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Ecological Inventory of Cape Horn State Forest

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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: Looking south along the Cape Horn ring dike, with the exemplary ***rich mesic forest*** *at the base of the slope to the east.* Photo by Scott Bailey.

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ACKNOWLEDGEMENTS

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SUMMARY

In 2001, the New Hampshire Natural Heritage Bureau (NH Heritage) conducted a landscape analysis of all state-owned properties in New Hampshire, in order to determine the highest priority sites for ecological inventory. As a result of this process, Cape Horn State Forest (CHSF) was identified as being one of the highest priority properties in the state, due to its unique geologic features and potential to support rare plant species and exemplary natural communities.

NH Heritage conducted the ecological inventory of the state forest during the field seasons of 2005 and 2006. The purpose of this was to provide the Division of Forests and Lands and the Division of Parks and Recreation with an in-depth accounting of the biodiversity of the property, in order to inform future management and planning decisions. As a result of this survey, 7 exemplary natural communities and natural community systems and 13 rare plant species were documented in the forest.

US Forest Service geologist Scott Bailey has been independently developing a comprehensive flora of Cape Horn, and a draft of his work is included as an appendix. He has also provided an in-depth discussion of the geology and soils of CHSF for this report.

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 2001) 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 **Cape Horn State Forest** (CHSF), a 2,074-acre tract in the town of Northumberland, which is centered around the 2,040 ft. ridge known as Cape Horn. During 2005 and 2006, NH Heritage conducted an ecological inventory and assessment of CHSF, 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

A property-scale 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 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 the study area. We also 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. A GPS unit was also used to determine the location of invasive plant populations. The accuracy of the data collected by the GPS was generally within 15 meters. Field data and site locations of exemplary natural communities and rare plant populations have been catalogued and incorporated into the NH Natural Heritage database.

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

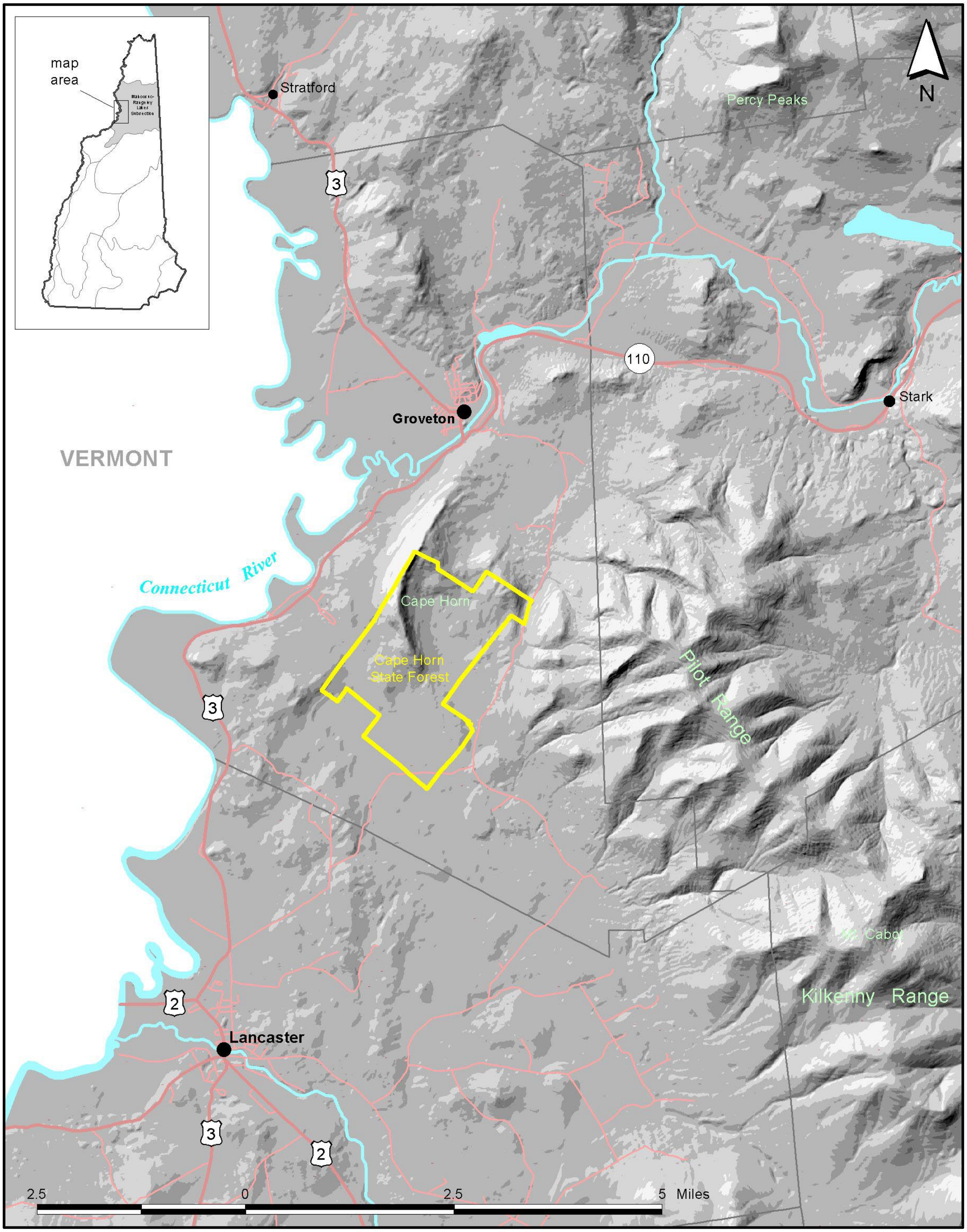

Figure 1. Regional setting of Cape Horn State Forest.

RESULTS

NATURAL SETTING OF CAPE HORN STATE FOREST

Cape Horn State Forest is located in northern New Hampshire, within the White Mountains Section (see Figure 1)[1]. This section consists of an area extending from northern New Hampshire into northern Maine. 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). CHSF falls into the Mahoosuc-Rangeley Lakes subsection, which occupies the area north of the higher elevations of the White Mtns. and south of the towns of Colebrook and Dixville. The geology of this region is complex, with igneous granitic bedrock interspersed with areas of metasedimentary rocks. Where the bedrock type has a greater degree of mineral enrichment or is subject to more rapid weathering, enriched soil conditions can develop that are conducive to increased plant diversity and rare species.

The primary feature of the property is the arcing ridge known as Cape Horn, which has an elevation of 2,040 ft. at its highest point (which is actually on private property just outside the CHSF boundary). The ridge is oriented on a primarily north-south axis, with the concave side of the arc to the east. The upper slopes of the ridge are very steep, with extensive cliffs and ledges on both sides. Below the cliffs are large accumulations of talus, below which the slopes become gentler as they grade into the surrounding rolling terrain of the Connecticut River valley.

Most of the ridge and its eastern slope lie within CHSF, as does the southern half of its western slope. The cove at the base of the eastern slope forms the headwaters of Dean Brook, which flows south past the property boundary before making an abrupt turn to the northwest and returning to CHSF. It crosses the entirety of the southern portion of CHSF, which consists of flat to gently rolling terrain, passing between the main ridge and a low knob called Beech Hill (just off the site), and flowing into the Connecticut River just to the west. The point where the brook leaves the property is the lowest elevation on CHSF, at around 980 ft.

BEDROCK GEOLOGY

The bedrock underlying Cape Horn State Forest includes Ordovician granites to diorites west and south of Cape Horn, syenite on Cape Horn itself, and mica schists to quartzites on the northwest and east side (Lyons et al. 1997). The oldest rocks are Ordovician granites to diorites

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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.

that are part of the Lost Nation pluton, dated at 442 million years old. Outcrops on the state forest are mostly dioritic, composed of plagioclase, hornblende and epidote, with lesser amounts of biotite and quartz. These rocks predate the Acadian Orogeny, the major mountain building

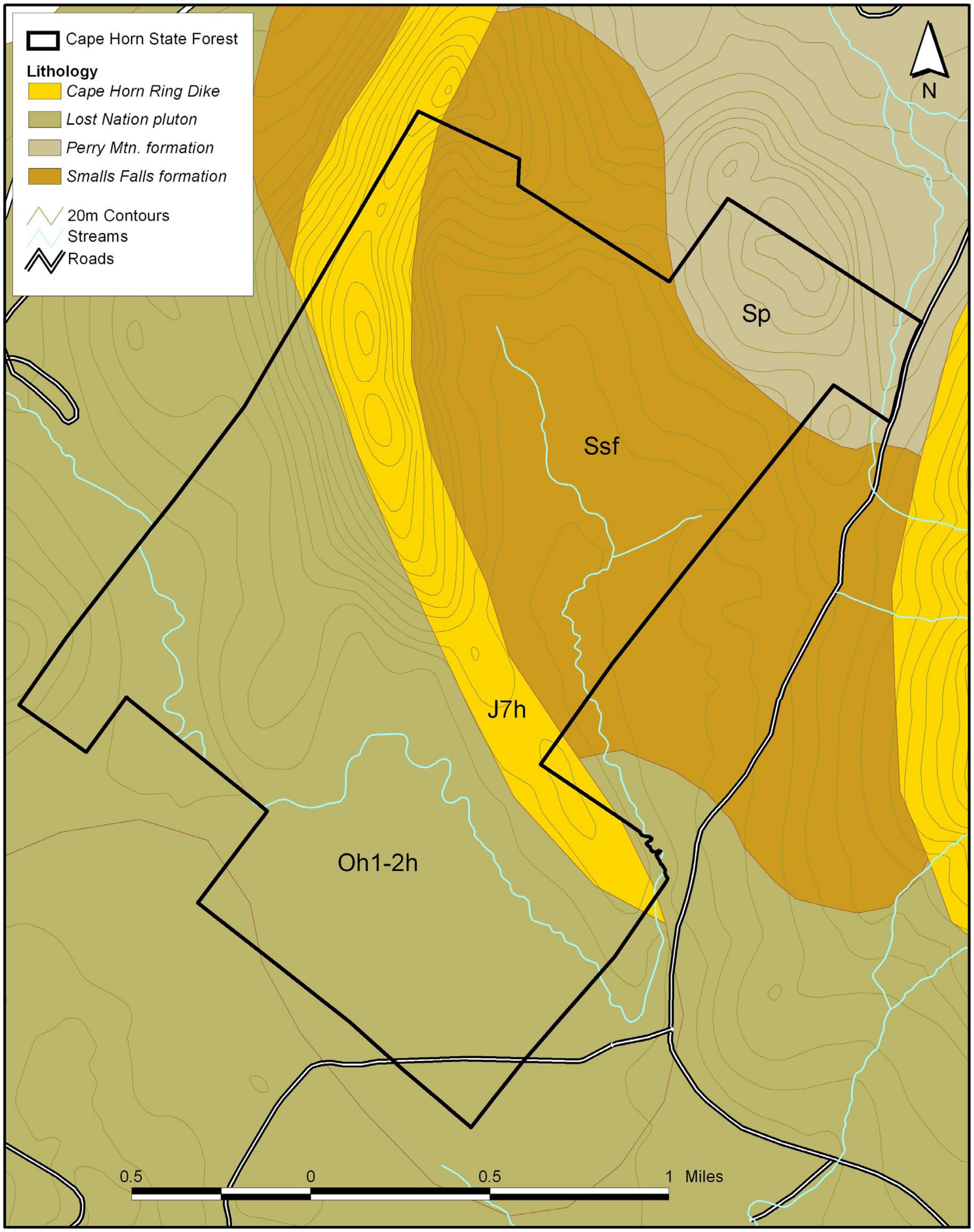


Figure 2. Bedrock geology of Cape Horn State Forest.

event that formed this portion of the Appalachian Mountains. As such, they are among the most highly altered igneous rocks of the region, as evidenced by the epidote content, along with lesser amounts of sericite, chlorite and calcite. Calcite is highly unstable in humid weathering environments, while epidote, hornblende and calcic-plagioclase are moderately unstable, and have a relatively high content of a number of nutrient elements. Groundwater percolating through these rocks, and soils formed from glacial materials composed of these rocks, tend to have higher pH and mineral nutrient content compared to other sites in the region.

The schists and quartzites were laid down as silty to sandy sediments in an ocean basin that closed with the formation of the Appalachians. They belong to the Perry Mountain (428 – 421 million years old) and Smalls Falls (421 – 414 million years old) Formations. The Smalls Falls is more schistose, composed primarily of micaceous minerals, and is typically sulfidic. Pyrite, the chief sulfide mineral, is highly unstable in the weathering environment, leaving outcrops with a heavy rusty stain. In general, the Smalls Falls is a poor outcrop former due to its susceptibility to both mechanical and chemical weathering. Relatively low sulfate concentrations in surface and groundwater at CHSF suggest that it has little influence on the biogeochemistry of the forest. The Perry Mountain Formation tends to be more quartzose, reflecting a sandier sedimentary origin. It is more resistant to weathering and tends to support more acidic, nutrient poor habitats. At CHSF, it underlies the hill on the northeastern portion of the property.

If New Hampshire has a geologic claim to fame, it is probably ring dikes. These are conspicuous bodies of both intrusive and extrusive igneous rocks with a circular outline in map view. The most complete ring dike, and the source of the classic study of this type of intrusion, is the Ossipee ring dike. Other ring dikes include Mt. Pawtuckaway, the Belknaps, and Mt. Tripyramid. The main portion of the White Mountains consists of several large, composite ring dikes, mostly cored by Conway Granite, and surrounded by concentric circular to crescent shaped dikes of igneous rocks of a range of textures and compositions. Immediately to the north, the Pliny Ring Dike Complex is a similar, if somewhat smaller version of the White Mountain complex. Cape Horn is underlain by a crescentic dike that is the westernmost portion of the Pliny Complex. This complex is Jurassic in age, dated at 182 million years old (Randall and Foland 1986). All of these ring dikes are part of the White Mountain Magma Series, a sequence of plutonic and volcanic rocks that were derived directly from a mantle hot-spot at about the time of the initial opening of the Atlantic Ocean basin.

Cape Horn is considered to be the best topographically expressed structure of its type in North America (Chapman 1948). The crescent shape of Cape Horn corresponds exactly to the boundaries of a black to dark-green syenite, which is highly resistant to erosion, accounting for the rugged, steep-sided topography of Cape Horn. The dike is thought to dip at an angle of about 75 degrees to the west, similar in style to comparable structures found in Scotland (Chapman 1935), although direct evidence of this at Cape Horn is limited by a lack of exposure of the contact with the older neighboring rocks. However, this is consistent with the slabby nature of many ledges on the west side of the hill, in contrast to the overhanging cliffs typical of the east side.

The stability of this syenite is due to both its mineralogy and texture. It is composed chiefly of orthoclase (potassium feldspar) a mineral that is highly resistant to chemical weathering. The texture of this rock is porphyritic, meaning that there are some larger crystals (orthoclase) in a generally fine-grained groundmass. This dense, fine-grained matrix makes the rock extremely tough and difficult to fracture. The groundmass is composed of orthoclase, hornblende and hedenbergite, with minor amounts of diopside, quartz, magnetite, apatite and a variety of other accessory minerals. Hornblende is relatively unstable in humid weathering environments, while hedenbergite and diopside are somewhat less stable still. Decomposition of these minerals results in a tan to brownish weathering rind and buffers acidity while contributing a variety of nutrient elements to percolating waters. Due to the overall resistance of syenite to weathering, these reactions are likely confined to portions that are more highly fractured, increasing the surface area of minerals and the residence time of exposure to water.

Surficial Geology and Soils

Up to several meters or more of unconsolidated surfical materials blanket most of the bedrock at CHSF. Glacial till, an unsorted mixture of sand, silt, clay and boulders deposited directly from glacial ice approximately 12,000 years ago, is by far the dominant parent material for mineral soils on the state forest. It typically has a fine sandy loam texture, and is formed from a variety of lithologies. Pebbles and boulders exposed in streams at Cape Horn suggest that locally the till was derived from a mixture of granitic to dioritic rocks from the Lost Nation Pluton immediately to the west of Cape Horn, schists immediately to the north and west, and phyllites and Devonian two-mica granites from further northwest in adjacent Essex County, Vermont. Some of the phyllites and Lost Nation plutonic rocks contain calcite and it is likely that deeper, unweathered portions of the till are slightly calcareous. A sample of till taken from a core of the ***northern white cedar - balsam fir swamp*** east of Dean Brook tested calcareous with weak HCl. However, it is uncertain whether this reaction was due to primary calcite in the till, or to mixing with overlying lacustrine sediments, which contain mollusk and gastropod shells.

The wetlands adjacent Dean Brook are partially underlain by finer, better sorted materials, probably deposited during periods of ponding, during or shortly after retreat of the Wisconsinan ice sheet. Sandy loams and silt loams are present beneath organic deposits in mixed conifer and northern white cedar swamps while a small area of silty clay was observed adjacent a vernal pool at the headwaters of Dean Brook. Organic materials of a range of origins and states of decomposition form the parent material for soils in the wetlands along Dean Brook. These materials are dominated by well-decomposed mucks. Poorly decomposed peats, of both sedge and Sphagnum origin, are found at some locations. At depth in areas of former ponding is a gelatinous material that appears to be composed of coprogenous earth, derived from lacustrine macroinvertebrates. The lacustrine origin of this material is evidenced by shells of small mollusks and gastropods. There are also plant macrofossils in this material, including sedge, willow and spruce leaves. These macrofossils, along with microfossils such as pollen, could be studied to provide information on past climates and vegetational succession in the Cape Horn region.

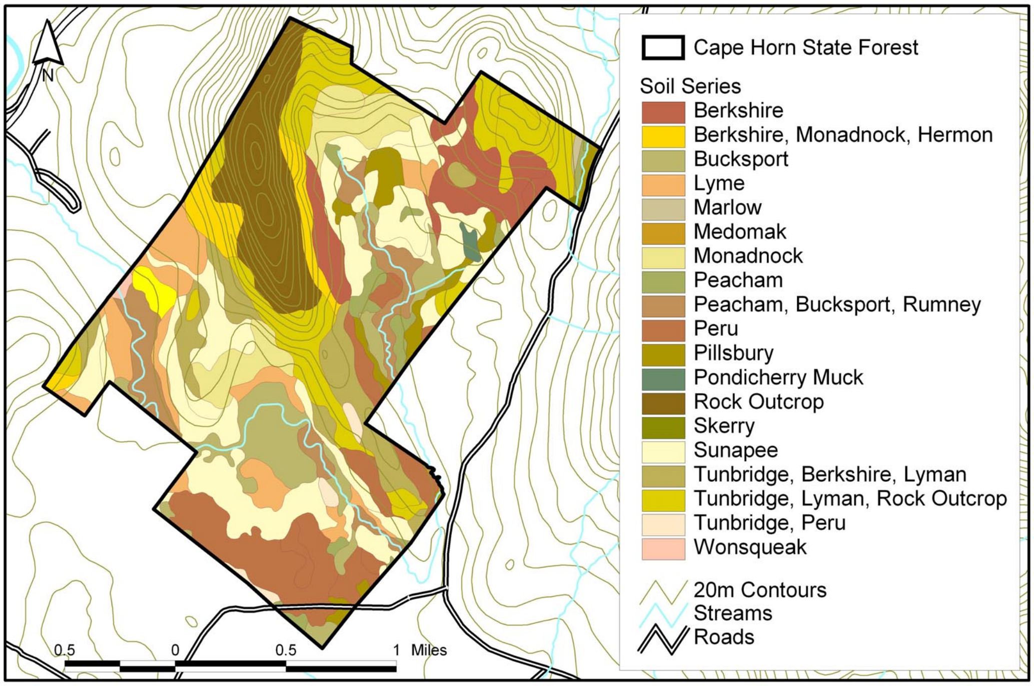


Figure 3. Soils of Cape Horn State Forest.

Specific soils of Cape Horn include Spodosols of the Lyman, Tunbridge and Peru Series, formed in moderately well to well drained firm glacial till, listed in order of increasing depth to bedrock (Figure 3). In more enriched habitats, with lower acidity, Inceptisol variants of these soils are present. In somewhat poorly to poorly drained habitats, these same parent materials form Inceptisols of the Colonel and Pillsbury Series. Histosols formed from well decomposed plant remains are most similar to the Bucksport Series, although at Cape Horn they are not acidic enough to be in the accepted range for this series.

FACTORS OF NUTRIENT ENRICHMENT IN SOIL AND WATER

Much of Cape Horn State Forest contains plants and soil that reflect a relative enrichment in nutrients compared to what would be considered typical for northern New Hampshire. Several factors contribute to nutrient enrichment in soils and surface waters, operating at different spatial scales, and interacting to produce a mosaic of habitat quality. They are listed here in order, from processes that tend to affect larger areas, to very local effects.

Soil mineralogy determines that rate and proportions of nutrients released by mineral decomposition (weathering). In the region of Cape Horn, soil mineralogy is determined by the lithologic source of glacial parent material (Figure 2). It is modified by depletion of more reactive phases over 10,000+ years of weathering and by secondary coatings that armor minerals from further alteration. Glacial materials are fairly well homogenized with gradients in soil parent material composition mostly evident at the scale of square kilometers or more. Depletion of reactive phases is highly dependent on landscape position, with more reactive phases typically depleted from the rooting zone of shoulder and summit positions, but still present in foot and toe slope positions. At Cape Horn, glacial till is relatively enriched in mineral nutrients. For example, C-horizon samples from several sites on the White Mountain National Forest (WMNF) immediately southeast of Cape Horn had 2.2 - 2.7% total Calcium (Ca) content. In comparison, total Ca content in glacial till on other portions of the WMNF ranged from 0.7 to 2.6%.


Bedrock fracturing on cliff face. Photo by Scott Bailey.

Discharge of mineral enriched groundwater brings weathering products from subsoil and bedrock to the rooting zone. The influence of seepage on plant communities is driven by distribution of fractures in bedrock, hydraulic conductivity of bedrock and surfical materials, and topography. Benches, breaks in slope, and toeslopes are typical locations of groundwater discharge. Seepage generally results in enrichment at the scale of a hillside, usually in mid to lower physiographic positions. Well fractured bedrock, with closely spaced joints in two or more intersecting orientations, results in discharge from outcrops and cliffs, even at relatively high physiographic positions. Cape Horn, and Moore Mountain, an extension of the same ring dike, are excellent examples of enriched communities on higher position cliffs that depend on seepage. Typically surface waters in north-central New Hampshire contain 1 – 2 mg L^{-1} Ca with a pH in the 5's. In comparison, cliff seepage at Cape Horn contains up to 19 mg L^{-1} Ca with a pH as high as 7.8. Concentrations of magnesium and sodium are also enhanced in cliff seepage, consistent with weathering of the mafic minerals (hornblende, diopside and hedenbergite) in the syenite.

Besides influencing depletion of reactive soil minerals, as well as groundwater discharge, topography further influences patterns of enrichment by controlling the relative effectiveness of litter entrapment. Topography, acting with prevailing wind patterns, focuses litter accumulation in concave portions of hillslopes and on the leeward side of hills. Cove forests are excellent examples of this pattern of enrichment. Larger hillslopes, such as the 130 acre ***rich mesic forest*** on the concave east side of the crescent-shaped Cape Horn reflect this pattern. At a smaller scale, rocky terrain may enhance litter accumulation by providing traps between glacial boulders, or among blocks of rock at the base of talus slopes.

The most local enrichment factor is observed around the base of large trees, where cover of rich woods species, especially spring ephemerals, is often greater than it is elsewhere. Enhanced litter accumulation and stemflow both improve nutrient and moisture relations at these sites.

This pattern is especially noted for species that have foliage with relatively high concentrations of nutrients and low concentrations of tannins and lignins (which enhances decomposition rates), such as sugar maple, white ash, and basswood.

In general, most of Cape Horn exhibits one or more factors of nutrient enrichment, resulting in an area of high biodiversity. The richest sites are those where all of the above factors are present. At CHSF, this is the portion of the eastern side of Cape Horn with concave topography across the slope, between the base of the talus and the toe. This area has soils developed in relatively mineral-rich glacial till, receiving enriched seepage from ***montane circumneutral cliff*** communities, and with enhanced litter accumulation at the toe of the talus on a hillside that is concave across the slope. Two soil profiles have been described and sampled in this vicinity and can be compared to a large study of northern hardwood soils in four states, and covering a range of parent material sources from unglaciated sandstones to dolomitic marble. Over the region, extractable nutrients varied by almost three orders of magnitude. For example, upper B-horizon exchangeable Ca varied by a factor of about 500, from 0.04 to 25 $cmol_c kg^{-1}$. In comparison, exchangeable Ca at the two Cape Horn sites was 11.5 and 0.65 $cmol_c kg^{-1}$, placing these two sites above the 95 and around the 70 percentile compared to the regional sample.

Vegetation

The unique geology and topography of Cape Horn State Forest has led to the development of a diverse flora and a wide variety of natural community types. On top of Cape Horn, running most of the length of the ridge, is a ***red pine rocky ridge*** community. *Pinus resinosa* (red pine) is the dominant, and often only, species in the canopy, although *Quercus rubra* (red oak) and *Acer rubrum* (red maple) are not uncommon associates.

Below the crest of Cape Horn, on the eastern side of the ridge, is a suite of communities collectively comprising a **montane cliff system**. These cliffs run the length of the ridge, and descend the slope face, broken by a series of narrow terraces. Like most cliff communities, they consist of vertical or near-vertical surfaces of exposed bedrock that are primarily devoid of vascular vegetation, with scattered plants occurring in the cracks and on the ledges of the cliff face. The community occupying the largest percentage of this area is the ***montane acidic cliff***. The vascular plants in this community are mainly species that are typical of dry, nutrient-poor sites, or sites with large areas of exposed bedrock and/or boulders, such as *Deschampsia flexuosa* (common hairgrass), *Corydalis sempervirens* (pale corydalis), and *Polypodium virginianum* (rock polypody).

Other portions of the cliff support species that are indicative of increased levels of mineral enrichment. These areas are classified as the ***montane circumneutral cliff*** community. In addition to supporting the tree *Thuja occidentalis* (northern white cedar), the circumneutral cliffs at CHSF harbor two rare plant species, *Dryopteris fragrans* (fragrant fern) and *Cryptogramma stelleri* (slender cliffbrake). These rare ferns (particularly the *Cryptogramma*) often occur in areas where groundwater emerges from cracks in the bedrock, which are classified as a separate community type, the ***cliff seep***. These seeps can occur on both acidic and circumneutral cliffs, but at CHSF they tend to be more prevalent in the latter, and thus provide habitat for rare plants.

As cliff faces erode over time, the debris from this erosion is often deposited at the base of the cliff in the form of large boulder fields. These boulder fields are known as *talus*, and the communities that occupy these areas at CHSF are collectively described as a **montane acidic talus system**. At CHSF, this system is comprised primarily of two communities: ***spruce - birch - mountain maple wooded talus*** and ***montane lichen talus barren***. The talus barren consists of extensive areas of lichen-covered talus boulders, with little or no soil development, and minimal cover of vascular plants, which are generally present only in cracks between the rocks. The wooded talus community typically has an open woodland structure, with scattered individuals of *Betula papyrifera* (paper birch), *Betula alleghaniensis* (yellow birch), and *Acer spicatum* (mountain maple), with occasional *Picea rubens* (red spruce).

Below the talus system the topopgraphic gradient moderates, and much of this slope is covered with ***rich mesic forest***. This forested community is dominated by hardwoods such as *Acer saccharum* (sugar maple) and *Fraxinus americana* (white ash), and is characterized by a lush and diverse herbaceous layer. Typical herbs in this community include *Adiantum pedatum* (northern maidenhair fern), *Caulophyllum thalictroides* (blue cohosh), *Laportea canadensis* (wood nettle), *Solidago flexicaulis* (zigzag goldenrod), *Osmorhiza claytonii* (Clayton's sweet cicely), and *Deparia acrostichoides* (silvery spleenwort). Several rare species are present in this community, including *Dryopteris goldiana* (Goldie's fern), *Sanicula trifoliata* (beaked sanicle), *Galearis spectabilis* (showy orchis), and *Dicentra canadensis* (squirrel corn). This community occurrence is one of the largest in the state, and extends from the base of the talus slope to the edge of the wetlands associated with Dean Brook. There is also a similar, although smaller, example on the western slopes of the ridge that supports rare plant species.

In a basin near the headwaters of Dean Brook is a ***northern white cedar - balsam fir swamp***. This forested wetland type occurs primarily in areas where the groundwater has an elevated level of mineral enrichment. *Thuja occidentalis* (northern white cedar) is the dominant tree, with *Abies balsamea* (balsam fir) and *Fraxinus nigra* (black ash) as frequent associates. The forest floor is covered by a lush cover of bryophytes which support a diverse array of herbaceous species. Typical herbs include *Mitella nuda* (naked miterwort), *Carex trisperma* var. *trisperma* (three-seeded sedge), *Circaea alpina* (small enchanter's nightshade), *Carex pedunculata* (long-stalked sedge), and *Rubus dalibarda* (false violet).

Downstream of the northern white cedar swamp, the Dean Brook corridor supports a wide variety of wetland communities. Most frequent are open wetlands associated with the **emergent marsh - shrub swamp system**. These communities range from the ***deep emergent marsh - aquatic bed*** to the ***alder - dogwood - arrowwood alluvial thicket***, and are characterized by the presence of primarily mineral or muck substrates. In areas where the buildup of organic matter has led to the development of peat soils, open wetlands of the **medium level fen system** occur. These peatland communities are characterized by the presence of a *Sphagnum* mat, and typical medium fen species such as *Chamaedaphne calyculata* (leatherleaf), *Myrica gale* (sweet gale), *Carex utriculata* (bottle-shaped sedge), and *Eriophorum virginicum* (tawny cotton-grass). Throughout the stream corridor, the creation and subsequent abandonment of beaver ponds has created a shifting mosaic of communities in these two systems.

In areas where there is a broad lowland associated with Dean Brook, coniferous swamps occupy the zone between the open riparian wetlands and the surrounding uplands. On the south side of the brook, different forms of the ***black spruce - larch swamps*** are present. In the forest variant, *Picea mariana* (black spruce) forms a virtually monotypic canopy above a dense carpet of *Sphagnum* mosses, with the primary herbaceous species being *Gaultheria hispidula* (creeping snowberry) and *Carex trisperma* (sedge). In the woodland variant, there is less than 50% tree cover, and a dense shrub layer dominated by *Rhododendron canadense* (rhodora), with *Kalmia angustifolia* (sheep laurel), *Ledum groenlandicum* (Labrador tea), and *Chamaedaphne calyculata* (leatherleaf). Other plants typical of poor fens include *Sarracenia purpurea* (pitcherplant), *Vaccinium oxycoccos* (small cranberry), and *Andromeda polifolia* var. *glaucophylla* (bog rosemary).

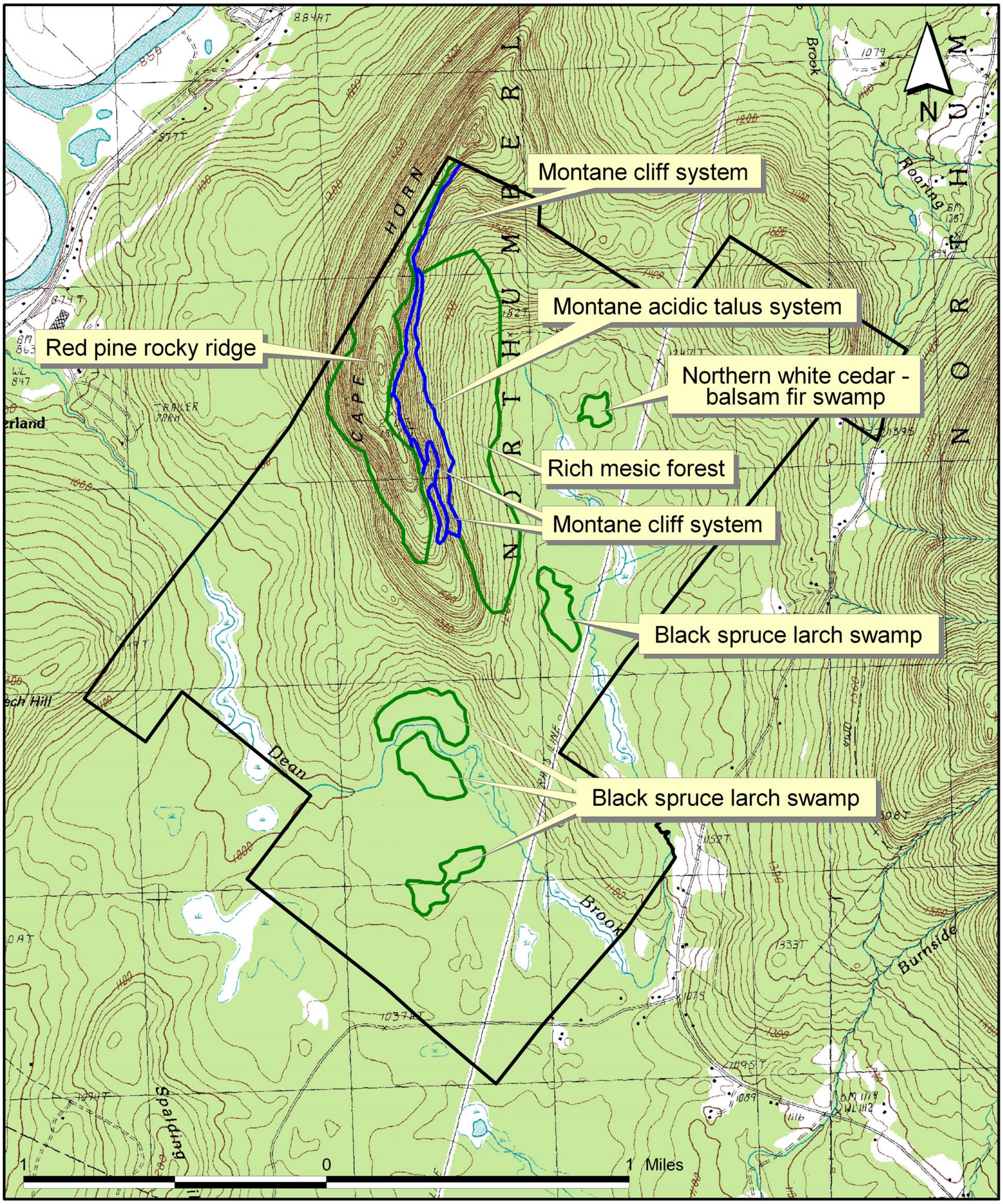


Figure 4. Exemplary natural communities and natural community systems at Cape Horn State Forest.

EXEMPLARY NATURAL COMMUNITIES AND NATURAL COMMUNITY SYSTEMS

Red pine rocky ridge (S2)

This community occupies the crest of the ridge of Cape Horn and much of the upper west-facing slopes. *Pinus resinosa* (red pine) is the dominant, and in some places, only canopy tree. But it is often accompanied by *Quercus rubra* (red oak), *Acer rubrum* (red maple), and *Pinus strobus* (white pine). In depressions or other portions of the ridge with more mesic soil conditions, these hardwoods become dominant, and red pine may drop out entirely in these small inclusions. Low heath shrubs such as *Vaccinium angustifolium* (lowbush blueberry) and *Vaccinium myrtilloides* (velvet-leaf blueberry) are common, as are herbs like *Pteridium aquilinum* (bracken), *Maianthemum canadense* (Canada mayflower), *Cypripedium acaule* (pink lady's slipper), and *Polypodium virginianum* (rock polypody).

Exemplary ***red pine rocky ridge*** community on the crest of Cape Horn. Photo by Ben Kimball.

Montane cliff system

This natural community system occupies the series of cliffs that stretch for roughly a mile along the upper eastern face of Cape Horn. In places, the cliff is a monolithic wall 10 m and greater in height. More frequently, it is a series of shorter faces that descend the ridge in stair-step fashion, with vertical sections separated by flat benches or inclined slabs. The community that occupies that greatest proportion of the cliff area is the ***montane acidic cliff*** (S5). This is a community that is widespread in the White Mtns. and northward, and supports plants common to bedrock exposures such as *Polypodium virginianum* (rock polypody), *Corydalis sempervirens* (pale corydalis), *Aquilegia canadensis* (wild columbine), and *Dryopteris marginalis* (marginal wood fern), among others.

The more unusual community in this system is the ***montane circumneutral cliff*** (S2S3), which provides suitable conditions for several uncommon plant species. On circumneutral cliffs, there is a greater degree of mineral enrichment than on acidic cliffs, which may be the result of a variety of factors. The bedrock of circumneutral cliffs generally has a greater degree of fracturing than other cliffs, which allows for greater infiltration by groundwater and subsequently, a greater degree of mineral weathering into the water. These minerals are then available to plants along cracks where groundwater is able to reach the surface. The plant most indicative of these conditions is *Dryopteris fragrans* (fragrant fern), which is found at several locations along the cliff (see *Rare Plant Species* section below). This community probably accounts for somewhere between 10% and 25% of the overall system area, although in a vertical, often difficult-to-access setting, these percentages are only coarse estimates.

Cliff seeps (S3S4) are found wherever there is a persistent source of groundwater flowing over the surface of the rock. These seeps can be found on both acidic and circumneutral cliff faces, but it is in the circumneutral settings that the rare fern *Cryptogramma stelleri* (slender cliffbrake) is found (see *Rare Plant Species* section below). This species is found in at least three of these seeps at Cape Horn.

Exemplary ***montane cliff system*** on the east face of Cape Horn. Photo by Ben Kimball.

Montane acidic talus system

Below a portion of the cliff system, and extending well to the south of the cliffs, is an extensive area of talus - boulder fields created by the erosion of cliffs and steep slopes. This talus system is classified as acidic because, despite the enriched conditions present on the cliffs above (and in the ***rich mesic forest*** below), there is very little evidence of enrichment in the talus communities. The most conspicuous community in the system is the ***montane lichen talus barren*** (S3). These barrens are essentially large open boulder fields, with lichens covering the rocks, but very little cover of vascular plants.

Areas that are vegetated are generally classified as ***spruce - birch - mountain maple wooded talus*** (S3). The dominant trees in this community are *Betula alleghaniensis* (yellow birch) and *Betula papyrifera* (paper birch). *Acer spicatum* (mountain maple) is frequent in the understory, along with *Acer pensylvanicum* (striped maple) and *Viburnum lantanoides* (hobblebush). *Picea rubens* (red spruce) is present, but usually in low abundance. *Polypodium virginianum* (rock polypody) is abundant on rocks, along with *Dryopteris marginalis* (marginal wood fern) and *Aralia nudicaulis* (wild sarsaparilla). In some areas at the base of the talus, there is a narrow transition zone to the rich forest below. Areas with significant cover of rich-site indicator species were generally classified as ***rich mesic forest***.

Exemplary ***montane acidic talus system*** on the eastern slopes of Cape Horn. Photo by Ben Kimball.

Rich mesic forest (S3)

Throughout New Hampshire, ***rich mesic forests*** are among the most biologically diverse of upland communities, and the occurrence of this community at CHSF is one of the largest in the state. The characteristic canopy tree is *Acer saccharum* (sugar maple), with *Fraxinus americana* (white ash) and *Tilia americana* (basswood) as frequent associates. The species diversity is greatest in the herbaceous layer, with some of the most abundant species including *Adiantum pedatum* (northern maidenhair fern), *Caulophyllum thalictroides* (blue cohosh), *Laportea canadensis* (wood nettle), *Solidago flexicaulis* (zigzag goldenrod), *Osmorhiza claytonii* (Clayton's sweet cicely), *Botrychium virginianum* (rattlesnakefern), *Aralia racemosa* (spikenard), and *Carex plantaginea* (plantain-leaved sedge). This community is also host to several rare species, including *Dryopteris goldiana* (Goldie's fern) and *Sanicula trifoliata* (beaked sanicle) (see *Rare Plant Species* section below).

Exemplary ***rich mesic forest*** community east of Cape Horn. Photo by Ben Kimball.

Northern white cedar - balsam fir swamp (S2)

This swamp community is indicative of mineral-enriched conditions, and occurs near the head of the Dean Brook drainage. The diagnostic species in the canopy is *Thuja occidentalis* (northern white cedar), but other trees include *Fraxinus nigra* (black ash), *Abies balsamea* (balsam fir), and *Picea glauca* (white spruce). Shrubs are sparse in the understory, and there is a dense carpet of bryophytes, including several species of *Sphagnum* moss. Herbaceous cover is lush and diverse, with dominant species such as *Osmunda cinnamomea* (cinnamon fern), *Oxalis montana* (northern wood sorrel), *Tiarella cordifolia* (foamflower), *Oclemena acuminata* (whorled aster), and *Onoclea sensibilis* (sensitive fern). Other species that are indicative of enriched conditions include *Carex disperma* (two-seeded sedge), *Geum rivale* (purple avens), and *Coeloglossum viride* (green-bracted orchis).

Exemplary ***northern white cedar - balsam fir swamp*** at Cape Horn State Forest. Photo by Dan Sperduto.

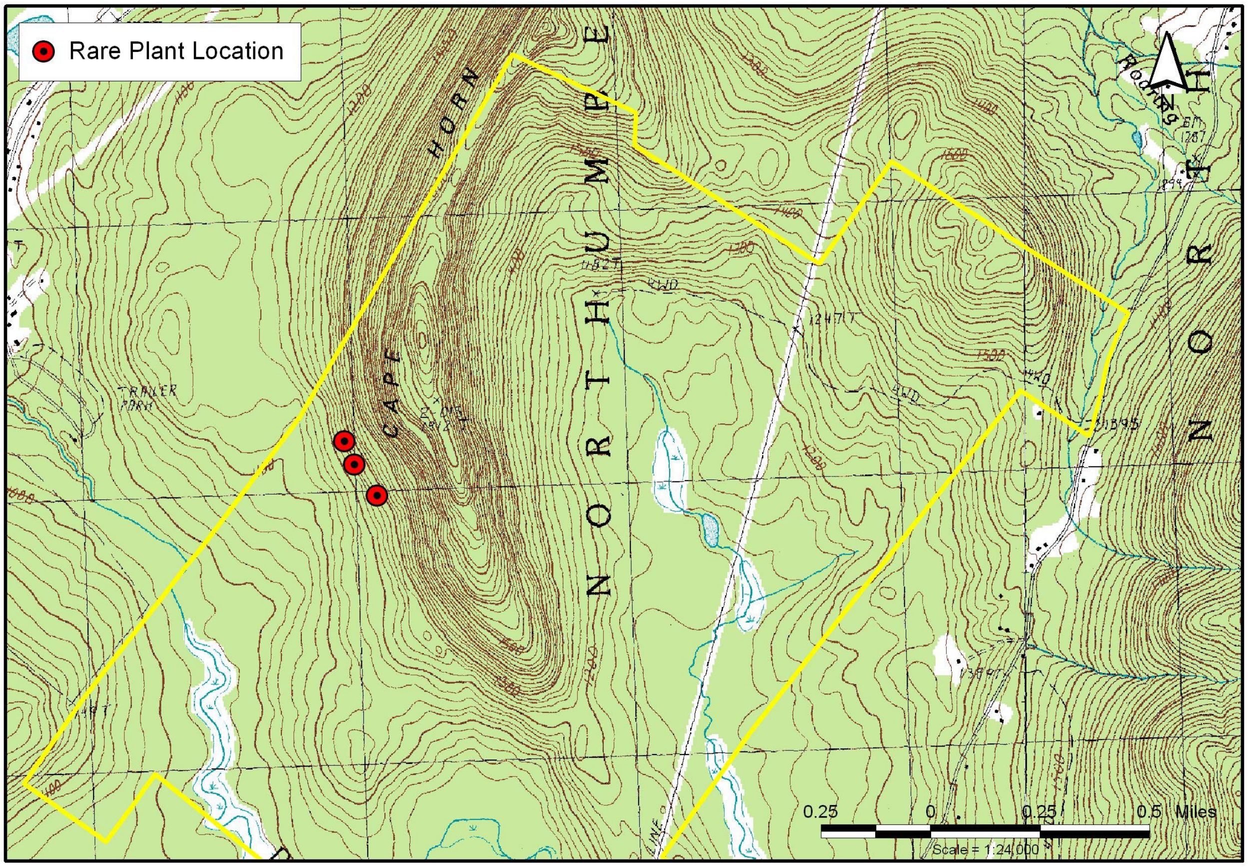
Black spruce - larch swamp (S3)

There are two exemplary occurrences of this community at CHSF, both associated with Dean Brook. The first (Figure 4) occurs just east of the southern end of Cape Horn, and is categorized as the *larch variant* of this type. This variant is more minerotrophic than the typic variety, as it receives somewhat enriched groundwater flow from the slopes of Cape Horn. The majority of this swamp is dominated by a mix of *Larix laricina* (eastern larch) and *Abies balsamea* (balsam fir), along with smaller amounts of spruces, *Thuja occidentalis* (northern white cedar), and hardwoods (maple and ash). The dominant herbs in this occurrence are *Osmunda cinnamomea* (cinnamon fern) and *Oxalis montana* (northern wood sorrel), along with other species such as *Rubus pubescens* (dwarf raspberry), *Carex trisperma* var. *trisperma* (three-seeded sedge), and *Cornus canadensis* (bunchberry).

The second occurrence of the ***black spruce - larch swamp*** occurs on either side of Dean Brook as it flows westward south of Cape Horn. This occurrence is divided into three areas which are near to one another, but are not contiguous, with each area representing a different variant of this community. The area on the north side of Dean Brook (Area 1) is an example of the *larch variant* of the community, like the occurrence to the east of Cape Horn. Like the other occurrence, it receives more minerotrophic groundwater from the slopes to the north, and has a similar species composition. Areas 2 and 3 are on the south side of Dean Brook, and are separated from the more nutrient-rich groundwater to the north. As a result, both areas are much more acidic and nutrient poor, and these differences are reflected in the vegetation. Area 2 has a thin canopy of *Picea mariana* (black spruce), with numerous shrub-dominated openings, and fits into the *typic woodland variant* of the community. The shrub cover is dense, and is dominated by *Rhododendron canadense* (rhodora), along with *Kalmia angustifolia* (sheep laurel), *Chamaedaphne calyculata* (leatherleaf), and *Ledum groenlandicum* (Labrador tea), above a thick *Sphagnum* carpet. Frequent species in the herb layer include *Eriophorum virginicum* (tawny cotton-grass), *Sarracenia purpurea* (pitcherplant), and *Vaccinium oxycoccos* (small cranberry). Area 3 is also dominated by black spruce, but has a much denser canopy, and is categorized as the *forest variant* of the type. Beneath the canopy, the shrub layer is sparse, with occasional *Vaccinium myrtilloides* (velvet-leaf blueberry), *Ledum groenlandicum* (Labrador tea), and *Nemopanthus mucronatus* (mountain holly). The *Sphagnum* carpet is dense, and supports *Gaultheria hispidula* (creeping snowberry), *Carex trisperma* var. *trisperma* (three-seeded sedge), *Cornus canadensis* (bunchberry), and *Sarracenia purpurea* (pitcherplant).

Typic woodland variant of an exemplary ***black spruce - larch swamp*** along Dean Brook. Photo by Ben Kimball.

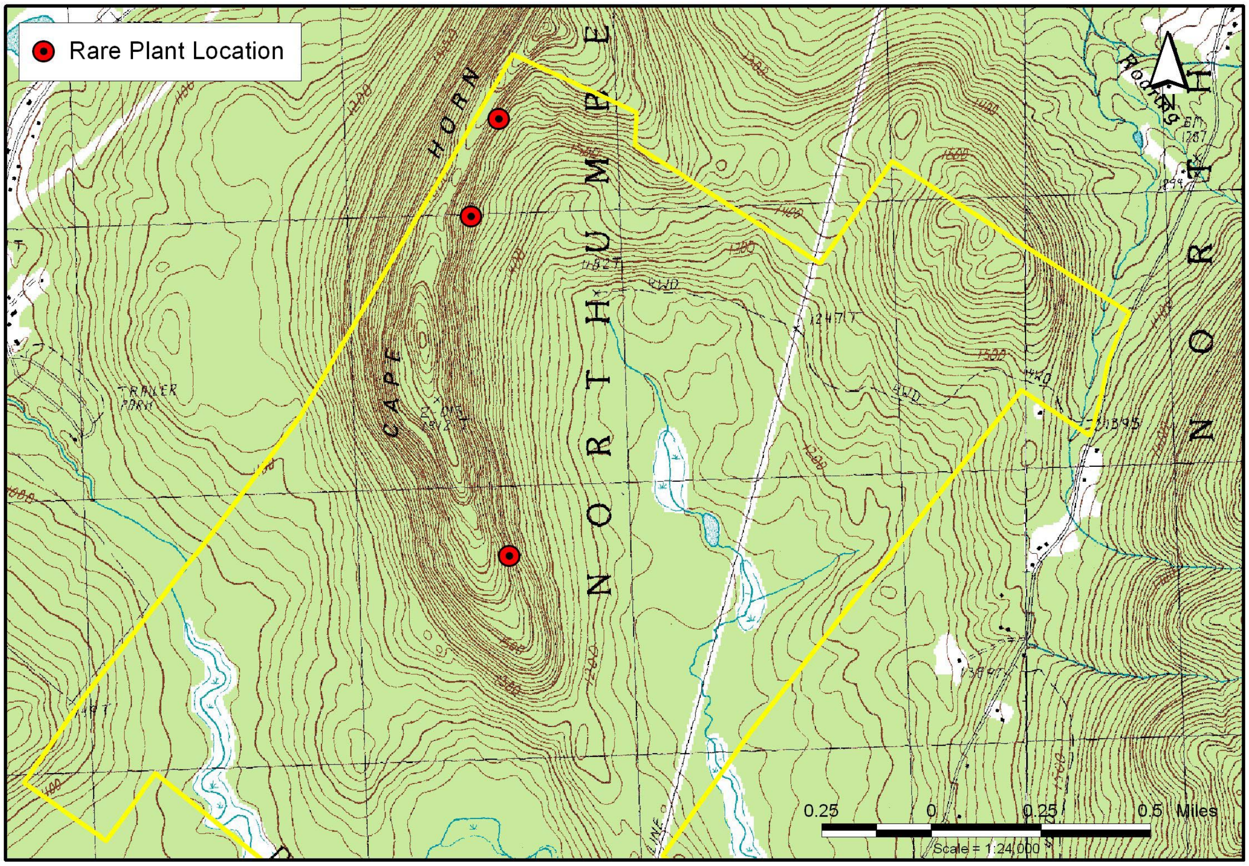
Rare Plant Species



Carex backii (Back's sedge) (S2)

This unusual sedge was located growing among rock slabs within an enriched hardwood forest on the western side of the ridge. There were approximately 29 clumps scattered in three separate areas. There have been specimens collected of this species scattered across New Hampshire, but the only other recent record is at Pawtuckaway State Park (Bowman et al 2005).

Carex backii (Back's sedge). Photo by Scott Bailey.



Cryptogramma stelleri (slender cliffbrake) (S2)

This unusual fern is found in circumneutral ***cliff seeps*** on the east face of Cape Horn. It was observed in three seeps, and may be present elsewhere on the cliff system. Statewide, it is restricted to sites in the Connecticut River valley.

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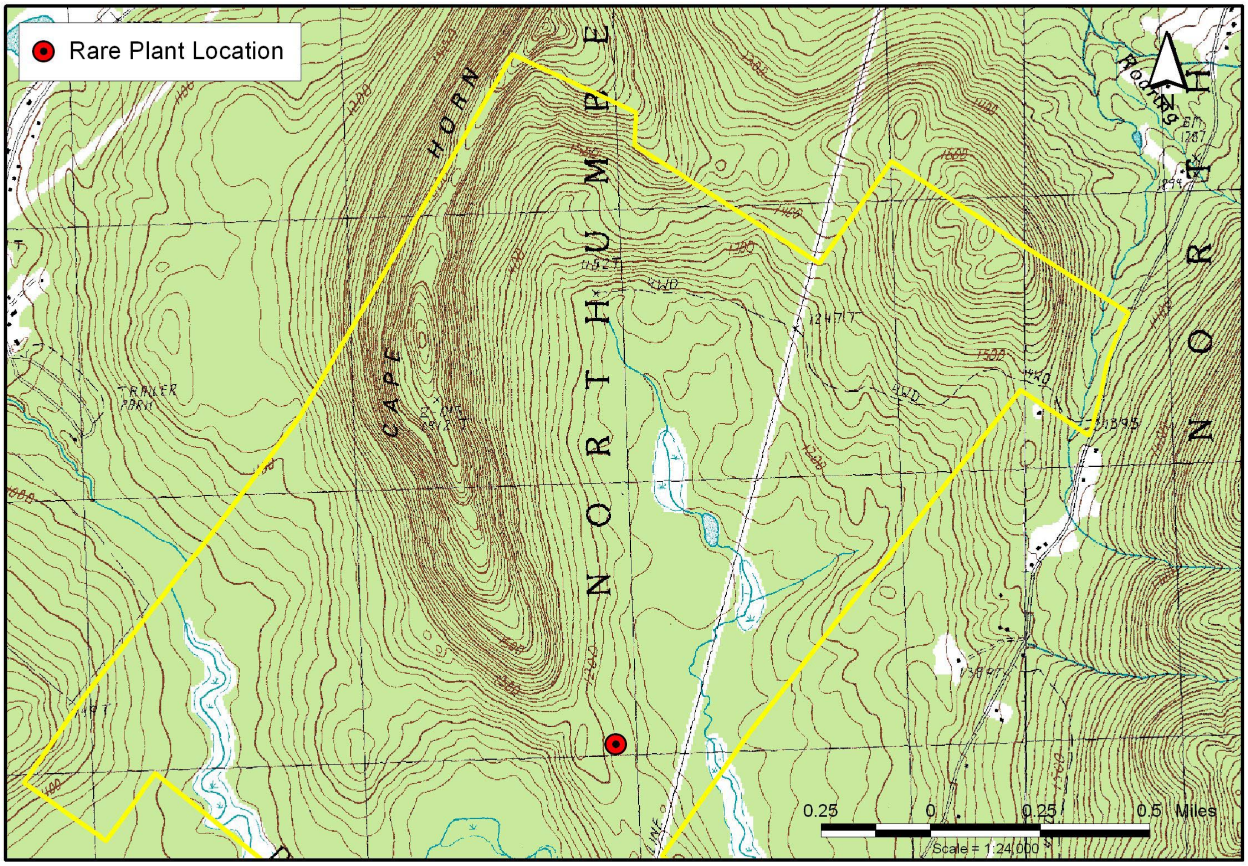
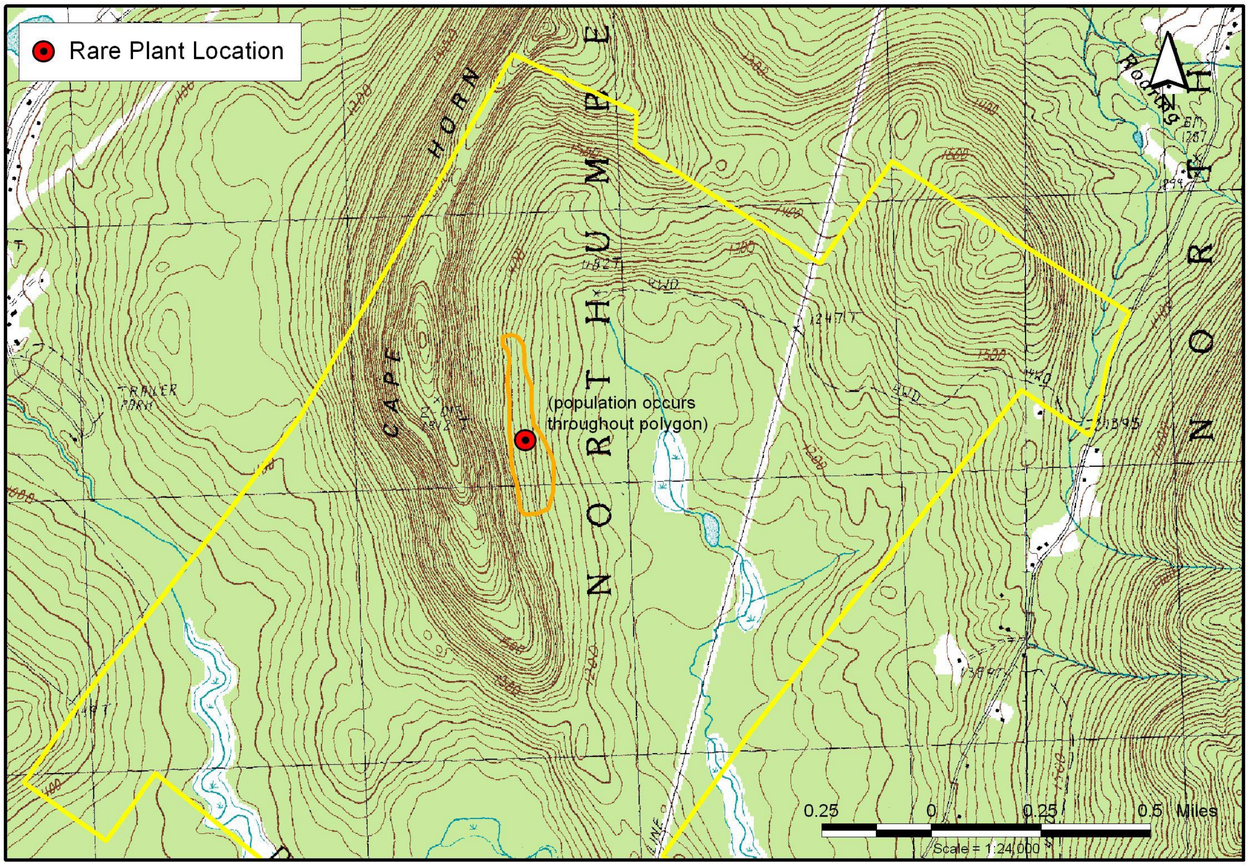
Cryptogramma stelleri (slender cliffbrake). Photo by Ben Kimball.



Cynoglossum virginianum var. *boreale* (wild comfrey) (S1)

This species was located in small areas of enrichment near the southern end of the Cape Horn ridge. It is a very small population, with only eight individuals found in three small patches. However, it is only the second population known to be extant in New Hampshire.

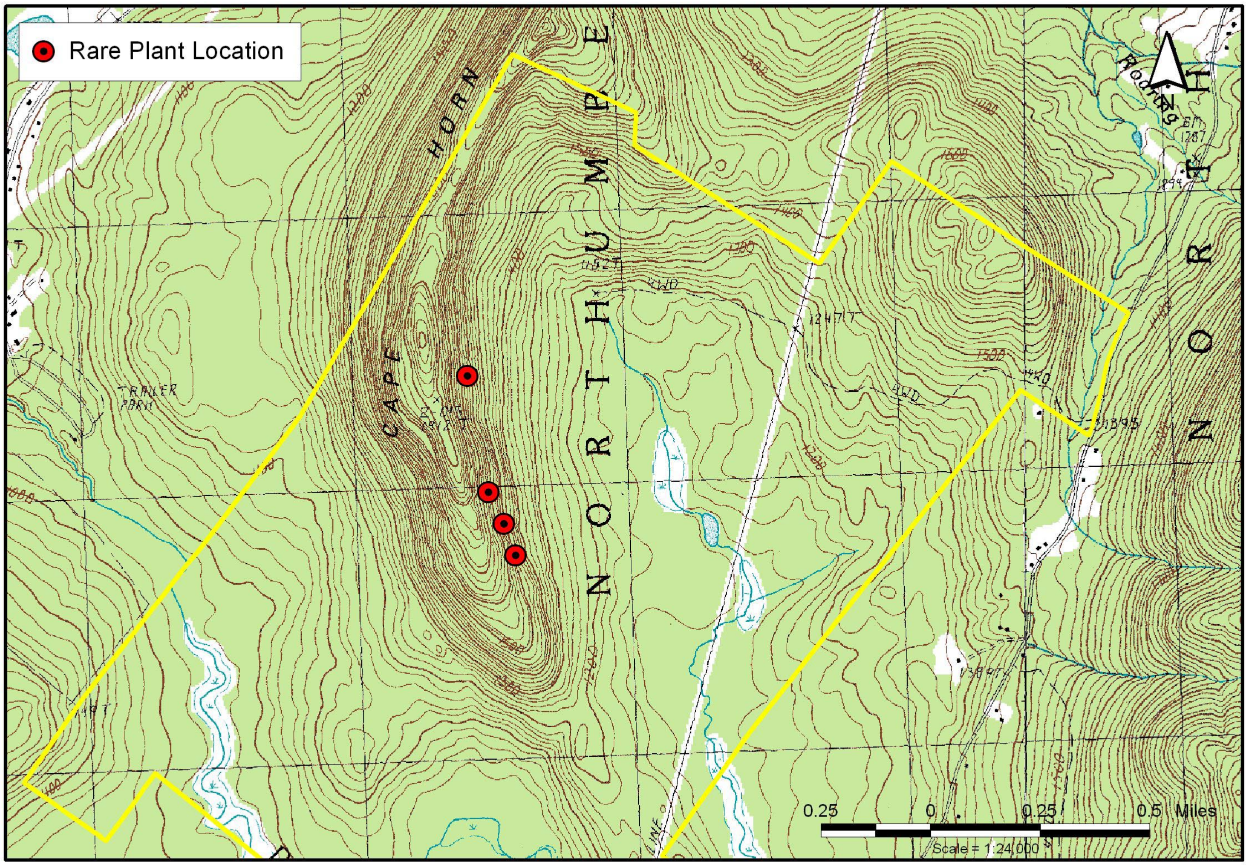
Cynoglossum virginianum var. *boreale* (wild comfrey). Photos by Scott Bailey.



Dicentra canadensis (squirrel corn) (S2)

This delicate spring ephemeral occurs by the thousands in the exemplary ***rich mesic forest***. It is usually found with its more common relative *Dicentra cucullaria* (Dutchman's breeches).

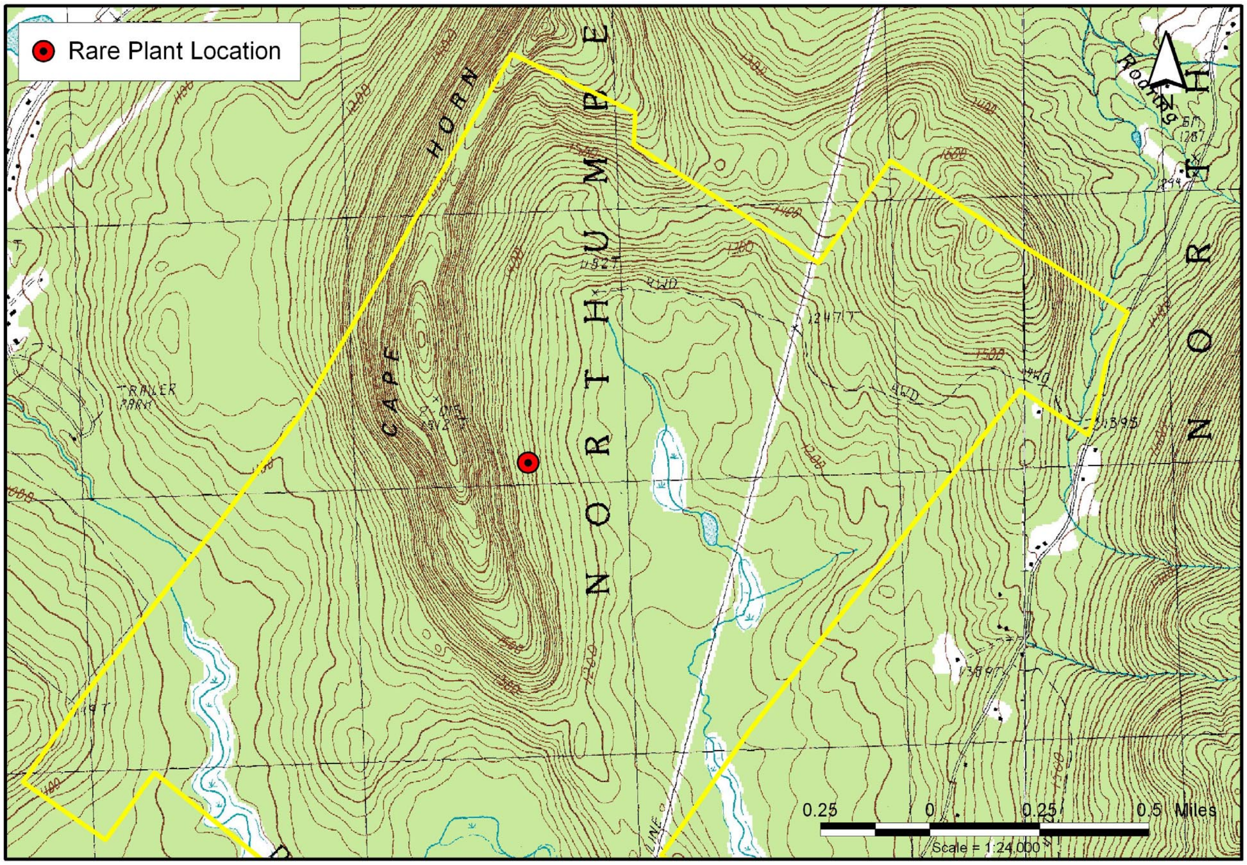
Dicentra canadensis (squirrel corn). Photo by Scott Bailey.



Dryopteris fragrans (fragrant fern) (S2)

This is a rare fern of circumneutral cliff habitats. It is scattered across the cliff system where enriched conditions will support it.

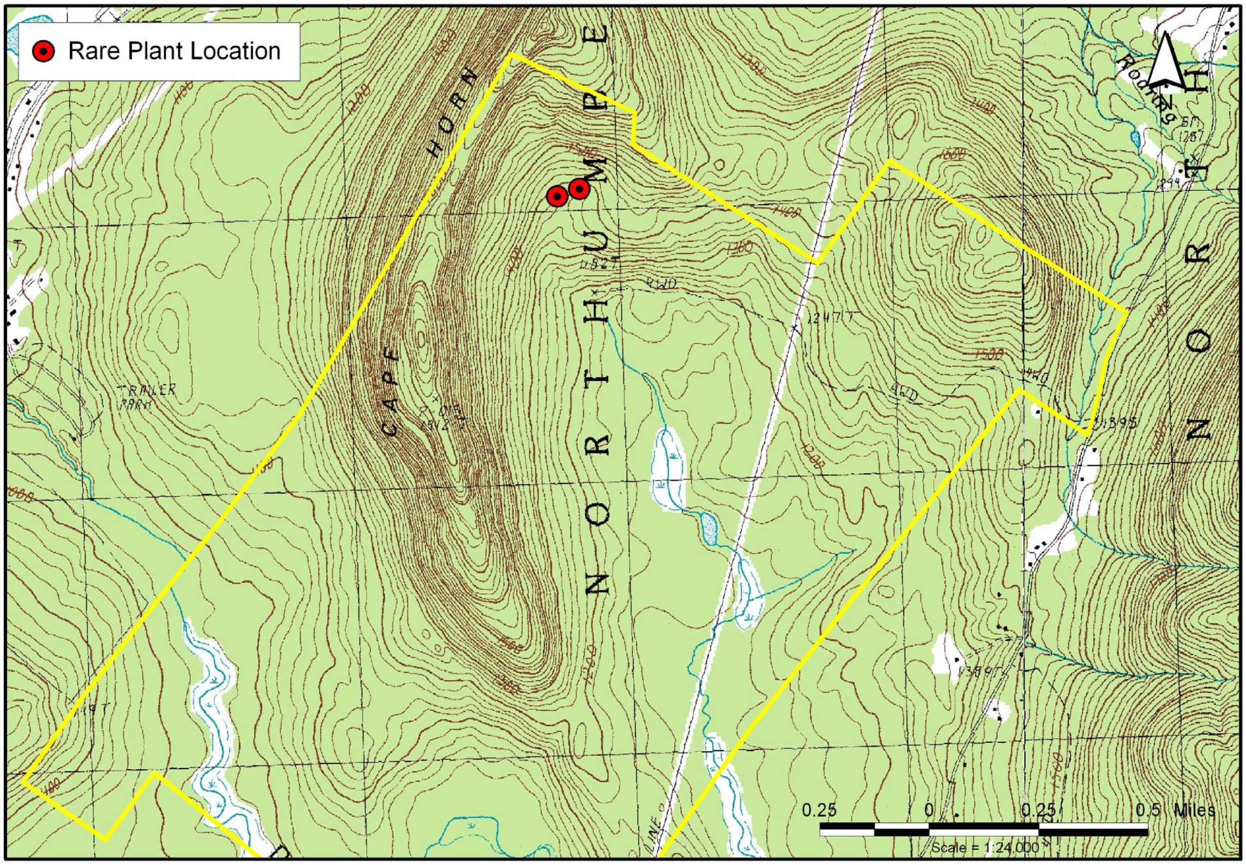
Dryopteris fragrans (fragrant fern). Photo by Scott Bailey.



Dryopteris goldiana (Goldie's fern) (S2)

This robust fern is a species of rich forests. Only a single clump of this plant was located in 2006 by Scott Bailey. The occurrence has been documented since 1988, but the population does not appear to have expanded at all, and may in fact have decreased in size.

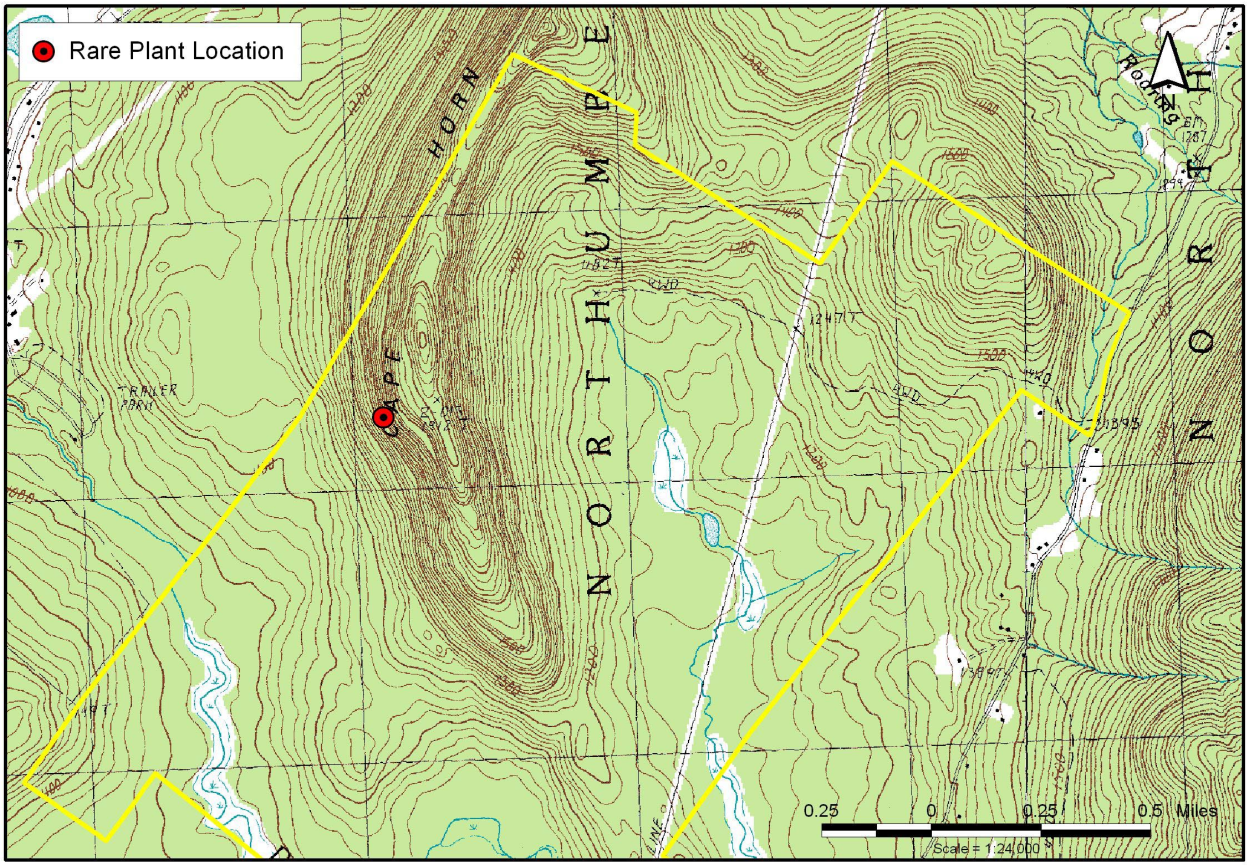
Dryopteris goldiana (Goldie's fern).
Photo by Ben Kimball.



Galearis spectabilis (showy orchis) (S2)

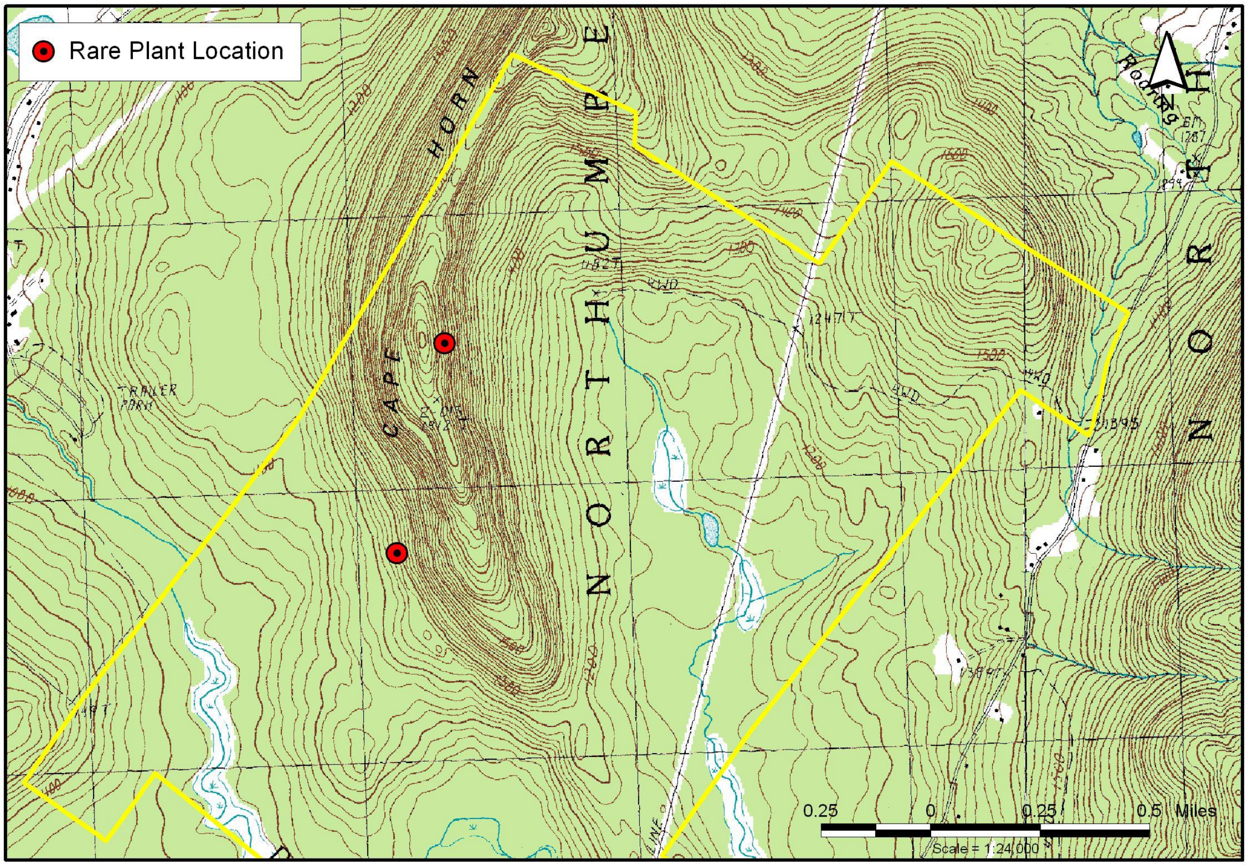
This rare orchid was found in two locations near the northern end of the exemplary ***rich mesic forest***, and is the first record of this species for Coos County. Between the two locations, 24 plants were located.

Galearis spectabilis (showy orchis). Photo by Scott Bailey.



Houstonia longifolia (long-leaved bluets) (S1)

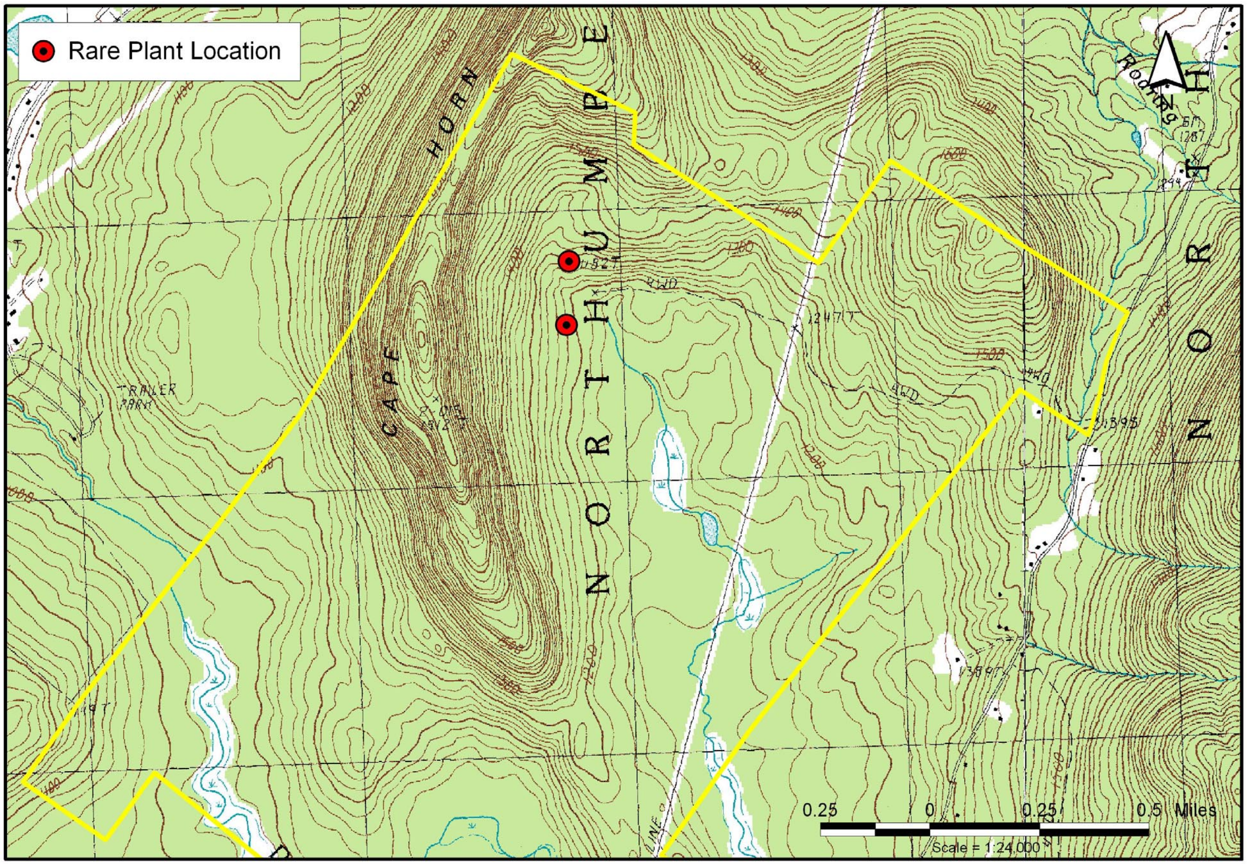
A large patch of this small herb was found growing in cracks between rock slabs within the exemplary ***red pine rocky ridge*** community. The only other known location for this species in the state is along the Merrimack River in southern New Hampshire.



Malaxis unifolia (green adder's mouth) (S2)

This tiny orchid is difficult to locate and probably often overlooked. It is most often found in swampy habitats, but at CHSF, it was seen in dry soil at the base of cliffs in two places, with a single plant on the east side of the ridge and one on the west.

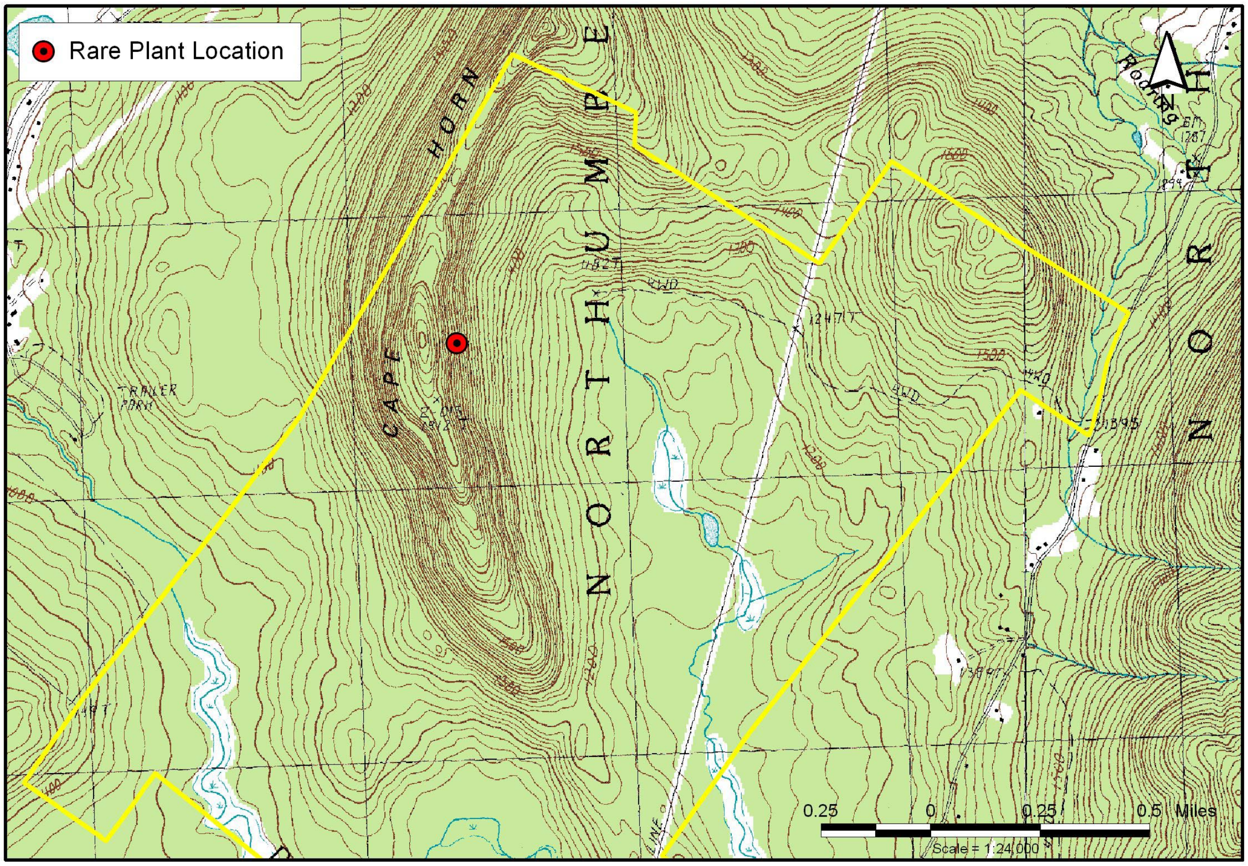
Malaxis unifolia (green adder's mouth). Photo by Ben Kimball.



Sanicula trifoliata (beaked sanicle) (S1)

This species was observed in at least two locations within the exemplary ***rich mesic forest*** community. It is restricted to enriched forests throughout the state, and the population at CHSF represents the northernmost known occurrence in New Hampshire.

Sanicula trifoliata (beaked sanicle). Photo by Scott Bailey.



Woodsia glabella (smooth woodsia) (S1)

Approximately twenty clumps of this small fern were found on lower portions of the cliff on the eastern side of Cape Horn. This is a species of enriched sites, so it is possible that it may be present elsewhere on the ***montane circumneutral cliff*** community.

Woodsia glabella (smooth woodsia). Photo by Scott Bailey.

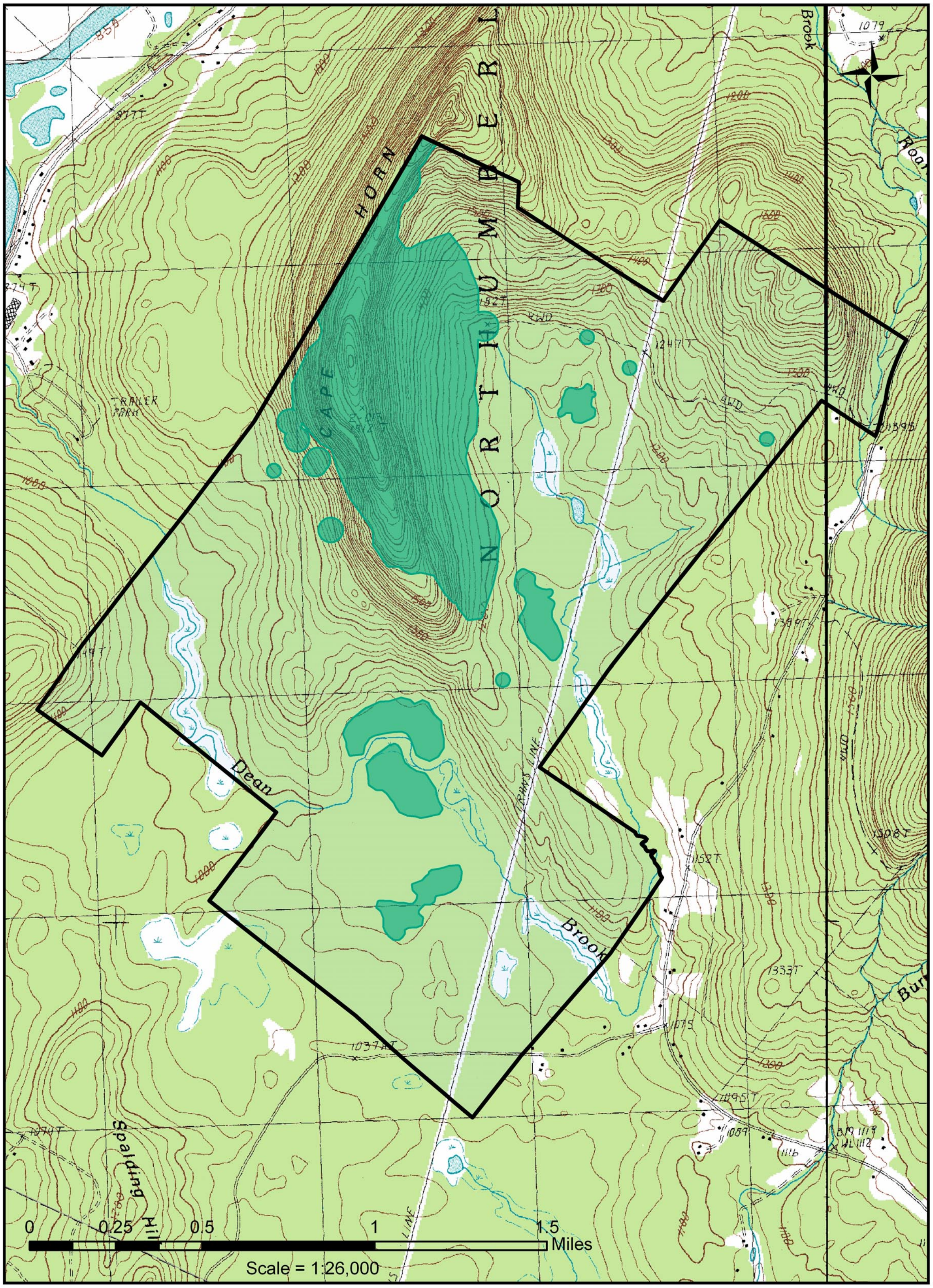


Figure 5. Rare and exemplary elements of biodiversity at Cape Horn State Forest.

MANAGEMENT CONSIDERATIONS

The geology and setting of Cape Horn State Forest support a unique and diverse suite of significant biodiversity features. This study identified or confirmed the presence of 7 exemplary natural communities or natural community systems, and 13 rare plant species. For the most part, these species and communities are associated with two features—the Cape Horn ridge and Dean Brook (Figure 5). Potential impacts to these features may come from a variety of sources, including timber management, recreation, invasive species, and beaver activity. Managers of CHSF may need to take into account all of these potential impacts when planning management activities.

Timber management

Many of the significant biodiversity features at CHSF occur in areas that are essentially inoperable for timber harvesting operations, either because the land is too steep or too wet for commercial management. However, in areas where timber harvesting is possible, we recommend that commercial management activities be excluded from exemplary natural communities and natural community systems. In addition, for occurrences of rare plants which occur outside the exemplary natural communities, we recommend these populations, and adjacent suitable habitat, be buffered from logging activity by a suitable distance. Specific buffer widths may vary depending on the type of management, the intensity of impacts, and local site features.

Recreational activity

Based purely on observations, CHSF appears to receive relatively little recreational use compared to other properties of similar size. There are access points at two gates on public roads, and with the exception of one snowmobile trail which crosses the southern portion of the property, the established network of public trails is limited. The most significant potential impact from recreation is the illegal use of all-terrain vehicles (ATVs) on the property. Numerous studies have shown that use of ATVs on and off trails can have serious negative impacts, including soil erosion and compaction, sedimentation of streams and wetlands, spread of invasive plant species, and destruction of virtually all forms of vegetation (Natural Trails and Waters Coalition 2005). Although illegal use by ATVs does not appear to be a problem at this time (D. Falkenham, pers. comm.), the property should be monitored for trespassing and the prohibition strictly enforced.

Invasive species

In general, invasive species are found in low abundance and do not appear to be a problem at this time in the exemplary natural communities or natural community systems at CHSF. However, outside of these occurrences, the most prevalent invasive exotic plant appears to be *Frangula alnus* (alder-buckthorn), which grows in dense patches adjacent to open wetlands along Dean Brook, as well as in wet woods at the western base of Cape Horn. It is unknown what the long-term impacts of this species will be to the local ecology, although presumably it is limiting the presence and abundance of other wetland species through direct competition for space, light, and nutrients. Considering its abundance and location in wetland areas, it is likely that attempts to control this species in these locations would be quite difficult and of limited efficacy, so management is probably not an option at this time. However, because it is present in low abundance in the exemplary swamps associated with the brook and near the western base of the ridge, it may be possible to conduct targeted control measures in these significant areas.

Beaver activity

Beavers are clearly active along Dean Brook. Through their activities, they have affected significant stretches of the brook, and although it is unlikely, they have the potential to impact some of the exemplary wetland communities adjacent to it. Considering these potential impacts, it may be necessary at some point in the future to conduct management of the beaver population in order to preserve exemplary communities and rare species that are threatened by beaver activity.

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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).

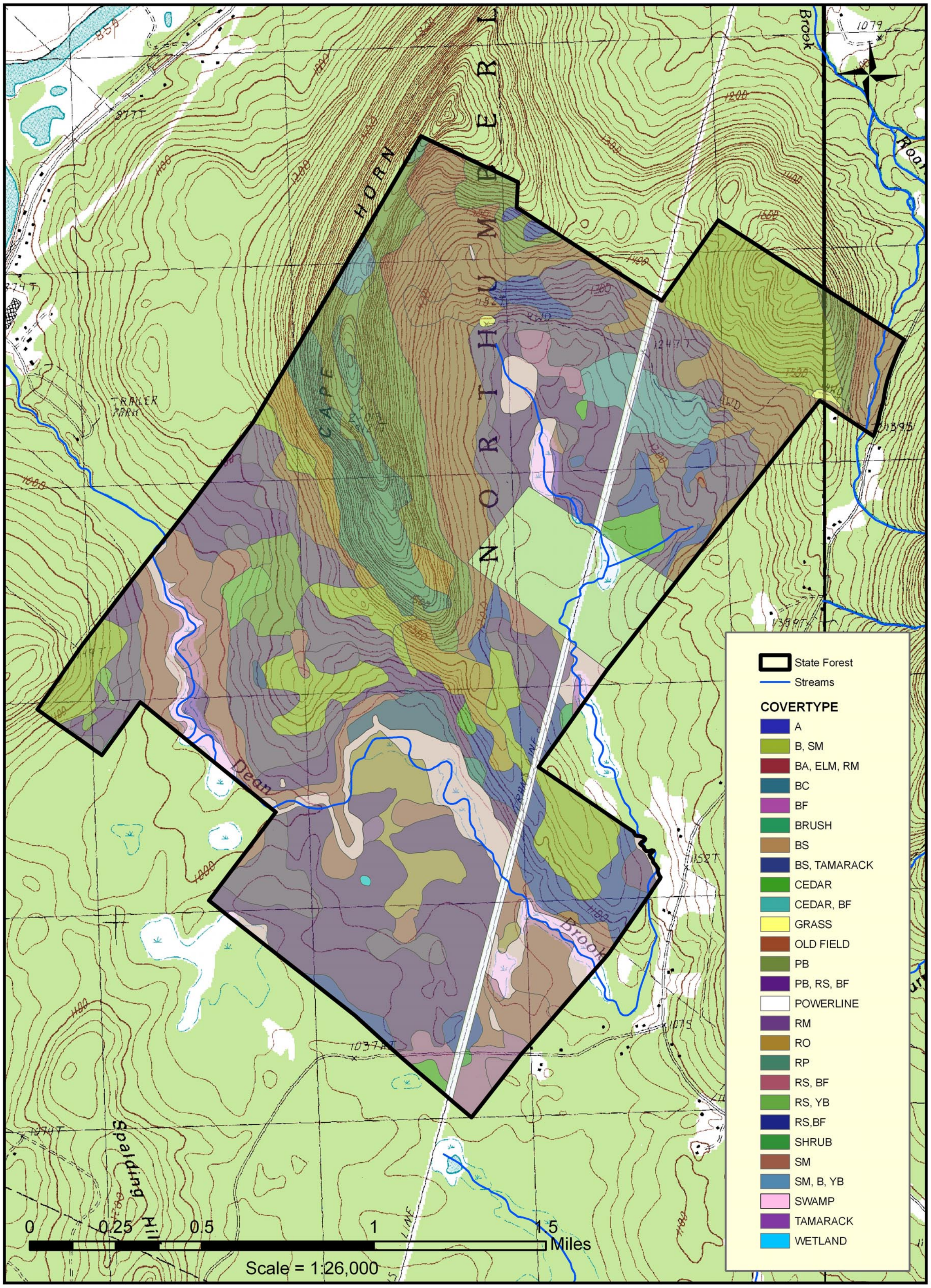
Modifiers are used as follows.

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 Cape Horn State Forest.



Appendix 4. Preliminary Checklist of the Vascular Plants of Cape Horn, Northumberland, Coos County, New Hampshire

Compiled by Scott Bailey

This preliminary checklist of the vascular flora of Cape Horn is based on historical collections reported in Pease (1964) and on modern observations made from 1999 through June, 2007. Historical collectors include Stanley Pease, Emile Williams and Albion Hodgdon. Scott Bailey, Tanya and David Tellman, Iris Baird, Daniel Sperduto, Brett Engstrom, Joann Hoy and Peter Bowman contributed recent observations.

A total of 372 taxa in 65 families have been documented from the state forest. Twenty-one species are introduced, mostly along roads and log landings, while 351 species are considered native. One introduced species *Frangula alnus* (alder-buckthorn) is invasive and has the potential to displace native vegetation in wetlands and lower forested slopes. An unusual number of state or regionally rare taxa were found, as discussed in the text.

Relative abundance ranks
1 = dominant in a common habitat
2 = important and easy to find
3 = widely scattered, but not difficult to find
4 = infrequent; difficult to find
5 = very difficult to find; limited to uncommon habitat

Habitat codes
r = ridge
c = cliff/slab
t = talus
f = forest
w = wetland

		r	c	t	f	w	notes
ACERACEAE							
	Acer pensylvanicum (striped maple)		3	3	2		
	Acer rubrum (red maple)				3	2	
	Acer saccharum (sugar maple)				1		dominant in rich hardwoods
	Acer spicatum (mountain maple)			1	3		characteristic of talus
ALISMATACEAE							
	Sagittaria latifolia (common arrowhead)						open water
ANACARDIACEAE							
	Rhus typhina (staghorn sumac)			4			
	Toxicodendron rydbergii (Rydberg's poison ivy)			2		3	
APIACEAE							
	Aralia hispida (bristly sarsaparilla)	4					
	Aralia nudicaulis (wild sarsaparilla)				2		
	Aralia racemosa (spikenard)				3		
	Cicuta bulbifera (bulbiferous water hemlock)					4	
	Hydrocotyle americana (water pennywort)					3	open water
	Osmorhiza claytonii (Clayton's sweet cicely)				2		
	Sanicula marilandica (black snakeroot)				4		moist woods
	Sanicula trifoliata (beaked sanicle)				5		
	Sium suave (water parsnip)						open wetlands
	Zizia aurea (golden alexanders)						

AQUIFOLIACEAE						
Ilex verticillata (winterberry)					2	
Nemopanthus mucronatus (mountain holly)	4			4	3	
ARACEAE						
Arisaema triphyllum (Jack-in-the-pulpit)				2	4	
Calla palustris (wild calla)					4	
ASTERACEAE						
Achillea millefolium var. *occidentalis* (common yarrow)				3		introduced, woods roads, log landings
Ambrosia artemisiifolia (common ragweed)				3		introduced, woods roads, log landings
Anaphalis margaritacea (pearly everlasting)	3			3		dry, open areas
Antennaria neglecta (field pussytoes)		3	4			ledges and disturbed areas
Aster divaricatus (white wood aster)				3		
Aster macrophyllus (large-leaved aster)				3		
Bidens cernua (nodding bur-marigold)					4	introduced
Erigeron annuus (daisy fleabane)				4		
Erigeron canadensis (horseweed)				4		
Erigeron philadelphicus (Philadelphian fleabane)				4		
Erigeron pulchellus (Robin's plantain)				4	4	disturbed areas
Eupatorium maculatum var. *foliosum* (northeastern spotted Joe-pye-weed)					3	open wetlands
Eupatorium perfoliatum (perfoliate boneset)					4	disturbed areas
Euthamia graminifolia (flat-topped goldenrod)				3		
Hieracium aurantiacum (orange hawkweed)				3		introduced, woods roads, log landings
Hieracium caespitosum (yellow hawkweed)				3		introduced, woods roads, log landings
Hieracium paniculatum (panicled hawkweed)				4		
Nabalus trifoliolatus (three-leaved rattlesnake root)					3	
Oclemena acuminata (whorled aster)			2	2		
Packera aurea (golden ragwort)				5		
Packera schweinitziana (Robbins' ragwort)				4	4	
Solidago arguta (northern toothed goldenrod)		2				
Solidago bicolor (silverrod)				4		disturbed areas
Solidago canadensis (Canada goldenrod)				3		woods roads, log landings
Solidago flexicaulis (zigzag goldenrod)				3		rich mesic hardwoods
Solidago juncea (early goldenrod)				4		
Solidago puberula (downy goldenrod)				4		
Solidago rugosa (rough goldenrod)		3		3		
Solidago simplex ssp. *randii* var. *racemosa* (riverbank goldenrod)		2				
Symphyotrichum puniceum (purple-stemmed aster)					3	
Taraxacum officinale (common dandelion)				4		introduced, disturbed areas
Tussilago farfara (coltsfoot)				4		introduced, skid roads
BALSAMINACEAE						
Impatiens capensis (spotted touch-me-not)				2	3	
BERBERIDACEAE						
Caulophyllum thalictroides (blue cohosh)				3		
BETULACEAE						
Alnus incana ssp. *rugosa* (speckled alder)					1	shrub swamp

	Betula alleghaniensis (yellow birch)				3		
	Betula papyrifera (paper birch)			2			
	Betula populifolia (gray birch)		3		3	4	disturbed areas
	Corylus cornuta (beaked hazelnut)				4	3	
	Ostrya virginiana (ironwood)			3	2		
BORAGINACEAE							
	Cynoglossum virginianum var. *boreale* (wild comfrey)				5		one small colony
BRASSICACEAE							
	Cardamine diphylla (broad-leaved toothwort)				4		
	Cardamine parviflora var. *arenicola* (dry-land bitter cress)						not seen since Pease 1948
	Cardamine pensylvanica (Pennsylvania bitter cress)		3		4		
CAMPANULACEAE							
	Campanula rotundifolia (harebell)		2				
CAPRIFOLIACEAE							
	Diervilla lonicera (bush honeysuckle)				3		
	Linnaea borealis (twinflower)				4	3	
	Lonicera canadensis (Canadian honeysuckle)				3		
	Sambucus racemosa (red elderberry)			3	2		
	Viburnum lantanoides (hobblebush)				3		
	Viburnum lentago (nannyberry)					3	
	Viburnum nudum var. *cassinoides* (witherod)					2	
	Viburnum opulus var. *americanum* (American highbush cranberry)			5		4	
CARYOPHYLLACEAE							
	Lychnis flos-cuculi (ragged robin)				4		introduced, woods roads, log landings
CLUSIACEAE							
	Hypericum boreale (northern St. John's-wort)					3	
	Hypericum punctatum (spotted St. John's-wort)		4				
	Triadenum virginicum (marsh St. John's-wort)					2	
CORNACEAE							
	Cornus alternifolia (alternate-leaved dogwood)				3		
	Cornus canadensis (bunchberry)	3					
	Cornus rugosa (round-leaved dogwood)		4	4			only on west side
	Cornus sericea (red osier dogwood)					2	
CUPRESSACEAE							
	Juniperus communis var. *depressa* (ground juniper)	3	3				
	Thuja occidentalis (northern white cedar)	3	2	3		3	
CYPERACEAE							
	Carex appalachica (Appalachian sedge)				3		
	Carex argyrantha (silvery sedge)		4				
	Carex arctata (contracted drooping wood sedge)				2		
	Carex backii (Back's sedge)		5				forested slabby ledges
	Carex brunnescens ssp. *brunnescens* (mountain brownish sedge)	3	2	3	3		
	Carex communis (colonial sedge)		3		4		
	Carex crawfordii (Crawford's sedge)					3	
	Carex debilis var. *rudgei* (Rudge's sedge)				3		

Carex deflexa (northern sedge)				4		
Carex deweyana (Dewey's sedge)				3		
Carex disperma (two-seeded sedge)				3		
Carex echinata (prickly sedge)				3	3	
Carex foenea (bronzy sedge)		3				
Carex gracilescens (slender sedge)						need to confirm
Carex gracillima (very slender sedge)				3		
Carex granularis (granular sedge)						need to confirm
Carex gynandra (perfect-awned sedge)					2	
Carex intumescens (inflated sedge)				3	3	
Carex lacustris (lake sedge)					2	open wetlands
Carex laxiculmis (spreading sedge)				4		
Carex laxiflora (loosely-flowered sedge)				3		rich mesic hardwoods
Carex lasiocarpa (hairy-fruited sedge)					3	
Carex leptalea (delicate sedge)				3		
Carex leptonervia (fine-nerved sedge)				3		
Carex lurida (sallow sedge)					3	
Carex magellanica ssp. *irrigua* (bog sedge)					4	poor fen
Carex merritt-fernaldii (Fernald's sedge)				5		disturbed areas
Carex novae-angliae (New England sedge)				3		mats in woods roads
Carex pallescens (pale sedge)				4		
Carex peckii (Peck's sedge)						not seen since Pease 1948
Carex pedunculata (long-stalked sedge)				4	3	characteristic of cedar swamps
Carex pensylvanica (Pennsylvanian sedge)				3		
Carex plantaginea (plantain-leaved sedge)				3		characteristic of rich woods
Carex projecta (beaded broom sedge)					3	
Carex scabrata (rough sedge)					2	
Carex stipata (awl sedge)					3	
Carex stricta (tussock sedge)					2	beaver meadows
Carex trisperma var. *trisperma* (three-seeded sedge)				3		
Carex umbellata (hidden sedge)		4				
Carex utriculata (bottle-shaped sedge)					3	
Carex vesicaria (inflated sedge)					3	beaver meadows
Dulichium arundinaceum (three-way sedge)					3	open wetlands
Eriophorum virginicum (tawny cotton-grass)					4	poor fen
Scirpus atrocinctus (black-girdled bulrush)					2	beaver meadows
Scirpus cyperinus (woolly bulrush)					2	beaver meadows
Scirpus pedicellatus (stalked bulrush)					3	
DROSERACEAE						
Drosera rotundifolia (round-leaved sundew)					3	
EQUISETACEAE						
Equisetum arvense (field horsetail)				4	3	
Equisetum sylvaticum (wood horsetail)				3		
Equisetum variegatum (variegated horsetail)					4	disturbed seepy areas

ERICACEAE							
	Andromeda polifolia var. *glaucophylla* (bog rosemary)					5	poor fen
	Chamaedaphne calyculata (leatherleaf)					4	poor fen
	Chimaphila umbellata var. *cisatlantica* (pipissewa)	4					
	Epigaea repens (trailing arbutus)	4					
	Gaultheria hispidula (creeping snowberry)			4		3	
	Gaultheria procumbens (wintergreen)	3					
	Kalmia angustifolia (sheep laurel)					4	poor fen
	Kalmia polifolia (bog laurel)					4	poor fen
	Ledum groenlandicum (Labrador tea)					5	powerline
	Moneses uniflora (one-flowered shinleaf)					4	
	Monotropa hypopithys (pinesap)				4		
	Monotropa uniflora (Indian pipes)	3		4	3		
	Orthilia secunda (one-sided shinleaf)	3			3		
	Pyrola americana (round-leaved shinleaf)	3					
	Pyrola elliptica (common shinleaf)				4		
	Rhododendron canadense (rhodora)	4				3	
	Vaccinium angustifolium (lowbush blueberry)	3				4	
	Vaccinium myrtilloides (velvet-leaf blueberry)	2		2			
	Vaccinium oxycoccos (small cranberry)					5	poor fen
	Vaccinium pallidum (hillside blueberry)	4					
	Vaccinium vitis-idaea ssp. *minus* (mountain cranberry)	5					
FABACEAE							
	Trifolium aureum (palmate hop clover)				3		introduced, woods roads, log landings
	Trifolium pratense (red clover)				3		introduced, woods roads, log landings
	Trifolium repens (white clover)				3		introduced, woods roads, log landings
	Vicia villosa (hairy vetch)				3		introduced, woods roads, log landings
FAGACEAE							
	Fagus grandifolia (American beech)				3		
	Quercus rubra (red oak)			3	3		
GERANIACEAE							
	Geranium bicknellii (northern geranium)		4				
	Geranium robertianum (herb Robert)				4		
GROSSULARIACEA							
	Ribes cynosbati (dogberry)				3		
	Ribes glandulosum (skunk currant)		3				
	Ribes lacustre (spiny swamp currant)		3				
	Ribes triste (swamp red currant)				3		
HAMAMELIDACEAE							
	Hamamelis virginiana (witch hazel)					3	
IRIDACEAE							
	Iris versicolor (northern blue flag)					3	open wetlands
JUGLANDACEAE							
	Juglans cinerea (butternut)				5		
JUNCACEAE							
	Juncus effusus (soft rush)					2	open wetlands

	Juncus militaris (bayonet rush)					3	open wetlands
	Juncus tenuis (path rush)					3	wood roads, log landings
	Luzula acuminata (pointed woodrush)				4	3	moist woods
LAMIACEAE							
	Galeopsis tetrahit (brittlestem hemp nettle)					3	introduced
	Lycopus americanus (American water horehound)					3	
	Lycopus uniflorus (common water horehound)					3	
	Prunella vulgaris var. *vulgaris* (heal-all)				3	3	introduced, woods roads, log landings
	Scutellaria galericulata (marsh skullcap)					3	
LILACEAE							
	Clintonia borealis (blue-bead lily)	3			3		
	Erythronium americanum (trout lily)				2		
	Maianthemum canadense (Canada mayflower)	3			2		
	Maianthemum racemosum (false Solomon's seal)	3		3	3		
	Maianthemum trifolium (three-leaved false Solomon's seal)					4	
	Medeola virginiana (Indian cucumber root)				2		
	Polygonatum pubescens (hairy Solomon's seal)				3		
	Streptopus amplexifolius (white mandarin)			5			
	Streptopus lanceolatus (rose twisted stalk)				3		
	Trillium erectum var. *erectum* (wakerobin)				3		
	Trillium undulatum (painted trillium)	3			3	4	
	Uvularia sessilifolia (sessile-leaved bellwort)				3		
	Veratrum viride (false hellebore)					3	
LYCOPODIACEAE							
	Diphasiastrum complanatum (northern ground-cedar)				3		
	Diphasiastrum digitatum (southern ground-cedar)				3		
	Huperzia lucidula (shining clubmoss)	3			3		
	Lycopodium annotinum (stiff clubmoss)	3		3	3		
	Lycopodium clavatum (staghorn clubmoss)				4		
	Lycopodium obscurum (princess pine)	3			3		
MYRICACEAE							
	Myrica gale (sweet gale)					3	beaver meadows
OLEACEAE							
	Fraxinus americana (white ash)				2		
	Fraxinus nigra (black ash)					3	
ONAGRACEAE							
	Circaea alpina (small enchanter's nightshade)		3		3		wet woods and cliffs
	Epilobium angustifolium (great willowherb)		4				
	Epilobium ciliatum (ciliated willowherb)		5				not seen since Pease 1935
	Epilobium coloratum (eastern willowherb)					3	cedar swamp
	Epilobium leptophyllum (narrow-leaved willowherb)					4	mixed forest swamp
OPHIOGLOSSACEAE							
	Botrychium lanceolatum ssp. *angustisegmentum* (narrow triangle grapefern)				4		
	Botrychium matricariifolium (daisyleaf grapefern)				4		
	Botrychium oneidense (blunt-lobed grapefern)				4		
	Botrychium simplex (dwarf grapefern)					5	cedar swamp

	Botrychium virginianum (rattlesnakefern)				2		
ORCHIDACEAE							
	Coeloglossum viride (green-bracted orchis)				5		rich woods
	Corallorhiza maculata (spotted coralroot)				4		
	Corallorhiza trifida (early coralroot)					4	
	Cypripedium acaule (pink lady's slipper)	4		3	4		
	Epipactis helleborine (helleborine)				3		introduced
	Galearis spectabilis (showy orchis)				5		two small colonies; first Coos record
	Goodyera tesselata (checkered rattlesnake plantain)			4	3		
	Malaxis unifolia (green adder's mouth)				5		
	Platanthera grandiflora (large purple-fringed orchid)					4	
	Platanthera huronensis (northern green orchid)					4	
OROBANCHACEAE							
	Epifagus virginiana (beechdrops)				3		
OSMUNDACEAE							
	Osmunda cinnamomea (cinnamon fern)				2	2	
	Osmunda claytoniana (interrupted fern)				3		
	Osmunda regalis var. *spectabilis* (royal fern)				3	3	
OXALIDACEAE							
	Oxalis montana (northern wood sorrel)				3	3	
	Oxalis stricta (showy yellow wood sorrel)				3		woods roads, log landings
PAPAVERACEAE							
	Corydalis sempervirens (pale corydalis)		2				
	Dicentra canadensis (squirrel corn)				3		
	Dicentra cucullaria (Dutchman's breeches)				3		
PINACEAE							
	Abies balsamea (balsam fir)	2		2	3		
	Larix laricina (eastern larch)					3	
	Picea glauca (white spruce)	4		4		4	
	Picea mariana (black spruce)					4	poor fen
	Picea rubens (red spruce)	2		4	3	3	
	Pinus resinosa (red pine)	1					
	Pinus strobus (white pine)	4		3			
	Tsuga canadensis (hemlock)				3		
POACEAE							
	Agrostis hyemalis var. scabra (early ticklegrass)		3				
	Agrostis perennans (upland bentgrass)					3	
	Agrostis sp. (a grass)		4				
	Brachyelytrum septentrionale (northern short husk grass)		2				
	Bromus ciliatus (fringed brome grass)				3		
	Calamagrostis canadensis var. *canadensis* (robust bluejoint)					3	
	Cinna latifolia (drooping woodreed)				3		
	Danthonia spicata (poverty oatgrass)	3	2	3			
	Deschampsia flexuosa (common hairgrass)	2	2	3			open, rocky areas
	Dichanthelium acuminatum ssp. *fasciculatum* (clustered		3				

	panic grass)						
	Dichanthelium boreale (purplish northern panic grass)		3				
	Dichanthelium linearifolium (linear-leaved panic grass)		4				
	Dichanthelium xanthophysum (yellow bladders panic grass)		4				
	Elymus trachycaulus (slender wheatgrass)		2				
	Glyceria melicaria (northeastern mannagrass)					2	
	Glyceria striata (fowl mannagrass)				3		
	Milium effusum var. cisatlanticum (millet grass)				5		rich woods
	Muhlenbergia mexicana (Mexican muhly)		4				
	Oryzopsis asperifolia (rough-leaved rice grass)	3			3		
	Phalaris arundinacea (reed canary grass)					4	opening in wet woods
	Phleum pratense (common timothy)				3		introduced, woods roads, log landings
	Poa alsodes (grove bluegrass)		3				
	Poa pratensis (Kentucky bluegrass)				3		
	Poa saltuensis (pasture bluegrass)				4	3	
	Schizachne purpurascens (purple oatgrass)		3				
POLYGONACEAE							
	Fallopia cilinodis (fringed bindweed)			3	3		
	Persicaria sagittata (arrow-leaved tearthumb)					3	
	Rumex obtusifolius (bitter dock)				3		introduced, woods roads, log landings
POLYPODIACEAE							
	Adiantum pedatum (northern maidenhair fern)				3		
	Asplenium platyneuron (ebony spleenwort)			5			one plant observed
	Asplenium trichomanes ssp. *quadrivalens* (Meyer's maidenhair spleenwort)		3				
	Athyrium filix-femina var. *angustum* (northern lady fern)				2		
	Cryptogramma stelleri (slender cliffbrake)		3				seepy overhanging cliffs
	Cystopteris fragilis (fragile fern)		2				
	Cystopteris tenuis (Mackay's brittle fern)		2		4		
	Dennstaedtia punctilobula (hay-scented fern)	3		4	3		
	Deparia acrostichoides (silvery spleenwort)				2	4	
	Dryopteris campyloptera (mountain wood fern)					4	
	Dryopteris carthusiana (spinulose wood fern)				4		
	Dryopteris cristata (crested wood fern)					3	
	Dryopteris fragrans (fragrant fern)		3				overhanging fractured cliffs
	Dryopteris goldiana (Goldie's fern)				5		one small colony
	Dryopteris intermedia (intermediate wood fern)				2		
	Dryopteris marginalis (marginal wood fern)		2	2	3		
	Gymnocarpium dryopteris (oak fern)				3		
	Matteuccia struthiopteris var. *pensylvanica* (ostrich fern)				2		
	Onoclea sensibilis (sensitive fern)				3	2	
	Phegopteris connectilis (long beech fern)		3	4	3		
	Polypodium virginianum (rock polypody)		2	1	3		
	Polystichum acrostichoides (Christmas fern)				3		
	Polystichum braunii (Braun's holly fern)				5		
	Pteridium aquilinum var. *latiusculum* (bracken)	3	4	4	3	4	
	Thelypteris noveboracensis (New York fern)				3		

	Thelypteris palustris var. *pubescens* (marsh fern)					3	
	Woodsia glabella (smooth woodsia)		5				overhanging seepy cliffs
	Woodsia ilvensis (rusty woodsia)		2				
PORTULACACEAE							
	Claytonia virginica (Virginia spring beauty)				2		
PRIMULACEAE							
	Lysimachia terrestris (swamp candles)					3	
	Trientalis borealis (starflower)	3			3		
RANUNCULACEAE							
	Actaea pachypoda (white baneberry)				3		
	Actaea rubra (red baneberry)				3		
	Anemone americana (blunt-lobed hepatica)				4		south side only
	Aquilegia canadensis (wild columbine)		3				
	Caltha palustris (marsh marigold)					2	open wetlands
	Clematis virginiana (virgin's bower)			3		3	
	Coptis trifolia (goldthread)				3		
	Ranunculus abortivus (kidney-leaved buttercup)				3		rich woods
	Ranunculus recurvatus (hooked buttercup)					3	
	Thalictrum dioicum (early meadow-rue)				3		
	Thalictrum pubescens (tall meadow-rue)					3	
RHAMNACEAE							
	Frangula alnus (alder-buckthorn)				4	3	introduced, invasive
	Rhamnus alnifolia (American alder buckthorn)					4	
ROSACEAE							
	Agrimonia gryposepala (tall hairy agrimony)					4	
	Amelanchier arborea (downy shadbush)			3	3		
	Amelanchier bartramiana (Bartram's serviceberry)	3					
	Crataegus sp. (a hawthorn)			5			
	Fragaria vesca (woodland strawberry)		4	4			rocky areas
	Fragaria virginiana (wild strawberry)				3		woods roads, log landings
	Geum aleppicum (yellow avens)					3	
	Geum rivale (purple avens)					3	
	Malus pumila (apple)				4		introduced, log landing
	Potentilla simplex (old-field cinquefoil)				3		woods roads, log landings
	Prunus pensylvanica (pin cherry)		3				
	Prunus serotina (black cherry)				4		
	Prunus virginiana (choke cherry)		3				
	Rosa cf. acicularis ssp. *sayi* (prickly rose)			5			
	Rubus dalibarda (false violet)					3	
	Rubus idaeus ssp. *idaeus* (red raspberry)				3	3	disturbed areas
	Rubus odoratus (purple-flowering raspberry)			3			
	Rubus pubescens (dwarf raspberry)				3	3	
	Sorbus americana (American mountain ash)			3			
	Sorbus decora (showy mountain ash)					4	
	Spiraea alba var. *latifolia* (eastern meadowsweet)					3	
	Spiraea tomentosa (steeple bush)					3	

RUBIACEAE						
Galium asprellum (rough bedstraw)					3	
Galium circaezans var. *hypomalacum* (northern hairy wild licorice)				4		rich woods
Galium triflorum (sweet-scented bedstraw)				3		
Houstonia longifolia (long-leaved bluets)		5				slabby ledges
Mitchella repens (partridgeberry)			3	3		
SALICACEAE						
Populus balsamifera (balsam poplar)				4		
Populus tremuloides (quaking aspen)			3			
Salix bebbiana (long-beaked willow)				3	3	
Salix discolor (large pussy willow)					3	
Salix eriocephala (stiff willow)					3	
Salix humilis var. *humilis* (small pussy willow)	4		4			
Salix lucida (shining willow)					5	
Salix petiolaris (meadow willow)					4	
Salix pyrifolia (balsam willow)					5	
Salix sericea (silky willow)					3	
SARRACENIACEAE						
Sarracenia purpurea (pitcherplant)					4	poor fen
SAXIFRAGACEAE						
Chrysosplenium americanum (golden saxifrage)				3	3	
Mitella nuda (naked miterwort)					3	cedar swamp
Saxifraga virginiensis (early saxifrage)		3				moist outcrops
Tiarella cordifolia (foamflower)				2	3	
SCROPHULARIACEAE						
Chelone glabra (white turtlehead)					3	
Verbascum thapsus (common mullein)				3		introduced, woods roads, log landings
Veronica americana (American speedwell)					3	
SELAGINELLACEAE						
Selaginella rupestris (rock spikemoss)		5				
TAXACEAE						
Taxus canadensis (Canada yew)				3	3	
TILIACEAE						
Tilia americana (basswood)				3		rich mesic hardwoods
TYPHACEAE						
Typha latifolia (common cattail)					3	open wetlands and powerline
ULMACEAE						
Ulmus americana (American elm)				4		
URTICACEAE						
Laportea canadensis (wood nettle)				3		rich streamsides and seeps
VERONICACEAE						
Gratiola aurea (golden pert)					4	
Mimulus ringens (monkey flower)					4	
Veronica officinalis (common speedwell)				3		introduced; woods roads, log landings
VIOLACEAE						

	Viola blanda (red-stemmed violet)				2		
	Viola canadensis (Canada white violet)				4		rich mesic hardwoods
	Viola pubescens (downy yellow violet)				3		
	Viola renifolia (kidney-leaved violet)				3		
	Viola rotundifolia (round-leaved violet)				2		
VITACEAE							
	Parthenocissus vitacea (woodbine)		3	3			