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Ecological Inventory of Fall Mountain State Forest

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A Quick Overview of the NH Natural Heritage Bureau's Purpose and Policies

The New Hampshire Natural Heritage Bureau is mandated by the Native Plant Protection Act of 1987 (NH RSA 217-A) to determine protective measures and requirements necessary for the survival of native plant species in the state, to investigate the condition and degree of rarity of plant species, and to distribute information regarding the condition and protection of these species and their habitats.

The Natural Heritage Bureau provides information to facilitate informed land-use decision-making. We are not a regulatory agency; instead, we work with landowners and land managers to help them protect the State's natural heritage and meet their land-use needs.

The NH Natural Heritage Bureau has three facets:

Inventory involves identifying new occurrences of sensitive species and classifying New Hampshire's biodiversity. We currently study more than 600 plant and animal species, 196 natural communities, and 46 natural community systems. Surveys for rarities and/or communities on private lands are conducted only with landowner permission.

Tracking is the management of occurrence data. Our database currently contains information about more than 4,000 plant, animal, natural community, and system occurrences in New Hampshire.

Interpretation is the communication of Natural Heritage Bureau information. Our goal is to cooperate with public and private land managers to help them *protect* rare species populations and exemplary natural communities and systems.

Cover: ***Scirpus ancistrochaetus*** *habitat at North Pond. Photo by Pete Bowman.*

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SUMMARY

In 2005, the NH Department of Resources and Economic Development's Division of Forests and Lands accepted a donation from The Nature Conservancy (TNC) of a 950-acre property on Fall Mountain, in the towns of Charlestown and Langdon. TNC acquired this property primarily to protect the habitat of *Scirpus ancistrochaetus* (northeastern bulrush), a federally-endangered plant known from only eight populations in New Hampshire. The property had been identified as harboring three of these populations, and after the transfer to the state was designated Fall Mountain State Forest (FMSF).

In 2006, the New Hampshire Natural Heritage Bureau conducted an ecological inventory of the new state forest. The purpose of this survey was to gather data on the floristic and ecological diversity of FMSF, which would then inform the development of a management plan for the property. As a result of the inventory, one exemplary natural community was identified, as well as three rare plant populations (in addition to the *Scirpus ancistrochaetus* (northeastern bulrush)).

INTRODUCTION

The NH Natural Heritage Bureau, in the NH Division of Forests and Lands, facilitates the protection of New Hampshire's rare plants, exemplary natural communities (which are outstanding examples of different types of forests, wetlands, grasslands, etc.) and natural community systems. Our mission, as mandated by the Native Plant Protection Act of 1987 (RSA 217-A), is to determine protective measures and requirements necessary for the survival of native plant species in the state, to investigate the condition and degree of rarity of plant species, and to distribute information regarding the condition and protection of these species and their habitats.

During the summer of 2006 the NH Natural Heritage Bureau (NHB) conducted an ecological inventory and assessment of **Fall Mountain State Forest** (FMSF), a 955-acre property in the towns of Charlestown and Langdon, which is located on a broad ridge above the Connecticut River. This property was recently acquired by the state from The Nature Conservancy (TNC), who purchased it in order to protect populations of the federally-endangered plant *Scirpus ancistrochaetus* (northeastern bulrush). As a newly acquired property with known populations of a federally listed species, FMSF was identified as a high priority for a NHB inventory. Funding for the project was provided by the Division of Forests and Lands through the Forest Management and Protection Fund.

METHODS

LANDSCAPE ANALYSIS

The landscape analysis process identified areas that were particularly likely to contain features of interest and allowed us to prioritize survey areas to increase the efficiency of field visits. Information sources used during landscape analysis included National Wetland Inventory maps, surficial (Goldthwait 1950) and bedrock (Lyons *et al*. 1997) geological maps, soil surveys (NRCS 2001), land cover data (GRANIT 2001), and USGS topographic quadrangles. Digital coverages of some of these data layers, used with GIS computer mapping software (ArcView v.3.3a), allows rapid comparison and integration of information from different sources. The NHB database was queried to identify specific locations of known rare species and exemplary natural communities within potential study areas. Finally, aerial photographs were reviewed to determine vegetation patterns and conditions.

FIELD SURVEY

Data were collected at specific locations called observation points (OPs) during field surveys. The following information was collected at most observation points:

1. natural community system type, following Sperduto (2005);

2. natural community type, following Sperduto and Nichols (2004);
3. identification of all native and non-native plant species;
4. percent coverage estimates for all plant species;
5. other descriptive notes, including soil descriptions and other physical site characteristics, evidence of human disturbance, size of the community, and wildlife evidence.

Most plants were identified in the field during the inventory; others were collected and keyed out using the resources available at NHB. Vascular plant nomenclature generally follows the Flora of North America Editorial Committee (1993a, 1993b, 1997, 2000, 2002a, 2002b, 2002c, 2003), then Gleason and Cronquist (1991), and occasionally Fernald (1950), with common names generally following George (1998).

A Global Positioning System (GPS) was used to determine both the location of observation points in each natural community type and the location of rare plant populations in the study area. A GPS unit was also used to determine the location of invasive plant populations. The accuracy of the data collected by the GPS was generally within 15 meters. Field data and site locations of exemplary natural communities and rare plant populations have been catalogued and incorporated into the NHB database.

A more detailed description of NHB's ecological approach can be found in Appendix 1.

RESULTS

NATURAL SETTING OF FALL MOUNTAIN STATE FOREST

Fall Mountain State Forest is located in western New Hampshire, within the Vermont-New Hampshire Uplands Section (see Figure 1)[1]. This section consists of an area extending from Vermont and New Hampshire south into Massachusetts. It is distinguished from surrounding areas by particular climatic, geomorphological, and vegetative characteristics, and has been further divided into "subsections" using finer-scale physical and biological criteria (Keys and Carpenter 1995). FMSF falls into the Northern Connecticut River Valley subsection, which in New Hampshire forms a narrow band along the Connecticut River and is filled with glacial outwash and lake deposits that abut lower slopes of adjacent hills comprised of glacial till

[1] **Sections** are landscape divisions developed by the U.S. Forest Service that cover tens of thousands of square miles and have similar biological and physical characteristics – particularly climate, topography, and soils – and broad distribution patterns of plants and animals (Keys and Carpenter 1995). New Hampshire lies within three sections: White Mountains; Lower New England/Northern Piedmont; and Vermont-New Hampshire Uplands. Sections consist of aggregations of finer-scale subsections that share numerous natural communities uncommon in or absent from adjacent sections.

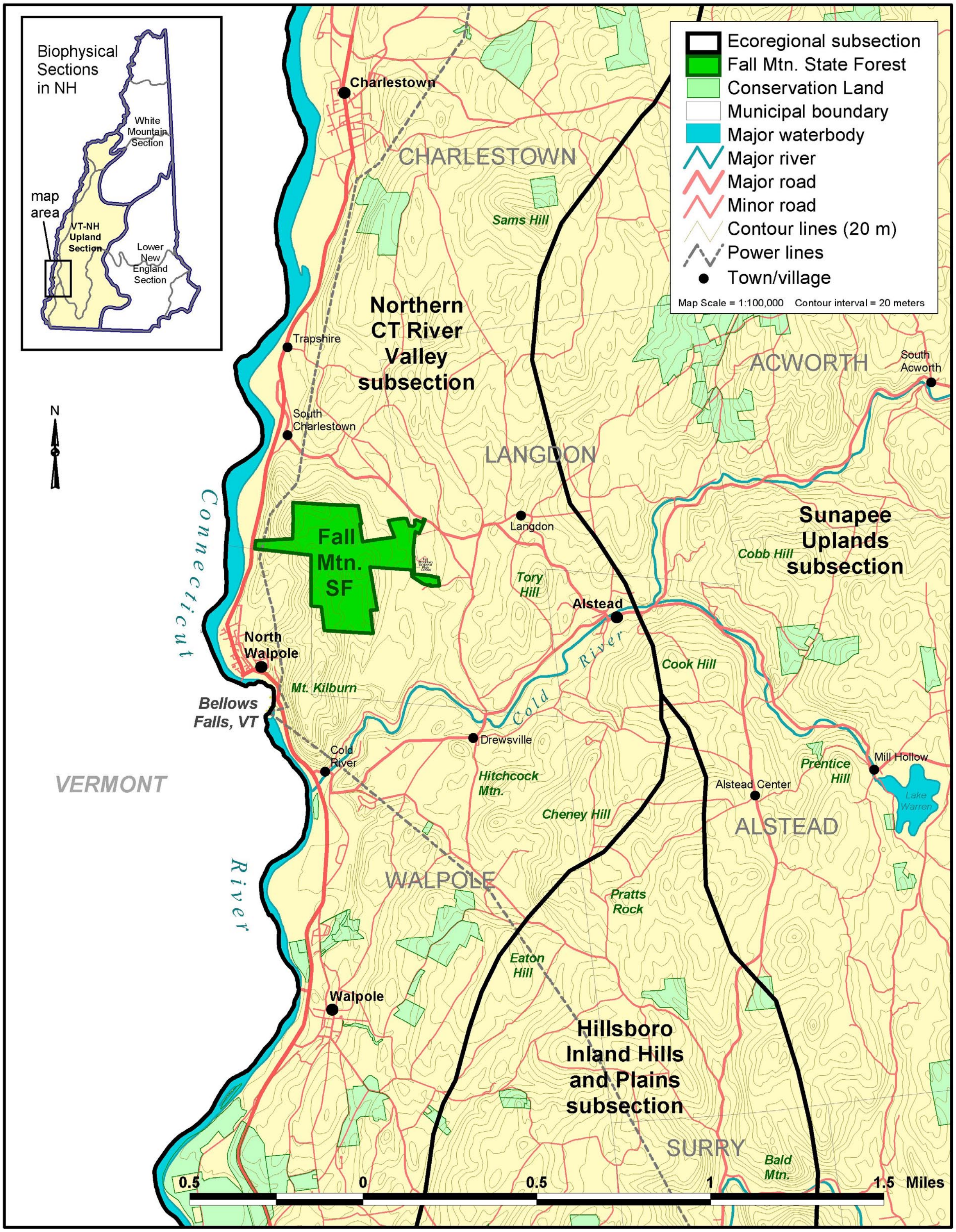

Figure 1. Ecoregional context of Fall Mountain State Forest in southwest New Hampshire.

(Sperduto and Nichols 2004). However, Fall Mountain itself shares many characteristics with the nearby Sunapee Uplands subsection, which is characterized by isolated hills and peaks of hard, resistant rock, with generally shallow and stony soils.

Fall Mountain is a broad ridge that is oriented parallel to the Connecticut River. The uneven summit ridge is characterized by numerous small hillocks and hollows, with the highest point at roughly 1115 ft. elevation. Mountain Brook runs from north to south between the main summit ridge to the west, and a second ridge of hilltops to the east, and is impounded in several locations by beaver, creating or enhancing a string of open ponds and emergent wetlands. The state forest occupies most of the northern half of the ridge, which includes all of the significant wetlands on the brook. South of the property, the summit of the ridge narrows to a point at Mt. Kilburn, which features dramatic cliffs on the western slopes above the Connecticut River.

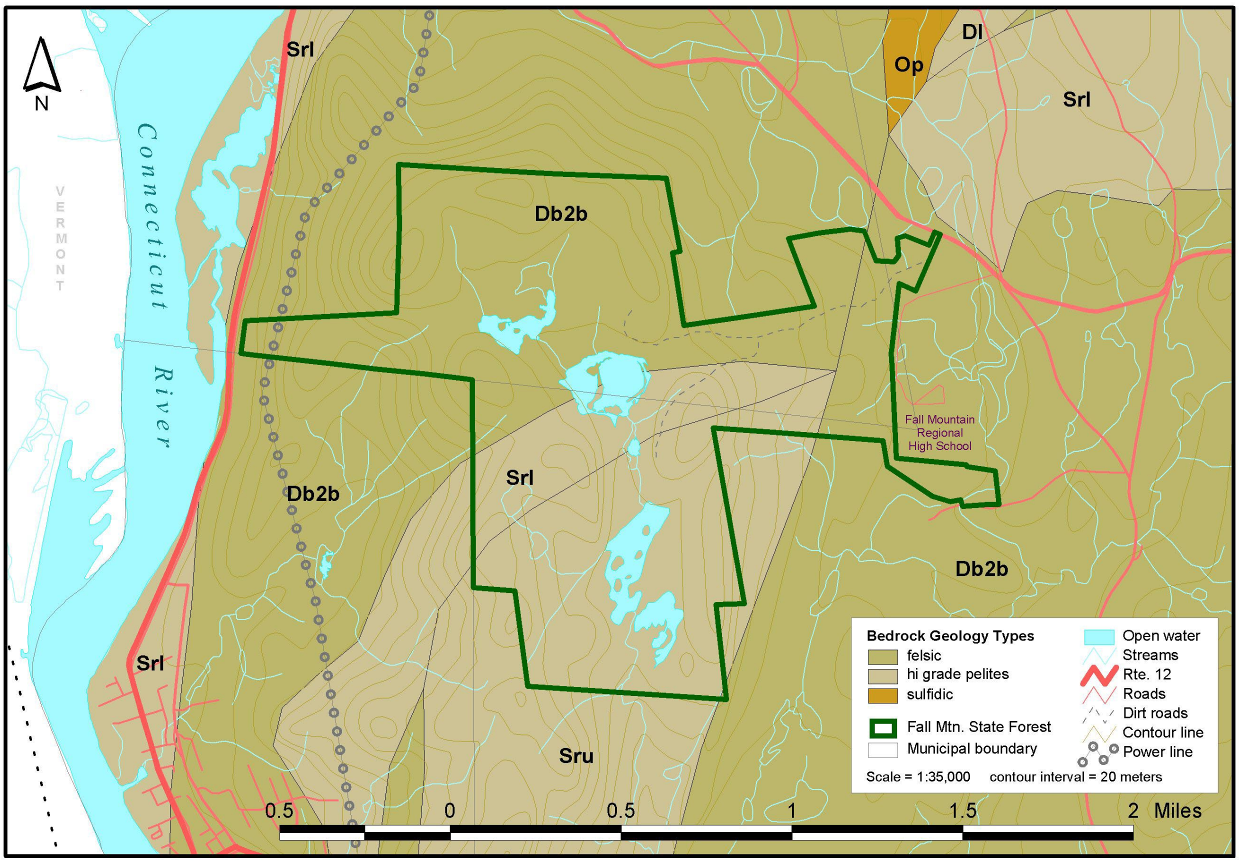

Figure 2. Bedrock Geology at Fall Mountain State Forest.

Geology and Soils

The bedrock of FMSF is divided into two major formations (Figure 2). The southern half of the property is underlain by rocks in the Rangeley Formation. This formation consists primarily of schists, with some metasandstones. These highly metamorphosed sedimentary rocks are collectively referred to as high-grade pelites, and in New Hampshire, the weathering of this type of rock happens slowly, and generally leads to acidic soil conditions with low nutrient levels. The bedrock under the northern half of the property is Bethlehem granodiorite, an igneous rock that occurs as sheet-like horizontal intrusions within the surrounding metasedimentary layers (Kruger 1946). The lithography of these igneous rocks is categorized as felsic, which are high in silica content (>65%), and like the high-grade pelites, they tend to weather slowly and produce acidic soil conditions with low nutrient availability for plants. Although nutrient poor conditions tend to prevail on sites derived from these bedrock types, locally enriched conditions are still possible due to fine-scale variation in topographic position, geologic composition, and/or the degree of fracturing of the parent bedrock and amount of groundwater flow within it. The soils across most of FMSF are sandy loams derived from glacial till and are very stony (Figure 3). They are primarily in the Lyman and Monadnock soil series, and are interspersed with areas of exposed bedrock in such an intricate pattern that they are mapped as a single unit (Shook 1983). Lyman soils are generally shallow and somewhat excessively drained, while Monadnock soils are deeper and well drained.

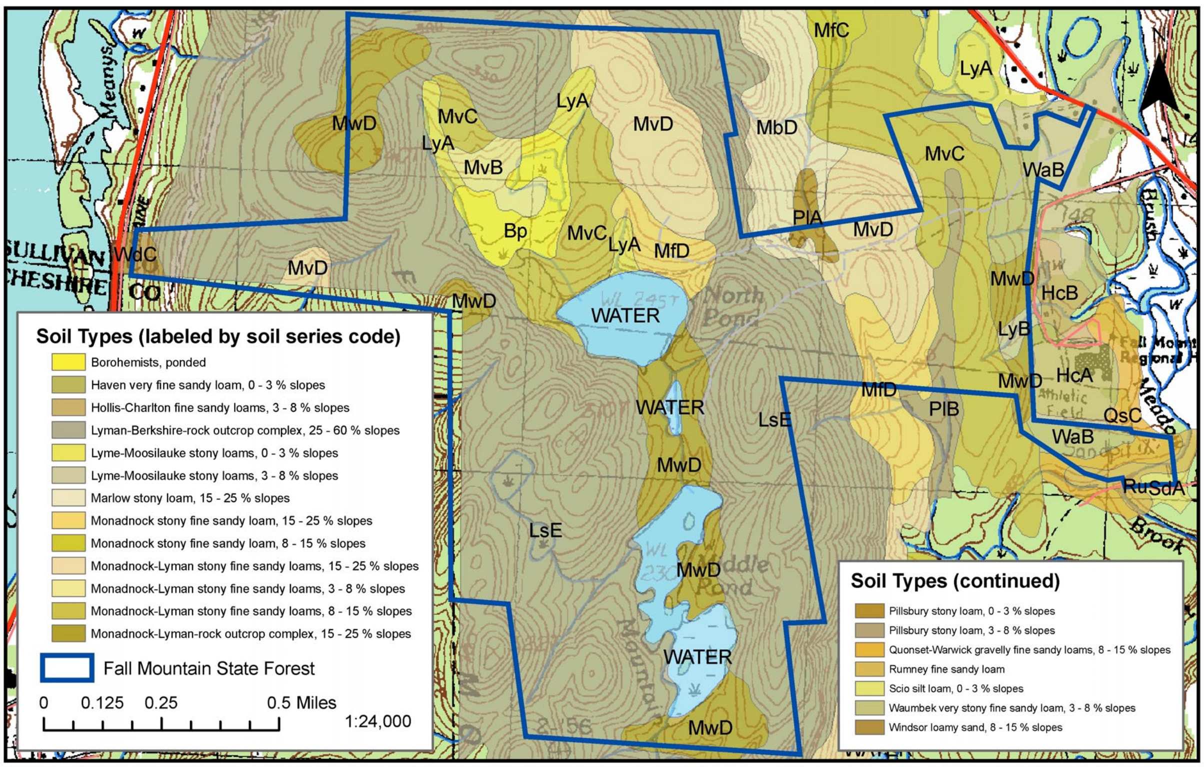

Figure 3. Soil Types at Fall Mountain State Forest.

VEGETATION

Fall Mountain State Forest is near the boundary of two ecological subsections, and this is reflected in the transitional nature of the vegetation on the site. The dominant matrix forest community throughout most of southern and central New Hampshire is the ***hemlock - beech - oak - pine forest***. The composition of individual stands within this community type is highly variable, but the dominant species in the tree canopy are generally some mix of *Pinus strobus* (white pine), *Quercus rubra* (red oak), *Tsuga canadensis* (hemlock), and *Fagus grandifolia* (American beech). In contrast, in many areas of the Connecticut and Merrimack River valleys, as well as in southeastern New Hampshire, are forests with a more southern affinity. These forest communities, which can collectively be described as the ***Appalachian oak - pine forest system***, are characterized by the presence of woody plants such as *Quercus alba* (white oak), *Quercus velutina* (black oak), *Quercus montana* (chestnut oak), *Carya ovata* (shagbark hickory), *Sassafras albidum* (sassafras), and *Kalmia latifolia* (mountain laurel), as well as some rare herbaceous species.

At FMSF, most of the upland forests contain elements of both these regional forest types, and reflects the geographic position of FMSF near the northern regional limit of Appalachian oak – pine forest species with more southern centers of distribution. In some areas, white oak occurs as a co-dominant species in the canopy along with red oak and white pine. In other locations, the forest has a more typical ***hemlock - beech - oak - pine forest*** composition, with an abundance of hemlock and beech. In general, because white oak is more distinctly characteristic of a regional type, forests in which white oak is dominant or co-dominant are classified as ***dry Appalachian oak - hickory forest***, even though other southern oak and hickory species may not be present. In the absence of white oak or other southern species, much of the remaining upland forest can be classified as ***dry red oak - white pine forest***. Like many of the communities in the ***Appalachian oak - pine forest system***, this forest type occurs on dry sites and is dependent on some level of disturbance by fire to maintain its species composition. In the absence of fire, shade tolerant species like hemlock and beech would eventually become important components of the canopy.

The forest with the most distinctive southern character at FMSF is the ***rich Appalachian oak rocky woods*** community found along the property corner northwest of North Pond. The tree species composition of this forest is unique on the property, and harbors two rare plant species, *Conopholis americana* (American cancerroot) and *Aureolaria pedicularia* var. *intercedens* (fern-leaved false foxglove). This forest is described below under Exemplary Natural Communities.

The wetland areas at FMSF are extensive, and are primarily associated with Mountain Brook. A series of large open ponds and marshes, totaling roughly 60 acres, occur along the stream. All of these wetlands have been created—or at least modified—and maintained by beaver along this stream. These wetlands are now occupied by a variety of different community types. Areas that are permanently inundated by open water are classified as ***aquatic bed*** or ***deep emergent marsh - aquatic bed*** communities, in which the only vascular plants are floating-leaved species such as *Nymphaea odorata* (white waterlily) and *Potamogeton* spp. (pondweeds), or deep water emergent species such as *Nuphar variegata* (variegated yellow pondlily) and *Pontederia cordata* (pickerel weed). Closer to shore are a series of emergent wetland communities whose composition is determined primarily by water depth and inundation period. These communities include the ***medium-depth emergent marsh***, ***peaty marsh***, ***tall graminoid emergent marsh***, and ***mixed tall graminoid - scrub-shrub marsh***. The species composition of each of these communities is different, but there are a number of common wetland plants that can be found in multiple community types, such as *Dulichium arundinaceum* (three-way sedge), *Sagittaria latifolia* (common arrowhead), *Peltandra virginica* (arrow arum), *Typha latifolia* (common cattail), *Calamagrostis canadensis* (bluejoint), and *Scirpus cyperinus* (woolly bulrush).

These wetlands are most notable for the presence of *Scirpus ancistrochaetus* (northeastern bulrush). This plant is listed as federally endangered, and has been observed at three locations on FMSF. These occurrences are described below under Rare Plant Species. The wetlands are also notable for occurring within a small and relatively isolated watershed. Because the wetland complex is located in a small watershed near the top of a surrounding ring of ridges, and because there is a lack of significant anthropogenic disturbances within the watershed, contamination and sedimentation from runoff are not significant threats to these features.

EXEMPLARY NATURAL COMMUNITIES

Rich Appalachian oak rocky woods (S1)

This community occupies a steep, rocky, south-facing slope around a corner of the property west of North Pond. The species composition of this type differs dramatically from other upland forests at FMSF, reflecting the enriched soil conditions of the site. The dominant species in the tree canopy are *Quercus alba* (white oak) and *Quercus rubra* (red oak), with *Carya ovata* (shagbark hickory) and *Pinus strobus* (white pine) being frequent components. *Ostrya virginiana* (ironwood) is a frequent and characteristic tree in the understory.

These trees occur as a thin canopy (50-60% cover) over a lawn-like herbaceous layer dominated by *Deschampsia flexuosa* (common hairgrass), with *Carex pensylvanica* (Pennsylvanian sedge) present in large patches. *Campanula rotundifolia* (harebell) is an herb characteristic of this community, while species like *Solidago caesia* (blue-stemmed goldenrod) and *Uvularia sessilifolia* (sessile-leaved bellwort) are species typical of somewhat enriched sites. Two rare plants were also observed in this community: *Conopholis americana* (American cancerroot) and *Aureolaria pedicularia* var. *intercedens* (fern-leaved false foxglove). Both of these populations are described below under Rare Plant Species.

This exemplary occurrence represents the northernmost known location for this forest type in New Hampshire, and is probably very near the northern limit of the range for this community. The moderated climate conditions of this part of the Connecticut River valley, the low elevation and southern exposure of the hillside, and possibly local variation in bedrock conditions are likely contributing factors in its occurrence here.

Exemplary ***rich Appalachian oak rocky woods*** community.

A browsed stem of *Aureolaria pedicularia* var. *intercedens* (fern-leaved false foxglove).

Rare Plant Species

Aureolaria pedicularia var. *intercedens* (fern-leaved false foxglove) (Threatened)

Fern-leaved false foxglove is an annual herb of open, rocky habitats including cliffs and ridgetops. It is found at scattered locations in New Hampshire. At FMSF, it occurs as a small population of roughly eight clumps on an open sunny ledge within the exemplary ***rich Appalachian oak rocky woods*** community. All of the plants that were observed had been heavily browsed, and were unlikely to produce flowers. Because it is an annual, there is a concern about the lack of seed production, but there is a good chance that the species will persist at the site.

Bartonia paniculata ssp. *paniculata* (twining screwstem) (Endangered)

Twining screwstem is a small, very fine-stemmed herb which flowers in the fall and grows in mossy swamps and bogs. The observation at FMSF was of a single plant growing on a mossy log along a small stream that drains into the lower portion of Middle Pond. Prior to 2006, there were no records for this species in New Hampshire, but in this year, two separate populations were discovered in different areas in the state, the FMSF population being one of them. The other occurrence is believed to be subspecies *iodandra* (purple screwstem), making the FMSF occurrence the only location in the state for the typical subspecies. The *iodandra* subspecies is generally thought to be a northern form, with a range extending south to Massachusetts, while the subspecies *paniculata* is found to the south. It is unknown how many other states have both subspecies, but the discovery of both in New Hampshire in the same year is rather remarkable.

Conopholis americana (American cancerroot) (Threatened)

American cancerroot is an achlorophyllous root parasite, meaning that it does not use chlorophyll to produce its own food, but rather absorbs nutrients from the roots of other plants. This unusual plant resembles a cluster of pine cones emerging from the forest floor. In New Hampshire, it is found at scattered locations around the state, typically in habitats where organic matter has accumulated and likely produced elevated nutrient levels in the soil. The population at FMSF consists of approximately 12 clumps occurring in a portion of the exemplary ***rich Appalachian oak rocky woods*** community around the base of a steep slope where there is a thick layer of leaves and other forest litter.

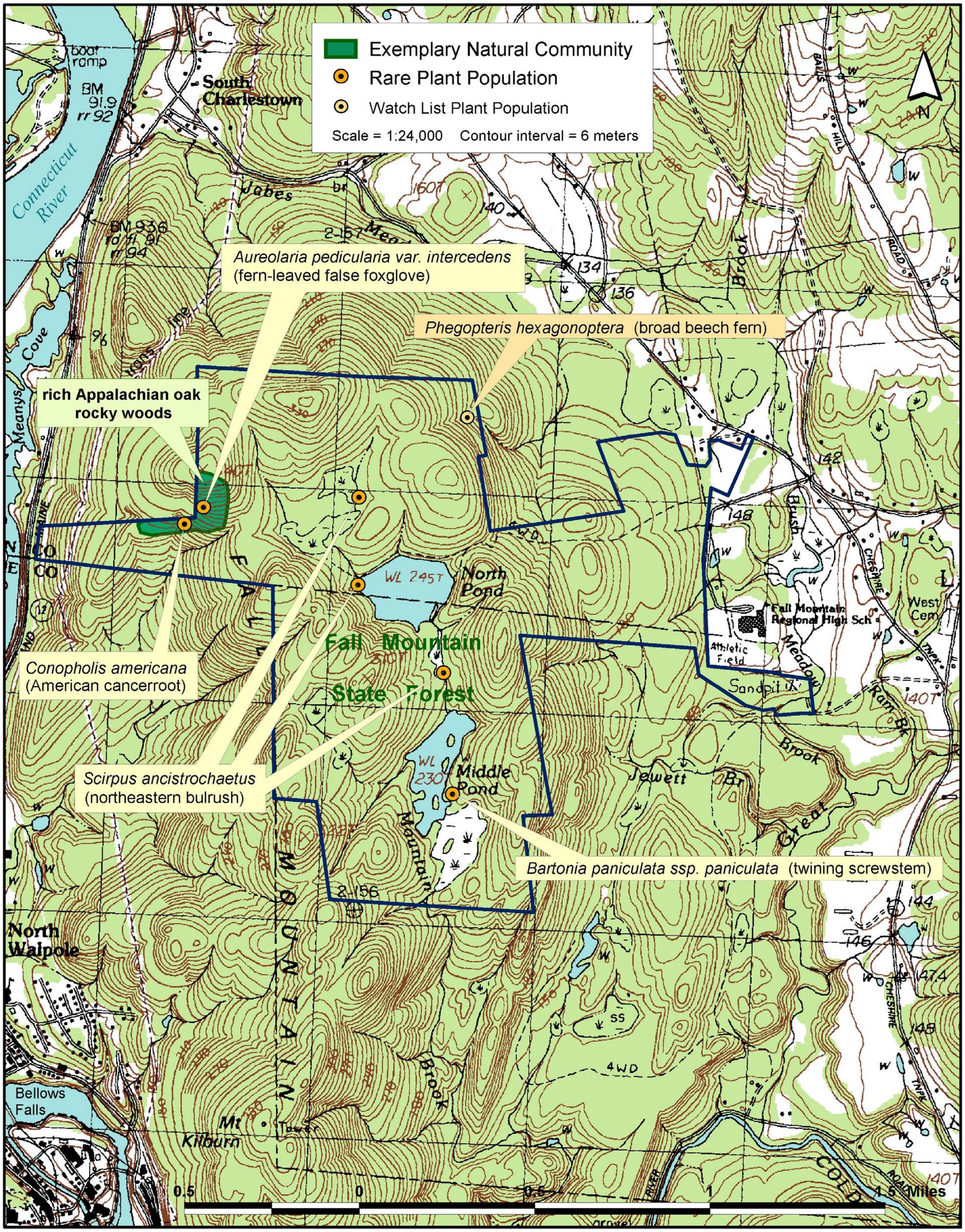

Figure 4. Exemplary natural communities, rare plant populations, and watch list plant populations at Fall Mountain State Forest.

Scirpus ancistrochaetus (northeastern bulrush) (Threatened)

Northeastern bulrush is a rare sedge that is listed as Federally Endangered by the US Fish and Wildlife Service. The presence of three populations of this plant at Fall Mountain is what led to the property being protected by The Nature Conservancy and subsequently transferred to the state. The first two observations of this plant at Fall Mountain were made in 1992. The third occurrence was discovered in 1994.

All three populations were visited in 2005, and again in 2006 as part of this survey. In both years, the results were the same. The population in North Pond was observed in the ***peaty marsh*** at the western end of the pond. However, the other two populations—one in the large beaver wetland northwest of North Pond, and one in a smaller open wetland between North and Middle Ponds—were not seen. The disappearance of these occurrences is a concern, but is not necessarily surprising. According to the *Northeastern Bulrush Recovery Plan* (Copeyon 1992):

> In assessing the survey data from various states, it appears that *S. ancistrochaetus* experiences drastic fluctuations in population size from year to year (in some cases, the plants have "disappeared" for several years before re-emerging).

Apparently, the annual variations in population size are driven by the fluctuating water levels in the plant's preferred habitat, which are the result of a variety of variables, including precipitation and beaver activity. However, the report goes on to say that these variations may be more a problem of perception, in that whole populations may not flower in a given year as a response to environmental conditions. In the absence of flowering culms, the vegetative leaves of this plant may be very difficult to identify in a setting with numerous similar species. Thus, it is likely that the populations that were not observed recently are still present in a vegetative form or as latent seeds in the soil, and will produce reproductive material when hydrologic conditions are suitable.

Scirpus ancistrochaetus (northeastern bulrush). Photo by Bill Nichols.

State Watch

Plants on the state Watch List are not considered rare enough to be tracked in the NHB database. However, they are uncommon (generally having 21-100 natural occurrences in the state), or are vulnerable to becoming threatened due to other considerations (population size and trends, area of occupancy, overall viability, geographic distribution, habitat rarity and integrity, and/or degree of protection).

Phegopteris hexagonoptera (broad beech fern)

Broad beech fern is a distinctive fern that occurs in rich forests. This uncommon species was found on an enriched slope in the northeast corner of the property. The majority of occurrences in New Hampshire are found in the southern portion of the state, particularly along the Connecticut River. Other species indicative of rich forests were seen with *P. hexagonoptera*, including *Adiantum pedatum* (maidenhair fern), *Anemone americana* (blunt-lobed hepatica), and *Actaea pachypoda* (white baneberry), but the site was not large enough to merit designation as a ***rich mesic forest*** community.

Phegopteris hexagonoptera (broad beech fern). Photo by Pete Bowman.

OTHER NATURAL FEATURES

During the field surveys, approximately 10 heron nests were seen in snags in the southern half of Middle Pond. No activity was observed on any of these nests at the time of the inventory, so the occurrence was not entered into the NHB database. However, herons are generally on the nest from April to June (Audubon Society of NH 1994), prior to the timing of these field visits, so the rookery may still be active. A return visit in the spring would be necessary to determine if this is an active nesting site.

MANAGEMENT CONSIDERATIONS

The exemplary ***rich Appalachian oak rocky woods*** community at FMSF occurs further north than any other known occurrence of this type in western New Hampshire. As in other exemplary natural communities, commercial timber harvest should be excluded. However, because this community occurs on a dry slope and has such an open, park-like character, it is possible that some degree of fire is necessary to maintain its structure and composition. The forest should be monitored over time to determine if any structural or compositional changes are taking place as a result of the absence (or exclusion) of natural wildfire. Further research on site history (age structure, fire and cutting history, etc.) would be useful in formulating specific ecological management strategies. The rare species in this community (*Aureolaria pedicularia* var. *intercedens* (fern-leaved false foxglove) and *Conopholis americana* (American cancerroot)) are likely to persist as long as the habitat is maintained, and may benefit from fire (wild or prescribed), particularly the *Aureolaria*.

Similarly, the ***dry Appalachian oak - hickory forest***, which is frequent in the uplands at FMSF, may also require some level of fire disturbance to maintain its composition. Although it is not exemplary by NHB standards, the occurrence of such an extensive area of this southern forest type at the edge of its range is significant. Any management plans or forestry operations should include objectives to maintain or preserve the Appalachian character of these woods (primarily *Quercus alba* (white oak)).

Bartonia paniculata ssp. *paniculata* (twining screwstem)

Because this species was first identified for New Hampshire in 2006, this is a very significant occurrence. However, the population is so small, and so little is known about what distinguishes this spot as suitable habitat, that no reasonable management recommendations can be made for it other than to leave it undisturbed. Hopefully, future surveys will locate other populations that can provide some insight into its preferred habitat characteristics.

Scirpus ancistrochaetus (northeastern bulrush)

According to the 1992 Recovery Plan, the primary threat to Federally Endangered plant *Scirpus ancistrochaetus* (northeastern bulrush) across its range appears to be destruction or modification of its habitat. Although the protection of the property alleviated the threat of habitat destruction, other threats still exist. Other potential anthropogenic threats identified in the plan include alteration of the hydrologic regime, timber harvesting, and off-road vehicles.

Any alteration of the (current) hydrologic regime at FMSF would likely be the result of beaver activity. Although this has been identified as a threat to this species in other states, in many places, including New Hampshire, the plants appear to thrive in beaver created wetlands. It is therefore likely that the plant is adapted to the type of fluctuations associated with beaver ponds. Although conditions in any one location may not be consistently habitable over time considering changes in water level and vegetative succession, it appears that the plant is able to maintain itself somewhere within the broader range of hydrologic conditions driven by beaver activity. Monitoring of populations and status of wetland conditions over time will be important to understanding the plant's long-term requirements at FMSF, as well as potentially locating new populations. This monitoring should occur annually for several years to establish baseline levels for the population sizes, and with reduced frequency of every 3-5 years thereafter.

The Recovery Plan identifies potential impacts to *S. ancistrochaetus* as a result of timber harvesting. The first is that removal of a large number of trees near *Scirpus* habitat could result in alteration of the natural hydrologic regime, because the water that had previously been transpired by the trees subsequent will run into the neighboring pond. Another potential impact of logging is erosion and sediment deposition in wetland habitats. Finally, the disturbance and increased light availability associated with timber harvest may encourage the introduction or spread of invasive exotic plants.

The Deed of Conservation Easement (The Nature Conservancy 2005) associated with this property stipulates a forest management buffer of 200 ft. from streams and along shores of ponds and non-forested wetlands less than 10 acres in size, and 300 ft. along shores of ponds and wetlands greater than 10 acres in size. The implementation of these buffers around *Scirpus* wetlands during timber operations should mitigate any potential impacts. There is one site in Maryland at which logging roads adjacent to wetlands have negatively affected this species through erosion and sedimentation (NatureServe 2006), but presumably appropriate buffers would avoid these impacts elsewhere.

Off-road vehicles are probably the greatest potential threat to *S. ancistrochaetus* rangewide (NatureServe 2006). Although there have not been any obvious impacts to the wetlands at FMSF by ORVs, there are several miles of roads and trails on the property, and the area has likely been utilized by ORV riders for a long time. Periodic monitoring of ORV use at FMSF could help to ensure that *Scirpus* populations are not affected by these activities.

Other management issues

Along the road leading from the parking area to North Pond, several invasive plant species were seen, including *Berberis thunbergii* (Japanese barberry), *Celastrus orbiculatus* (Asian bittersweet), *Elaeagnus umbellata* (autumn olive), *Lonicera* spp. (bush honeysuckle), and *Frangula alnus* (alder-buckthorn). Most of these occurrences were of scattered individuals, and there were no infestations observed away from the disturbed zone of the road. However, implementing some sort of control program in the short term would help reduce the threat of infestation in the forest habitats in the future, and reduce the potential labor commitment required to control the plants should their populations increase.

LITERATURE CITED

Anderson, M., P. Bourgeron, M.T. Bryer, R. Crawford, L. Engelking, D. Faber-Langendoen, M. Gallyoun, K. Goodin, D.H. Grossman, S. Landaal, K. Metzler, K.D. Patterson, M. Pyne, M. Reid, L. Sneddon, and A.S. Weakley. 1998. International Classification of Ecological Communities: Terrestrial Vegetation of the United States. Volume II. The National Vegetation Classification System: List of Types. The Nature Conservancy, Arlington, VA.

Audubon Society of New Hampshire. 1994. Atlas of Breeding Birds in New Hampshire, Carol Foss, ed. Arcadia, Dover, NH.

Chase, V.P., L.S. Deming, and F. Latawiec. 1995. Buffers for Wetlands and Surface Waters: A Guidebook for New Hampshire Municipalities. Audubon Society of New Hampshire, Concord, NH.

Copeyon, C.K. 1992. Northeastern Bulrush (*Scirpus ancistrochaetus*) Recovery Plan, Technical/Agency Draft. U.S. Fish and Wildlife Service, Region Five, Newton Corner, MA.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service. FWS/OBS-79/31.

Fernald, M.L. 1950. Gray's Manual of Botany, Eighth Edition (corrected printing, 1970). Van Nostrand Company, NY.

Flora of North America Editorial Committee. 1993a, 1993b, 1997, 2000, 2002a, 2002b, 2002c, 2003. Flora of North America North of Mexico, Volumes 1, 2, 3, 22, 23, 25, 26, 4. Oxford University Press, NY.

George, G.G. 1998. Vascular Plants of New Hampshire. NH Natural Heritage Inventory, Department of Resources and Economic Development, Concord, NH.

Gleason, H.A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. The New York Botanical Garden, Bronx, NY.

Goldthwait, J.W. 1950. Surficial Geology Map. New Hampshire State Planning and Development Commission, Concord, New Hampshire.

GRANIT. 2001. Preliminary release of land cover data based on LANDSAT Thematic Mapper (TM) imagery, August 2001.

Grossman, D.H., D. Faber-Langendoen, A.S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K.D. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International Classification of Ecological Communities: Terrestrial Vegetation of the United States. Volume I. The National Vegetation Classification System: Development, Status, and Applications. The Nature Conservancy, Arlington, VA.

Keys, J.E. and C.A. Carpenter. 1995. Ecological Units of the Eastern United States: First Approximation. USDA Forest Service.

Kruger, F.C. 1946. The Geology of the Bellows Falls Quadrangle, New Hampshire and Vermont. New Hampshire Planning and Development Commission, Concord, NH.

Lyons, J.B., W.A. Bothner, R.H. Moench, and J.B. Thompson. 1997. Bedrock Geologic Map of New Hampshire. U.S. Geological Survey in cooperation with the U.S. Department of Energy and the State of New Hampshire.

NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 6.0. NatureServe, Arlington, VA. Available http://www.natureserve.org/explorer. (Accessed: October 26, 2006).

New Hampshire Ecological Reserve System Project. 1998a. Protecting New Hampshire's Living Legacy: A Blueprint for Biodiversity Conservation in the Granite State. Concord, NH.

New Hampshire Ecological Reserve System Project. 1998b. An Assessment of the Biodiversity of New Hampshire with Recommendations for Conservation Action. Concord, NH.

Northern Forests Lands Council. 1994. Finding Common Ground: The Recommendations of the Northern Forests Lands Council. Concord, NH.

Shook, Jr., R.A. 1983. Soil Survey of Sullivan County, New Hampshire. U.S. Department of Agriculture, Soil Conservation Service, Claremont, NH.

Sperduto, D.D. 2005. New Hampshire Natural Community Systems. NH Natural Heritage Bureau, Concord, NH.

Sperduto, D.D. and W.F. Nichols. 2004. Natural Communities of New Hampshire. NH Natural Heritage Bureau, Concord, NH. Pub. UNH Cooperative Extension, Durham, NH.

Sperduto, D.D., W.F. Nichols, K.F. Crowley, S.J. Cairns, B.D. Kimball, and L. Chute. 2001. An Ecological Assessment of International Paper Lands in Northern New Hampshire. NH Natural Heritage Bureau, Concord, NH.

Taylor, J., T. Lee, and L. Falk McCarthy, eds. 1996. New Hampshire's Living Legacy: The Biodiversity of the Granite State. New Hampshire Fish and Game Department, Concord, NH.

Appendix 1. NH Natural Heritage Bureau Ecological Approach.

NATURAL COMMUNITIES

The NH Natural Heritage Bureau classifies the landscape with "natural communities," which are recurring assemblages of species found in particular physical environments. Each natural community type is distinguished by three characteristics: (1) a definite plant species composition; (2) a consistent physical structure (such as forest, shrubland, or grassland); and (3) a specific set of physical conditions (such as different combinations of nutrients, drainage, and climate conditions). Natural communities include both wetland types (e.g., red maple basin swamp) and uplands such as woodlands (e.g., rich red oak-sugar maple/ironwood talus woodland) and forests (e.g., hemlock-beech-oak-pine forest).

Across the landscape, natural communities form a mosaic of patches of different sizes. Some tend to be small (such as forest seeps) while others may cover large areas (such as montane spruce - fir forests). Further, boundaries between natural community types can be either discrete (and therefore easily identified in the field) or gradual (thus making some areas difficult to map). Below we describe how and why natural communities are classified and explain the concept of "exemplary" natural communities and their importance to conservation.

NATURAL COMMUNITY CLASSIFICATION

Classifying natural communities enables ecologists, land managers, and others to communicate effectively and to make management decisions regarding ecological systems. Community classification is a powerful tool because it provides a framework for evaluating the ecological significance of pieces of the landscape in both state and regional contexts. Understanding both the rarity of a community within the state and region and the quality of each example is critical to informed conservation planning. As landscape units that share physical and biological characteristics important to many species, natural communities help focus management and conservation attention in an efficient manner, particularly since our knowledge of the individual species in a particular community is often incomplete. In addition, use of a natural community classification can help us understand how ecological processes in one community may affect neighboring communities. For example, knowing that the surrounding upland forest soils are a primary source of nutrients flowing into a poor fen community is important information for land managers to consider when planning management activities.

The classification of natural communities in New Hampshire is based on data from more than 10 years of ecological research by ecologists with NHB and The Nature Conservancy, plus extensive reviews of scientific literature (Sperduto and Nichols 2004). These data have been compiled and used to define natural community types in part through the application of ordination and classification techniques. Most state natural heritage programs continually update their classifications and cooperate with The Nature Conservancy's regional and national ecologists to ensure that natural community types are comparable across state lines.

The names of natural community types generally begin with the dominant or most characteristic plant species, and may include the name of a landscape feature or vegetative structure that is typical of that community. For example, the community type "black gum-red maple basin swamp" refers to a basin swamp (a specific landscape feature, as opposed to a streamside swamp) with black gum *and* red maple in the canopy. In addition, like all Society of American Foresters (SAF) forest cover types, forested natural communities may have many overlapping species and other characteristics, but they are defined by distinct and diagnostic combinations of species and physical characteristics. For example, the red spruce - northern hardwood natural community has considerably more red spruce in the overstory, and is generally higher in elevation, than the standard northern hardwood forest (sugar maple-beech-yellow birch forest natural community) despite many species that occur in both.

NATURAL COMMUNITIES COMPARED TO OTHER CLASSIFICATION SYSTEMS

Many classification schemes are used to define vegetation types or other land units. While many of them have utility for certain purposes, most differ from the natural community classification in terms of their founding principles, attributes, and goals. In the following paragraphs, several of these classification schemes are contrasted with the natural community classification used by NHB.

SAF COVER TYPES

While natural community names can be similar to the names of SAF forest cover types, natural communities are defined using a broader range of considerations. SAF forest cover types are primarily based on dominant tree species, while natural communities are based on all plant species, the structure of these species, and the specific physical environment. Trees are often subtle indicators of their environments. A number of natural communities can be distinguished based largely on trees, and in some cases a difference in tree composition is the main difference between two community types. However, some trees are so broadly adapted that their presence does not precisely indicate site conditions (e.g., white pine or red maple). Differences in tree canopy composition may also primarily relate to cutting or other disturbances.

For example, there are four SAF spruce - fir cover types that correspond to the "montane spruce - fir forest" natural community type. These different cover types primarily relate to stand disturbance history or the successional stage rather than to major environmental differences. The four cover types also do not differentiate between upland spruce - fir forests and spruce - fir swamps. When one considers understory species and soils, upland spruce - fir forests are markedly different from the red spruce/*Sphagnum* basin swamp natural community. In fact, the differences between these two natural communities are more dramatic than the internal differences among the four SAF spruce - fir cover types. SAF cover types are useful, however, for timber management purposes.

National Vegetation Classification System

At a national level, The Nature Conservancy has published a National Vegetation Classification System (NVC; Grossman *et al*. 1998; Anderson *et al*. 1998) that uses a formal classification hierarchy emphasizing differences in both vegetation structure and floristic composition. This system is periodically updated to include new information from more specific natural community classifications developed at the state level, such as the New Hampshire natural community classification. The Federal Geographic Data Committee has adopted a vegetation classification standard derived from the NVC for use by federal agencies, and future development of the classification is expected to be a collaborative effort (Grossman *et al*. 1998). Natural communities are synonymous in scale and in concept to the "association" level of the NVC. The primary difference between the two classifications is that the New Hampshire classification uses environmental characteristics directly in the organizational hierarchy (*e.g.*, floodplain forests and talus slopes), whereas the NVC hierarchy is based primarily on vegetation characteristics alone.

USFWS Wetland Classification

A classification scheme frequently used in wetland and aquatic systems was produced by Cowardin *et al.* (1979) for the U.S. Fish and Wildlife Service (USFWS). In the USFWS system, wetlands and deepwater habitats are defined by their vegetation, substrate, and frequency of flooding in a hierarchy that emphasizes flooding regimes and attributes of vegetation at a coarse scale (e.g., vegetation structure, life-form, persistence, etc.). This classification system is useful because of its applicability to broad geographical regions and because it can be readily applied in conjunction with aerial photograph interpretation. It was the basis for wetland typing in the National Wetland Inventory mapping effort.

Natural community types can typically nest within the hierarchical structure of the USFWS system. In addition to the flooding regimes and coarse vegetation characteristics used to distinguish USFWS types, however, the natural community classification considers factors such as nutrient regime, water source, and geomorphic setting, as indicated by specific differences in floristic composition. For example, under the USFWS system, red maple/*Sphagnum* saturated basin swamps and red maple-black ash/swamp saxifrage seepage swamps would both be considered saturated, palustrine broad-leaved deciduous forested wetlands. This grouping does not reflect important differences between the two communities, including differences in species composition (ground cover by *Sphagnum* versus forb species), nutrient levels (species indicative of nutrient-poor versus minerotrophic conditions), water sources (upland runoff versus groundwater seepage), geomorphic settings (basin depression versus headwater seepage area), and soils (deep peat versus shallow peat over silt). The natural community classification provides additional detail regarding ecological conditions and processes that helps clarify the distribution of biological diversity across the landscape.

Ecological Land Types

Defined to date only for national forest lands in New Hampshire, the U.S. Forest Service's Ecological Land Types (ELTs) emphasize particular soil features, including depositional environment, soil texture, and soil depth. Although some ELTs correspond reasonably well to groups of communities, they are not easily compared to natural communities for five primary reasons. First, ELTs in New Hampshire are limited to uplands. Second, they are mapped as units of 100 or more acres, so natural communities that occur as smaller patches are not detected and often occur within many ELT types. Third, ELTs can be related to general tree species composition, but the composition of other plant species is not considered directly. Fourth, ELTs do not directly reflect the mineral composition of soil and bedrock, whereas natural communities do. Finally, ELTs describe some fine-scale soil characteristics that may have silvicultural significance but sometimes have no known corresponding floristic expression.

EXEMPLARY NATURAL COMMUNITIES

NHB places particular emphasis on and gives conservation priority to "exemplary" natural communities. Exemplary natural communities include all examples of rare types (such as a rich mesic forest) and high-quality examples of common types. High-quality natural communities are identified as having relatively little human impact. These areas have greater potential to contain or achieve natural dynamics that are characteristic of the original community types. A forested natural community need not be "old growth" to obtain exemplary status. Typical exemplary forested natural communities have a variety of characteristic species, natural regeneration within forest gaps, multiple age classes, diverse structural characteristics, abundant standing and fallen woody debris, intact soil processes, and little direct evidence of human disturbance. Such characteristics can only be studied, preserved, and understood by having appropriate reference sites. Further, exemplary natural communities represent the best remaining examples of New Hampshire's flora, fauna, and underlying ecological processes.

The effects of natural disturbances, such as the 1998 ice storm, do not preclude any natural community from being designated exemplary. Damages caused by natural disturbances, including ice storms, blowdowns, and fire, are part of the suite of natural processes influencing natural community dynamics. We take disturbance such as heavy ice damage into account when assessing natural communities, but if a community also displays exemplary attributes, including minimal human influence, then we are likely to classify it as such.

Rarity

NHB considers the rarity of a natural community or a species both within New Hampshire and across its total range. We identify the degree of rarity within New Hampshire with a state rank and throughout its range with a global rank. Ranks are on a scale of 1 to 5, with a 1 indicating critical imperilment, a 3 indicating that the species or natural community is uncommon, and a 5 indicating that the species or natural community is common and demonstrably secure. Species and natural communities considered to be globally rare or state rare are those designated G1-G3 or S1-S3, respectively. Some species are rare both globally and in New Hampshire (e.g., G2 S1), while others are common elsewhere but rare in New Hampshire (e.g., G5 S1). Many communities have not been assigned global ranks at this time, pending a comprehensive review of their status and distribution range-wide.

QUALITY RANKS

In addition to considering the rarity of a natural community or species as a whole, NHB ranks the quality of individual natural community occurrences and rare plant populations. These "Quality Ranks" give a more detailed picture of significance and conservation value. Quality ranks are based on the *size*, *condition*, and *landscape context* of a natural community or rare species population. These terms collectively refer to the integrity of natural processes or the degree of human disturbances that may sustain or threaten long-term survival. There are four quality ranks:

Rank	Description
A	**Excellent Occurrence:** An A-ranked natural community is a large example nearly undisturbed by humans or which has nearly recovered from early human disturbance and will continue to remain viable if protected. An A-ranked rare species occurrence is large in both area and number of individuals, is stable, exhibits good reproduction, exists in a natural habitat, and is not subject to unmanageable threats.
B	**Good Occurrence:** A B-ranked community is still recovering from early disturbance or recent light disturbance by humans and/or may be too small in size to be an A-ranked occurrence. A B-ranked population of a rare species occurrence is at least stable, grows in a minimally human-disturbed habitat, and is of moderate size and number.
C	**Fair Occurrence:** A C-ranked natural community is in an early stage of recovery from disturbance by humans and/or a small sized representative of the particular type of community. A C-ranked population of a rare species is in a clearly human-disturbed habitat and/or small in size and/or number, and possibly declining.
D	**Poor Occurrence:** A D-ranked natural community is severely disturbed by humans, its structure and composition are greatly altered, and recovery is unlikely. A D-ranked occurrence of a rare species is very small, has a high likelihood of dying out or being destroyed, and exists in a highly human-disturbed and vulnerable habitat.

For example, consider a population of a rare orchid growing in a bog that has a highway running along one border. The population may be large and apparently healthy (large *size* and intact *condition*), but the long-term threats posed by disturbance at the bog's edge – its low-quality *landscape context* (pollution from cars and roads, road-fill, garbage, altered hydrology, reduced seed dispersal, etc.) – may reduce the population's long-term viability. Such a population of orchids would receive a lower rank than a population of equal *size* and *condition* in a bog completely surrounded by a forest (i.e., with a higher quality *landscape context*).

NHB, in collaboration with other state heritage programs and The Nature Conservancy, is working to develop quality rank specifications for all of New Hampshire's natural communities and rare plant species. Unfortunately, limited time and incomplete knowledge, both on local and global scales, have prevented the development of thoroughly tested and peer reviewed quality rank specifications for most of New Hampshire's natural communities and rare species.

In the absence of rank specifications for each natural community, NHB uses broad guidelines for assigning preliminary quality ranks. The guidelines for assessing the size, condition, and landscape context for natural communities are described below.

SIZE

Occurrence size is a quantitative measure of area occupied by a species or natural community and accounts for such factors as population abundance, fluctuation, density, and area of occupancy for species. All else being equal, the larger a natural community is, the more viable it will be. Large size is correlated with increased heterogeneity of internal environmental conditions, integrity of ecological processes, species richness and size of constituent species populations and their respective viability, potential resistance to change, resilience against perturbations, and ability to absorb disturbances. Size is used in a relative sense with respect to the range of sizes exhibited by the particular natural community type.

CONDITION

Condition is a combined measure of the quality of reproduction (for species), development/maturity (for communities), degree of integrity of ecological processes, species composition, biological and physical structure, and abiotic physical factors within the occurrence. For example, old growth forests with little anthropogenic disturbance and intact biotic and abiotic factors, structures, and processes, would warrant an “A” rank for condition regardless of size.

Excellent Condition: Old growth or minimally disturbed by human impacts with recovery essentially complete, or in the case of disturbance-maintained communities (e.g., pitch pine/scrub oak barrens), the natural disturbance regime has prevailed continuously with no significant or irreversible alterations by humans; ecological processes, species composition, and structural features are intact.

Good Condition: Mature examples with only minor human impacts or good potential for recovery from relatively minor past human impacts; ecological processes, species composition, and structural features are largely intact.

Fair Condition: Immature examples or those with significant human impacts with questionable recovery potential or in need of significant management and/or time to recover from present condition; ecological processes, species composition, and structural features have been altered considerably but not to the extent that the occurrence is no longer viable if managed and protected appropriately.

Poor Condition: Little long term viability potential.

LANDSCAPE CONTEXT

Landscape context is a combined measure of (a) the quality of landscape structure, (b) the extent (including genetic connectivity), and (c) the condition of the surrounding landscape that influences the occurrence's condition and viability. Dynamic natural community occurrences have a better long-term viability when they are associated with large areas of diverse habitat that support dynamic ecosystem processes. Potential factors to be considered include: (a) the degree of landscape fragmentation; (b) the relationship of a natural community to contiguous wetland or upland natural communities; (c) the influence of the surrounding landscape on susceptibility to disturbance; (d) the relative position in a watershed; (e) susceptibility of the occurrence to pollutants and hydrologic change (Chase *et al*. 1995); and (f) the functional relationship of the natural community to surrounding natural landscape features and larger-scale biotic and abiotic factors. For example, open peatlands are extremely sensitive to nutrient input, basin swamps are moderately sensitive, and streamside/riverside communities and seepage swamps are less sensitive.

In general, landscape condition is weighted towards the immediate 30-300 m (100-1000') buffer area around the natural community where direct impacts of land use may be most significant. The adjacent 1.6-3.2 km^2 (1-2 mi^2) area or relevant watershed area around the natural community is considered to a lesser degree. In turn, the larger area beyond the relevant watershed receives the least consideration. The actual size applied for a natural community varies according to the characteristics of the particular natural community and the specific context of the occurrence in the landscape.

Excellent Landscape Context: Natural community is embedded in a matrix of undisturbed, unfragmented surrounding natural communities that have functional connectivity to the occurrence; past human disturbances that potentially influence the community are minimal or negligible.

Good Landscape Context: Surrounding landscape is largely intact and minimally fragmented, or human disturbance/fragmentation is of a configuration and magnitude that is consistent with maintaining the current condition of the occurrence, or disturbances can be managed to achieve viability.

Fair Landscape Context: Significant human impacts, development, fragmentation, and other disturbances characterize the landscape around the natural community and may affect the long term viability and condition of the occurrence.

Poor Landscape Context: Functional human impacts, fragmentation and loss of natural communities dominate the surrounding landscape; the occurrence is probably not viable, even with management.

NATURAL COMMUNITY SYSTEMS

Natural community systems are repeating associations of natural communities (Sperduto 2005). Systems can be useful for the following reasons: (1) they can be used as a tool to track locations and compare entire sites without having to refer to all communities at a site, particularly when these communities may intergrade and be difficult to map; (2) they allow general classification of a system when detailed information is not available or detailed surveys are not feasible; (3) systems can provide a more practical scale for conservation planning and site comparisons; and (4) systems may be more suitable mapping units than communities for integrating wildlife occurrence data and habitat needs with plant information. The classification and mapping of exemplary natural community systems can therefore be effective at identifying conservation targets of the highest priority.

PROTECTING NEW HAMPSHIRE'S BIODIVERSITY

WHAT IS AND WHY SHOULD WE PROTECT BIODIVERSITY?

WHAT IS BIODIVERSITY?

Biodiversity can be defined as the variety and variability of all living organisms (Taylor *et al*., eds. 1996). Biodiversity includes the entire combination of organisms, their genes, the natural communities in which they live, and the complex interactions among and between organisms and their physical environment. Natural levels of biodiversity may be very high, as in tropical regions with favorable growing conditions and high species counts per unit area. Natural levels of biodiversity can also be very low, where conditions are harsh and few species can survive (such as in deserts and arctic regions). The biodiversity in a given area decreases when species suffer local extinctions, when invasive species form a monoculture that displaces a variety of native species, and when natural habitats (which support the local species) are fragmented or destroyed. On a landscape scale, unique components of biodiversity (such as species or natural communities that only occur within a limited area) are a focal point for conservation efforts.

WHY SHOULD WE PROTECT BIODIVERSITY?

Reasons for biodiversity protection include the following:

- **Direct benefits:** Both individual species and functioning natural communities provide a large array of direct economic and other benefits. These include, but are not limited to: flood prevention, water quality improvement, fire prevention, food, medicines and herbal remedies, genetic resources, recreation, crop pollination, and pest control.

Due to the extensive interactions among all species, even species with no obvious direct benefits to humans may play a critical role in the survival of beneficial species or in the suppression of harmful ones. The loss of a single species, or the disturbance of a natural community, can have extensive and unpredictable consequences.

- **Scientific knowledge:** To understand how ecosystems work, and how human activities impact them, scientists need to be able to study undisturbed systems and the full array of naturally occurring species.

- **Ethics:** Many people believe that all life has an intrinsic right to exist, and humans have a moral obligation to uphold that right.

- **Aesthetics:** Many people value species and their habitats simply for the opportunity to look at them. For these people, quality of life is diminished by the loss of a favorite species or natural area.

WHY FOCUS BIODIVERSITY PROTECTION ON NATURAL COMMUNITIES?

Since communities by definition are assemblages of multiple species (animal and plant), protecting a community provides protection for many individual species. Therefore, if we protect an adequate number of viable examples of each natural community type, we can protect the majority of New Hampshire's species. This is sometimes referred to as a "coarse-filter" approach to protecting biodiversity.

Because the coarse filter can miss some important species, however, it needs to be augmented with a finer filter. The "fine-filter" approach generally focuses on specific rare species whose habitats have not been included in "coarse-filter" areas. By locating populations of these species, and then protecting the natural community examples where they are found, we can successfully protect the full range of biodiversity.

In addition to the living species in a community, "biological legacies" are important elements of natural systems. Biological legacies are organic materials that accumulate over time, such as seed banks, coarse woody debris, and soil nutrients. Topsoil, the layer of mineral earth that contains a large quantity of organic material from the growth, death, and decomposition of plants, is an example of a biological legacy. These legacies take years to develop, yet can be rapidly lost if natural communities are disturbed or natural processes are interrupted. Successful protection of a natural community will usually protect these important landscape features, which would otherwise take many years to replace.

In many cases, protection of one natural community may require protection of groups of adjacent communities within a larger landscape. With the possible exception of large matrix communities, no community is completely self-sufficient. Processes such as erosion, windfalls, fire frequency, and nutrient accumulation are all strongly affected by what happens in adjacent communities. In addition, animal species typically depend on having access to a combination of communities, usually in close proximity: different natural communities provide critical shelter and food at different times of the year.

Even when intact adjacent communities are not required to protect a particular example of a natural community, overall biodiversity protection is greatly enhanced when protected areas include a variety of adjacent and connected communities. In general, long-term community viability increases with the size of protected areas, and certain wide-ranging animals can be supported that would not occur in smaller areas. Edge effects (such as infiltration by invasive species) are also reduced. The importance of scale to effective biodiversity protection is discussed in more depth in Sperduto *et al*. (2001) (see “Protecting Biodiversity on IP Lands in Northern New Hampshire”).

PROTECTING NEW HAMPSHIRE'S BIODIVERSITY

In 1994, the Northern Forest Lands Council (1994) concluded that “maintaining the region's biodiversity is important in and of itself, but also as a component of stable forest-related economies, forest health, land stewardship, and public understanding.” In response to recommendations by the Northern Forest Lands Council, the NH Division of Forests and Lands and the NH Fish and Game Department established the Ecological Reserves System Project. One of the project's primary objectives was to “assess the status of biodiversity in New Hampshire and the extent to which it is protected under the current system of public and private conservation lands” (NH Ecological Reserve System Project 1998a). This question was then explored by a 28-member Scientific Advisory Group, who took the question beyond the northern forest and considered it in a statewide context. The conclusions of the group indicated that there was a serious need for continued biodiversity conservation in New Hampshire (NH Ecological Reserve System Project 1998b):

> Though conservation lands comprise approximately 20% of the land area in New Hampshire, the current system of conservation lands in New Hampshire does not appear to provide comprehensive, long-term protection of biodiversity at the species, natural community, or landscape levels.

NHB strives to facilitate protection of the state's biodiversity through the protection of key areas that support rare species, rare types of natural communities, and high quality examples of common natural community types. Exemplary natural communities are particularly important because we assume that, if we protect an adequate number of viable examples of each natural community type, we can protect the majority of New Hampshire's species. This is sometimes referred to as a “coarse-filter” approach to protecting biodiversity.

The coarse filter can miss important species, however, so it needs to be augmented with a finer filter. The “fine-filter” approach generally focuses on specific rare species. For example, the rare, federally threatened *Isotria medeoloides* (small whorled pogonia) occurs in a variety of second-growth hardwood forests in southern New Hampshire. This orchid’s habitat may not be captured by the coarse-filter approach, so we need to employ a fine-filter approach (i.e., survey for the plant itself) to ensure that the species is protected.

Long-term protection of New Hampshire's species, natural communities, and ecological processes requires a variety of conservation approaches. The goal of NHB's coarse- and fine-filter approaches is to inform management decisions by identifying those sites that have a relatively greater potential for maintaining the natural diversity within the state.

The foundation for successful biodiversity protection is a series of representative, high-quality examples of all the state's natural community types, with their constituent species and their underlying ecological processes. The best option for this kind of protection would be a series of connected, high-quality natural community types; this series would ensure that ecological processes that connect natural communities remain functionally intact within a broader landscape context. In short, there is a need for reserve areas with natural communities protected within a diverse landscape, not just in isolation.

NH Natural Areas

The Department of Resources and Economic Development (DRED) places the lands it manages into four principal categories based on general land use: agricultural lands, conservation easements, forestry lands, and recreation lands. Within DRED, the Division of Forests and Lands (NH DFL) actively manages and classifies forestry lands, and occasionally recreation lands, into resource areas according to recognized resource values or dominant natural features. During forest inventory and forest management work when this zoning is established, NH DFL may designate particular sections of a property as belonging to a natural preserve area.

A natural preserve area, or natural area, is defined as an area that “has retained its natural character, although not necessarily completely undisturbed, and/or which contains floral, faunal, ecological, or geological features of global, national, regional, and/or statewide significance of scientific and/or educational interest” (NH DRED 1996). Beyond this definition, formal specifications have not yet been developed for the establishment of natural preserves on DRED lands. Proposed criteria to govern these designations include the following (NH DRED 1995):

A. Sites which provide habitat for rare or endangered species;

B. Sites that contain a rare natural community or high quality representative of a common natural community, or larger landscape units containing important combinations of communities and/or species;

C. Sites largely undisturbed by humans or largely recovered from human disturbance;

D. Sites which provide habitat for large numbers or uncommon associations of native plant and animal species; and

E. Sites with special geological or paleontological significance.

Appendix 2. Explanation of Global and State Rank Codes.

Ranks describe rarity both throughout a species' range (globally, or "G" rank) and within New Hampshire (statewide, or "S" rank). The rarity of sub-species and varieties is indicated with a taxon ("T") rank. For example, a G5T1 rank shows that the species is globally secure (G5) but the sub-species is critically imperiled (T1).

Code	*Examples*		*Description*
1	G1	S1	Critically imperiled because extreme rarity (generally one to five occurrences) or some factor of its biology makes it particularly vulnerable to extinction.
2	G2	S2	Imperiled because rarity (generally six to 20 occurrences) or other factors demonstrably make it very vulnerable to extinction.
3	G3	S3	Either very rare and local throughout its range (generally 21 to 100 occurrences), or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction because of other factors.
4	G4	S4	Widespread and apparently secure, although the species may be quite rare in parts of its range, especially at the periphery.
5	G5	S5	Demonstrably widespread and secure, although the species may be quite rare in parts of its range, particularly at the periphery.
U	GU	SU	Status uncertain, but possibly in peril. More information needed.
H	GH	SH	Known only from historical records, but may be rediscovered. A G5 SH species is widespread throughout its range (G5), but considered historical in New Hampshire (SH).
X	GX	SX	Believed to be extinct. May be rediscovered, but evidence indicates that this is less likely than for historical species. A G5 SX species is widespread throughout its range (G5), but extirpated from New Hampshire (SX).

Modifiers are used as follows.

Code	*Examples*		*Description*
Q	G5Q	GHQ	Questions or problems may exist with the species' or sub-species' taxonomy, so more information is needed.
?	G3?	3?	The rank is uncertain due to insufficient information at the state or global level, so more inventories are needed. When no rank has been proposed the global rank may be "G?" or "G5T?"

When ranks are somewhat uncertain or the species' status appears to fall between two ranks, the ranks may be combined. For example:

G4G5	The species may be globally secure (G5), but appears to be at some risk (G4).
G5T2T3	The species is globally secure (G5), but the sub-species is somewhat imperiled (T2T3).
G4?Q	The species appears to be relatively secure (G4), but more information is needed to confirm this (?). Further, there are questions or problems with the species' taxonomy (Q).
G3G4Q S1S2	The species is globally uncommon (G3G4), and there are questions about its taxonomy (Q). In New Hampshire, the species is very imperiled (S1S2).