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# Ecological Inventory of Pisgah State Park

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

The New Hampshire Native Plant Protection Act (RSA 217-A) declared that native plants should be protected and conserved for human need and enjoyment, the interests of science, and the economy of the state. The state maintains and enhances populations of native plants to insure their perpetuation as viable ecosystem components.

The Natural Heritage Bureau administers the Native Plant Protection Act. Natural Heritage collects and analyzes data on the status, location, and distribution of rare or declining native plant species and exemplary natural communities in the state. More than 600 plant and animal species and 120 natural communities are currently under study. The Natural Heritage database contains information about more than 4,000 plant, animal, and natural community occurrences in New Hampshire.

In addition, Natural Heritage develops and implements measures for the protection, conservation, enhancement, and management of native New Hampshire plants. State agencies assist and cooperate with the Natural Heritage Bureau to carry out the purposes of the Native Plant Protection Act. The Natural Heritage Bureau also assists and advises the private sector upon request.

*Cover: Pisgah Reservoir. (Photo by Pete Bowman)*

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## SUMMARY

The New Hampshire Natural Heritage Bureau conducted an ecological inventory of Pisgah State Park (Pisgah) from 2006 and 2008. The 13,400-acre property is located in the towns of Winchester, Chesterfield, and Hinsdale in southwestern New Hampshire. The purpose of the survey was to gather data on the floristic and ecological diversity of Pisgah, which the Division of Forests and Lands would use to inform the management of the property. The survey identified two exemplary natural community systems and three rare plant populations in the park.

## BACKGROUND

The Natural Heritage Bureau (NHB) protects and conserves New Hampshire's rare plants, exemplary natural communities[1], and natural community systems under the auspices of the Native Plant Protection Act (RSA 217-A). The NHB program encompasses four elements. First, NHB collects and analyzes data on the status, location, and distribution of rare and declining native plant species and exemplary natural communities. Second, NHB determines if any species of plant or any community requires protection. Third, NHB develops and implements measures for the protection, conservation, enhancement, and management of native plants. Fourth, NHB acts as an information resource program to assist and advise state and local agencies, and private sector development projects upon request.

NHB conducted an *Ecological Analysis of NH State Lands* (Crowley and Sperduto 2001) to identify state-owned lands with the highest priority for ecological inventory. One of the properties identified as the highest priority (Tier 1) was Pisgah State Park (Pisgah), a 13,400-acre property in the towns of Winchester, Chesterfield, and Hinsdale in southwestern New Hampshire. Pisgah State Park is a popular outdoor recreation destination with an extensive network of hiking, skiing, and motorized trails. NHB conducted an ecological inventory and assessment of Pisgah from 2006 and 2008, with the goal of locating and identifying occurrences of rare plant species, exemplary natural communities, and natural community systems.

## METHODS

### LANDSCAPE ANALYSIS

NHB conducted an initial landscape analysis to identify areas with the greatest potential to contain features of interest. This process allowed NHB to prioritize survey areas to increase the efficiency of field visits. Information sources used during the landscape analysis included National Wetland Inventory (NWI) maps, surficial (Goldthwait 1950) and bedrock (Lyons *et al*. 1997) geologic maps; soil surveys (NRCS 2001), land cover data (GRANIT 2001), and USGS topographic quadrangles. Digital layers of some of these data, used with GIS computer mapping software (ArcView), allowed rapid comparison and integration of information from different sources. In addition, NHB queried the Natural Heritage database to identify specific locations of known rare species and exemplary natural communities within Pisgah State Park. NHB then reviewed aerial photographs to determine vegetation patterns and conditions, and assessed forest stand type and condition information provided by the Department of Resources and Economic Development Division of Forests and Lands (see Appendix 3).

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[1] Exemplary natural communities are the highest quality occurrences of each type in the state. For rare natural community types, the Natural Heritage Bureau considers all viable occurrences as exemplary. For more common community types, the Natural Heritage Bureau designates only higher quality examples as exemplary (those of good or excellent quality).

NHB examined the site's geographic context, including its location within the state and elevation gradients within the property. This narrowed the range of natural communities and plant species that have the potential to occur on the property. Next, NHB looked for patterns of dominant communities and embedded features. The combination of aerial photographs, topographic maps, soil surveys, elevation range, and forest stand data helped form a picture of the dominant forest cover and probable corresponding natural community types. Aerial photographs were particularly useful for identifying evidence and location of past forest management and agricultural activities, and general forest stand maturity. Forested areas with few indicators of recent management and correspondence to unusual settings or conditions were of greatest interest, and deemed most likely to harbor exemplary natural communities or rare plant species.

The distribution, abundance, and characteristics of smaller patch features embedded in the dominant forest matrix were of particular ecological interest. Small, embedded features often contribute a large proportion of the diversity of species. These features include wetlands, drainages, floodplains, enriched forests, rocky ridges and outcrops, steep slopes, and sand plains.

Mineral enriched areas (i.e., rich sites) support numerous uncommon and rare plants and communities. Rich sites occur where bedrock type, topographic position, soil moisture, and the accumulation of organic matter (colluvium) combine to enrich the soil. Calcium is the mineral most closely associated with enriched conditions in New Hampshire, and bedrock types having a carbonate-bearing lithology have the greatest potential to provide this nutrient. Rocks in the intermediate and mafic lithologic categories can also produce enriched soils, as well as rock types that undergo chemical weathering at higher rates. NHB used topographic maps to identify various features often associated with enriched conditions on the ground. The bases of steep slopes, benches on slopes, and coves were of interest because they accumulate organic matter, water, and nutrients. Steep, rocky slopes with highly fractured bedrock near the surface were also of interest because they may support rich site plants adapted to rocky conditions. Finally, NHB used soil survey data to identify soil types that may have elevated levels of mineral enrichment, such as silt or loam soils.

In addition to supporting enriched communities, steep slopes may indicate the presence of a number of uncommon cliff and talus communities. These slopes may also support areas of undisturbed (old-growth) forest condition because of the difficulty of conducting timber management activities on steep terrain. NHB identified areas of steep slopes at Pisgah State Park through the visual examination of topographic maps.

NHB targeted wetlands, including stream and river corridors, for surveys because of the diversity of communities and species they support. NHB consulted NWI and soil maps to identify wetland locations, broad vegetation types, and hydrologic classifications. NWI and soil maps were useful for predicting natural communities, although they were not diagnostic. In addition to NWI maps, NHB used topographic maps to determine wetland size, landscape position, and setting (i.e., degree of isolation, connectedness to streams, association with water bodies), and aerial photo signatures to predict probable natural community types. NHB elected to inventory wetlands based on the potential for uncommon or rare community types, and the potential to constitute exemplary occurrences of more common communities.

### FIELD SURVEY

NHB conducted initial field data collection in the areas prioritized by the landscape analysis. However, NHB recognized that remote landscape analysis is inherently limited and risks missing important communities. Consequently, NHB conducted additional field inventories to obtain representative information on all apparent natural communities at Pisgah State Park, and to establish landscape context.

NHB designed field survey routes to encompass targeted high priority destinations, and to ensure intersection with representative areas of medium and lower priority. Field staff collected data at locations representative of the surrounding natural community, when there was an apparent change in community type, and when there was a significant change in apparent ecological condition. NHB ecologists used their knowledge and experience to identify parts of the study area most interesting ecologically (e.g., rare or uncommon communities; large, high integrity communities), and focused attention on these locations. The survey was modified in transit to investigate small-scale habitat conditions not identified by the landscape analysis (e.g., seeps, small areas of enrichment, rocky outcrops, and plant species indicative of particular conditions).

NHB collected the following data at 635 observation points at Pisgah State Park:

1. Natural community system type (Sperduto 2005)
2. Natural community type (Sperduto and Nichols 2004)
3. Identification of all native and non-native plant species
4. Percent cover estimates for all plant species
5. Other descriptive notes including information on soils and other physical site characteristics, evidence of human disturbance, size of the community, and wildlife

Staff ecologists identified most plant species *in situ*. Other plant species were collected, pressed, and keyed using 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). Voucher specimens of rare plants were retained for deposit at the University of New Hampshire Hodgdon Herbarium (NHA). Staff used a digital camera to photograph representative and noteworthy features, and the photographs were stored in the NHB photo archive. The location of observation points in each natural community type and the location of rare plant populations in the study area was determined with a Global Positioning System (GPS). The accuracy of the data collected by the GPS was generally within 15 meters. NHB catalogued and incorporated into the Natural Heritage database field data and site locations of exemplary natural communities and systems, and rare plant populations. Additional details of NHB's ecological approach are in Appendix 1.

## RESULTS

### NATURAL SETTING

Pisgah State Park is located in southwest New Hampshire, within the U.S. Forest Service's Vermont-New Hampshire Uplands Section that extends from Vermont and New Hampshire south into Massachusetts (Figure 1)[1]. Pisgah State Park is on the border between two subsections within the Vermont-New Hampshire Uplands Section. Most of the park is in the Hillsboro Inland Hills and Plains subsection characterized by isolated hills of hard, resistant rock, with generally shallow, stony soils (Sperduto and Nichols 2004). These bedrock conditions tend to produce relatively acidic soils with low nutrient availability for plants. The northwest portion of the park falls within the Connecticut River Valley subsection, which extends as a narrow band along much of the length of the river in New Hampshire. Glacial outwash and glacial lake deposits fill the valley bottoms, and till soils occupy the adjacent hillsides. The valley bottoms soils are not present in this portion of Pisgah State Park, which instead consists of low hills covered in glacial till akin to the rest of the park.

The physical landscape of Pisgah consists of a series of low, north to south trending ridges and intervening valleys. At a finer scale, the topography is complex, with abundant small, rocky knobs and moist depressions. Elevations at Pisgah State Park range from 460 feet near the Ashuelot River at the south end of the park, to 1,319 feet at the top of Mount Pisgah.

Much of Pisgah State Park is drained by several large streams, all of which flow south to the Ashuelot River. The streams are, from east to west, Broad Brook, Tufts Brooks, Tongue Brook, and Kilburn Brook. Some areas near the margins of Pisgah are not within these watersheds, particularly in the northwest part of the park where streams drain into the Connecticut River above its confluence with the Ashuelot.

Pisgah State Park has several named ponds, the largest of which is 123 acre Pisgah Reservoir. Damming Tufts Brook in 1870 created the reservoir and inundated Round Pond. Other named ponds include North Round Pond, Kilburn Pond, Fullam Pond, Baker Pond, Lily Pond, and Tufts Pond. Numerous other areas of the park are perennially inundated as a result of beaver activity.

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[1] Sections are U.S. Forest Service landscape divisions with similar biological and physical characteristics – particularly climate, topography, and soils – and broad distribution patterns of plants and animals (Keys and Carpenter 1995). Divisions cover tens of thousands of square miles. 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.

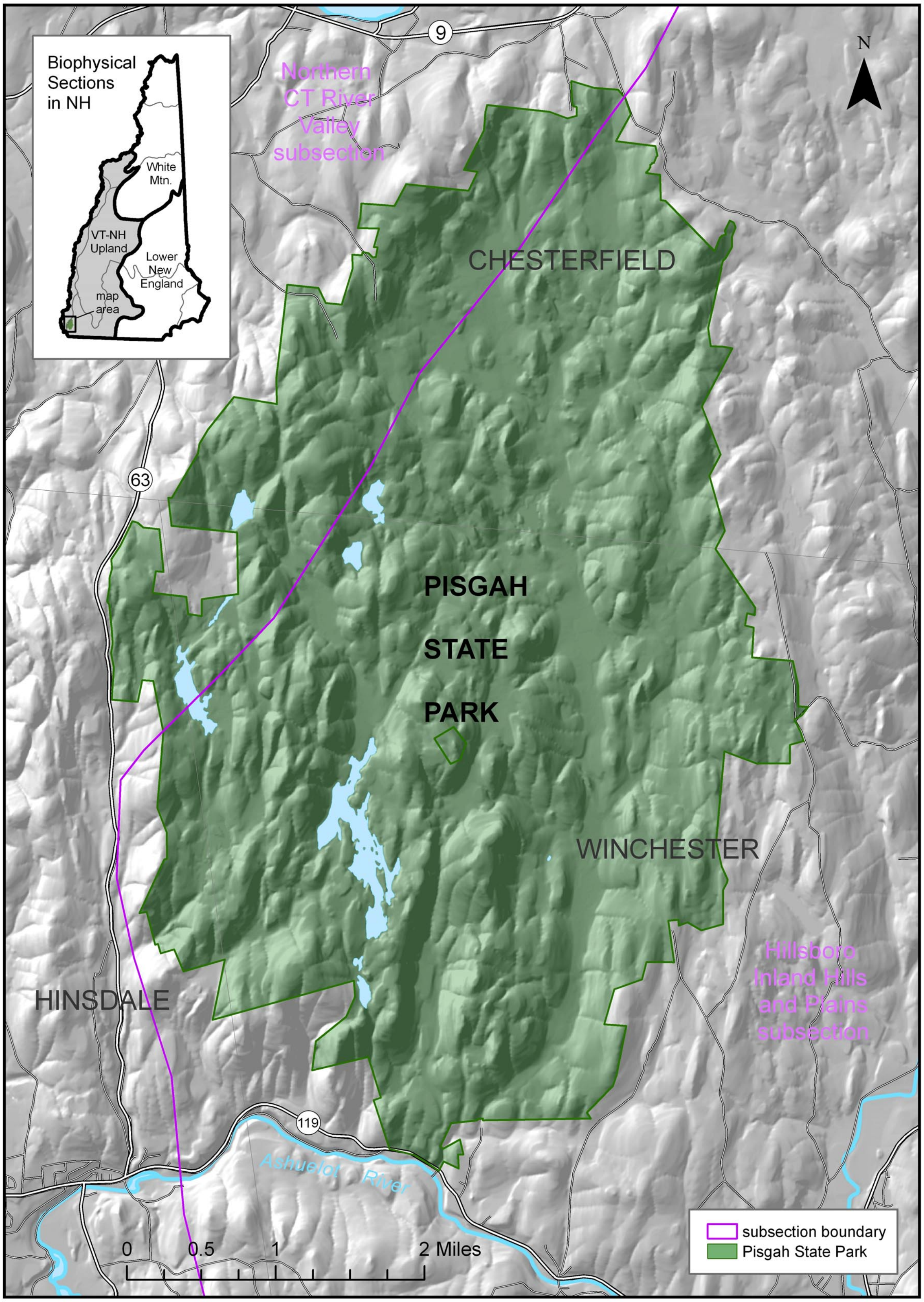


**Figure 1.** Regional context of Pisgah State Park in southwestern New Hampshire. Most of the property lies within the Hillsboro Inland Hills and Plains subsection.

### *Geology and Soils*

The bedrock of Pisgah State Park consists almost entirely of Kinsman granodiorite (Figure 2), which is primarily composed of granite and other related rocks (Lyons et al. 1997). Lithologically, Kinsman granodiorite is a felsic rock. Felsic rocks are of volcanic origin, high in silica content (>65%), and tend to weather slowly producing soil conditions that are acidic and have low nutrient availability for plants.

The soils of Pisgah fall primarily into one of two major groups (Rosenberg 1989). The first group consists of combinations of soils mainly in the Lyman and Tunbridge Series, along with some in the Berkshire Series. These soil complexes are the dominant types across the majority of the park and, as mapped, account for approximately 7,260 acres (54 percent) of the property. The one portion of Pisgah where these soils are not predominant is the far western section, where soils in the Cardigan and Kearsarge Series are characteristic. As mapped, the Cardigan and Kearsarge soils cover approximately 2,300 acres (17 percent). In general, the soils at Pisgah are shallow to moderately deep and very stony, often with significant areas of exposed bedrock. All of these soil types are very strongly acidic, which usually indicates low nutrient availability for plants, and contributes to low plant species diversity.

### *Vegetation*

Forest covers 11,000 acres (85 percent) of Pisgah State Park. The vast majority of this forest corresponds to the ***hemlock - hardwood - pine forest system***, with the dominant natural community in this system the ***hemlock - beech - oak - pine forest***. This matrix[1] forest community is highly variable, but is dominated by a mix of hemlock (*Tsuga canadensis*), American beech (*Fagus grandifolia*), red oak (*Quercus rubra*), and white pine (*Pinus strobus*). The relative abundances of these species vary depending on the age of a given stand, topographic position, soil conditions, and history of disturbance. Hemlock is the dominant or co-dominant tree across large portions of the landscape at Pisgah, and where it occurs to the exclusion of other tree species patches constitute a separate community type, the ***hemlock forest***.

The ***sugar maple - beech - yellow birch forest*** community, often referred to as northern hardwood forest, is the dominant matrix forest type at higher elevations of central and northern New Hampshire. The community is relatively uncommon in the southern portion of the state. Large patches of this community are located on mesic sites at higher elevations in the northern half of Pisgah State Park. As the community name indicates, the dominant tree species in this forest are sugar maple (*Acer saccharum*), American beech, and yellow birch (*Betula alleghaniensis*), with white ash (*Fraxinus americana*) often a common associate. As in northern hardwood forests elsewhere in the state, the tall shrub hobblebush (*Viburnum lantanoides*) is common at Pisgah. However, other herbaceous species characteristic of this community, such as

[1] Matrix is the most extensive and most connected landscape element type present, which plays the dominant role in landscape functioning (Formon and Godron 1986).

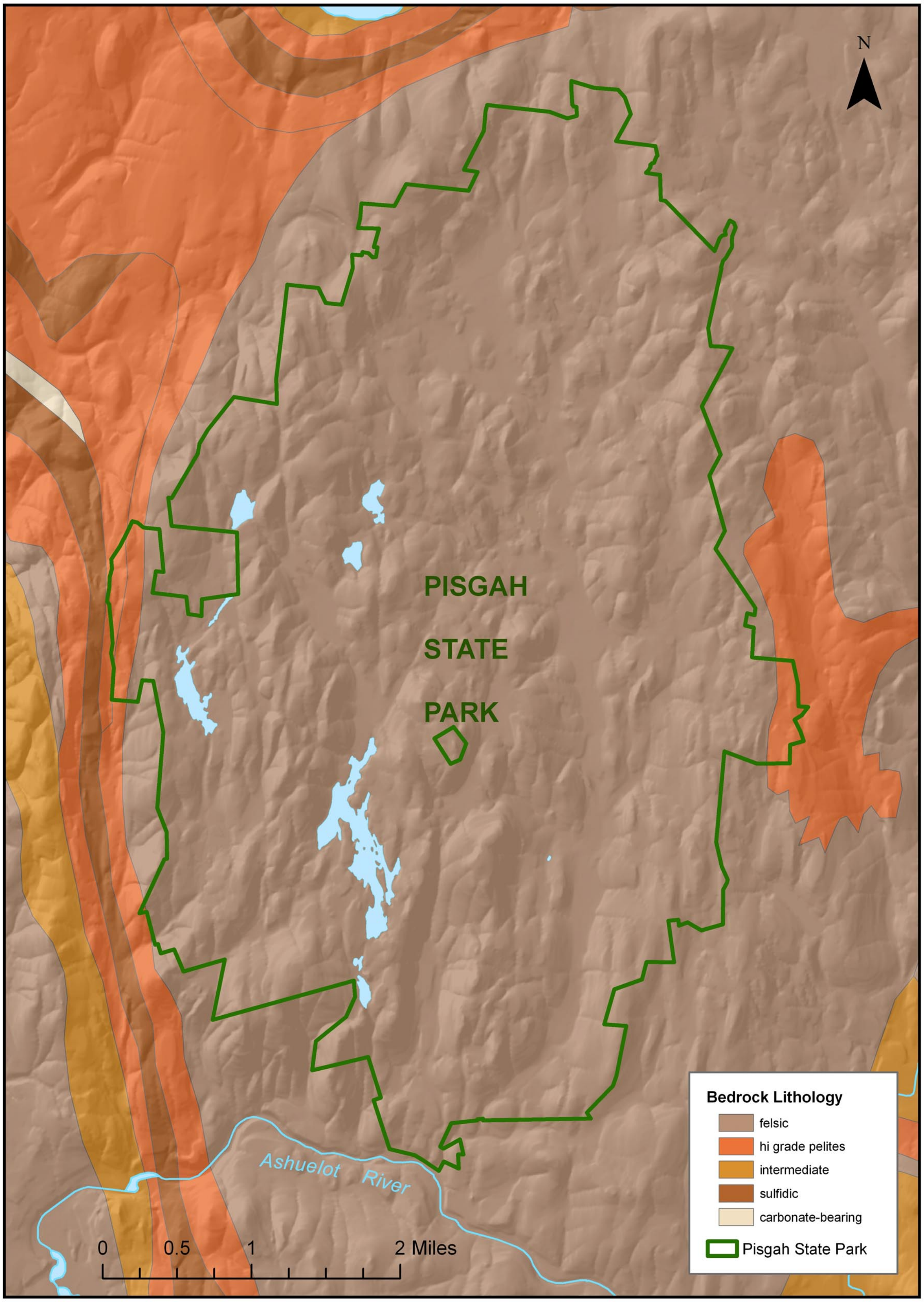


**Figure 2.** Bedrock geology of Pisgah State Park.

northern wood sorrel (*Oxalis montana*), blue-bead lily (*Clintonia borealis*), and bunchberry (*Cornus canadensis*), are absent or sparse in the park.

While the ***hemlock - beech - oak - pine forest*** and the ***sugar maple - beech - yellow birch forest*** are relatively well-defined forest types, there are also areas where the dominant species of these communities overlap. Northern hardwoods such as yellow birch and sugar maple are co-dominant with red oak or hemlock in ***Hemlock – oak – northern hardwood forest.*** Often viewed as a transition zone between the two forest types, this community often occurs along a gradient, although it can be more extensive in some settings.

The bedrock geology of Pisgah State Park is not conducive to the development of enriched soil conditions. However, limited areas with rich site plant species occur within the park. These rich conditions are the result of some combination of increased mineral nutrient concentrations (typically calcium), increased organic matter accumulation, and moist to wet soils. In some areas, these conditions are the result of topography and occur at the base of steep slopes, often in concave cove settings. Organic matter collects at the base of the slope and decomposes, a process called colluviation, in essence forming a natural compost bin. The resulting soil has higher concentrations of organic matter and mineral nutrients than soils of the surrounding landscape, and is usually very moist. These moist conditions may be enhanced by fine textured soils, which hold water more effectively than coarse-grained soils. Enriched conditions are often a result of groundwater seepage, which can carry mineral nutrients to the surface. At Pisgah, the groundwater may be passing through till soils with elevated concentrations of minerals, or through fractured bedrock, where minerals are leached from the rock over very long periods of time.

Hemlock-dominated forest in the ***hemlock - hardwood - pine forest system***. Photo by Pete Bowman.

Small patch[1] communities occur in areas where enriched conditions are present, contrasting with the surrounding matrix forest. These patch communities are typically ***semi-rich mesic sugar maple forests***. The canopy of this forest type is dominated by sugar maple, often with white ash and occasionally basswood (*Tilia americana*). Herbaceous cover is often quite lush; characteristic species include Christmas fern (*Polystichum acrostichoides*), sessile-leaved bellwort (*Uvularia sessilifolia*), wakerobin (*Trillium erectum*), Jack-in-the-pulpit (*Arisaema triphyllum*). Blue cohosh (*Caulophyllum thalictroides*), a species normally associated with the ***rich mesic forest*** community, occurs in some locations.

Wetland communities are diverse and extensive at Pisgah State Park. They are associated with three major settings: riparian corridors, isolated basins, and areas of groundwater seepage. Riparian wetlands are located along every significant stream in the park, and virtually all have been impacted by beaver activity. Beavers build dams and flood forested areas, killing the trees and creating areas of open water in which they build their lodges. Eventually, the beaver abandon the pond and the dam fails, draining most of the water from the pond. Herbaceous marsh species then colonize the drained basin. Over time, shrubs displace the herb species and form shrub thickets. If conditions are suitable, these shrub thickets are themselves replaced by trees, creating a forested swamp.

The variety of herbaceous and shrub communities that develop in this successional process collectively form the ***emergent marsh - shrub swamp system***. The system communities range from the ***deep emergent marsh - aquatic bed*** in areas of permanent standing water, to dense shrublands such as the ***alder - dogwood - arrowwood alluvial thicket***. ***Medium-depth emergent marsh*** and ***tall graminoid emergent marsh*** are other common communities in these wetlands. *Sphagnum*-dominated organic soils can develop, producing peatland communities in areas where the seasonal fluctuation of the water level is reduced. The ***fenny marsh*** is a transitional community, which typically has a thin layer of peat over mineral soils, and has a mix of marsh and peatland species. Where the organic layer is deeper and seasonal water level fluctuations are less pronounced, communities that are characteristic of a ***medium level fen system*** can occur.

Isolated basin wetlands differ from riparian wetlands in both function and composition. Typically, they occur as flat or slightly concave basins without any significant streams flowing through them, although they often have a small outlet that releases water when water levels are high. Almost all isolated basin wetlands are seasonally flooded, i.e., inundated in the winter and spring and drawn down in the summer in most years.

In larger isolated wetlands, the most common community type is the ***red maple - Sphagnum basin swamp***. Red maple (*Acer rubrum*) is the dominant tree in a sparse canopy and a robust tall shrub layer is characterized by highbush blueberry (*Vaccinium corymbosum*) and winterberry (*Ilex verticillata*). Cinnamon fern (*Osmunda cinnamomea*) is usually abundant, with other herbs present including follicled sedge (*Carex folliculata*), common water horehound (*Lycopus*

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[1] A patch is a nonlinear surface area differing in appearance from its surroundings (Forman and Godron 1986).

*uniflorus*), and three-seeded sedge (*Carex trisperma* var. *trisperma*). *Sphagnum* mosses are dominant, often forming a carpet across the basin. In a few Pisgah State Park red maple swamps, black gum (*Nyssa sylvatica*) is a frequent or co-dominant tree. In these instances, the community is a ***black gum - red maple basin swamp***. With the exception of the black gum, the composition is essentially the same as the ***red maple - Sphagnum basin swamp***. Swamps with black gum are uncommon, and the black gum trees in these communities can be 400 years old. Black gums in swamps elsewhere in New Hampshire are the oldest documented hardwood trees in eastern North America, and represent a unique ecological legacy.

In contrast, the surrounding forest shades smaller isolated basin wetlands and vascular plants are often absent. These small wetlands are vernal pools, and they perform a critical function in the landscape. The seasonal flood regime excludes fish predators, creating significant breeding areas for a variety of amphibian and invertebrate species.

Other wetlands at Pisgah State Park are associated with groundwater seepage. These include forest seeps and seepage swamps, which occupy tiny areas compared to riparian and isolated wetlands within the park. Forest seeps occur at the headwaters of many stream systems, are often less than ¼ acre in size, and have soft, saturated soils because of the near constant flow of groundwater. They are commonly found at slope breaks, where the slope angle changes from steep to relatively flat. Forest seeps have a higher concentration of mineral nutrients than the surrounding forest soils because of the movement of groundwater through the bedrock and soil. In some instances, the seep is large enough to be considered a ***subacid forest seep*** community. Characteristic plants include foamflower (*Tiarella cordifolia*), northeastern mannagrass (*Glyceria melicaria*), golden saxifrage (*Chrysosplenium americanum*), and small enchanter's nightshade (*Circaea alpina*). The topography at Pisgah State Park is conducive to the development of these seeps, and they are frequent.

***Red maple - black ash - swamp saxifrage swamps*** are larger than forest seeps, but much less common. There are three noteworthy occurrences of these swamps in Pisgah State Park, where mineral-rich water from seepage sources collects in a flat basin along a small stream. Red maple and black ash are the dominant trees, along with yellow birch. The herb layer is lush and diverse, with abundant species including swamp saxifrage (*Saxifraga pensylvanica*), Robbins' ragwort (*Packera schweinitziana*), northeastern mannagrass, dwarf raspberry (*Rubus pubescens*), sensitive fern (*Onoclea sensibilis*), and water pennywort (*Hydrocotyle americana*), among many others. The ***red maple - black ash - swamp saxifrage swamp*** community is uncommon in New Hampshire.

*HISTORY*

## Land use

Pisgah State Park has a long history of settlement following the arrival of Europeans in North America. European colonists settled portions of the park in Chesterfield and Winchester as early as the mid-18th century (Cline and Spurr 1942). Small farms sprung up across the northern and eastern sections of what is now the park. The extent of these farms was determined from town records identifing property locations and ownerships. NHB gathered additional information from field maps created during white pine blister rust surveys in the early 1930s. These maps denote the location of stone walls and cellar holes in the forest, and provide a remarkably detailed picture of the landscape. Evidence of these settlements can still be found in the form of stone walls, cellar holes, cemeteries, dams, and persistent horticultural plant species such as fruit trees.

Notably, a substantial portion of Pisgah State Park was never cleared for agriculture. The Dickinson family owned most of this land and several sawmills. They used the property as a timber reserve for times when supplies from other sources were low. The Dickinson property, along with another large adjacent parcel, was managed for timber for over 150 years beginning in the early 19$^{th}$ century.

In the 1960s the State of New Hampshire designated funds to acquire the property to establish a new state park in the Pisgah forest. The Dickinson lands formed the core of the new Pisgah State Park, which would eventually also include properties from over 50 different landowners.

**Disturbance history**

In 1927, after years of surveying and studying old growth trees in the Pisgah forest, the Harvard Forest purchased 20 acres that encompassed one of the finest remaining stands of large trees. A number of Harvard Forest staff, led by Professor J.T. Fisher, identified more than 60 old-growth stands both on their parcel and in the surrounding forest (Cline and Spurr 1942). However, in 1938 a powerful hurricane passed over New England, devastating forestlands and essentially wiping out the remnant old growth stands. Subsequent research has focused on reconstructing post-hurricane forest composition, disturbance impacts, and successional processes (Henry and Swan 1974, Foster 1988, Boose *et al.* 2001). These studies demonstrated that changes in forest composition over the course of centuries in uncut forests were largely a function of hurricanes or other periodic major disturbances (e.g., fire), which created conditions for the recruitment of varying combinations of tree species.

## EXEMPLARY NATURAL COMMUNITY SYSTEMS

### *Hemlock - hardwood - pine forest system*

This exemplary forest system covers about 6,400 acres of the central and southern portions of Pisgah State Park (Figure 3). It represents an unusually large, non-fragmented example of the matrix forest of southwestern New Hampshire. The system's land use history distinguishes it from other forestlands in the region. Although it has been used for timber production for over 200 years, it was never cleared for agricultural uses, and its soil has never been tilled.

The hemlock-hardwood-pine forest system is comprised of several natural communities. The primary matrix forest type of this system is the ***hemlock - beech - oak - pine forest***, which covers the majority of the acreage. Hemlock is the most abundant tree species, with substantial amounts of red oak and beech, and lesser numbers of white pine and black birch (*Betula lenta*). Areas where hemlock dominates to the essential exclusion of other species are classified as ***hemlock forest***. Most of the forest has a mid to late successional condition, with a few small patches that have been identified as old growth in other studies (Jones 2006). Although coring of sample trees in these patches did not confirm the presence of unusually old trees, NHB observed other characteristics of old growth forests including unusually high volumes of coarse woody material (e.g., large logs). Evidence of past cutting history can be found throughout the forest in the form of old stumps.

Fallen logs that remain from the hurricane of 1938. Large coarse woody material is one of the structural characteristics of "old growth" forests. Photo by Ben Kimball.

Small (10 to 20 acre) inclusions of ***sugar maple - beech - yellow birch forest*** occur within the hemlock - beech - oak - pine forest. Typified by sugar maple, yellow birch, and beech, the forests usually occur on rocky slopes. The herb layer in Pisgah State Park is characterized by rock polypody (*Polypodium virginianum*), hay-scented fern (*Dennstaedtia punctilobula*), sessile-leaved bellwort, and Christmas fern, but lacks the lush cover found in more northerly examples of this community. In addition, there are areas of the transitional community ***hemlock - oak - northern hardwood forest***, where the northern hardwood species sugar maple and yellow birch mix with hemlock, red oak, and beech.

Appalachian species, which have a more southern distribution, are generally absent in these forest communities, with two notable exceptions. Mountain laurel (*Kalmia latifolia*) is patchily distributed and is particularly frequent on slopes along the western boundary of the park and on scattered slopes just west of Pisgah Reservoir. Chestnut oak (*Quercus montana*) is also present, although its only significant concentrations are on Bishop Mountain in the southwest corner of the property.

Various wetland types and open water bodies also occur within the hemlock - hardwood - pine forest system. The areas occupy about 12 percent of the exemplary system's 6400 acres.

Beech-dominated hardwood forest in the ***hemlock - hardwood - pine forest system***. Photo by Pete Bowman.

***Emergent marsh - shrub swamp system***

An extensive complex of open wetland communities occurs at the headwaters of Broad Brook in the northern end of Pisgah State Park (Figure 3). The watershed of these headwaters is located almost entirely within Pisgah, and is essentially completely forested. These wetlands have been heavily influenced by beaver activity, and there are currently at least two active beaver dams and lodges. Beaver influenced natural community systems of this type are common at Pisgah, but this example is the largest group of connected wetland openings in the park, and the only one that meets NHB's size and ecological integrity criteria for exemplary status.

The dominant communities in the system are emergent marshes, particularly the ***tall graminoid emergent marsh***. This community is typically dominated by bluejoint grass (*Calamagrostis canadensis*), often in association with tussock sedge (*Carex stricta*). Peat mats can develop in areas with restricted flow and little influence by active stream channels, resulting in the ***fenny marsh*** community. This community typically has a mixture of marsh species, such as bluejoint and common cattail (*Typha latifolia*), and fen sedges such as bottle-shaped sedge (*Carex utriculata*) and hairy-fruited sedge (*Carex lasiocarpa*).

Exemplary ***emergent marsh - shrub swamp system*** at Pisgah State Park. Photo by Pete Bowman.

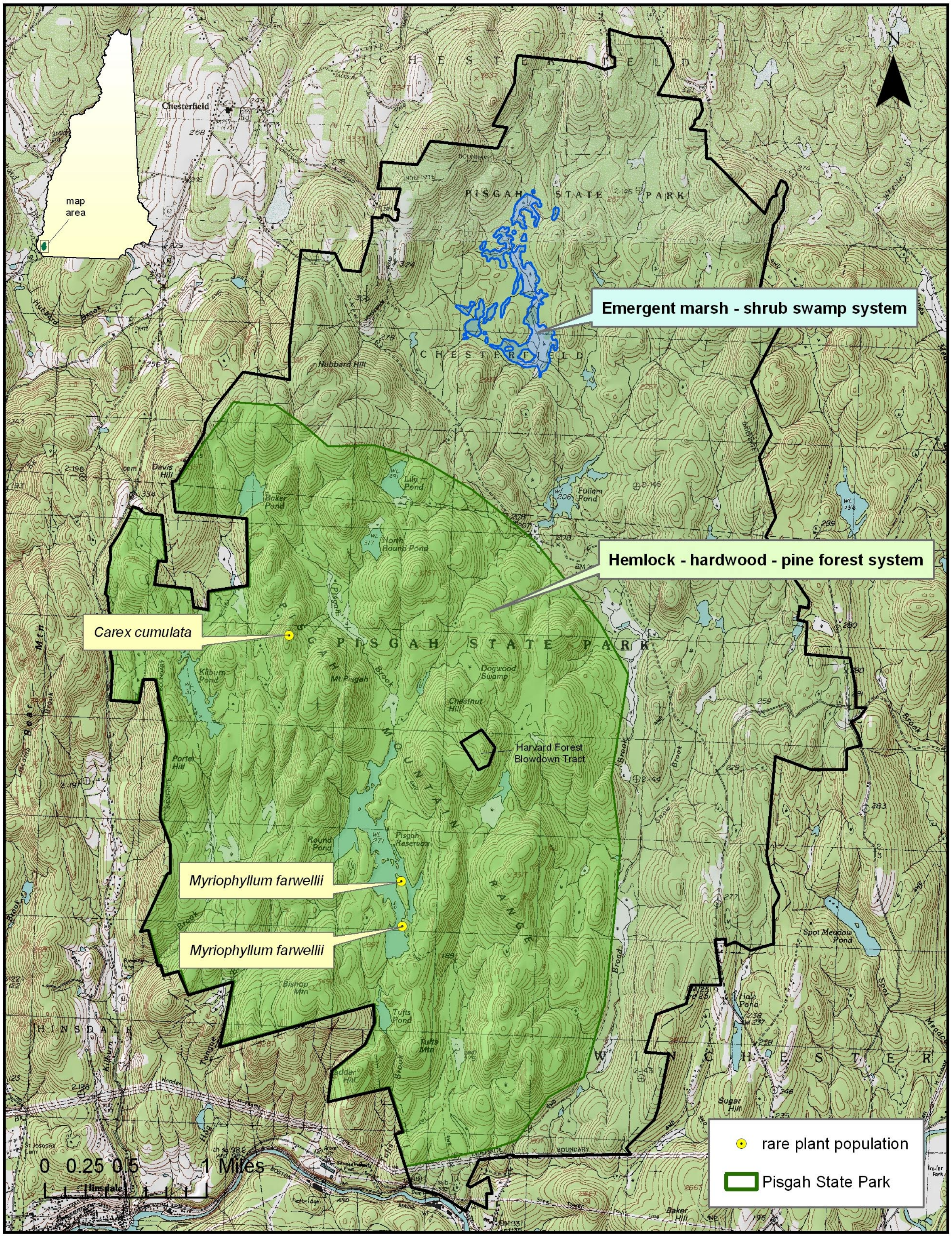


**Figure 3.** Rare plant and exemplary natural community system locations at Pisgah State Park.

## Rare Plant Species

*Carex cumulata* (piled-up sedge)

This small sedge is associated with dry, rocky habitats that often have a history of fire. In the park, the plant occurs at one site, the Pisgah Mountain Vista on Mt. Pisgah, a maintained opening that affords views of Mt. Monadnock and the surrounding landscape (Figure 3). Approximately 50 flowering stems occur in a very small, moist depression immediately adjacent to the Pisgah Ridge Trail. The proximity to the trail makes the plants vulnerable to trampling from hikers, although NHB did not observe trampling impacts. Under a natural disturbance regime, the habitat for this species would be maintained by wildfires, and the presence of pitch pine (*Pinus rigida*) nearby indicates that this ridge has a past fire history. Currently, the opening is being maintained for the view, which should keep these plants from being shaded out, but the exclusion of fire will preclude new habitat from being created.

*Carex cumulata* (piled-up sedge) patch on Mt. Pisgah. Photo by Ben Kimball.

*Myriophyllum farwellii* (Farwell's water milfoil)

Farwell's water milfoil is an aquatic plant observed at two locations in Pisgah Reservoir (Figure 3). Both locations are in shallow water (1-3 feet deep) near the southeastern shore of the lake. This species was first observed in the reservoir in 2004 during surveys for the invasive plant water chestnut (*Trapa natans*) (Callahan 2004). The 2004 survey also identified Farwell's water milfoil in Fullam Pond within the park, although that water body was not visited during this survey.

Fingerlike stalks of *Myriophyllum farwellii* (Farwell's water milfoil) growing in shallow water at Pisgah Reservoir. Photo by Pete Bowman.

*Panax quinquefolius* (ginseng)

This woodland herb occurs in areas of enriched soils at three separate locations within Pisgah. The largest population consists of roughly 50 plants scattered in a semi-rich ravine. The second population has two fruiting plants associated with an enriched seep. The last occurrence has only a single observed stem in a semi-rich ravine. NHB does not release the specific locations of ginseng populations to prevent illegal removal by commercial collectors.

*Panax quinquefolius* (ginseng) at Pisgah State Park. Photo by Pete Bowman.

## Features of Local Significance

Locally significant communities are too small or lack sufficient ecological significance at a statewide scale to be exemplary natural communities. However, locally significant communities have good ecological condition and integrity, encompass community types of limited extent in the state, contribute to biological diversity, and are significant at the local scale. Locally significant communities warrant consideration when planning management activities. NHB determined that two Pisgah State Park communities were locally significant features (Figure 4).

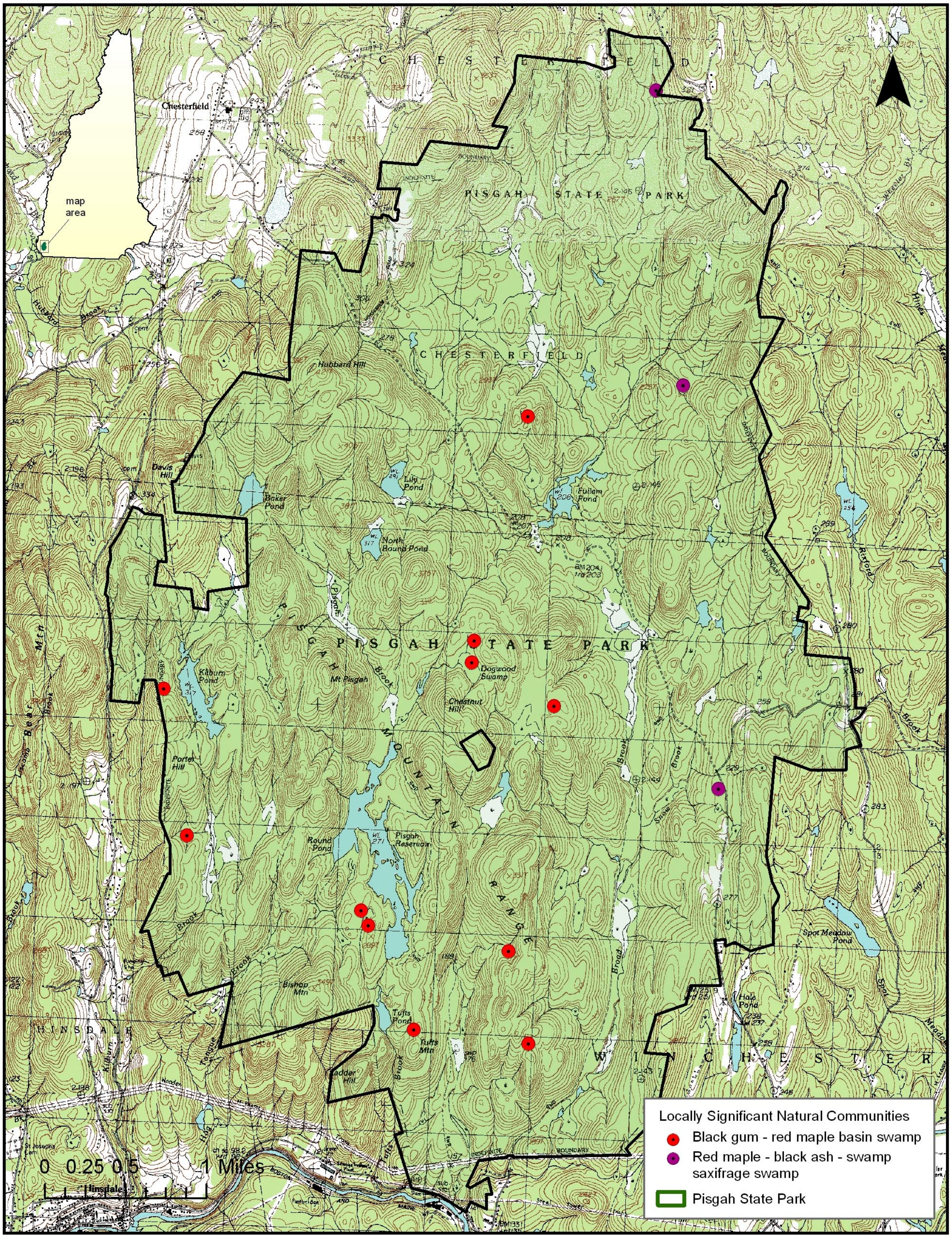


**Figure 4.** Locations of locally significant natural communities at Pisgah State Park.

### *Red maple - black ash - swamp saxifrage swamp*

This wetland type is associated with seepage of mineral-enriched groundwater, and is uncommon at Pisgah State Park. NHB identified three occurrences of this wetland community during the survey, each too small to be considered exemplary at a statewide scale. However, the ***red maple - black ash - swamp saxifrage swamps*** are noteworthy for their contribution to the vascular plant diversity of the park. A number of plant species found in this community occur nowhere else at Pisgah State Park, such as swamp saxifrage (*Saxifraga pensylvanica*), Robbins' ragwort (*Packera schweinitziana*), and great angelica (*Angelica atropurpurea*).

### *Black gum - red maple basin swamp*

This wetland type is very similar to the ***red maple - Sphagnum basin swamp*** community common across the landscape of Pisgah State Park. What differentiates the ***black gum - red maple basin swamp*** from ***red maple - Sphagnum basin swamp*** is the presence of black gum, a tree species that reaches the northern limit of its range in New Hampshire. Black gum is notable primarily for being an extraordinarily long-lived tree. An earlier NHB study of black gum swamps (Sperduto et al. 2000), mainly in the southeastern part of the state, found trees at a number of sites in excess of 300 years old, with extreme examples near 700 years old.

At Pisgah, there are roughly a dozen basins that contain ***black gum - red maple basin swamp*** communities, although none of them are large enough to be considered exemplary at a statewide scale. However, tree cores taken at three basins identified several trees over 300 years old, with the oldest tree over 400 years of age. It is likely that additional coring would reveal even older trees in some of these basins.

Deeply-furrowed bark of an old black gum tree (*Nyssa sylvatica*). Photo by Ben Kimball.

## INVASIVE PLANT SPECIES

Pisgah State Park has relatively few invasive plant species for a property of its size. This is most likely due to a combination of factors. First, many invasive species favor sites with nutrient-rich soils, which are sparse at Pisgah State Park. Second, most invasive plants require some sort of disturbance to become established, and rarely invade areas with mature, interior forest conditions.

Invasive plant species observed at Pisgah State Park usually occur along trails or roads, which are common pathways for establishment, or were associated with old fields that are being maintained for wildlife habitat. Notably, invasive plant species were most abundant in old fields and settlements along Old Chesterfield Road and John Hill Road in the southeast corner of the park. Asian bittersweet (*Celastrus orbiculatus*), alder or glossy buckthorn (*Frangula alnus*), Japanese barberry (*Berberis thunbergii*), and shrub honeysuckles (*Lonicera* spp.) were all observed along these roads.

In other parts of the park, the most frequent invasive plants in the park are the shrubs Japanese barberry and alder-buckthorn (also known as glossy buckthorn). Barberry frequently becomes established in soils with some degree of enrichment, although it can spread into dry hardwood forests. Buckthorn most often occurs along the fringes of wetlands, although it too can occur in upland settings.

NHB observed the large grass common reed (*Phragmites australis*) in two open wetlands in Pisgah State Park. Although not widespread, common reed is very aggressive and could spread in the park's extensive beaver marshes. Other invasive species NHB observed include garlic mustard (*Alliaria petiolata*) and purple loosestrife (*Lythrum salicaria*). Each apparently occurs in very small numbers, and control action was taken when found. Garlic mustard and purple loosestrife likely still occur in the park, and managers should be vigilant in identifying future occurrences.

## MANAGEMENT CONSIDERATIONS

At 13,400 acres, Pisgah State Park encompasses one of the largest pieces of essentially unfragmented forest in southern New Hampshire. There is no development in the park, with the exception of a network of trails and a small office building. Consequently, NHB centers its recommendations for management on maintaining the ecological integrity of the contiguous forest, the exemplary wetland complex, and locally significant patch communities.

### TIMBER MANAGEMENT

The Division of Forests and Lands has initiated timber harvests in Pisgah State Park, and expressed a commitment to integrate timber operations with ecological conservation, historical preservation, wildlife management, and recreation. To this end, NHB endorses timber operations by the Division of Forests and Lands in non-exemplary forest using practices that meet or exceed best management practices described in *Good Forestry in the Granite State* (New Hampshire Forest Sustainability Standards Work Team 1997; revision pending). Wetlands are pervasive within the forest, and require particular protection from timber activities. NHB endorses Division of Forests and Lands practices that establish site-specific wetland buffers through consideration of soil type, buffer vegetation type, adjacent land use, slope, runoff particle size, wetland quality, and indigenous wildlife. *Good Forestry in the Granite State*, NHB, or an experienced wetland scientist can provide guidance.

NHB designated about half of Pisgah State Park as an exemplary ***hemlock - hardwood - pine forest system***. Unlike most other forestlands in southern and central New Hampshire, this area was never cleared for cropland or pasture. The exemplary system has apparently been in forest cover since the time of European settlement, albeit with a history of timber management. Normally (see Bowman 2005, Bowman 2007), NHB recommends that management activities within exemplary natural communities and natural community systems be restricted to those with specific ecological goals, such as invasive species control or prescribed burning. However, the Pisgah State Park exemplary **hemlock – hardwood – pine forest system** offers an unusual opportunity for advancing forest research and the New Hampshire forest products industry.

- The exemplary system is large (6,400 acres) and relatively uniform.
- Harvard Forest has collected data on part of the system since 1907.
- Several universities are located in close proximity to the park.
- Forests are an integral component of New Hampshire's strategy to reduce greenhouse gas emissions.
- Old growth forest characteristics are under-represented in New Hampshire.

These factors argue for a thoughtful use of a small part of the exemplary system to continue Harvard Forest research, and to support additional research to address issues such as carbon sequestration and active management for old growth forest characteristics. NHB would endorse research by the Division of Forests and Lands within the exemplary system if NHB were a partner in the research, the research was multidisciplinary, and the goal was to enhance ecological processes.

### All-Terrain Vehicles (ATVs)

Pisgah State Park receives heavy use by ATVs. The Department of Resources and Economic Development permits ATVs on roads open to automobile traffic and on the Hinsdale Trail in the southwest portion of the park. NHB observed evidence of ATV use at a number of other locations in Pisgah, including on established trails not designated for ATV use and on unauthorized, unmapped trails entering the park along the northern boundary.

Many studies illustrate that inappropriate ATV activity results in soil erosion and compaction, sedimentation of streams and wetlands, the spread of invasive plant species, and destruction of vegetation (Natural Trails and Waters Coalition 2005). NHB endorses continued use of designated ATV trails within Pisgah State Park under the management of the Division of Parks and Recreation Trails Bureau. NHB encourages the Trails Bureau to maintain trails to avoid impacts to adjacent natural communities, and to monitor and enforce ATV use.

### Invasive Plant Species

Invasive plants are apparently geographically limited and sparse at Pisgah State Park. NHB endorses conduct of a comprehensive survey of invasive plant species in the park, and development of a plan to control existing invasive plants and prevent establishment of new populations of invasive plants.

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# Appendix 1. NH Natural Heritage Bureau Ecological Approach.

## NATURAL COMMUNITIES

The NH Natural Heritage Bureau (NHB) describes the landscape using "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 nutrient availability, soil drainage, and climate variables). Natural communities include both wetland types (e.g., red maple basin swamp) and uplands such as woodlands (e.g., red oak – black birch wooded talus) 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 takes into account that communities have different size ranges. Some common communities tend to cover large areas and form the "matrix" of a landscape. Other communities are imbedded in this matrix as large or small patches. The great majority of the landscape area consists of relatively few common community types, whereas the majority of the community types occupy a minority of the area. Large areas occupied by common communities may harbor relatively low community and plant species diversity, but they contribute important ecosystem processes and functions.

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 NH Heritage.

#### 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

Cowardin et al. (1979) produced a classification scheme for the U.S. Fish and Wildlife Service (USFWS) for application to wetland and aquatic systems. In this classification, wetlands and deepwater habitats are defined primarily by their flood regime, substrate, and dominant vegetation structure. This classification system is useful because of its applicability to broad geographical regions and because it can be readily applied in conjunction with aerial photography interpretation. It was the basis for wetland typing in the National Wetland Inventory (NWI) mapping effort.

Natural community and USFWS types often do not correspond to one another in direct (1:1) and consistent ways, primarily because the two classification systems are based on and emphasize different ecosystem attributes and have different ranges of variation within categories. The natural community classification considers and integrates a broader range of factors (other than flood regime and coarse vegetation structure). Differences in nutrient regime, water source, and geomorphic setting, which are not directly incorporated into the USFWS system, are often important determinants of natural community type (and indicated by differences in floristic composition). For example, red maple - *Sphagnum* basin swamps and red maple - black ash swamps would both be considered saturated, palustrine broad-leaved deciduous forested wetlands (PFO1). This common 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 evaluates the ecological significance of individual natural community occurrences by assigning a quality rank to each one. Quality ranks are a measure of the ecological integrity of a community relative to other examples of that particular type. These ranks are based on three main criteria: community size, ecological condition, and the surrounding landscape context of the community. Each of these factors affects the integrity of natural processes and the viability of plants and animals within a community.

To help inform conservation decisions, NHB identifies and keeps track of "exemplary" natural communities. Exemplary natural communities are the highest quality occurrences of each type in the state. For rare natural community types, all viable occurrences are considered exemplary (those of "fair" or better quality). For more common community types, only higher quality examples are designated exemplary (those of "good" or "excellent" quality). As the best occurrences of their types, exemplary natural communities are among the best remaining examples of New Hampshire's natural diversity.

## **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 (ECOLOGICAL INTEGRITY ASSESSMENT)

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 BIODIVERSITY AND WHY SHOULD WE PROTECT IT?*

#### 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.

# 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). |

## Appendix 3. Observation Points (OPs) at Pisgah State Park.