshire's 9 ecoregional subsections in which northern hardwood-conifer was expected to occur. Ecological Land Units, created by TNC's Conservation Science Support, were then added to capture additional areas likely to have geophysical conditions favorable to northern hardwood-conifer, or remove areas likely to have geo-physical conditions unfavorable to northern hardwood-conifer (TNC 2003). Specifically, south-facing sideslopes and south-facing coves were removed from some land cover/elevation groups, and some land cover/elevation groups were restricted to only north-facing sideslopes and north-facing coves.

NHFG had previously completed a model to map high-elevation spruce fir in New Hampshire, based on a Vermont Institute of Natural Science (VINS: Lambert et al. 2005) elevation threshold, which depicts the lower elevation limit of Bicknell's Thrush habitat, Hale's (in press) Bicknell's Thrush probability surface, and NHNHB exemplary high-elevation spruce-fir natural communities. Some areas fell between the lowest elevation of this high-elevation spruce fir model, and the upper elevation of the northern hardwood conifer model. Areas in this gap that met the other requirements for northern hardwood conifer were assigned to the northern hardwood conifer matrix type. Soils were not used in this model. NHFG then applied a filter to determine the majority forest type between neighboring polygons in the TNC model and smoothed the boundaries to generalize the transition between matrix forest types.

The lowland spruce-fir model layer was used to erase some areas of overlap from the northern hardwood-conifer layer, so that the lowland spruce fir model was considered to take precedence over the northern hardwood-conifer model. Criteria for the lowland spruce-fir model were based on more information than the northern hardwood-conifer model, and without the lowland spruce-fir precedence lowland spruce-fir appeared to be underpredicted.

Model results were reviewed by experts from TNC, NHFG, and NHB, who agreed that the broad patterns depicted by the model align with reasonable expectations. No ground truthing was conducted. This version of the model is considered a first version, and further refinements may be developed in the future.

1.7 Sources of Information

The Northern hardwood-conifer map was developed based on expert input from scientists from NHNHB and the New Hampshire Chapter of TNC. The results were reviewed by additional scientists from NHFG and ASNH. A variety of GIS data were used to generate the map, including USGS elevation data, landform data from TNC's eastern regional office, land cover data from the New Hampshire Landcover Assessment, among others.

1.8 Extent and Quality of Data

The habitat map is considered a first version but is thought to provide a useful depiction of broad landscape patterns. Additional refinements will likely be necessary based on ground truthing of the existing map. NRCS provided a table of soil series that were believed to be strongly correlated with northern hardwood-conifer forest (Homer 2005). Soils series were provided by ecoregional subsection and elevation ranges. There was considerable overlap between series outlined for northern hardwood-conifer and some of the other forest types. Thus, additional review and refinement are necessary prior to incorporating soils into a northern hardwood-conifer model. This was not possible for this initial version.

1.9 Distribution Research

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).

a) Fieldwork is also needed to ground truth the northern hardwood-conifer map to assist with refining it.
b) Spatially explicit information on age-class distribution for this forest type is needed.

Element 2: Species/Habitat Condition

2.1 Scale

County

2.2 Relative Health of Populations

Relative Health of Populations: An approximately 3% decrease in forest area occurred between 1992 and 1993 and 2001 in the two-county area where approximately 80% of New Hampshire's potential Northern Hardwood-Conifer forest occurs. An additional approximately 1% decrease is projected to occur between 2001 and 2025 (Calculated from data in SPNHF 2005).

2.4 Relative Quality of Habitat Patches

Analysis pending.

2.5 Habitat Patch Protection Status

Approximately 40% of potential Northern Hardwood-Conifer forest in the two-county area where approximately 80% of this forest type occurs is in conservation ownership (calculated from TNC and SPNHF data).

2.6 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).

2.7 Sources of Information

See 1.7

2.8 Extent and Quality of Data

See 1.8 regarding extent and quality of data associated with the TNC matrix forest map. Tree farm data from Thorne and Sundquist 2001 are based on a New Hampshire Tree Farm program database issued in August 2000. Data regarding changes in forest area from SPNHF 2005 include information from the New Hampshire Land Cover Assessment, 2001 and results of predictive modeling.

2.9 Condition Assessment Research

- Research is needed to determine the extent of this forest type that occurs in large unfragmented blocks.
- Research is needed to determine the age class distribution of this forest type on the landscape.

Element 3: Species and Habitat Threat Assessment

3.1.1 Acid Deposition

(A) Exposure Pathway: Combustion in vehicle engines, power plants, and other industrial processes generates nitrogen oxides and sulfur oxides, which enter the atmosphere and are transformed into acids. These chemicals can travel for hundreds of miles in the upper atmosphere before returning to earth as acid precipitation or dry deposition. In New Hampshire, vehicles generate 51% of nitrogen oxide emissions, while power plants generate 90% of sulfur oxide emissions and 39% of nitrogen emissions (NHDES 1989). However, much of the acidic deposition in the state comes from heavily industrialized areas in the mid-western and south-western United States (New Hampshire Comparative Risk Project 1997).

(B) Direct Evidence: Northern New Hampshire, where most of the State's Northern Hardwood-Conifer forest is located, lies within an area of particularly low pH precipitation and high nitrate and excess sulfate deposition (Freedman 1995). Long-term data from the Hubbard Brook Experimental Forest document a long history of severe acid deposition (Likens et al. 1984).

3.2 Sources of Information

Threat information was derived from a work session with forestry professionals and stakeholders, available data, published literature, and personal experience.

3.3 Extent and Quality of Data

Threats to Northern Hardwood – Conifer forest

resulting directly or indirectly from acid deposition, land conversion, and development are well-documented.

3.4 Threat Assessment Research

Long-term research regarding levels and effects of acid deposition is being addressed by the Hubbard Brook Experimental Forest.

Research to evaluate relative development pressure and vulnerability of different geographic areas within the range of Northern Hardwood – Conifer Forest would help to prioritize areas for protection and for application of land-use planning tools.
Element 4: Conservation Actions

4.1.1. Incorporate Habitat Conservation into Local Land Use Planning

See Strategies: Local Regulation and Policy

4.1.2. Advise Conservation Commissions and Open Space Committees

See Strategies: Local Regulation and Policy, Education and Outreach

4.1.3. Promote Role of the Regional Planning Commissions in Landscape-Scale Conservation

See Strategies: Local Regulation and Policy

4.1.4. Protect unfragmented blocks and other key wildlife habitats.

See Strategies: Land Protection

4.1.5. Develop a comprehensive land protection support program.

See Strategies: Land Protection

4.1.6. Advocate adoption of sustainable forestry.

See Strategies: Education and Outreach

4.1.7. Establish IRAT for pollutants to address acid deposition.

See Strategies: Interagency Regulation and Policy

4.2 Conservation Action Research

Research is needed to provide a scientific basis for new tools to help municipalities maintain large forest blocks and significant wildlife habitat in the face of development. Such research could examine:

- Road noise effects on forest bird distribution and breeding status
- Behavior and land use of mesocarnivores in relation to development and road densities
- Bear use of mast stands as a function of proximity to development
- Effects of residential lot sizes on habitat suitability and landscape permeability for selected wildlife species

and similar topics.

Element 5: References

5.1 Literature

Keys, J.E. and C.A. Carpenter. 1995. Ecological units of the eastern United States: first approximation. U.S. Department of Agriculture, Forest Service.

Lambert, J. D., K. P. McFarland, C. C. Rimmer, S. D. Faccio, and J. L. Atwood. 2005. A practical model of Bicknell's Thrush distribution in the northeastern United States. Wilson Bulletin 117:1-11.

Sperduto, D, and M. Zankel. 2005. Distribution of matrix forest systems in New Hampshire by subsection, elevation, slope, and aspect. NH Department of Resources and Economic Development, Division of Forests and Lands, Natural Heritage Bureau, and The Nature Conservancy, Concord, NH, U.S.A. Unpublished Report to New Hampshire Fish and Game Department.

5.2 Data sources

Complex Systems Research Center. 2001. New Hampshire land cover assessment – 2001. 30m raster data. Available from GRANIT, University of New Hampshire.

Homer, J. 2005. Soil types corresponding to the NH Natural Heritage Bureau forest systems classification. U.S. Department of Agriculture, Natural Resource Conservation Service, Lancaster, NH, U.S.A., Unpublished Report to New Hampshire Fish and Game Department.

Miles, P.D. May 11, 2005. Forest inventory mapmaker web-application version 1.7, St. Paul, MN: U.S.

Departmetn of Agriculture, Forest Service, North Central Research Station [www.ncrs2.fs.fed.us/4801/fiab/index.htm]

Natural Resources Conservation Service. Date varies, in progress with last revision in 2002. Soil Units of Rockingham, Sullivan, Cheshire, and Strafford Counties. Automated by and available from GRANIT, University of New Hampshire.

New Hampshire Natural Heritage Bureau. January 2005. Exemplary Natural Community Data. Scale varies, vector data. Available with permission from the NH Natural Heritage Bureau.

Sperduto, D, and M. Zankel. 2005. Distribution of matrix forest systems in New Hampshire by subsection, elevation, slope, and aspect. NH Department of Resources and Economic Development, Division of Forests and Lands, Natural Heritage Bureau, and The Nature Conservancy, Concord, NH, U.S.A. Unpublished Report to New Hampshire Fish and Game Department.

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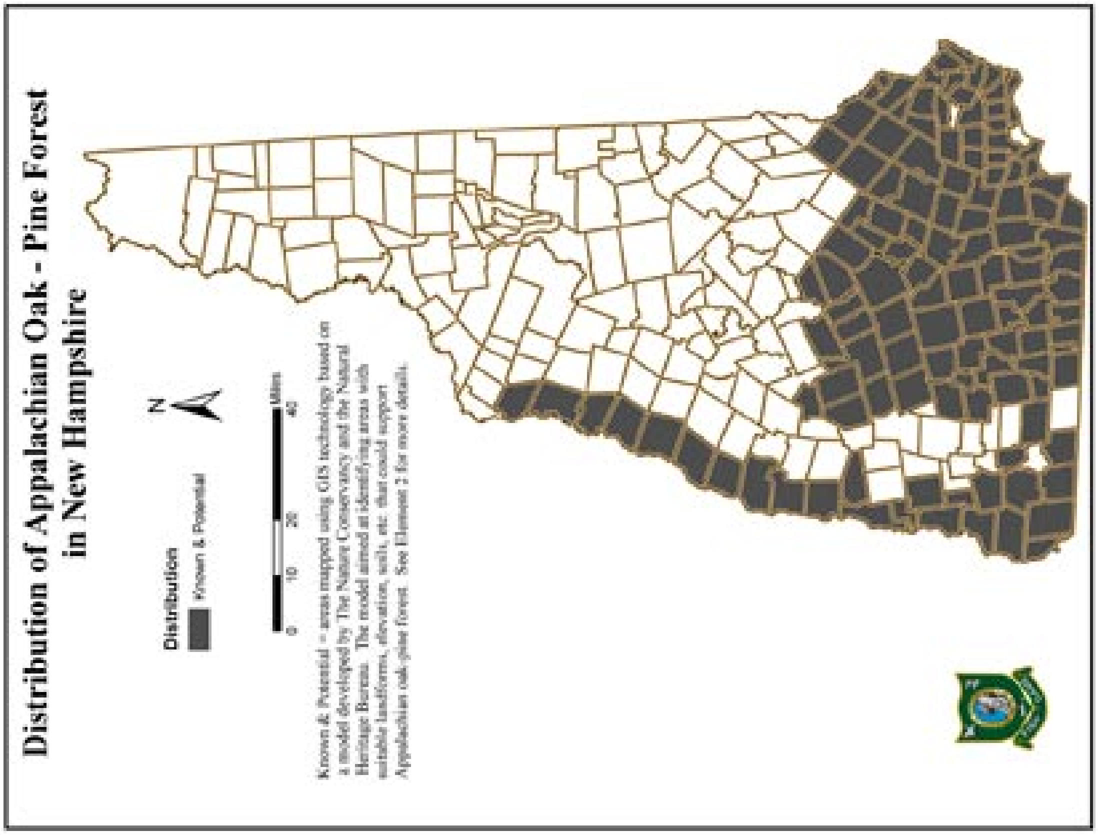
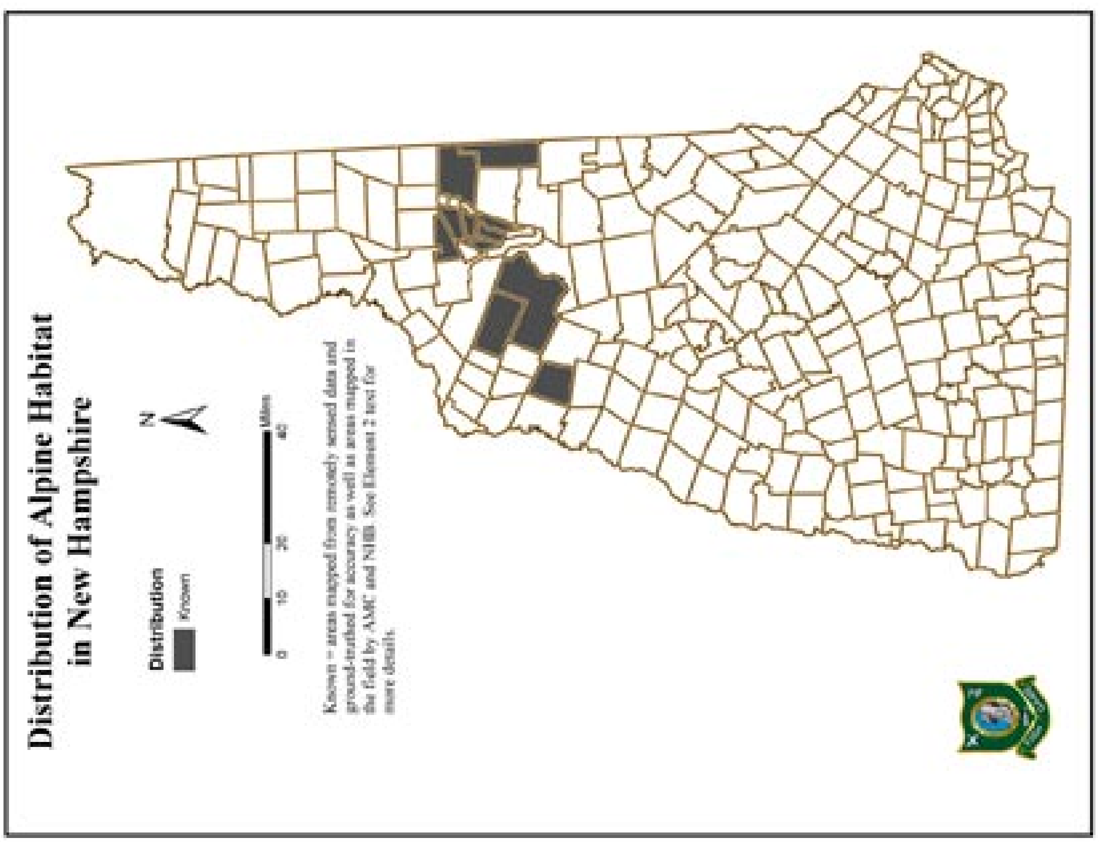
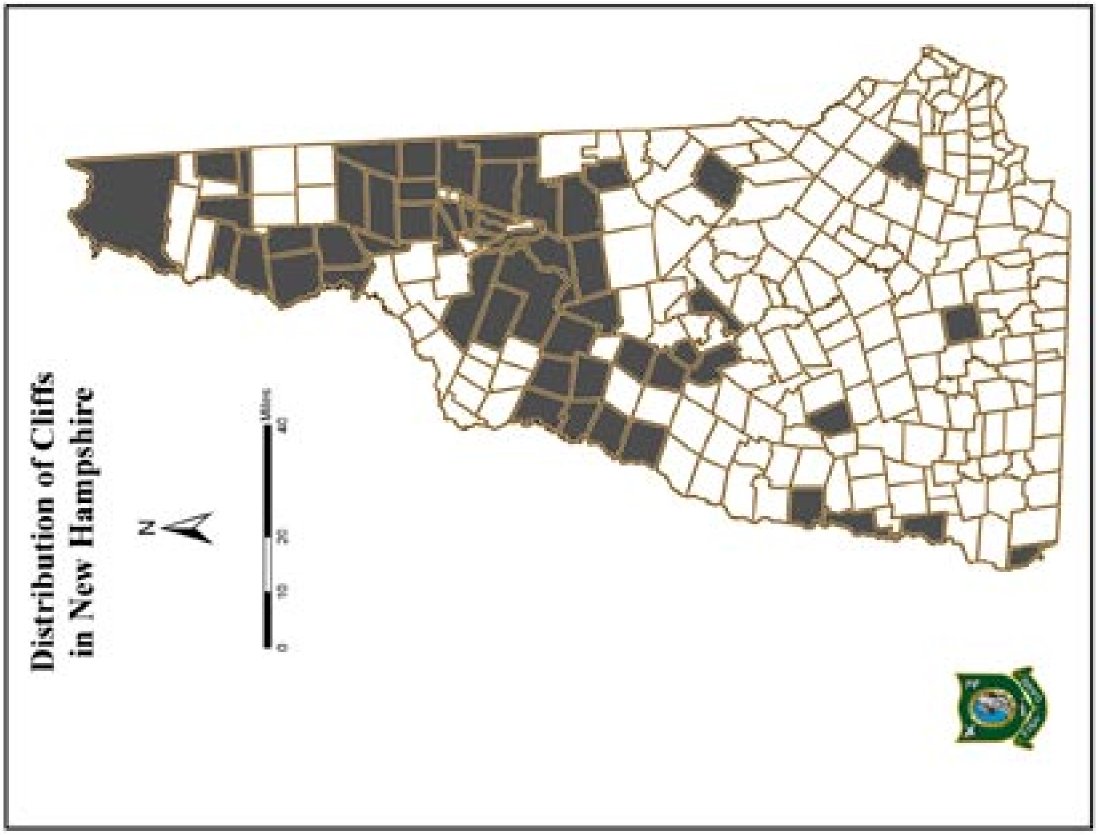
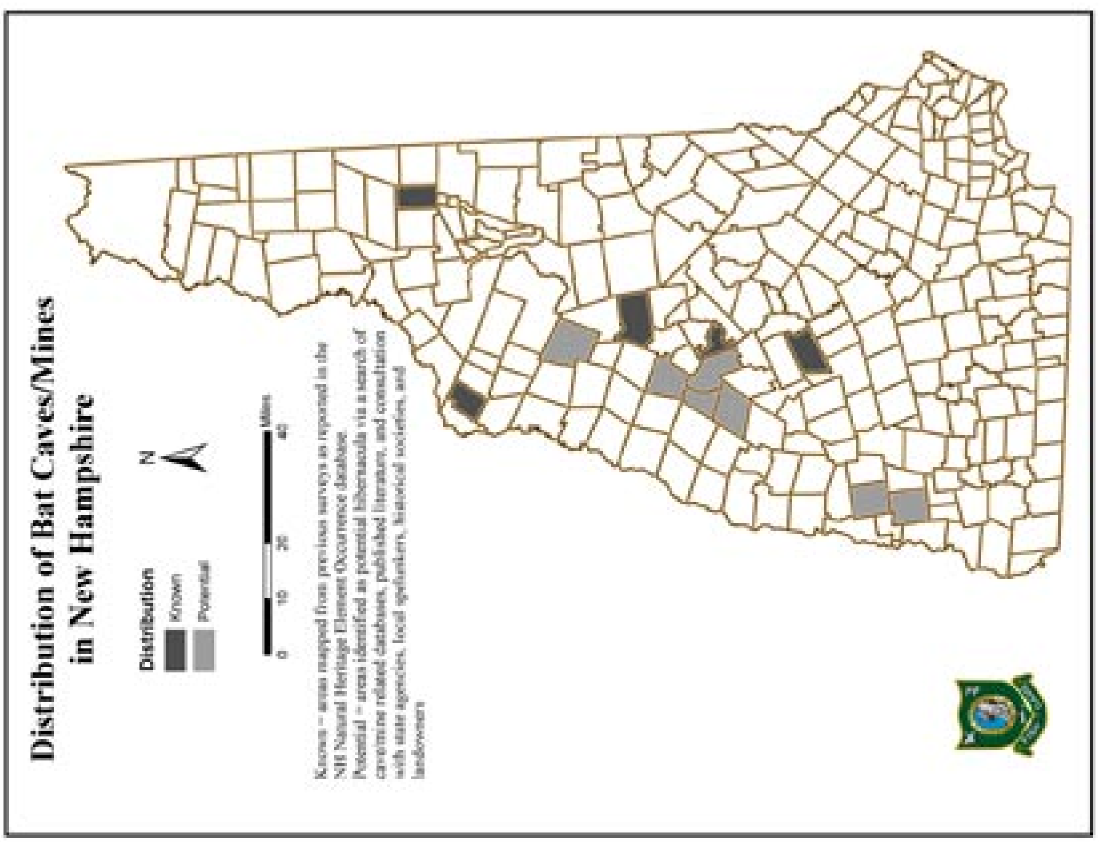
United States Geological Survey. Date varies, complete by 2003. National Elevation Dataset. 30m raster data. Projected by Complex Systems Research Center in January 2005, available from GRANIT, University of New Hampshire.

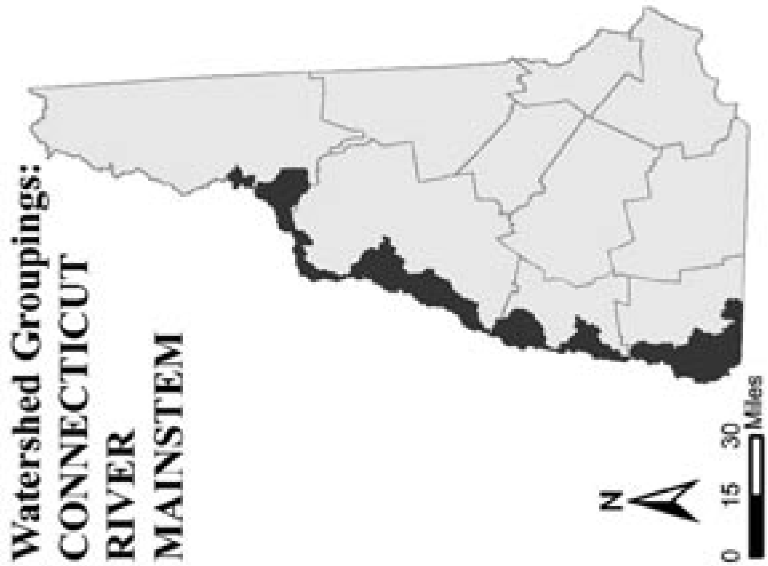
Mammal Maps


Distribution of Appalachian Oak - Pine Forest in New Hampshire
Distribution
Known & Potential
N
0 10 20 40 Miles
Known & Potential = areas mapped using GIS technology based on a model developed by The Nature Conservancy and the Natural Heritage Bureau. The model aimed at identifying areas with suitable landforms, elevation, soils, etc. that could support Appalachian oak-pine forest. See Element 2 for more details.


Distribution of Alpine Habitat in New Hampshire
Distribution
Known
N
0 10 20 40 Miles
Known = areas mapped from remotely sensed data and ground-truthed for accuracy as well as areas mapped in the field by AMC and NHB. See Element 2 text for more details.


Distribution of Cliffs
in New Hampshire
N
0 10 20 40
Miles


Distribution of Bat Caves/Mines
in New Hampshire
Distribution
Known
Potential
N
0 10 20 40
Miles
Known – areas mapped from previous surveys as reported in the NH Natural Heritage Element Occurrence database.
Potential – areas identified as potential hibernacula via a search of cave/mine related databases, published literature, and consultation with state agencies, local spelunkers, historical societies, and landowners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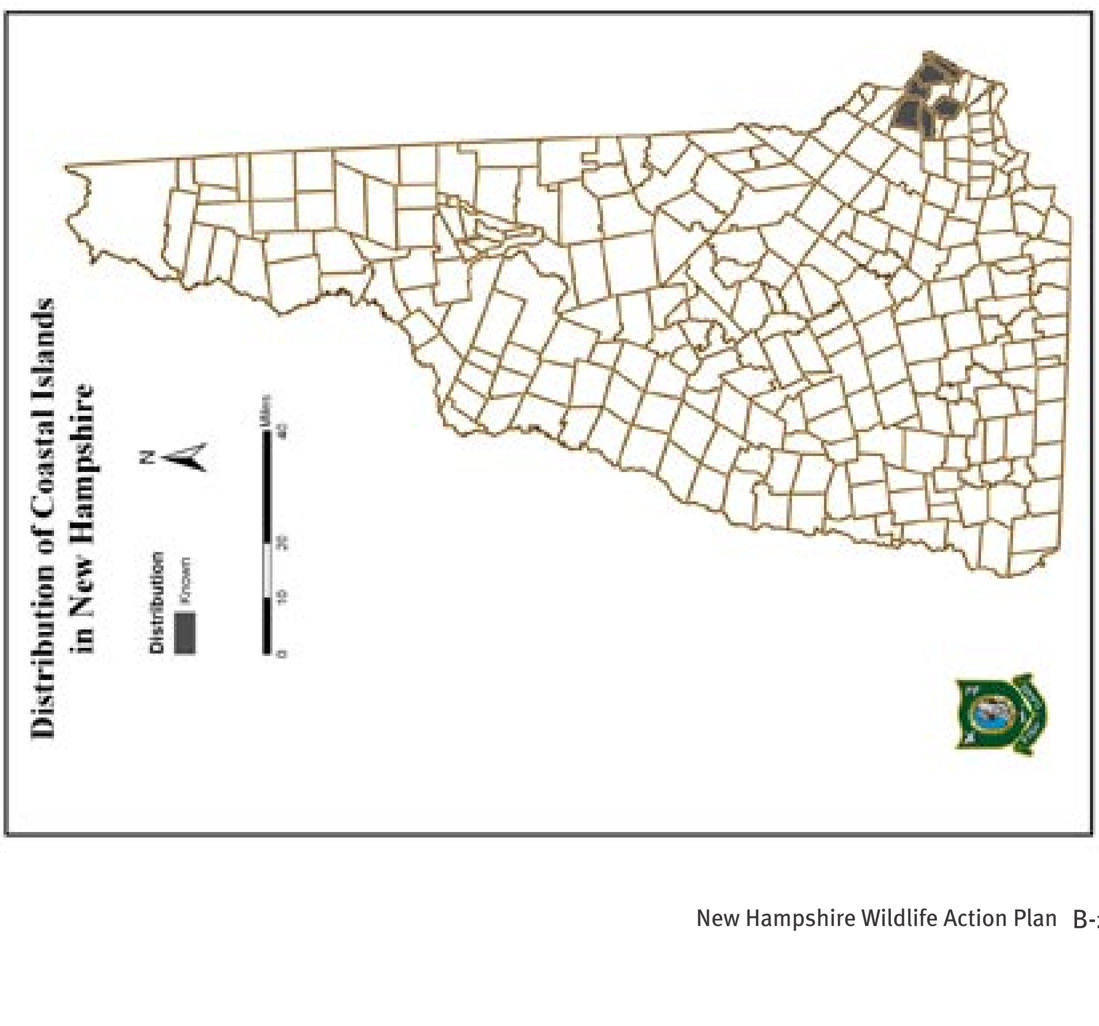
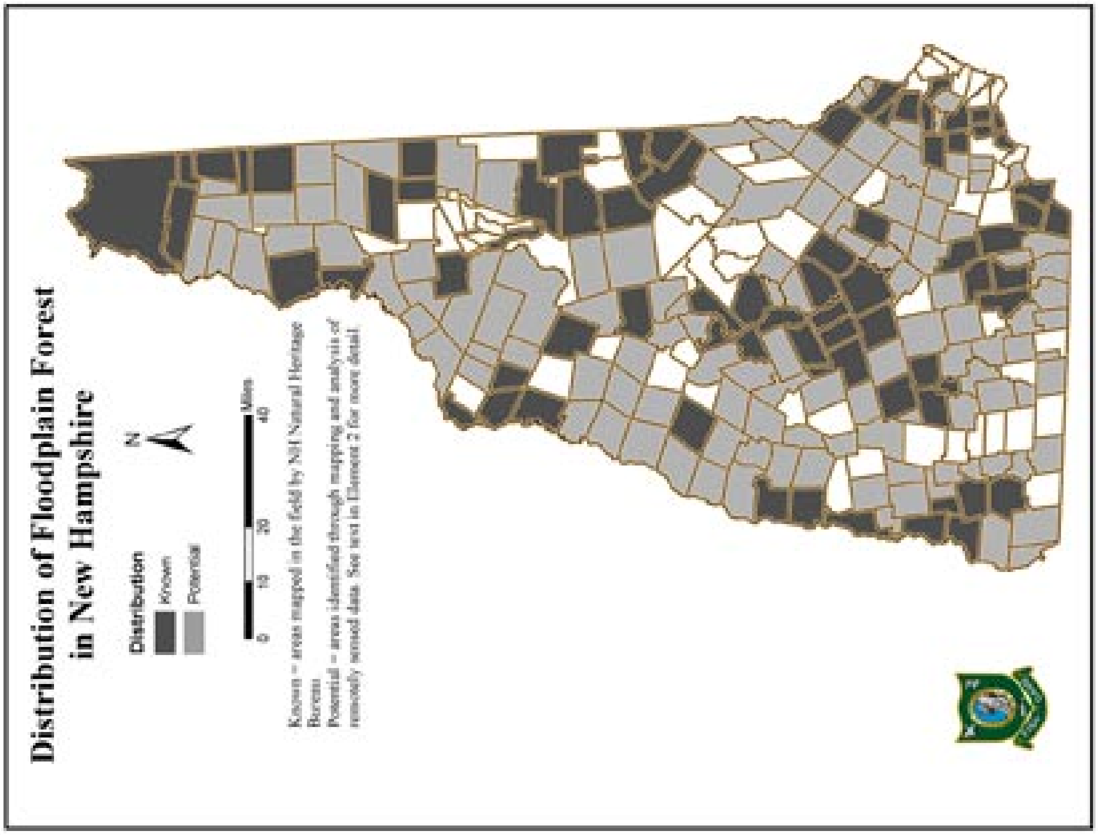
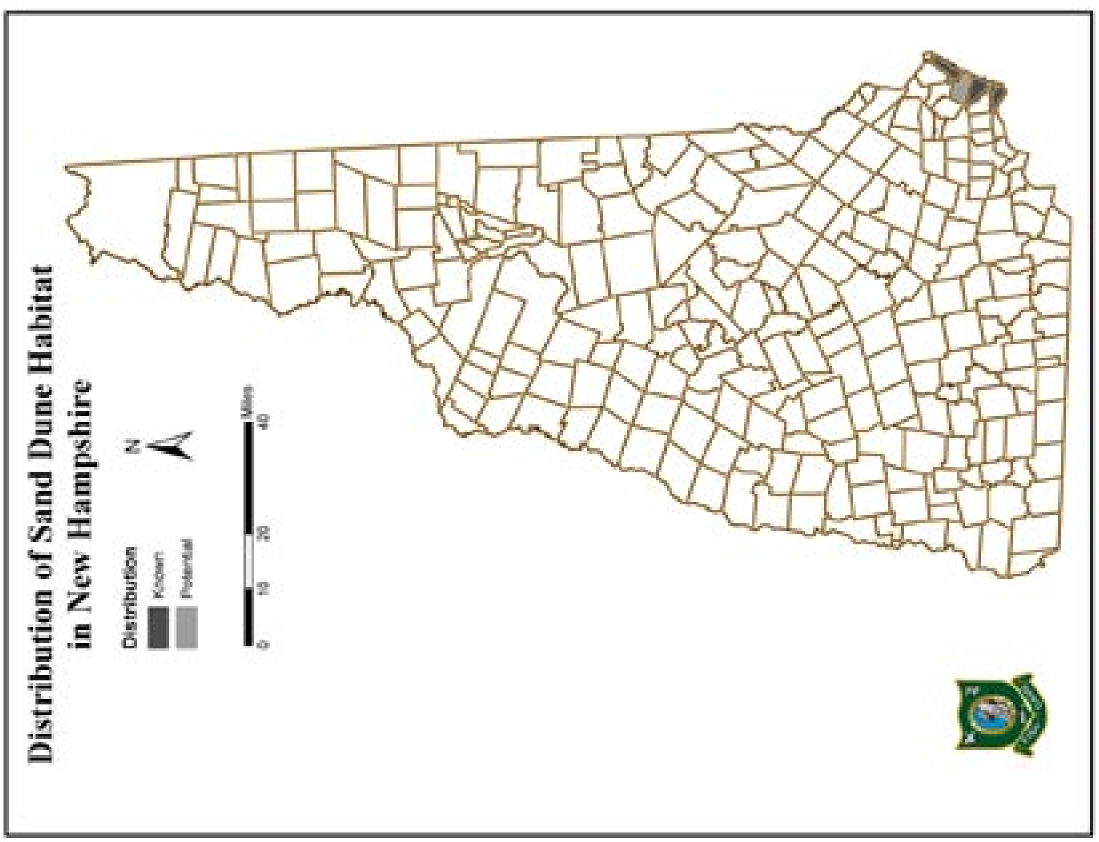
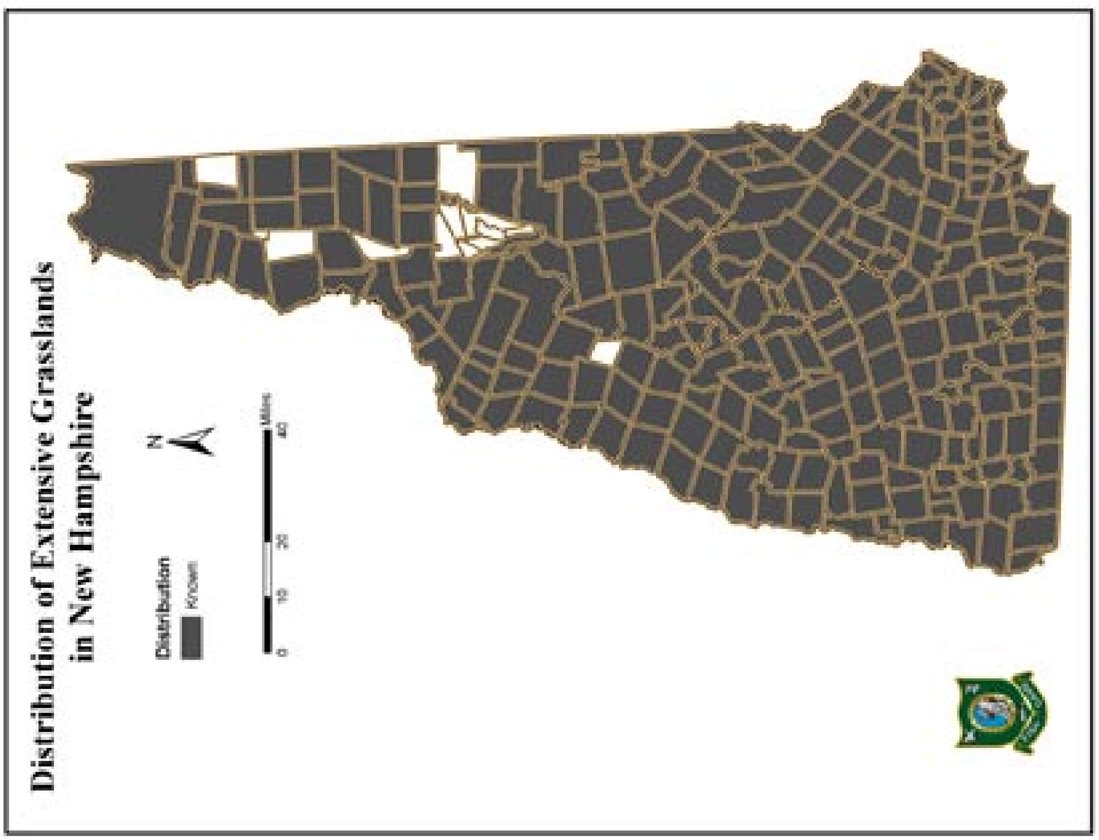
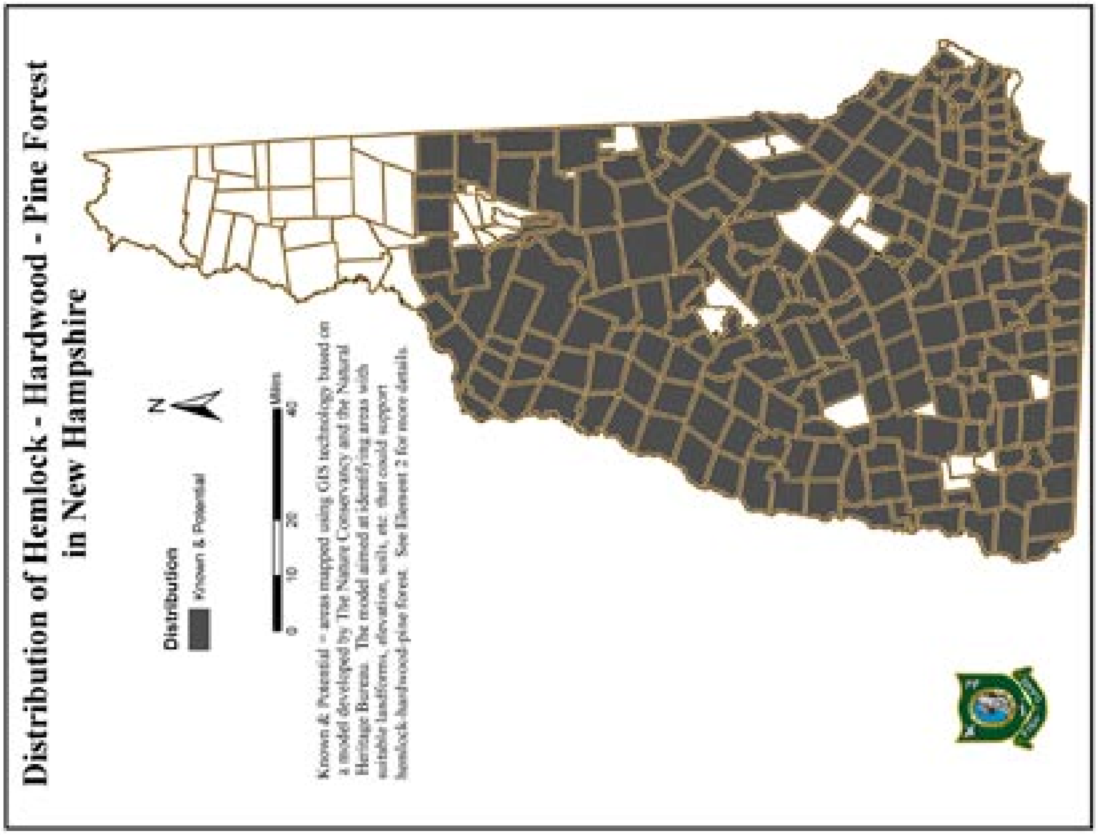
CONNECTICUT
RIVER
MAINSTEM
N
0 15 30
Miles

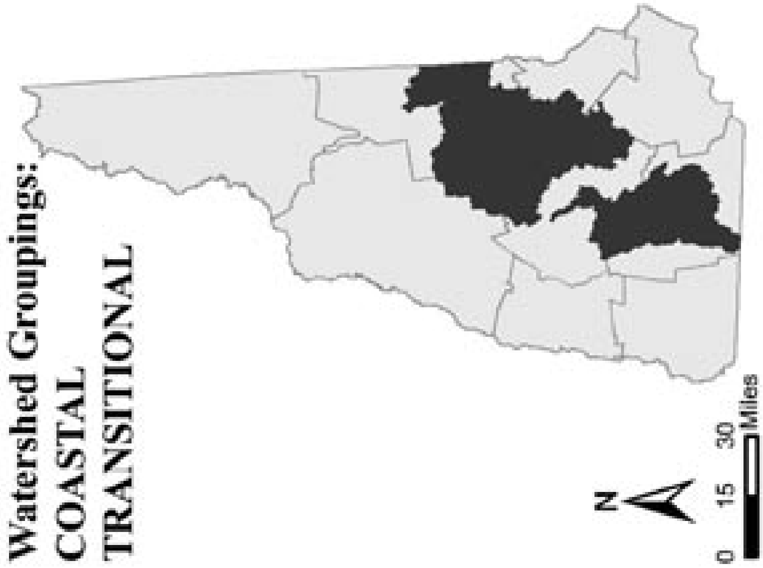

Distribution of Coastal Islands
in New Hampshire
Distribution
Known
N
0 10 20 40
Miles

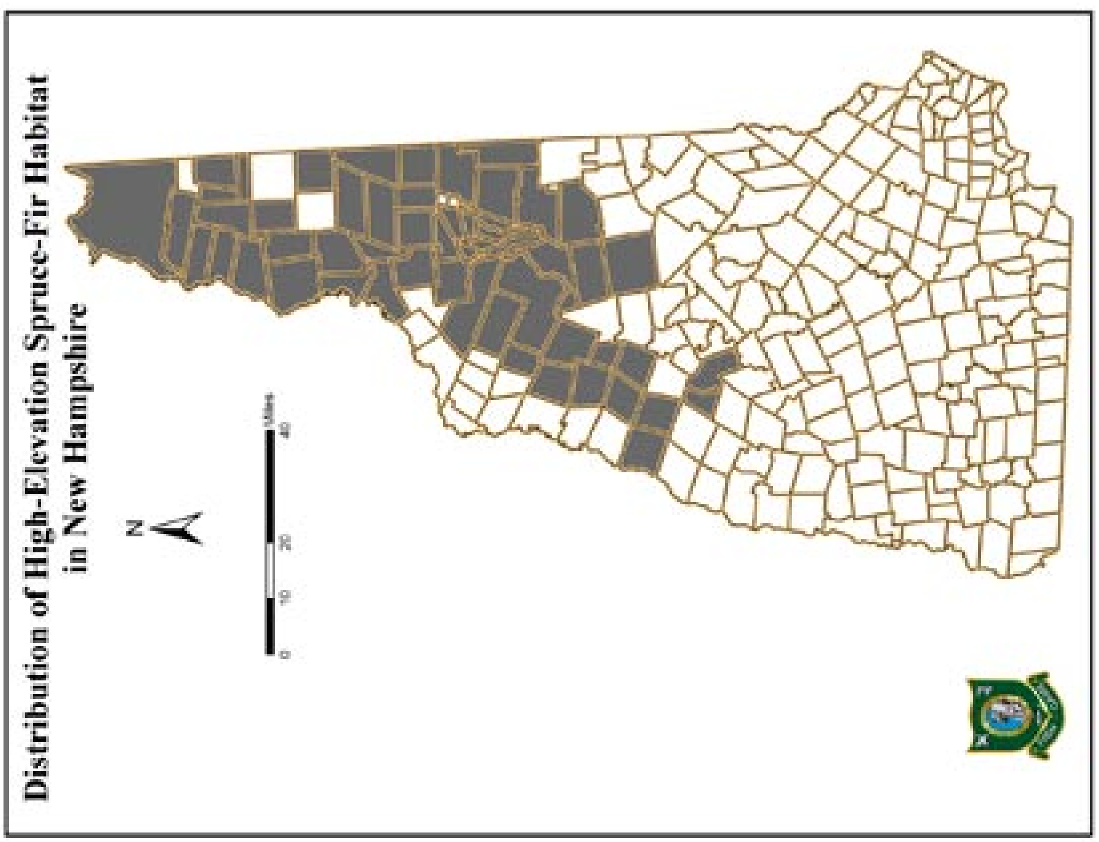

Distribution of Floodplain Forest
in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles
Known = areas mapped in the field by NH Natural Heritage Bureau
Potential = areas identified through mapping and analysis of remotely sensed data. See text in Element 2 for more detail.

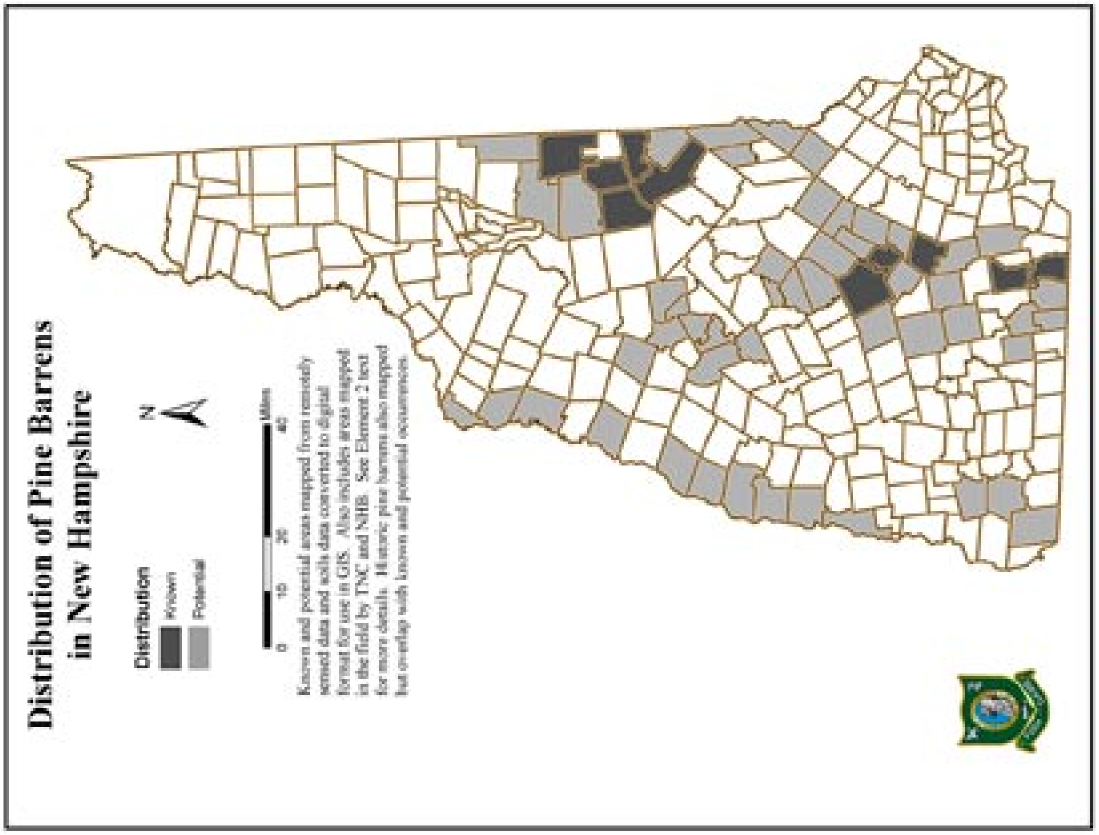

Distribution of Sand Dune Habitat
in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles

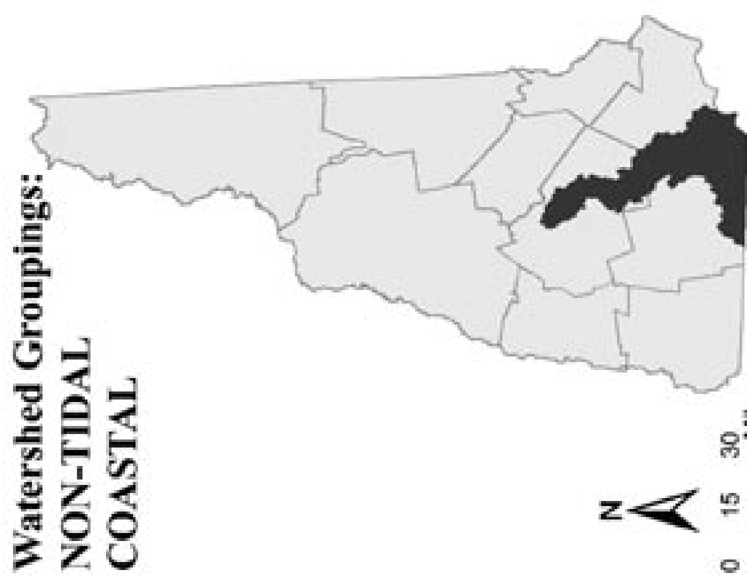

Distribution of Extensive Grasslands
in New Hampshire
Distribution
Known
N
Miles
0 10 20 40

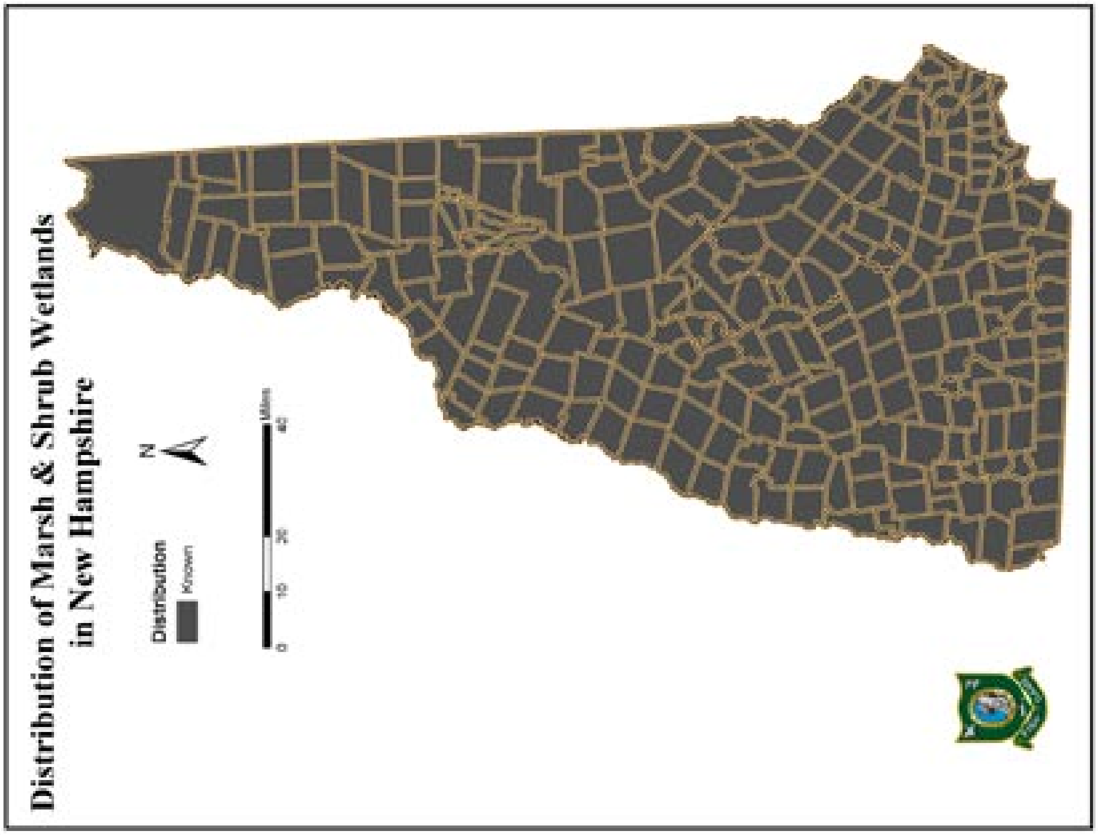

Distribution of Hemlock - Hardwood - Pine Forest
in New Hampshire
Distribution
Known & Potential
N
Miles
0 10 20 40
Known & Potential = areas mapped using GIS technology based on a model developed by The Nature Conservancy and the Natural Heritage Bureau. The model aimed at identifying areas with suitable landforms, elevation, soils, etc. that could support hemlock-hardwood-pine forest. See Element 2 for more details.

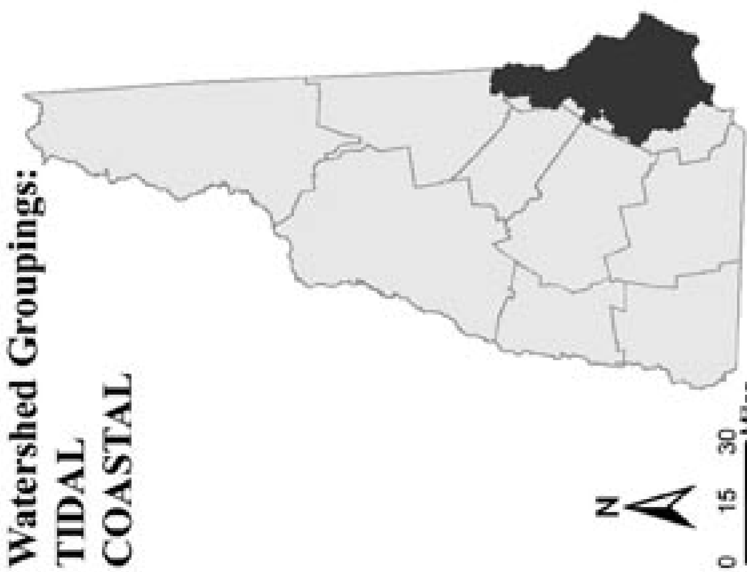

Watershed Groupings:
COASTAL
TRANSITIONAL
N
0 15 30 Miles

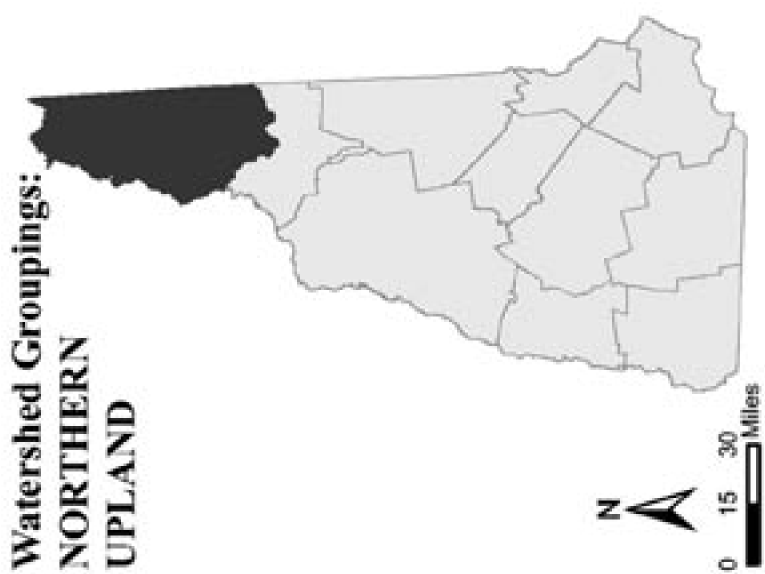

Distribution of High-Elevation Spruce-Fir Habitat in New Hampshire
N

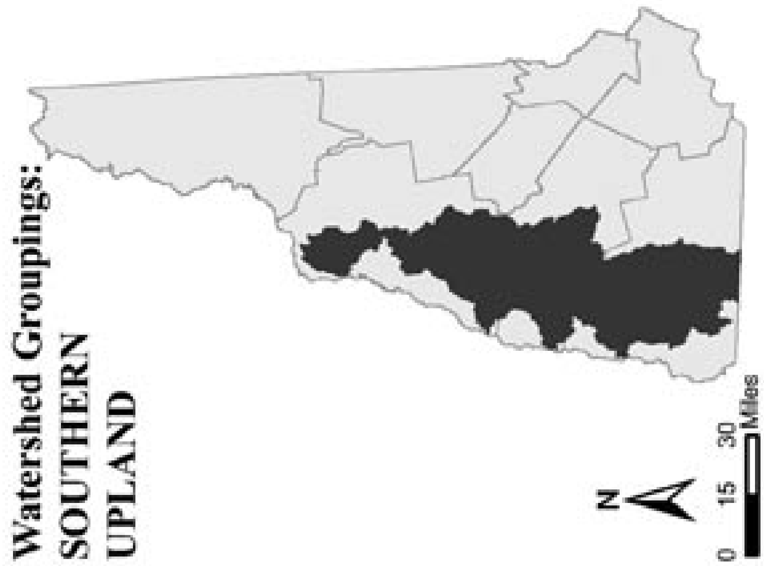

Distribution of Pine Barrens
in New Hampshire
Distribution
Known
Potential
N
0 10 20 40 Miles
Known and potential areas mapped from remotely sensed data and soils data converted to digital format for use in GIS. Also includes areas mapped in the field by TNC and NHB. See Element 2 text for more details. Historic pine barrens also mapped but overlap with known and potential occurrences.

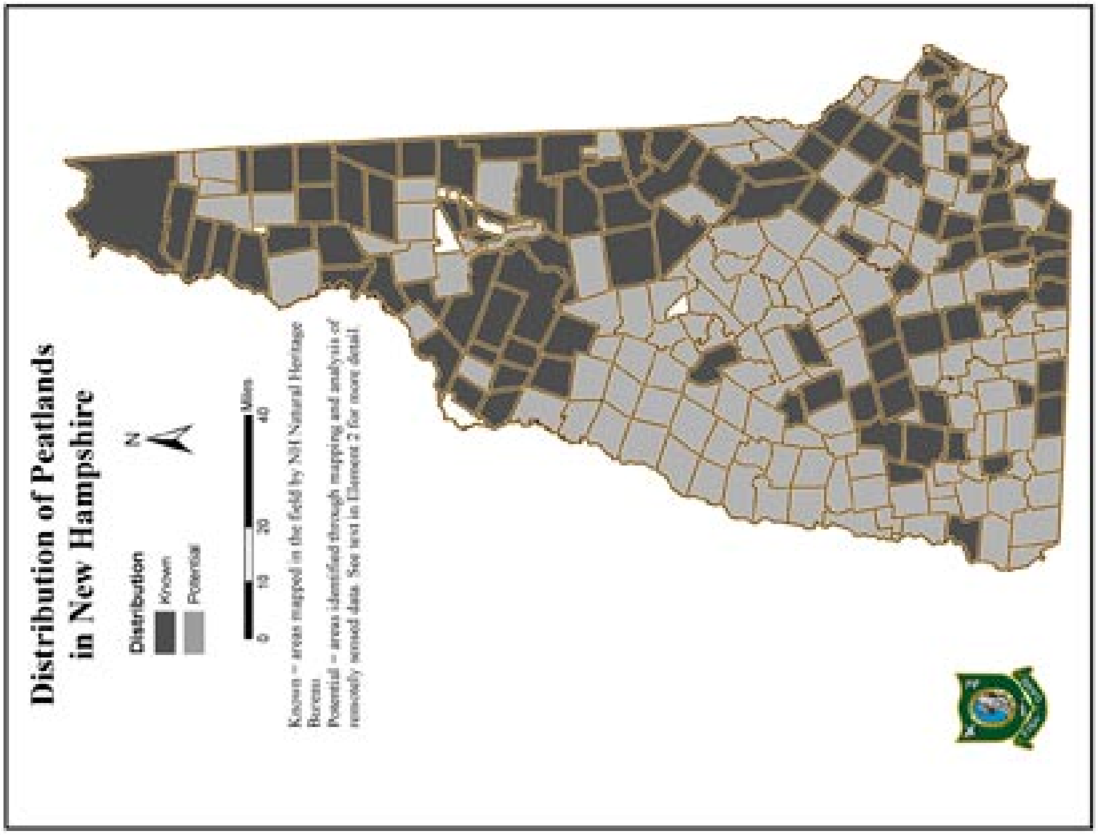

Watershed Groupings:
NON-TIDAL
COASTAL
N
0 15 30 Miles

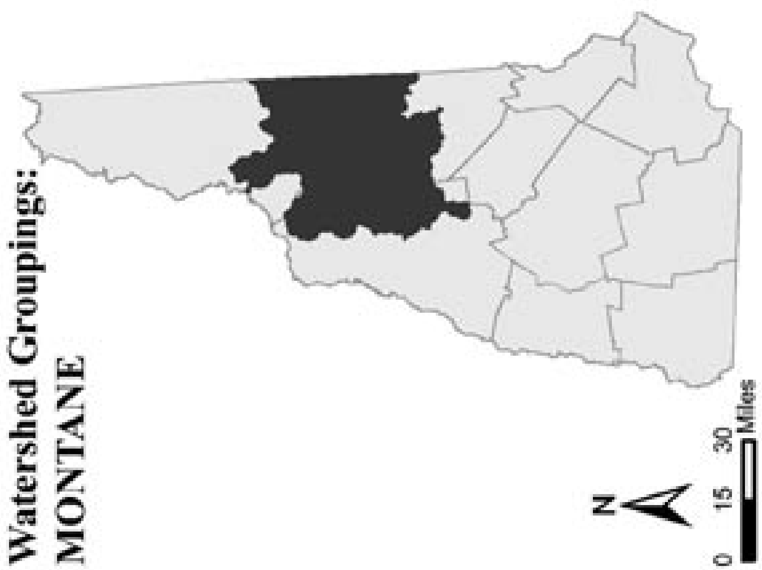

Distribution of Marsh & Shrub Wetlands
in New Hampshire
Distribution
Known
N

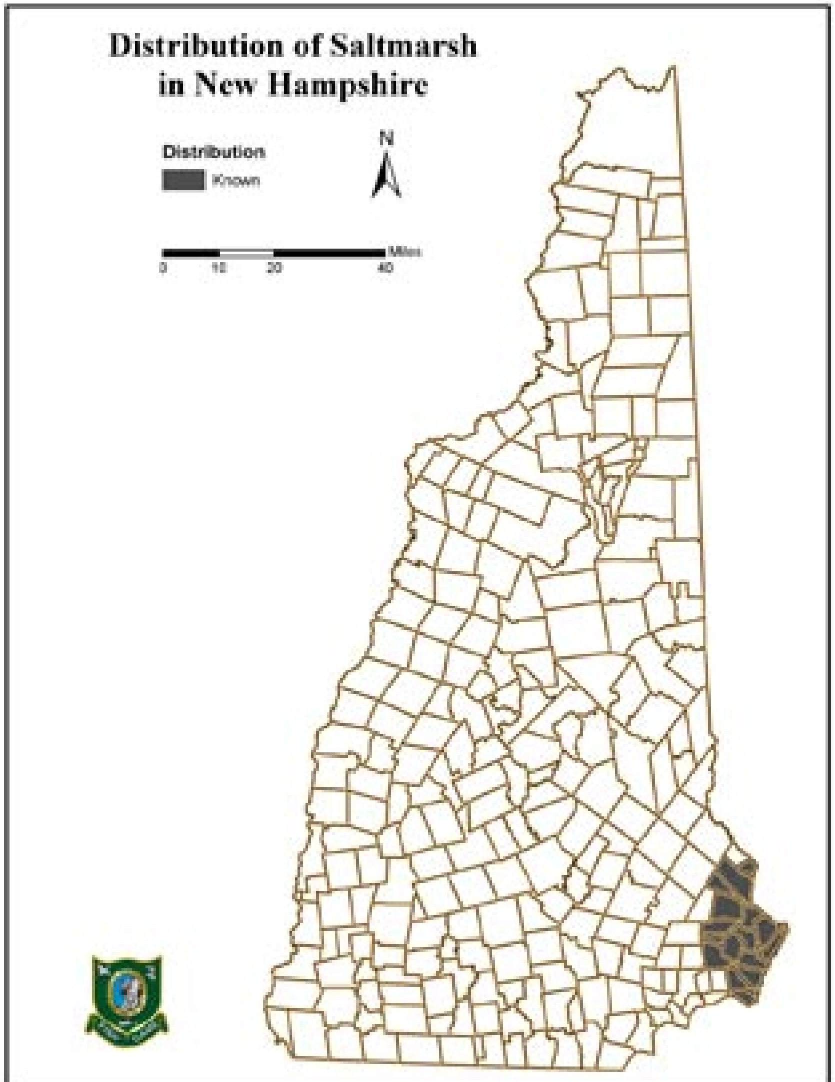

Watershed Groupings:
TIDAL
COASTAL
N
0 15 30 Miles

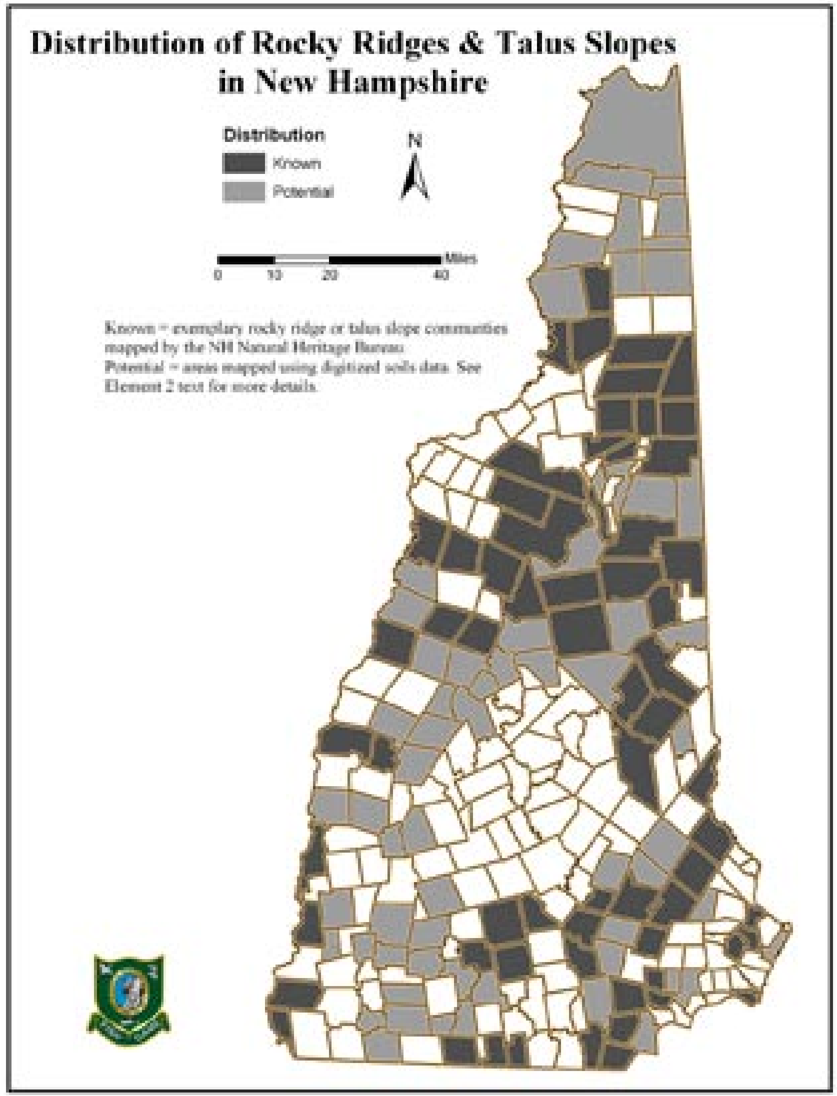

Watershed Groupings:
NORTHERN
UPLAND
N
0 15 30 Miles

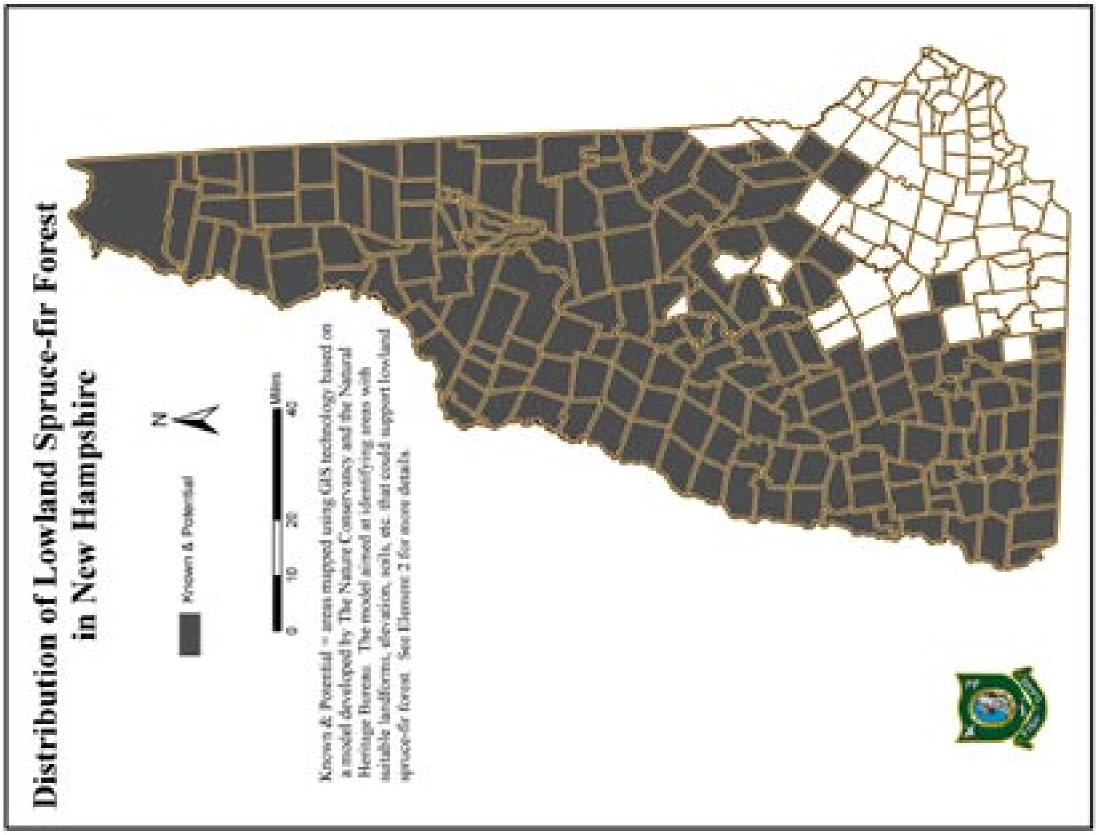

Watershed Groupings:
SOUTHERN
UPLAND
N
0 15 30 Miles

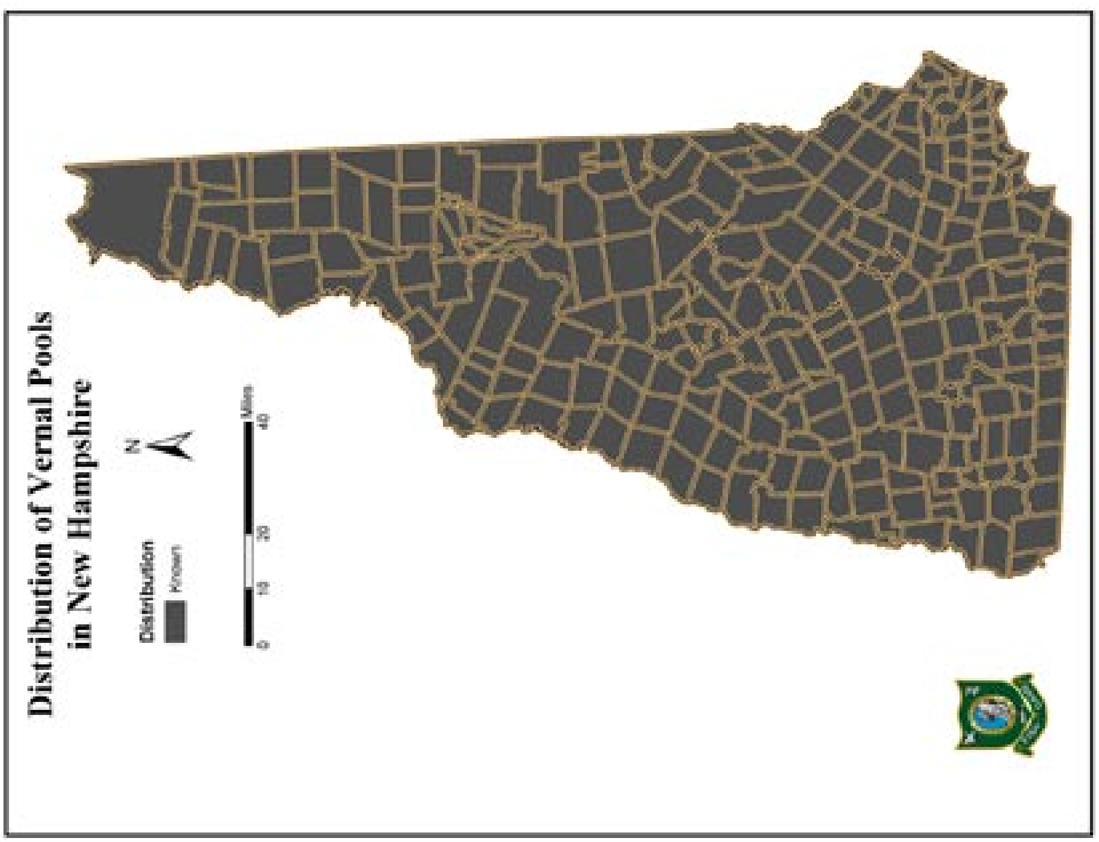

Distribution of Peatlands in New Hampshire
Distribution
Known
Potential
N
0 10 20 40 Miles
Known – areas mapped in the field by NH Natural Heritage Bureau
Potential – areas identified through mapping and analysis of remotely sensed data. See text in Element 2 for more detail.

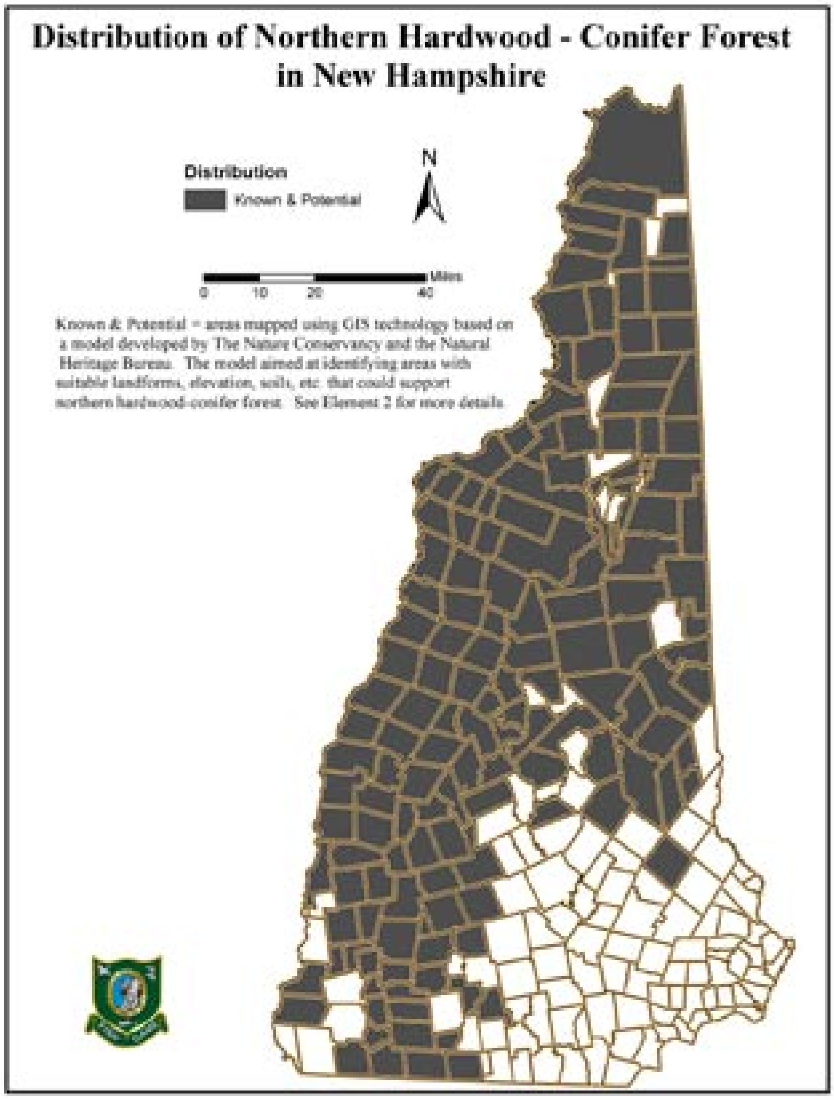

Watershed Groupings: MONTANE
N
0 15 30 Miles


Distribution of Saltmarsh
in New Hampshire
Distribution
Known
N
0
10
20
40
Miles


Distribution of Rocky Ridges & Talus Slopes
in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles
Known = exemplary rocky ridge or talus slope communities
mapped by the NH Natural Heritage Bureau.
Potential = areas mapped using digitized soils data. See
Element 2 text for more details.


Distribution of Lowland Spruce-fir Forest
in New Hampshire
Known & Potential
N
0 10 20 40 Miles
Known & Potential = areas mapped using GIS technology based on a model developed by The Nature Conservancy and the Natural Heritage Bureau. The model aimed at identifying areas with suitable landforms, elevation, soils, etc. that could support lowland spruce-fir forest. See Element 2 for more details.


Distribution of Vernal Pools
in New Hampshire
Distribution
Known
N
0 10 20 40 Miles



Distribution of Northern Hardwood - Conifer Forest in New Hampshire
Distribution
Known & Potential
N
Miles
0
10
20
40
Known & Potential = areas mapped using GIS technology based on a model developed by The Nature Conservancy and the Natural Heritage Bureau. The model aimed at identifying areas with suitable landforms, elevation, soils, etc. that could support northern hardwood-conifer forest. See Element 2 for more details.