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# Ecological Inventory of Cardigan Mountain State Forest

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A report prepared by the
New Hampshire Natural Heritage Bureau
DRED Division of Forests & Lands and The Nature Conservancy, Concord, NH

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

The 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 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 and 120 natural communities. Surveys for rarities 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, and natural community 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.

*Cover: The summit of Mt. Cardigan viewed from Firescrew.*

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NH Department of Resources and Economic Development.

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## ACKNOWLEDGEMENTS


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**SUMMARY**

In 2005 and 2006, the New Hampshire Natural Heritage Bureau conducted an ecological inventory of Cardigan Mountain State Forest (CMSF), a 5500-acre property in the towns of Alexandria and Orange. The purpose of this survey was to gather data on the floristic and ecological diversity of CMSF, which could then be used to inform the management of the property by the Division of Forests and Lands. As a result of this survey, two exemplary natural community systems were identified, and three rare plant populations were located, all near the summit of Mt. Cardigan.

## 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.

In 2001, the NH Natural Heritage Bureau (NH Heritage) conducted an *Ecological Analysis of NH State Lands* (Crowley and Sperduto) in order to identify state-owned lands that were the highest priority for ecological inventory. One of the properties identified as the highest priority (Tier 1), was **Cardigan Mountain State Forest** (CMSF), a 5500-acre property in the towns of Alexandria and Orange, which is centered around the 3121 ft. Mt. Cardigan. It is adjacent to property owned by the Appalachian Mountain Club (AMC), and is a very popular outdoor recreation destination. This site was considered high priority because of known occurrences of rare plants and exemplary natural communities near the summit of the mountain, as well as for the potential for enriched soil conditions and the sheer size of the property. During 2005 and 2006, NH Heritage conducted an ecological inventory and assessment of CMSF, with the goals of locating and identifying occurrences of rare plant species and exemplary natural communities and natural community systems on the property.

## METHODS

### LANDSCAPE ANALYSIS

An initial 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 we used during this 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. We queried the NH Heritage database to identify specific locations of known rare species and exemplary natural communities within potential study areas. We reviewed aerial photographs to determine vegetation patterns and conditions and assessed available information from DRED Division of Forests and Lands regarding stand type and condition (see Appendix 3).

**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 NH Natural Heritage. 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. 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 NH Natural Heritage database.

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

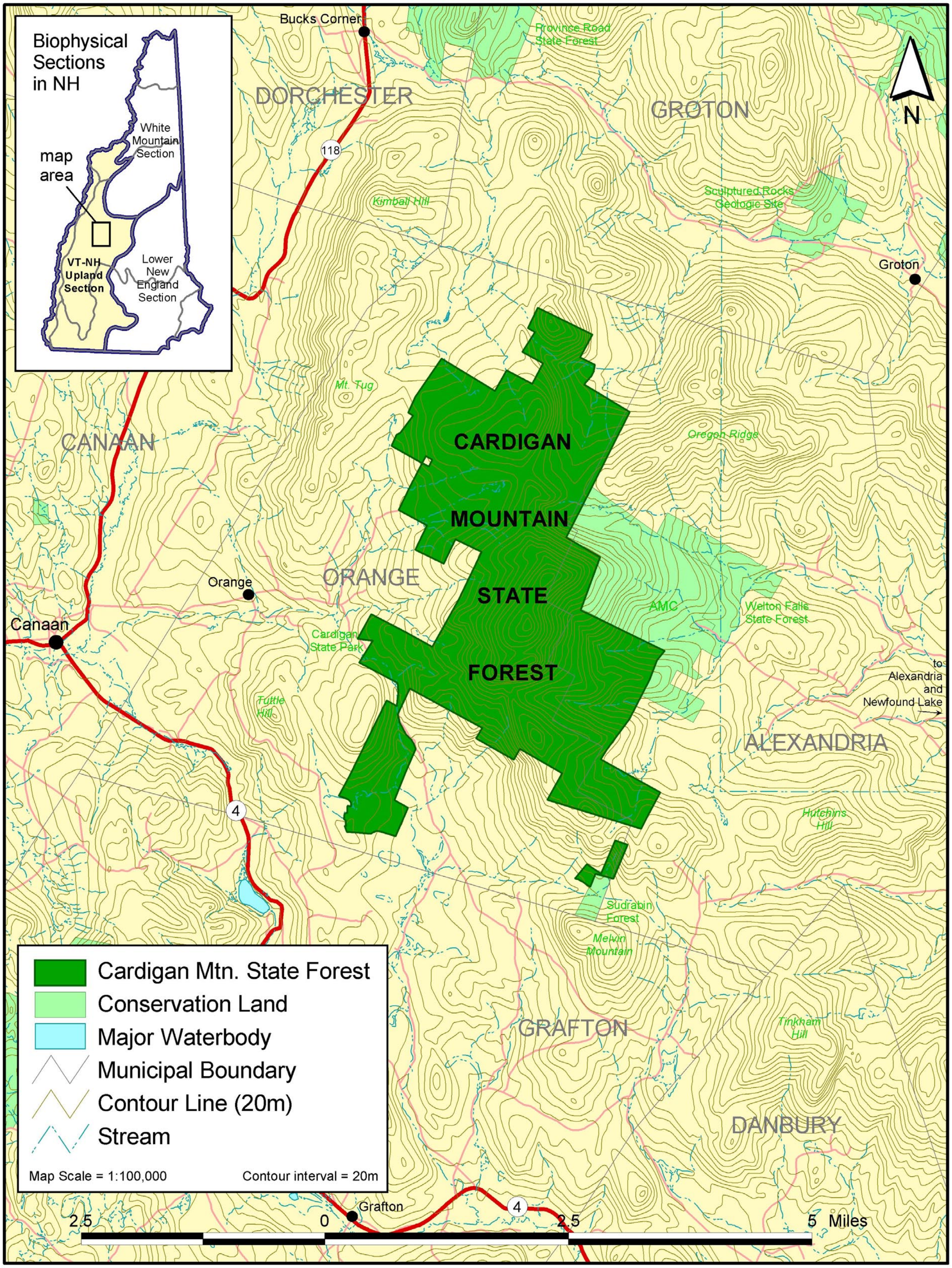


**Figure 1.** Regional context of Cardigan Mountain State Forest in west-central New Hampshire. The property lies entirely within the Sunapee Uplands subsection.

## RESULTS

### NATURAL SETTING OF CARDIGAN MOUNTAIN STATE FOREST

Cardigan Mountain State Forest is located in west central 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). CMSF falls into the Sunapee Uplands subsection, which occupies much of the western portion of the state, and is characterized by isolated hills of hard, resistant rock, with generally shallow, stony soils (Sperduto and Nichols 2004). These conditions tend to produce relatively acidic soils with low nutrient availability for plants.

The primary feature of the property is Mt. Cardigan, which dominates the surrounding area with its bare rock summit and fire tower. The main peak has an elevation of 3121 ft. at its highest point. The mountain has a broad ridge that leads northward away from the main summit to a secondary peak called Firescrew (3040 ft. elev.). Both of these peaks and the intervening ridge are characterized by large expanses of exposed bedrock, which allow for extensive views, and make the park an extremely popular hiking destination.

Below these summits, the upper slopes of the mountain fall away steeply in all directions, but it is on the eastern side where the drop is most dramatic. In fact, the eastern face of Mt. Cardigan is actually a continuation of an escarpment that extends well to the north of the mountain and is characterized by very steep rocky slopes and small cliffs, and includes the rock overhang known as Cilley's Cave as well as a similar feature known as Grotto Cave.

Across most of CMSF, elevations range from 1700 ft. at the lower end to over 3100 ft. at the summit of the mountain. However, there is a southwestern "lobe" of the property where elevations are generally lower, descending to around 1300 ft. at Orange Pond near the southernmost point of the site.

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[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.

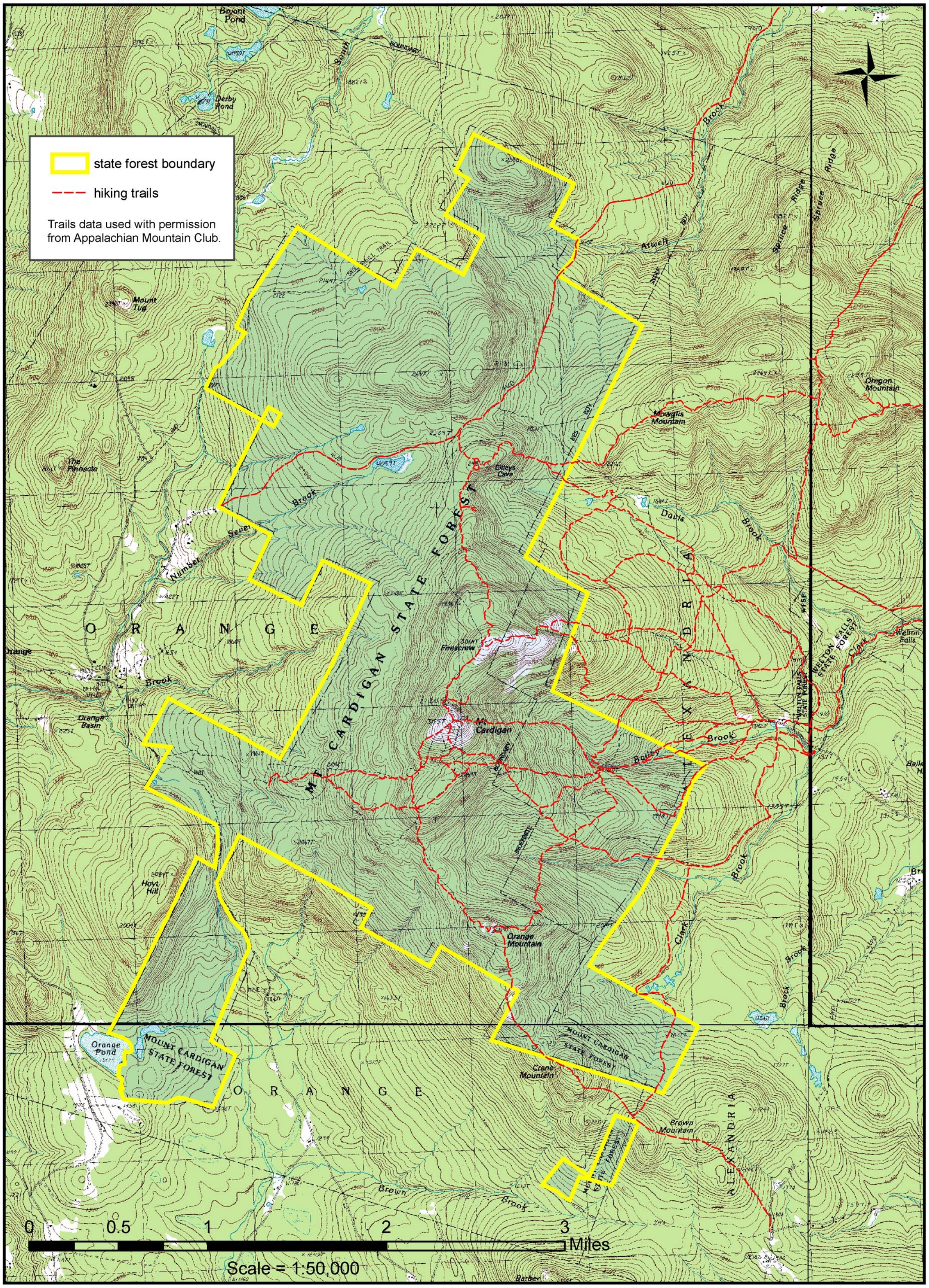


**Figure 2.** Trails at Cardigan Mountain State Forest.

*GEOLOGY AND SOILS*

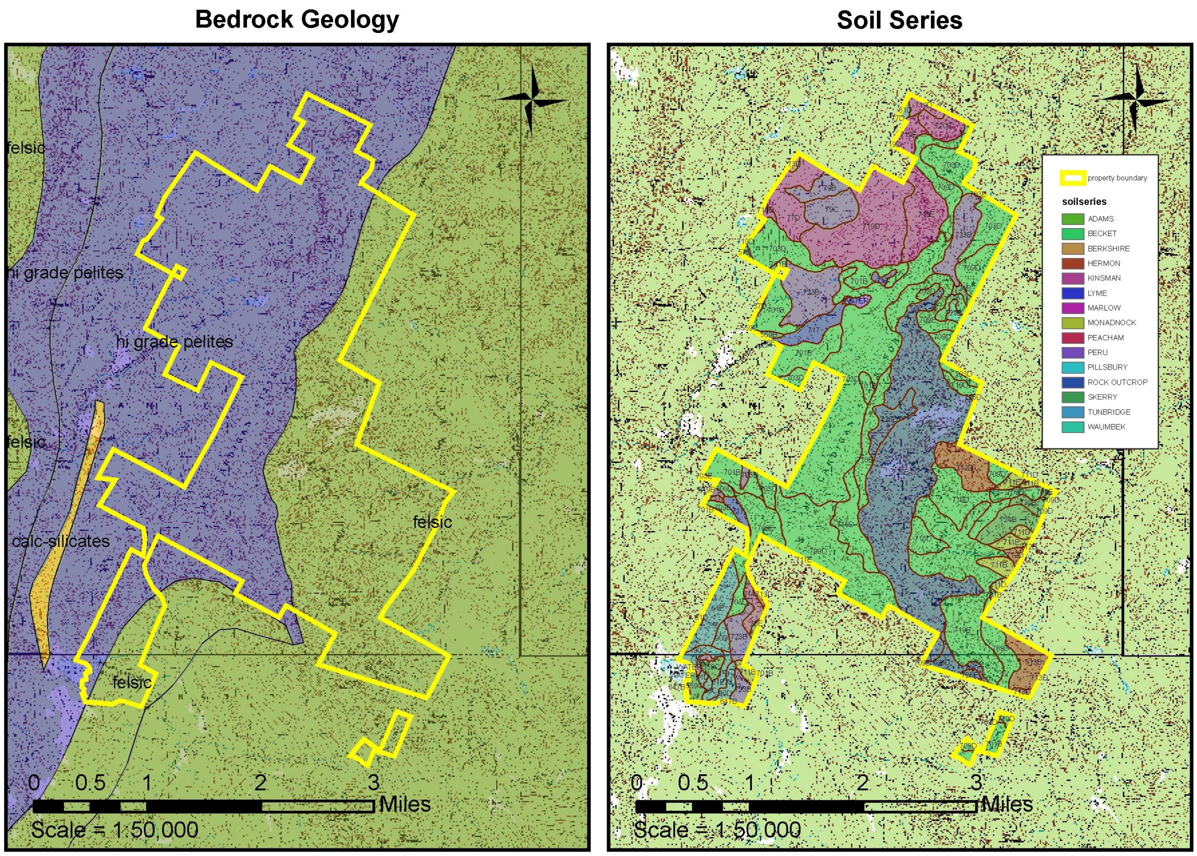


**Figure 3.** Bedrock geology and soils at Cardigan Mountain State Forest.

The bedrock of CMSF consists primarily of two major lithological formations (Figure 3). The eastern portion of the property, including the summit of Mt. Cardigan, is characterized by Kinsman granodiorite, a felsic rock. Felsic rocks are volcanic rocks that are high in silica content (>65%), and tend to weather slowly, typically producing soil conditions that are acidic and have low nutrient availability for plants. The western portion of the state forest is underlain by rocks in the Littleton Formation. This formation consists of highly metamorphosed sedimentary rocks such as quartzite and schist that are categorized lithologically as high-grade pelites. Although high-grade pelites and felsic rocks have very different origins, they are both highly resistant to weathering, and both tend to produce acidic soils with low nutrient availability.

There is a narrow band of bedrock just to the west of CMSF that falls into a third lithological category. This bedrock is known as the Littleton Formation, and is classified as a calc-silicate rock. Calc-silicates have greater weathering rates than felsic rocks or high-grade pelites, and have the potential to produce soils that have greater nutrient availability for plants. Although there was a possibility that glacial till reflecting these elevated nutrient levels was present at CMSF, no evidence of this was found in the form of enriched-site indicator species.

The soils of CMSF are grouped into several associations, usually in various combinations of Becket, Hermon, Lyman, Marlow, Monadnock, Peru, Pillsbury, Skerry, and Tunbridge soils. These soils are all derived from glacial till, and in general are characterized as sandy loams, typically very stony or bouldery, on moderate to steep slopes. There are isolated areas of sandy or sandy loam soils that are not stony, associated with stream bottoms, but these areas are minimal at CMSF due to the consistently steep slopes and lack of significant stream drainages.

*VEGETATION*

Although Cardigan Mountain State Forest is a relatively large property (5736 acres), the vegetation across the majority of the site is remarkably homogeneous. The upland forests throughout most of CMSF can be characterized as ***sugar maple - beech - yellow birch forest***, the classic "northern hardwoods" forest type. As the community name indicates, the dominant trees in this forest are *Acer saccharum* (sugar maple), *Betula alleghaniensis* (yellow birch), and *Fagus grandifolia* (American beech), although a number of other species are present, including *Acer rubrum* (red maple), *Betula papyrifera* (paper birch), and *Fraxinus americana* (white ash).

The southernmost "lobe" of CMSF occupies the eastern slopes of Hoyt Hill, and elevations are lower, dropping to around 1300 ft. near Orange Pond. At these lower elevations *Quercus rubra* (red oak) becomes a frequent or co-dominant component of the forest. The upper slopes of Hoyt Hill also have a distinctly semi-rich character that may reflect the influence of a calc-silicate bedrock type just to the west of the property. These dry, somewhat enriched woods include species like *Ostrya virginiana* (ironwood), *Solidago caesia* (blue-stemmed goldenrod), *Elymus hystrix* (bottlebrush grass), and *Streptopus lanceolatus* (rose twisted stalk).

Scattered *Picea rubens* (red spruce) can be found within the ***sugar maple - beech - yellow birch forest*** throughout the property, but it becomes increasingly prevalent with increasing elevation, until the forest transitions to the ***high-elevation spruce - fir forest*** community at around 2400-2500 ft. This forest is dominated by the conifers *Picea rubens* (red spruce) and *Abies balsamea* (balsam fir), although *Betula papyrifera* (paper birch) and *Betula cordifolia* (heartleaf birch) are frequent, and occasionally abundant, associates.

Climbing still higher on the mountain, the ***high-elevation spruce - fir forest*** eventually grades into the area where broad zones of exposed bedrock are interspersed with patches of vegetation on isolated soil pockets. A portion of the summit of Mt. Cardigan has probably been open since the first European settlers arrived, as it was known as "Old Baldface" as far back as 1835 (Murdock 1941). However, a severe fire swept over the summit and upper slopes in 1855, stripping vegetation and soil down to the bedrock (Fobes 1953, Hamel and Moulton 1969). The twisting column of smoke and fire on the northern section of the mountain gave rise to its current name, "Firescrew."

Today, these exposed areas near the summit are divided into two natural community systems. The lower areas, generally below 2800-2900 ft., and often occurring on steep slopes, are classified as the ***montane rocky ridge system***, and are typified by the characteristic ***red spruce - heath - cinquefoil rocky ridge*** community. Above 2800-2900 ft., near the summit of Mt. Cardigan, the ***montane rocky ridge system*** gives way to a suite of communities collectively referred to as the ***subalpine heath - krummholz/rocky bald system*** (both of these systems are described below under Exemplary Natural Community Systems).

Wetlands make up a very small portion of CMSF. Open emergent and scrub-shrub wetlands are restricted to zones around open water, such as Orange Pond in the southernmost portion of the property, and two beaver impoundments in the headwaters of Number Seven Brook in the northern half of the site. This vegetation is typically consistent with the species composition in ***medium level fen systems***, although the zones are generally rather narrow, usually 5-8 meters wide (occasionally up to 15m). In the shallower areas near the shore, peatland shrubs such as *Chamaedaphne calyculata* (leatherleaf) and *Myrica gale* (sweet gale) are typical, transitioning to herbaceous species in zones of deeper water or greater duration of inundation. Common species in the herbaceous communities include sedges such as *Eriophorum virginicum* (tawny cotton-grass), *Dulichium arundinaceum* (three-way sedge), *Carex stricta* (tussock sedge), and *Scirpus cyperinus* (woolly bulrush), as well as *Calamagrostis canadensis* (bluejoint), *Triadenum virginicum* (marsh St. John's-wort), and the shrub *Spiraea alba* var. *latifolia* (eastern meadowsweet).

## EXEMPLARY NATURAL COMMUNITY SYSTEMS

### *Montane rocky ridge system*

The summit and upper slopes of Firescrew, the broad ridge between Firescrew and the Cardigan summit, and much of the eastern and southern slopes of Cardigan between 2500 and 2800 feet elevation are occupied by ***montane rocky ridge system*** (Figure 4), which is represented primarily by the ***red spruce - heath - cinquefoil rocky ridge*** community. This is a woodland community with a short canopy of red spruce (25-60% cover). Shrubs and herbs are confined to crevices and

An island of ***red spruce – heath – cinquefoil rocky ridge*** vegetation surrounded by bedrock within the exemplary ***montane rocky ridge system***.

small patches of soil. *Sibbaldiopsis tridentata* (three-toothed cinquefoil) is the most frequent herbaceous species, along with *Deschampsia flexuosa* (common hairgrass). Low shrubs are common, particularly *Vaccinium angustifolium* (lowbush blueberry) and *Kalmia angustifolia* (sheep laurel). In pockets where moisture can collect and soil can develop, patches of ***montane heath woodland*** are present. This community shares many of the same species as the dominant type, but the tree canopy is generally taller and denser, with a well-developed tall shrub layer. Other depressions contain small open wetlands, with a layer of *Sphagnum* spp. (peat mosses) supporting scattered herbs including *Eriophorum virginicum* (tawny cotton-grass), *Carex trisperma* (sedge), and *Rhynchospora alba* (white beak-rush).

A small depression with wetland vegetation within the exemplary ***montane rocky ridge system***.

***Subalpine heath - krummholz/rocky bald system***

This system is restricted to roughly 38 acres on and around the summit of Mt. Cardigan above 2800 ft. (Figure 4). It is more extensive to the south of the summit, partially because these slopes descend more gradually than on the northern face. The two communities comprising this system are ***sheep laurel - Labrador tea heath - krummholz*** and ***subalpine rocky bald***. Both of these communities contain many of the species present in the ***montane rocky ridge system*** below, but tree species such as red spruce are present only in the stunted and twisted krummholz form. This system is distinguished from the surrounding zone by the presence of subalpine indicator species such as *Vaccinium vitis-idaea* (mountain cranberry), *Empetrum nigrum* ssp. *hermaphroditum* (black crowberry), and *Ledum groenlandicum* (Labrador tea), as well as the reduced stature and cover of trees. This natural community system also harbors three rare plant species: *Carex bigelowii* (Bigelow's sedge), *Carex capitata* (head-like sedge), and *Huperzia appalachiana* (mountain firmoss) (see Rare Plant Species below).

Exemplary ***subalpine heath - krummholz/rocky bald system***.

*Empetrum eamesii* ssp. *atropurpureum* (purple crowberry), one of the diagnostic species of the exemplary ***subalpine heath - krummholz/rocky bald system***.

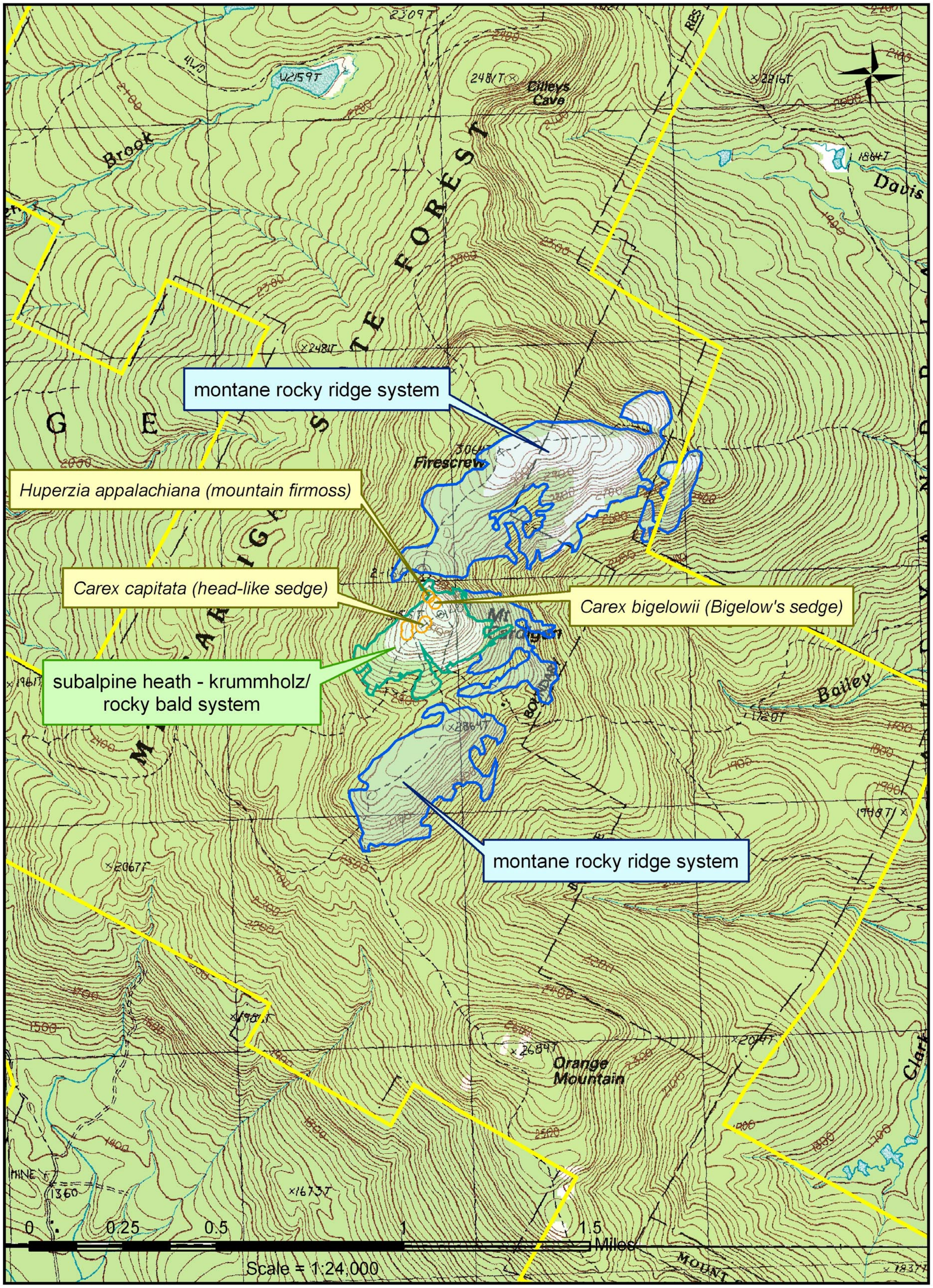


**Figure 4.** Exemplary natural communities and rare plants at Cardigan Mtn. State Forest.

**RARE PLANT SPECIES**

*Carex bigelowii* (Bigelow's sedge)

In New Hampshire, *Carex bigelowii* (Bigelow's sedge) is restricted to the alpine zone in the White Mountains, with the exception of the occurrence at Mt. Cardigan (Figure 4). The CMSF population is the most southerly in the state, and the only one below 3400 ft. elevation. It occurs essentially as a single patch roughly 15-20m$^2$ in size just to the north of the fire tower on the summit, although there may be scattered individual plants in other nearby vegetation patches.

*Carex bigelowii* (Bigelow's sedge) patch on the summit of Mt. Cardigan. Photos by Pete Bowman.

*Carex capitata* ssp. *arctogena* (head-like sedge)

CMSF is the only place *Carex capitata* ssp. *arctogena* (head-like sedge) occurs in New Hampshire outside of the alpine zone of Mt. Washington (Figure 4). This very fine-leaved sedge grows in several colonies on the open rock just west of the summit of Mt. Cardigan. It is found in mixed vegetation patches with a variety of other subalpine plants, such as *Empetrum nigrum* ssp. *hermaphroditum* (black crowberry), *Vaccinium vitis-idaea* (mountain cranberry), *Sibbaldiopsis tridentata* (three-toothed cinquefoil), and *Ledum groenlandicum* (Labrador tea).

*Carex capitata* ssp. *arctogena* (head-like sedge) on Mt. Cardigan. Photo by Pete Bowman.

*Huperzia appalachiana* (mountain firmoss)

This small fern relative was relocated during this study for the first time since 1972. Only a single plant was observed growing in a crack below a small ledge on the northern slope of the main peak (Figure 4). This plant is also known from Mt. Monadnock and from alpine peaks in the White Mountains.

*Huperzia appalachiana* (mountain firmoss) in rock cracks on Mt. Cardigan. Photos by Pete Bowman.

**OTHER NATURAL FEATURES**

There were two areas in the ***sugar maple - beech - yellow birch forest*** on the eastern slopes of Mt. Cardigan that held significant concentrations of large trees [62 cm (24") to 95 cm (37") dbh] (see Figure 5). The first area (Area A) is located on a moist slope between the Cathedral Forest Trail and the Vistamont Trail. The second area (Area B) is located in a cove at the head of Davis Brook, below the rock formation known as Cilley's Cave. In both of these areas, a number of large trees—both *Betula alleghaniensis* (yellow birch) and *Acer saccharum* (sugar maple)—were cored to get an estimate of their ages. The majority of the trees cored fell into an age range of 130-180 years. However, both areas held significantly older individual trees with an estimated age of 270 years. There were many trees which were not cored because of evidence of rot, which would have made an accurate age estimate impossible.

Although 270 year old trees can be indicative of old-growth conditions, the stands containing these trees lacked other characteristics typical of true old-growth northern hardwood forests in New Hampshire. First, these old trees comprised a small portion of the canopy trees. In addition, there was a lack of large amounts of coarse woody debris, as well as an absence of *Picea rubens* (red spruce), suggesting that this species had been removed through selective timber harvesting decades ago. Although these areas do not represent true old-growth forest, they probably contain the closest semblance to these conditions at CMSF and have had limited timber harvesting activity compared to other areas.

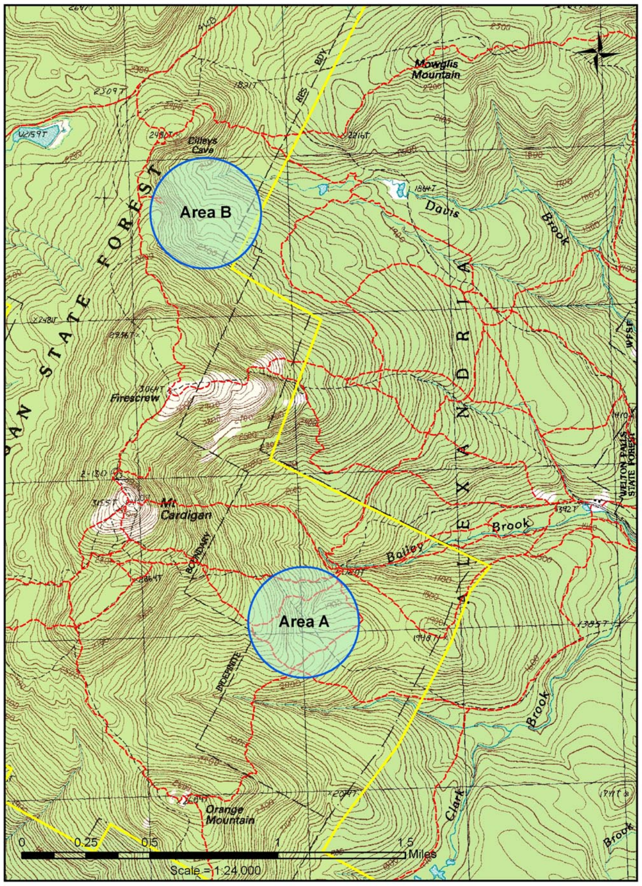


**Figure 5.** Areas with concentrations of large trees.

## MANAGEMENT CONSIDERATIONS

*Subalpine Zone*

Despite the large size of Cardigan Mountain State Forest, most of its significant biodiversity features are concentrated in the comparatively small area of the Mt. Cardigan summit and its upper slopes. The exemplary ***subalpine heath - krummholz/rocky bald system*** not only supports three rare plant species, but also a whole suite of subalpine species found in few places in New Hampshire outside of the White Mountains. All of these species currently experience their greatest stress from the pressures of recreational hikers. Several of the vegetation patches that support rare species are also very appealing locations for people to sit and rest, and hikers can walk freely across the summit, trampling the plants and exacerbating erosion of the thin soils.

The most significant step that could be taken to protect the rare and subalpine species is to educate visitors about the sensitivity of this area and to encourage them to tread lightly. Informative signs at the major trailheads on either side of the park, as well as at the summit, would likely provide the greatest benefit. These signs would indicate that the vegetation at the summit includes rare species and is very sensitive to human impacts, and would request that hikers stick to areas of exposed bedrock without plants or soil.

*Old Forest*

Old growth forests generally have several characteristics that separate them from younger forests of the same community type. They tend to have greater structural diversity, such as large amounts of coarse woody debris and large snags for cavity nesters, and a mix of age and size classes which are not usually present in younger forests (McGee et al. 1999). In addition, this increased structural diversity is often associated with aspects of biodiversity absent or rare in younger forests, particularly among more inconspicuous taxa such as invertebrates, lichens, and bryophytes (Selva 1996, Willett 2001, Cooper-Ellis 1998).

While the old forest stands at Area A and Area B (see figure 5) do not represent true old growth forest, they bare the closest resemblance to such forest conditions on the property, and are the most likely places at CMSF for old growth conditions to develop in the future. If future management planning considers promotion of older forest conditions a desirable goal, these are the best areas to consider for special designation (i.e., potential no-cut areas).

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## Appendix 1. NH Heritage Ecological Approach.

### NATURAL COMMUNITIES

NH Heritage 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 NH Heritage 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

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*

NH Heritage 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**

NH Heritage 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, NH Heritage 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*).

NH Heritage, 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, NH Heritage 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.

NH Heritage 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 NH Heritage'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). |

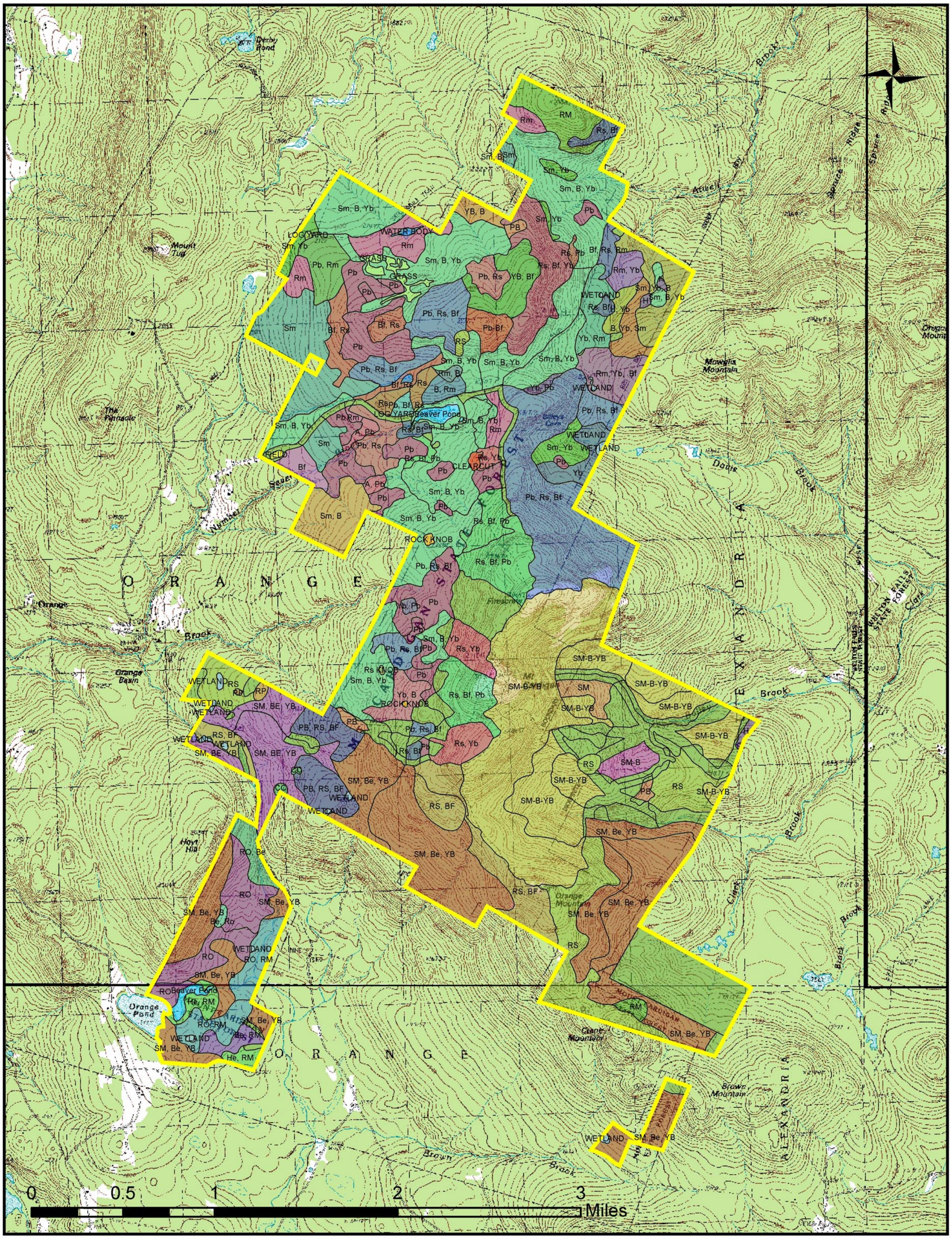
Modifiers are used as follows.

| *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). |

# Appendix 3. Cover Types at Cardigan Mountain State Forest.




Data source: Forest Type Map done by DRED staff (1997), based on a 400' grid plot. Complex Systems Research Center digitized stands into geo-referenced ACAD maps. Map scale = 1:50,000.