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Rare Plant and Exemplary Natural Community Inventory of Mt. Monadnock State Park, Gay State Forest, and Adjacent Town of Jaffrey Lands

Final Report

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NH Division of Forests & Lands by the New Hampshire Natural Heritage Program
DRED Division of Forests & Lands and The Nature Conservancy, Concord, NH

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

The Natural Heritage Program 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 Program 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 Program 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 Program information. Our goal is to cooperate with public and private land managers to help them *protect* rare species populations and exemplary natural communities.

cover: Mt. Monadnock summit.
Photo by Bill Nichols

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INTRODUCTION

The NH Natural Heritage Program is a bureau in the Division of Forests and Lands that facilitates the protection of the New Hampshire's rare plants and exemplary natural communities (which are outstanding examples of different types of forests, wetlands, grasslands, etc.). 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.

Mt. Monadnock, lying in southwest New Hampshire (see Figure 1), has a well-documented agricultural and fire history that has had significant effects on the vegetation (both in the forests and on the open ledges). The mountain also has a long legacy of botanical study. The late Henry Baldwin and numerous other naturalists (including Henry David Thoreau) have studied the plants on Mt. Monadnock. Almost all of this work however, was done more than 25 years ago. Also, the work focused heavily on the upper part of the mountain, often lacked site-specific locational information, and did not evaluate the statewide significance of natural communities and the rarity of plants. Nonetheless, this information forms an important historical context for a new survey by the NH Natural Heritage Program. Our objectives of the study were to (1) locate rare plant populations, (2) identify exemplary natural communities, and 3) discuss management issues pertinent to these features.

Fieldwork to identify rare plants and exemplary natural communities in Mt. Monadnock State Park, Gay State Forest, and adjacent parcels owned by the Town of Jaffrey was conducted by NH Natural Heritage ecologists during the summer and fall of 2001 and 2002. The summit of the mountain, owned by the Society for the Protection of New Hampshire Forests, was briefly surveyed for context given its connectivity with Mt. Monadnock State Park. A proposed parking area expansion on Forest Society property along Troy Road was also evaluated in the course of the project. Surveys of Forest Society land on Mt. Monadnock were brief, however, and cannot be considered comprehensive.

This report is divided into four major sections. In "NH Natural Heritage Ecological Approach" we lay the foundation for our work on the property, and include explanations of what natural communities are and how rarity is assessed. In the "Methods" section, we describe the field and office techniques we used to gather data. In the "Results" section, we summarize the vegetation of Mt. Monadnock, describe exemplary natural communities and rare plants of statewide significance, and also describe other features of local significance. Finally, in "Management Considerations and Recommendations" we discuss management issues pertaining to the protection of exemplary natural communities and rare species.

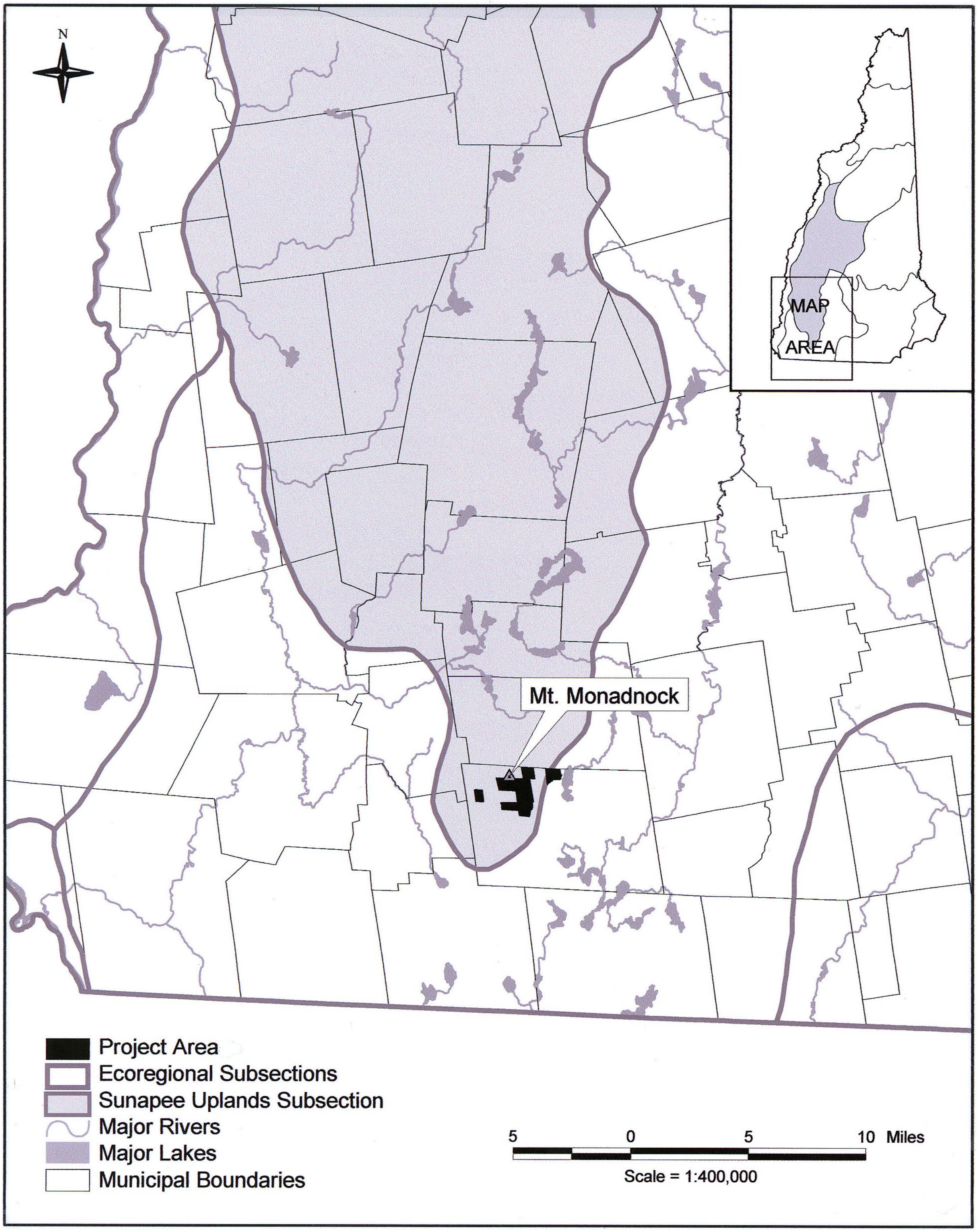

Figure 1. Project area and boundary of the Sunapee Uplands Subsection in New Hampshire.

NH NATURAL HERITAGE ECOLOGICAL APPROACH

NATURAL COMMUNITIES

NH Natural Heritage classifies the landscape in terms of "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 in size (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, show how our classification of them compares to other classification systems, 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 ten years of ecological research by ecologists with NH Natural Heritage, The Nature Conservancy, and NatureServe, plus extensive reviews of scientific literature. 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 and NatureServe 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.

How Natural Communities Compare 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 Natural 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 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, however, useful for timber management purposes.

NATIONAL VEGETATION CLASSIFICATION SYSTEM

At a national level, The Nature Conservancy and NatureServe have 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 National Vegetation Classification 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 geographic 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 also 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 across 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 Natural 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, blow-downs, 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 Natural 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 (see Appendix 1 for more details and Appendix 2 for related information). 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 Natural 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 Natural 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 Natural 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.

1. **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.
2. **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.
3. **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.
4. **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 around that 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.

1. **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.

2. **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.

3 **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.

4. **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.

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 & Lands and the NH Fish & 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 1998b). 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:

> 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 Ecological Reserve System Project 1998a).

NH Natural 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 Natural 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.

METHODS

LANDSCAPE ANALYSIS

The first step of the inventory is a process called "landscape analysis." All available site data were examined to prioritize survey areas and to increase the efficiency of field visits in potential study areas. We interpreted aerial photographs and various map resources to predict potential locations and patterns of rare plants and natural communities, including National Wetland Inventory maps, surficial (Goldthwait 1950) and bedrock geology maps (Lyons *et al*. 1997), Natural Resource Conservation Service soil survey maps (as available in the GRANIT system, 1999), and U.S. Geological Survey (USGS) topographic quadrangles. A review of the NH Natural Heritage database identified rare species and natural communities that were known to occur nearby and may be present within potential study areas. Historical land use information was assessed when available. We then categorized areas as high, medium, or low priority for field surveys, depending on their projected likelihood of supporting target exemplary natural communities and rare plant populations. In the year 2000, we selected a cross-section of moderate and high priority areas for field survey that represented the apparent range of natural community variation within the project area.

FIELD SURVEY

Data were collected at specific locations (observation points or OPs) and throughout each study site. The following information was collected at a general level at most observation points:

1. natural community type, following Sperduto (2000a; 2000b);
2. percent coverage estimates for all plant species;
3. estimated average and maximum diameter-at-breast height (DBH) of canopy trees;
4. tree cores from selected stands;
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 or collected and keyed out using the resources available at NH Natural Heritage. Vascular plant nomenclature follows Gleason and Cronquist (1991) and occasionally Fernald (1950), with common names generally following George (1998). Nomenclature of *Sphagnum* species follows Cleavitt *et al.* (2001).

NH Natural Heritage prepared descriptions of significant sites to summarize important ecological information, including existing threats and management recommendations. Each site was mapped on a copy of a 1:24,000 scale USGS topographic map, and significant sites were mapped using ArcView GIS version 3.2. A Trimble GeoExplorer II Global Positioning System (GPS) was used at selected sites to determine the location of plots or swamps and to gather natural community boundary information. The accuracy of the data collected by the GPS after differential correction was generally plus or minus 5 meters. Field data and site locations of exemplary natural communities have been catalogued and incorporated into the NH Natural Heritage database.

LIMITATIONS OF STUDY

The main goal of this project was to identify rare plant species and intact, high quality natural communities, to guide future conservation and help inform management decisions. This project was a *prioritized* inventory designed to focus survey attention on those portions of the landscape that have the greatest potential to contain significant features. It was not intended to be, nor can it replace, a more resource-intensive and detailed botanical survey of all lands. Second, there are inherent limitations to our ability to predict locations of certain community types (particularly small patch communities) and rare plants using available information sources. Third, it was beyond the scope of this project to document or map all natural community occurrences and their boundaries, although we recognize a definite management utility to mapping natural communities across entire ownerships. Finally, Natural Heritage was only funded to survey portions of the mountain belonging to the State of New Hampshire and the Town of Jaffrey; additional fieldwork is needed to better determine the extent and significance of rare plant populations and natural communities on the mountain outside the study area.

RESULTS

The results are presented in two major sections: (1) Vegetation History of Mt. Monadnock; and (2) Significant Natural Features of Mt. Monadnock. The first section describes the plants and communities of Mt. Monadnock, land use patterns, and some of the major physical factors that affect vegetation in this region. The second section includes descriptions of exemplary and locally significant natural communities and rare plants.

Our field surveys were distributed across a broad, representative array of the natural features in the study area. We recorded plot data and other specific observations at more than 200 locations in the landscape during our 16 days of fieldwork (see Figure 2). We extracted numerous tree cores and recorded stump (ring) counts (see Appendix 3) in many of the forest stands we visited, and have archived the cores at NH Natural Heritage for future reference and study.

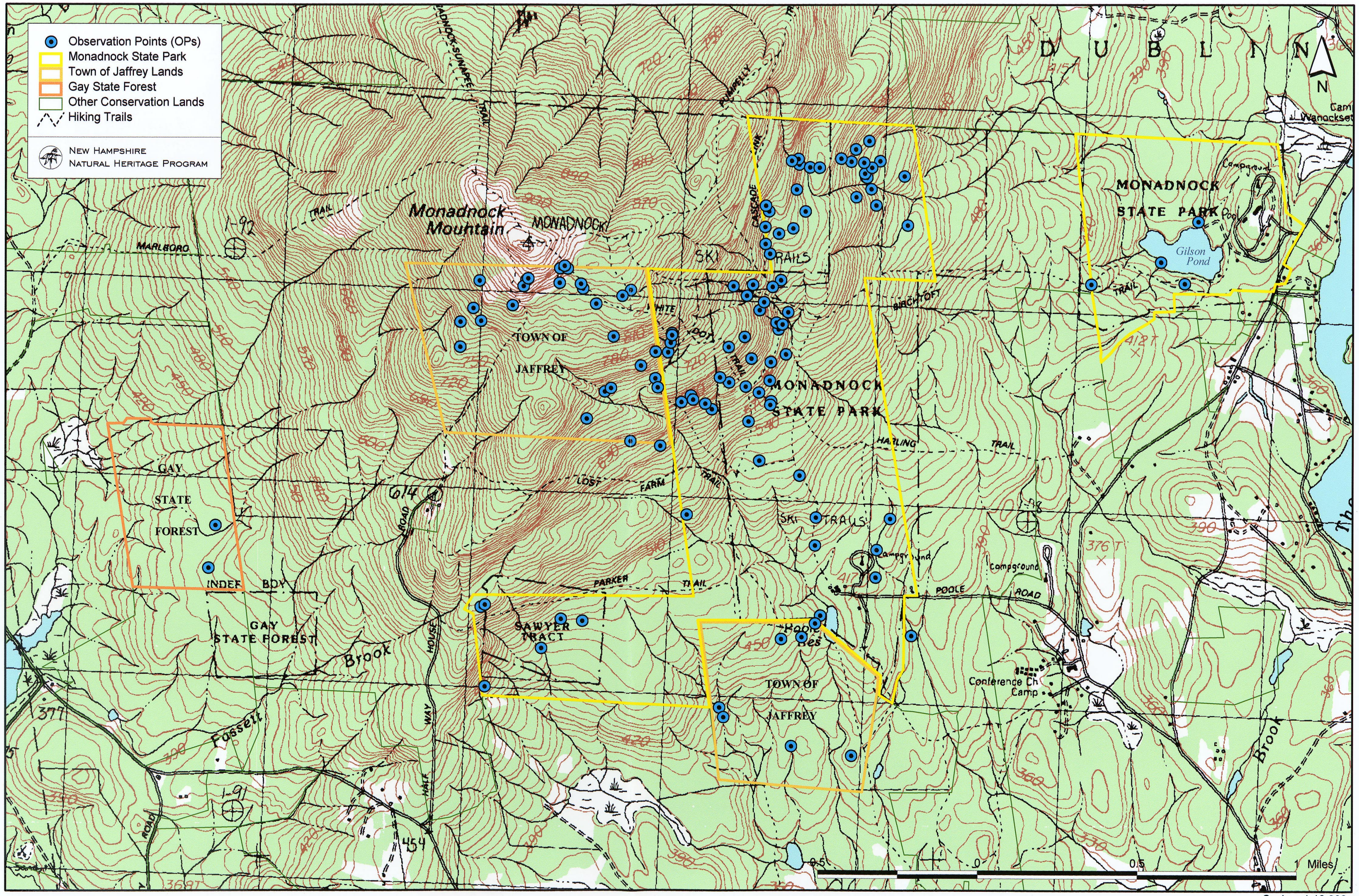

Figure 2. Locations of observation points (OPs) taken in the study area on Mt. Monadnock during the course of the inventory.

Vegetation History of Mt. Monadnock

Mt. Monadnock occurs in southwest New Hampshire, at the north end of the Lower New England Ecoregion[1]. The Lower New England Ecoregion consists of an area extending from southwest Maine to the northern New Jersey/Pennsylvania border that has similar broad climatic conditions and geomorphological and vegetative characteristics. This ecoregion can be subdivided into 14 "subsections" using finer scale climatic, geomorphological, and vegetative criteria (Keys and Carpenter 1995). Mt. Monadnock occurs in the Sunapee Uplands Subsection[2] (Figure 1) that, because of its northern position within the ecoregion, shares some characteristics of the Northern Appalachian Ecoregion just to the north in the White Mountains. Thus, Mt. Monadnock is at an "ecological crossroads" characterized by both northern and southern plants occurring in close proximity. The mountain rises a few thousand feet above the surrounding lowland landscape. Its bedrock is predominantly of the Littleton formation, mostly made of mica schist, quartz-mica schist, sillimanite schist, and sillimanite garnet schist. Much of the mountain's mid to lower western slopes are composed of Concord granite, a light-gray fine-grained to medium-grained massive to foliated granite, quartz monzonite, or granodiorite. It is composed of potash feldspar, oligoclase, quartz, biotite, and some muscovite (Fowler-Billings 1949).

The lower slopes of the mountain in the study area are dominated by **hemlock–beech–oak-pine forest**, a common forest type in New Hampshire on acid low elevation soils. Hemlock (*Tsuga canadensis*) and American beech (*Fagus grandifolia*) are the primary late successional tree species in this common and widespread community of central and southern New Hampshire. Variable amounts of white pine (*Pinus strobus*) and red oak (*Quercus rubra*) are present in early- to mid-successional examples. Yellow birch (*Betula alleghaniensis*), paper birch (*Betula papyrifera*), and red maple (*Acer rubrum*) are common associates. The expressions of this community vary considerably depending on cutting and fire history. For example, in some areas American beech and red oak dominate with almost no hemlock or white pine. This may be indicative of coarse washed till soils and a burn history that favors beech and red oak. Red oak commonly occurs up to 2200 ft., but will usually only reach this and higher elevations on rocky, south-facing slopes. The examples of hemlock–beech–oak-pine forest on Mt. Monadnock have in many places considerable red spruce (*Picea rubens*) in the understory (red spruce is uncommon in most other examples of this forest type in the state). Slightly more enriched and moist areas (**semi–rich mesic hardwood forest**) occur along drainages and concavities of the lower slopes.

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[1] **Ecoregions** are landscape divisions used by The Nature Conservancy and Natural Heritage programs nationwide 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 (Anderson *et al*. 1999). New Hampshire lies within three ecoregions: Northern Appalachian/Boreal Forest; Lower New England/Northern Piedmont; and North Atlantic Coast. Ecoregions consist of aggregations of finer-scale subsections (see below) that share numerous natural communities uncommon in or absent from adjacent ecoregions.

[2] **Subsections** are components of ecoregions that contain similar geologic substrates, soils, and vegetation (Keys *et al*. 1995). They are much smaller than ecoregions, with all or portions of nine subsections occurring within New Hampshire.

Above the hemlock–beech–oak–pine forest on the lower middle slopes are areas dominated by a mature **red oak forest**. This forest is an expression of the hemlock–beech–oak–pine forest and may be the result of red oak masting following pasture abandonment and/or from exposed mineral soils favoring red oak seedlings during the period of forest establishment following the extensive fires on the mountain.

Rocky talus areas occur on the steep middle slopes of the mountain above the red oak forest. These talus slopes are frequent on the mountain, moderately sized in a statewide context, and are either forested (>60% tree cover) or have a woodland structure (25–60% cover). Some are acidic talus slopes and include **red oak–black birch/marginal woodfern talus forest/woodlands** and the **yellow birch variant** of the northern hardwood–spruce–fir forest. Enriched examples correspond to the **dry rich red oak–ironwood talus forest/woodland**, a variant of the rich red oak–sugar maple/ironwood talus forest/woodland.

Montane spruce–fir forest generally occurs on slopes above 2200 ft. and below the rocky summit. This is dominated by red spruce with small amounts of yellow birch. Red oak is an associate in the lower elevation margins of the red spruce forest. Herb and shrub species are few here and their cover is low.

Rocky ridges dominate the mountain's higher slopes and summit and have certainly been expanded in extent by human related fires that occurred on the mountain beginning a few hundred years ago. This habitat includes extensive areas of largely barren rock with plants restricted to cracks and ledges (**subalpine rocky bald**) and more vegetated areas with scattered red spruce, heath shrubs, and low-growing subalpine herbs (**red spruce/heath/cinquefoil rocky ridge**). This area also supports several small **montane poor fen/bogs**.

Lowland wetlands are relatively sparse and small on Mt. Monadnock. Those present include small **emergent marshes** along streams and wooded **basin swamps** in stagnant headwater concavities. **Acidic** and **subneutral forest seeps** occur both in headwater positions and along margins of drainages. Seeps are small but frequent communities that occur at groundwater discharge points throughout the state.

Most rare plants on the mountain are associated with the open rocky ridge. Five are arctic-alpine species considerably disjunct (isolated) from most occurrences in the state and region and therefore have additional biological significance. These include boreal bent-grass (*Agrostis mertensii* [=*A. borealis*]), highland rush (*Juncus trifidus*), mountain sandwort (*Minuartia groenlandica*), Appalachian fir clubmoss (*Huperzia appalachiana*) and Sitka clubmoss *(Diphasiastrum sitchense)*. Rare piled-up sedge (*Carex cumulata*), if it still occurs on the mountain, is also likely associated with the open communities in the rocky ridge habitat. Green adder's-mouth (*Malaxis unifolia*), a second rare species whose location is unknown but has been documented as being on the mountain, would most likely be found in wetland communities. Thoreau noted large-flowered bellwort (*Uvularia grandiflora*) on a visit to the mountain in 1858. The location and persistence of this unsubstantiated record is not known.

Vegetation Prior to European Arrival

Mt. Monadnock was forested from its lower slopes across most of the summit when settlers of European descent first arrived in the area. Several published reports document the summit being forested when settlers first arrived (Dana 1816; Leonard 1855; Ellis 1880; and Child 1885). Thoreau (2001) wrote in his journal on September 6, 1852 "A man in Peterborough told me that his father told him that Monadnock used to be covered with forest…" Climatic treeline occurs at approximately 4,900 ft. in the White Mountains and theoretically around 5,200 ft. in the Monadnock region. Mt. Monadnock, positioned in the southwest corner of the state, is about 2,000 ft. below climatic treeline based on its elevation and latitude.

However, steep sloped knobs more exposed to the elements on and near the summit likely supported a montane rocky bald. In addition, the red spruce forest on the summit's thin and dry soils probably supported a fire regime with historic return intervals of perhaps a few hundred years, or more (C.V. Cogbill, personal communication with W. Nichols, 2002). These fires would create shifting areas of rocky openings that would come and go as a result of fire and reforestation cycles. The historic extent of rocky bald on Mt. Monadnock would then depend in large part on the intensity and frequency of fire. Accounts from a few sources suggest that some areas of the summit were historically open. A report in Cutter (1881) states "When the town was first settled the mountain was covered to its summit with forest trees, principally spruce, excepting a small peak southeast of the top, which was called the Bald Rocks." In 1725, Colonel Willard reported counting 26 ponds from the summit (Annett and Lehtinen 1937), a feat that today requires an unobstructed view in certain areas.

Mt. Monadnock came to be covered by forest since the last glacial retreat. Baldwin (1974) describes the likely succession on the mountain following glaciation: the first steps involved the establishment of lichens and mosses followed by shrubs and herbs including arctic-alpine plants able to survive conditions with severe cold, wind, and fluctuating moisture. Softwoods arrived as the climate moderated, with red spruce coming to dominate the upper slopes on thin, poorly developed soils. Just prior to the arrival of Europeans, the mountain was likely characterized by red spruce and hardwoods on the lower slopes and red spruce on the upper slopes right across most of the summit.

Vegetation Since European Arrival

The lower slopes were the first to be managed as they were cleared mostly to pasture cattle. Later, cleared areas extended up the mountain's higher and steeper slopes for sheep pasture. Annett and Lehtinen (1937) mention an early description of the mountain:

> Edward Bailey, now past ninety years of age, who lived as a boy on the foot hills, yet remembers how from his childhood home, he could look the entire length of the eastern face of the mountain stretching miles away, half across Jaffrey and half across Dublin, and see continuous cleared land in cultivated fields or well-stocked pastures.

Fire was often used to open land for pasture and to maintain the pasture once opened. Fires often escaped these areas and moved farther upslope into forested areas (Leonard 1855). Baldwin (1974) states that several fires have occurred on the mountain in the past 200 years. Two large fires may have cleared the summit, the first around 1800 burned for over two weeks consuming the soil humus and killing the trees. The 1815 hurricane toppled the snags, providing fuel for the second large fire around 1820. Charles Mason, orator at the Dublin Centennial in 1852 described this second fire (Annett and Lehtinen 1937).

> In the latter part of a dry summer, the fire from a clearing on the side of the mountain made its way up to the higher regions, where, feeding upon decayed wood, and nourished by the wind and the draught, it extended itself over almost the entire northern side.

Baldwin (1974) notes how Emerson remarked that the intensity of this second fire "was so great that it 'blasted the rock' into ravines and caused slides." This fire is said to have raged for weeks and cleared what was left remaining on the summit. The exact dates for these two large fires are uncertain. Thoreau (2001) mentions in his journal during a visit to the mountain on September 6, 1852 that forest once covered the mountain and…

> …that fires ran through it and killed the turf; then the trees were blown down, and their roots turned up and formed a dense and impenetrable thicket in which wolves abounded. They came down at night, killed sheep, etc., and returned to their dens, whither they could not be pursued, before morning; till finally they set fire to this thicket and it made the greatest fire they had ever had in the county.

Other smaller fires, many also set by farmers and loggers, are thought to have reached the summit before and after the 1820 fire. Thoreau (2001) notes in his journal during a visit to Wachusett on July 19, 1842 "A fire blazing on Monadnock that night, which lighted up the whole western horizon." Another relatively large fire occurred after the middle of the nineteenth century. Annett and Lehtinen (1937) state that according to old inhabitants…

> …it was caused by the Brigham boys, sons of Levi Brigham, on the present Pope Yeatman place, who attempted to smoke out a squirrel in a hollow tree and the neglected fire having got out of control burned over the whole south slope as far as the upper tree line.

A reference (Chamberlain 1975) to a fire in the 1880s describes how it started "…on the plateau east of the summit to stimulate the blueberry crop, and that it ran over a wide area above tree line before it died out." In 1953, the last fire of significance burned 160 acres of forest on the mountain's east side.

After pasture abandonment, mixed and hardwood forests established on the lower slopes, with red spruce establishing where soil remained on the upper slopes. Timber management for lumber and cordwood has occurred for the last century in certain areas on the lower slopes. Around the exposed summit, woody plant growth is generally limited to small pockets where soil is more protected from the wind, erosion, and extreme temperature fluctuations. Arctic-alpine species that became established on the higher exposed areas include highland rush (*Juncus* *trifidus*), mountain sandwort (*Minuartia groenlandica*), boreal bent-grass (*Agrostis mertensii* [*A. borealis*]), Appalachian fir clubmoss (*Huperzia appalachiana*), and mountain cranberry (*Vaccinium vitis-idaea*). Table 1 summarizes some of the vegetation changes on Mt. Monadnock over the last 200+ years and predicts future trends based on present vegetation cover and likely successional patterns.

Baldwin (1974) surveyed Mt. Monadnock between 1968–1972 and compiled a flora for elevations above 2000' based on his work and collection records from other botanists and naturalists.

Table 1. Summary of some of the past vegetation changes and predicted future trends on Mt. Monadnock.

Species	**<1800**	**1858–1860 Thoreau**	**1968–1972 Baldwin**	**2001–2002 NHNHP**	**Future trends**
Red spruce	Except for small rocky openings on the summit, mountain covered in forest, primarily red spruce on upper slopes; spruce and hardwoods on lower slopes.	Very little forest and red spruce.	Regrowth of forest over most of mountain; red spruce cover slowly increases; regrowth of vegetation at summit slow.	Red spruce cover continues to increase; slow to moderate rate in understory on middle slopes; slow to stagnant rate on rocky summit.	Overall, importance of red spruce will continue to increase, especially on middle slopes; less so on lower slopes; on the rocky summit, slow increase in cover (areas with heavy foot traffic – little to no change).
Arctic-alpine plants: mountain sandwort, highland rush, mountain cranberry, boreal bent-grass, Appalachian fir clubmoss	Absent to very little.	Present; scattered to occasional on higher slopes.	Present; scattered; increasingly restricted to northern side of peak.	Present; likely similar to somewhat less frequent to what Baldwin found.	Present; will decrease some as the slow encroachment by woody species continues near the summit, and/or in response to trampling.
Early low blueberry	Very little in forest understory on upper slopes.	May have extended from lower slopes to summit after the two large fires.	Absent to very little on upper slopes.	Continued decrease in cover on upper slopes.	Continued decrease in cover on upper slopes.

SIGNIFICANT NATURAL FEATURES OF MT. MONADNOCK

EXEMPLARY NATURAL COMMUNITIES

Exemplary natural communities located within the study area are described below. Each community is described separately but mapped together with other exemplary (and locally significant) natural communities at the site (Figure 3). Additional fieldwork is needed to better determine the extent and significance of these natural communities on the mountain outside the study area. See Appendix 1 for an explanation of state rank codes.

Subalpine rocky bald

The subalpine rocky bald occurs on the open rocky areas that dominate the mountain's higher slopes and summit. Frequent, human-caused fires that occurred on the mountain beginning a few hundred years ago destroyed the red spruce forest that once covered the summit and has significantly expanded the extent of subalpine rocky bald. The rocky bald is characterized by largely barren rock with plants restricted to cracks and somewhat protected pockets with thin soils. The regeneration of a woody dominated shrub cover (red spruce/heath/cinquefoil rocky ridge community) on the higher slopes in the most protected hollows is an early step in a process of revegetation. Given time and lack of human intervention, it is likely that red spruce forest will once again cover most of the remaining open habitat across the summit. Exceptions include areas along trails and at the actual summit, where hiker traffic is heavy. The subalpine rocky bald is considered marginally exemplary at statewide and regional scales because of its rarity, despite the historical context.

The microclimate on the higher slopes of Mt. Monadnock changed after fires destroyed the forest and erosion removed the soil. On the open rocky ridges, low growing, ground-hugging plants such as three-toothed cinquefoil (*Potentilla tridentata*) and mountain sandwort (*Minuartia groenlandica*) are adapted to tolerate exposed areas with increased wind exposure, soil moisture fluctuations, and temperature fluctuations.

Other characteristic species in this community on the mountain include common hair-grass (*Deschampsia flexuosa*), highland rush (*Juncus trifidus*), large-leaved aster (*Aster macrophyllus*), and a low cover of woody plants including red spruce (*Picea rubens*), mountain holly (*Nemopanthus mucronatus*), sheep laurel (*Kalmia angustifolia*), black chokeberry (*Aronia melanocarpa*), velvet-leaf blueberry (*Vaccinium myrtilloides*), mountain cranberry (*Vaccinium vitis-idaea*), showy mountain ash (*Sorbus decora*), American mountain ash (*Sorbus americana*), heartleaf birch (*Betula papyrifera* var. *cordifolia*), rhodora (*Rhododendron canadense*), witherod (*Viburnum nudum* var. *cassinoides*), and other less frequent species. Lichens are common on rock surfaces. In 1906 and 1908, R.H. Howe collected approximately 100 species of lichen on the mountain. Weedy species on the summit in the subalpine rocky bald include common plantain (*Plantago major*), sulfur cinquefoil (*Potentilla recta*), Canada bluegrass (*Poa compressa*), common beggar-ticks (*Bidens frondosa*), a knotweed (*Polygonum* sp.), and low cudweed (*Gnaphalium uliginosum*).

Statewide, this community is ranked S2.

Yellow birch variant of the northern hardwood–spruce–fir forest

Talus slopes are frequent on the mountain and largely support a yellow birch talus forest/woodland. It occurs on the steep middle slopes of the mountain above the red oak forest. This example is moderately sized in a statewide context and supports middle-aged as well as older stands. Several of the cored yellow birch trunks were between 150 and 200 years old (see Appendix 3). This community transitions into smaller talus forest/woodland types elsewhere on the mountain: on drier southerly-facing acidic soils or mesic acidic soils near the base of the talus on the lower middle slopes – red oak–black birch/marginal woodfern talus forest/woodlands; on more enriched soils – rich red oak–ironwood talus forest/woodland; and on poorer soils at higher elevations – yellow birch–red spruce talus forest/woodland (transitional between the yellow birch talus forest/woodland and the montane spruce–fir forest).

The yellow birch variant of the northern hardwood–spruce–fir forest on Mt. Monadnock is forested (>60% tree cover) in some areas and with a woodland structure (25–60% cover) in other areas. Yellow birch (*Betula alleghaniensis*) dominates the canopy. Common associates in the canopy can include red spruce (*Picea rubens*), red oak (*Quercus rubra*), paper birch (*Betula papyrifera*), and red maple (*Acer rubrum*). Shrubs include striped maple (*Acer pensylvanicum*), mountain maple (*Acer spicatum*), bush honeysuckle (*Diervilla lonicera*), showy mountain ash (*Sorbus decora*), and red raspberry (*Rubus idaeus*). Characteristic herbs are hay-scented fern (*Dennstaedtia punctilobula*), whorled aster (*Aster acuminatus*), intermediate wood fern (*Dryopteris intermedia*), blue-bead lily (*Clintonia borealis*), starflower (*Trientalis borealis*), Canada mayflower (*Maianthemum canadense*), marginal wood fern (*Dryopteris marginalis*), rock polypody (*Polypodium virginianum*), common hair-grass (*Deschampsia flexuosa*), distant sedge (*Carex* cf. *lucorum*), northern wood sorrel (*Oxalis acetosella*), wild sarsaparilla (*Aralia nudicaulis*), and fringed bindweed (*Polygonum cilinode*).

Statewide, this community is ranked S4.

Dry rich red oak–ironwood talus forest/woodland

This natural community is a variant of the rich red oak–sugar maple/ironwood talus forest/woodland. It occurs on the lower south-facing slopes of the mountain on the east side of Half Way House Road. Important associates of the dominant red oak (*Quercus rubra*) in the canopy and sub-canopy include white ash (*Fraxinus americana*), ironwood (*Ostrya virginiana*), sugar maple (*Acer saccharum*), and striped maple (*Acer pensylvanicum*). Pennsylvania sedge (*Carex pensylvanica*) and whorled aster (*Aster acuminatus*) are the most frequent herbs. Herbs present that usually prefer enriched conditions are sedges (*Carex* spp.) in section *Laxiflorae* and *Careyanae*, Christmas fern (*Polystichum acrostichoides*), hairy Solomon's seal (*Polygonatum pubescens*), and herb Robert (*Geranium robertianum*).

This community warrants a visit early in the growing season to survey for rare spring ephemerals and to better determine its extent on slopes outside the study area. Statewide, this community is ranked S2S3.

FEATURES OF LOCAL SIGNIFICANCE

The following sites contain features of local significance, including good examples of natural communities that are too small or whose ecological significance is not great enough to be considered exemplary in a statewide context. However, they do contribute greatly to the character of Mt. Monadnock and the overall local diversity of plants and communities present, and therefore warrant consideration when planning management activities. With time, and with appropriate protection and restoration of the ecological processes and integrity, these communities will become exemplary. Additional fieldwork is needed to better determine the extent and significance of these natural communities on the mountain outside the study area. See Appendix 1 for an explanation of state rank codes. The sites are described here and mapped in Figure 3.

Montane poor fen/bog

We observed numerous montane poor fens on the higher slopes of the mountain. Wetlands in bedrock depressions near the summit occur in all stages of hydrarch succession from unvegetated pools to well developed poor fens. Shallow pools in bedrock depressions seem to be first colonized by hare's-tail (*Eriophorum vaginatum* var. *spissum*) and the moss *Drepanocladus fluitans*. *Sphagnum* is next to move in and, once established, directs succession towards development of a poor fen through its water holding capacity, soil and water acidification, and peat accumulation. Finally herbs, shrubs, and trees typical of montane poor fens become more common across the peat mat. These include leather-leaf (*Chamaedaphne calyculata*), rhodora (*Rhododendron canadense*), mountain holly (*Nemopanthus mucronatus*), black chokeberry (*Aronia melanocarpa*), sheep laurel (*Kalmia angustifolia*), and other shrubs. Red spruce (*Picea rubens*) is common around poor fen edges.

Other plants fairly frequent in the poor fens include white beak-rush (*Rhynchospora alba*), silvery sedge (*Carex canescens*), tawny cotton-grass (*Eriophorum virginicum*), short-tailed rush (*Juncus brevicaudatus*), black-girdled bulrush (*Scirpus atrocinctus*), round-leaved sundew (*Drosera rotundifolia*), three-leaved false Solomon's seal (*Smilacina trifolia*), northern bog clubmoss (*Lycopodiella innundata*), three-seeded sedge (*Carex trisperma*), cinnamon fern (*Osmunda cinnamomea*), conifer cotton-grass (*Eriophorum tenellum*), *Polytrichum* spp., Labrador-tea (*Ledum groenlandicum*), heartleaf birch (*Betula papyrifera* var. *cordifolia*), eastern meadow-sweet (*Spiraea alba* var. *latifolia*), creeping snowberry (*Gaultheria hispidula*), mountain cranberry (*Vaccinium vitis-idaea*), witherod (*Viburnum nudum* var. *cassinoides*), velvet-leaf blueberry (*Vaccinium myrtilloides*), red maple (*Acer rubrum*), white pine (*Pinus strobus*), and American mountain ash (*Sorbus americana*).

Baldwin (1987) states that these fens were not present when the thick spruce forest covered the upper slopes and summit. He reasoned that the red spruce would have drawn down the water collected in the shallow depressions and prevented the establishment of shade-intolerant poor fen species. Baldwin goes on to speculate that the current absence of black spruce (*Picea mariana*) in these fens also indicates that these peatlands are no more than a few hundred years old.

Statewide, this community is ranked S3S4.

Montane spruce–fir forest

On Mt. Monadnock, montane spruce–fir forest occurs on slopes generally above 2200 ft. and below the rocky summit. This second growth forest is regenerating from past land use that created open habitat on most of the mountain, as described earlier. Given time and lack of human intervention, it is likely that red spruce forest will once again cover most of the remaining open habitat across the summit. Baldwin (1977) notes that the initial re-invasion of red spruce on the summit after the fires cleared the forest has slowed considerably. The remaining xeric, exposed rocky barrens will require much more time before it is covered by red spruce. In these areas, soil development from bare rock may require many hundreds to thousands of years.

In steep valleys and other areas, some of the red spruce stands are approaching 200 years old (Baldwin 1977; NH Natural Heritage surveys (see Appendix 3)). Canopy associates of the dominant red spruce (*Picea rubens*) include yellow birch (*Betula alleghaniensis*), paper birch (*Betula papyrifera*), red oak (*Quercus rubra*), balsam fir (*Abies balsamea*), and red maple (*Acer rubrum*). Understory species are few and their cover is generally low. They include velvet-leaf blueberry (*Vaccinium myrtilloides*), mountain holly (*Nemopanthus mucronatus*), sheep laurel (*Kalmia angustifolia*), showy mountain ash (*Sorbus decora*), hobblebush (*Viburnum alnifolium*), witherod (*Viburnum nudum* var. *cassinoides*), striped maple (*Acer pensylvanicum*), black chokeberry (*Aronia melanocarpa*), common hair-grass (*Deschampsia flexuosa*), round-branch ground-pine (*Lycopodium dendroideum*), wild sarsaparilla (*Aralia nudicaulis*), intermediate wood fern (*Dryopteris intermedia*), rock polypody (*Polypodium virginianum*), blue-bead lily (*Clintonia borealis*), northern wood sorrel (*Oxalis acetosella*), Canada mayflower (*Maianthemum canadense*), bunchberry (*Cornus canadensis*), and goldthread (*Coptis trifolia* var. *groenlandica*). Windthrow and breakage from heavy snow loads can create openings in the canopy, below which understory species become more prominent.

Statewide, this community is ranked S4.

Red spruce/heath/cinquefoil rocky ridge

This community occurs where trees and shrubs have regrown in hollows protected somewhat from exposure where more favorable soil moisture exists and snow accumulation provides shelter from the wind. The regeneration of a woody dominated cover follows a period of past land use that created open habitat on most of the mountain. Given time and lack of human intervention, it is likely that red spruce forest will once again cover most of the remaining open habitat across the summit. This community is a mid-successional cover type intermediate between the subalpine rocky bald and montane spruce–fir forest. The remaining more exposed rocky xeric areas will require much more time before they are covered by red spruce. Baldwin

(1977) notes that the initial re-invasion of red spruce on the summit after the fires cleared the forest has slowed considerably.

Baldwin (1977) determined the age range of the red spruce (*Picea rubens*) in the scrub zone to be 20–80 years old and averaging 40 years (also see Appendix 3). Associates include black chokeberry (*Aronia melanocarpa*), sheep laurel (*Kalmia angustifolia*), mountain holly (*Nemopanthus mucronatus*), witherod (*Viburnum nudum* var. *cassinoides*), rhodora (*Rhododendron canadense*), velvet-leaf blueberry (*Vaccinium myrtilloides*), heartleaf birch (*Betula papyrifera* var. *cordifolia*), red maple (*Acer rubrum*), American mountain ash (*Sorbus americana*), showy mountain ash (*Sorbus decora*), common hair-grass (*Deschampsia flexuosa*), and bunchberry (*Cornus canadensis*).

Statewide, this community is ranked S3S4.

Red oak forest

This mature red oak forest generally occurs upslope of the hemlock–beech–oak–pine forest. It is an expression of the hemlock–beech–oak–pine forest and may be the result of red oak masting following pasture abandonment and/or from exposed mineral soils favoring red oak seedlings during the period of forest establishment following the extensive fires on the mountain. Several of the cored trees are between 100 and 150 years old; others are between 150 to over 200 years old (see Appendix 3). These older red oak are primarily restricted to the base of talus slopes, most often in association with the yellow birch variant of the northern hardwood–spruce–fir forest.

The mature red oak canopy appears to be a product of natural succession. Red oak is a long-lived species and this forest will persist in better-drained loamy soils for centuries. In areas where the soil quality is poor, the stand of red oak may be somewhat shorter-lived with red spruce inevitably reassuming dominance. This is reflected in several areas where red spruce regeneration is moderate to high beneath the somewhat shade-intolerant red oak in the canopy.

Mature red oak (*Quercus rubra*) dominates the canopy. Common canopy associates include yellow birch (*Betula alleghaniensis*), red spruce (*Picea rubens*), paper birch (*Betula papyrifera*), red maple (*Acer rubrum*), white pine (*Pinus strobus*), American beech (*Fagus grandifolia*), and black cherry (*Prunus serotina*). Shrubs include striped maple (*Acer pensylvanicum*), mountain maple (*Acer spicatum*), red raspberry (*Rubus idaeus*), bristly dewberry (*Rubus hispidus*), early low blueberry (*Vaccinium angustifolium*), velvet-leaf blueberry (*Vaccinium myrtilloides*), and hobblebush (*Viburnum alnifolium*). Characteristic herbs are hay-scented fern (*Dennstaedtia punctilobula*), whorled aster (*Aster acuminatus*), intermediate wood fern (*Dryopteris intermedia*), starflower (*Trientalis borealis*), Canada mayflower (*Maianthemum canadense*), marginal wood fern (*Dryopteris marginalis*), rock polypody (*Polypodium virginianum*), Pennsylvanian sedge (*Carex pensylvanica*), wild sarsaparilla (*Aralia nudicaulis*), princess pine (*Lycopodium obscurum*), Rudge's sedge (*Carex debilis*), and several other less frequent species.

In many areas, the boundary of the mature red oak forest gradually transitions into a younger oak dominated hemlock–beech–oak–pine forest. Because of the difficulty delineating the exact boundary of the mature red oak forest in these areas, additional fieldwork is needed, particularly outside the study area, to more accurately determine its extent. Embedded within this area are small pockets of forest with red spruce codominanting with red oak in the canopy.

Statewide, this community is ranked S5, but examples dominated by red oak over such an extensive area are uncommon to rare in New Hampshire.

RARE SPECIES

The eight rare plant species described below have been documented on Mt. Monadnock. One rare plant population, boreal bent-grass (*Agrostis mertensii* [*A. borealis*]), was newly discovered by NH Natural Heritage ecologists. Of the seven rare plant populations that were first documented prior to this study, three were relocated during the survey. The remaining four are considered historical (not seen in at least 20 years). We track endangered (SE; S1) and threatened (ST; S2) plant species in our database. Although less rare than endangered and threatened species, state watch species (SW; S3) are also rare and warrant consideration when planning management activities. See Appendix 1 and 2 for an explanation of global and state ranks and state listing codes.

Appalachian fir clubmoss (*Huperzia appalachiana*)

Walter Deane first collected *Lycopodium Selago* (=*Huperzia appalachiana*) on the mountain in August 1891. It was later collected by Henry Baldwin during his 1968-1972 survey. Deane's specimen is at New England Botanical Club (NEBC). This taxon was more recently split into two species, with the Mt. Monadnock material being ascribed to *Huperzia appalachiana*. Three stations are known in the subalpine rocky bald community (Observation Points 12, 14, & 198). Associates include mountain sandwort (*Minuartia groenlandica*), common hair-grass (*Deschampsia flexuosa*), highland rush (*Juncus trifidus*), three-toothed cinquefoil (*Potentilla tridentata*), large-leaved aster (*Aster macrophyllus*), and a low cover of woody plants including red spruce (*Picea rubens*), mountain holly (*Nemopanthus mucronatus*), sheep laurel (*Kalmia angustifolia*), black chokeberry (*Aronia melanocarpa*), velvet-leaf blueberry (*Vaccinium myrtilloides*), mountain cranberry (*Vaccinium vitis-idaea*), showy mountain ash (*Sorbus decora*), American mountain ash (*Sorbus americana*), heartleaf birch (*Betula papyrifera* var. *cordifolia*), rhodora (*Rhododendron canadense*), witherod (*Viburnum nudum* var. *cassinoides*), and other less frequent species. Lichens are common on rock surfaces.

This population occurs near the summit, outside the study area. Appalachian fir clubmoss is currently proposed for "threatened" status in New Hampshire (proposed ST; S2). It is secure globally (G4G5). The species is restricted to alpine and subalpine habitats in the state.

Boreal bent-grass (*Agrostis mertensii* [=*A. borealis*])

This plant was found at one location (Observation Point 14) in the subalpine rocky bald by NH Natural Heritage ecologists in 2001. Associates include mountain sandwort (*Minuartia groenlandica*), common hair-grass (*Deschampsia flexuosa*), highland rush (*Juncus trifidus*), three-toothed cinquefoil (*Potentilla tridentata*), large-leaved aster (*Aster macrophyllus*), and a low cover of woody plants including red spruce (*Picea rubens*), mountain holly (*Nemopanthus mucronatus*), sheep laurel (*Kalmia angustifolia*), black chokeberry (*Aronia melanocarpa*), velvet-leaf blueberry (*Vaccinium myrtilloides*), mountain cranberry (*Vaccinium vitis-idaea*), showy mountain ash (*Sorbus decora*), American mountain ash (*Sorbus americana*), heartleaf birch (*Betula papyrifera* var. *cordifolia*), rhodora (*Rhododendron canadense*), witherod (*Viburnum nudum* var. *cassinoides*), and other less frequent species. Lichens are common on rock surfaces.

This population occurs near the summit, outside the study area. Boreal bent-grass is "watch-listed" (SW; S3) in New Hampshire and secure globally (G5). The species is primarily restricted to alpine and subalpine habitats and montane riverbanks in the state.

Green adder's-mouth (*Malaxis unifolia*)

This is an historical record, collected by F. Hunt in 1946. The location and persistence of the population on the mountain are unknown. The specimen is at University of New Hampshire (NHA). Green adder's-mouth is "threatened" in New Hampshire (ST; S2) and secure globally (G5).

Highland rush (*Juncus trifidus*)

Highland rush was reported by Henry David Thoreau and collected by C.W. Swan in August 1883 and by Henry Baldwin during his 1968-1972 survey. Swan's specimen is at New England Botanical Club (NEBC). NH Natural Heritage ecologists observed numerous stations in the subalpine rocky bald on the mountain's higher slopes and summit in 2001–2002. Associates include mountain sandwort (*Minuartia groenlandica*), common hair-grass (*Deschampsia flexuosa*), three-toothed cinquefoil (*Potentilla tridentata*), large-leaved aster (*Aster macrophyllus*), and a low cover of woody plants including red spruce (*Picea rubens*), mountain holly (*Nemopanthus mucronatus*), sheep laurel (*Kalmia angustifolia*), black chokeberry (*Aronia melanocarpa*), velvet-leaf blueberry (*Vaccinium myrtilloides*), mountain cranberry (*Vaccinium vitis-idaea*), showy mountain ash (*Sorbus decora*), American mountain ash (*Sorbus americana*), heartleaf birch (*Betula papyrifera* var. *cordifolia*), rhodora (*Rhododendron canadense*), witherod (*Viburnum nudum* var. *cassinoides*), and other less frequent species. Lichens are common on rock surfaces.

Highland rush is "watch-listed" (SW; S3) in New Hampshire and secure globally (G5). The species is restricted to alpine and subalpine habitats in the state.

Large-flowered bellwort (*Uvularia grandiflora*)

Thoreau (2001) noted this plant and some of its associates on a visit to the mountain on June 2, 1858:

> Thereabouts first I noticed the *Ribes prostratum*, abundantly in bloom, apparently in prime, with its pretty erect racemes of small flowers, sometimes purplish with large leaves. There, too, the *Trillium erythrocarpum*, now in prime, was conspicuous, – three white lanceolate waved-edge petals with a purple base. This the handsomest flower of the mountain, coextensive with the wooded sides. Also the *Viburnum latanoides*, apparently in prime, with

its large and showy white outer florets, reminding me by its marginal flowering of the tree-cranberry, coextensive with last; and *Uvularia grandiflora*, not long begun to bloom. Red elder-berry not open, apparently, there; and *Amelanchier Canadensis* var. *Botryapium* not long in bloom.

Based on the presence of this plant along with some of the other plants mentioned, Thoreau may have come upon an enriched colluvial pocket somewhere on the lower slopes. The location and persistence of this unsubstantiated record for large-flowered bellwort is not known. The report is not considered valid and the record has not been entered into the NH Natural Heritage database; however, it does remain a rare plant lead for the mountain. Large-flowered bellwort is "endangered" in New Hampshire (SE; S1) and secure globally (G5).

Mountain sandwort (*Minuartia groenlandica*)

This was first reported by Henry David Thoreau between 1858–1860 and later collected by Thomas Hope in 1879 and Henry Baldwin during his 1968–1972 survey. Hope's specimen is at New England Botanical Club (NEBC). NH Natural Heritage ecologists observed numerous stations in the subalpine rocky bald on the mountain's higher slopes and summit in 2001–2002. Associates include common hair-grass (*Deschampsia flexuosa*), highland rush (*Juncus trifidus*), three-toothed cinquefoil (*Potentilla tridentata*), large-leaved aster (*Aster macrophyllus*), and a low cover of woody plants including red spruce (*Picea rubens*), mountain holly (*Nemopanthus mucronatus*), sheep laurel (*Kalmia angustifolia*), black chokeberry (*Aronia melanocarpa*), velvet-leaf blueberry (*Vaccinium myrtilloides*), mountain cranberry (*Vaccinium vitis-idaea*), showy mountain ash (*Sorbus decora*), American mountain ash (*Sorbus americana*), heartleaf birch (*Betula papyrifera* var. *cordifolia*), rhodora (*Rhododendron canadense*), witherod (*Viburnum nudum* var. *cassinoides*), and other less frequent species. Lichens are common on rock surfaces.

Mountain sandwort is "watch-listed" (SW; S3) in New Hampshire and secure globally (G5). The species is primarily restricted to alpine and subalpine habitats in the state.

Piled-up sedge (*Carex cumulata*)

This is an historical record, collected by C. W. Jenks in 1883. The location and persistence of the population on the mountain are unknown. The specimen is at New England Botanical Club (NEBC). Piled-up sedge is "endangered" (SE; S1) in New Hampshire and apparently secure globally (G4?) although the rank is uncertain due to insufficient information at the global level.

Sitka clubmoss *(Diphasiastrum sitchense)*

This is an historical record, originally collected by Walter Deane on the summit in 1891. The specimen is at The Smithsonian Institution (US). This species is probably extirpated from Mt. Monadnock, but our survey of the summit was not adequate to definitively confirm its presence or absence.

Sitka clubmoss is proposed for listing as endangered in New Hampshire (SE; S1) and globally secure (G5) but very rare in New England.

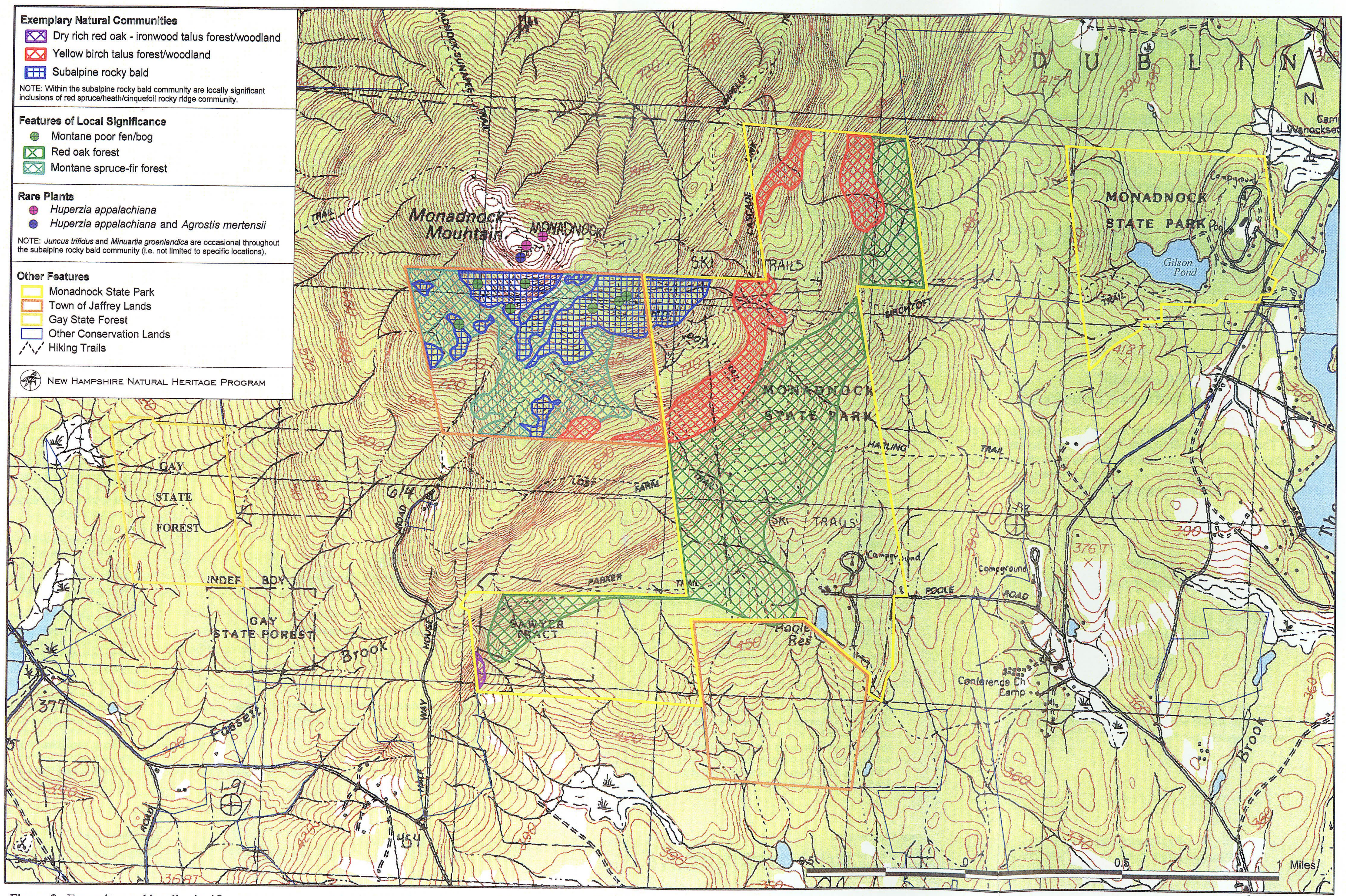

Figure 3. Exemplary and locally significant natural communities and rare plants documented during the 2001-2002 study on Mt. Monadnock.

MANAGEMENT CONSIDERATIONS AND RECOMMENDATIONS

The Rocky Ridge and Red Spruce Forest Recovery: The rocky ridge communities on the higher slopes of Mt. Monadnock have important ecological value. Although they share the same historical context in the rocky ridge habitat, the subalpine rocky bald is considered marginally exemplary at statewide and regional scales because of its rarity (S2), whereas the red spruce/heath/three-toothed cinquefoil rocky ridge is considered locally significant because it is more common (S3S4). Both should be protected and managed with their ecological importance in mind. However, because the current natural communities on the summit are still significantly linked to past land use and reflect less the historic vegetation patterns just prior to the arrival of the earliest European settlers, in one sense, the ecological value of this area will increase as the forest slowly reclaims the upper slopes. This will be particularly true when forest recovery is coupled with a management plan that addresses the impacts associated with current levels of hiking activity. Management of the mountains higher slopes and summit should aim to maximize the rate of forest recovery by minimizing the impacts of hiking activity; this will also prevent the elimination of the rare plant populations in the coming centuries, particularly where they are concentrated at the summit cone which may take centuries or thousands of years to reforest.

The present extent of rocky ridge is largely an artifact of uncontrolled fires started for pasture management and other purposes in the early to mid 1800s (see "Vegetation Since European Arrival"). We believe that it is unlikely site conditions and the historic natural fire regime ever supported a similar extent of open habitat on the summit prior to the arrival of the first European settlers. Since the previous red spruce summit probably supported a fire regime with an historic return interval of a few hundred years or more, the rocky ridge that existed on the summit was likely small, patchy, and in various stages of succession. Once a summit is open, a fire every few hundred years is thought to be sufficient to maintain rocky ridge habitat (Wessels 2001). Therefore, the majority of the current rocky ridge is considered to be in the early stages of a slow recovery from past intensive land use patterns that likely are dissimilar in significant ways from natural disturbance patterns. Based on site conditions and known fire history, in the absence of human intervention, most of the current rocky ridge would slowly move back to a red spruce dominated forest. Baldwin (1987) stated more than a thousand years would be required to develop soil from weathering rock and accumulation of organic matter that could support a forest of the former forest's size and density. This may be a conservative estimate. It may take several thousand years to go from bare rock to forest cover on an exposed summit (C.V. Cogbill, personal communication with W. Nichols, 2002). Ironically, under current fire suppression practices, if ever the summit nears a state of reforestation, fire management would be required to maintain a smaller extent of rocky ridge that likely historically existed.

As red spruce (*Picea rubens*), rhodora (*Rhododendron canadense*), mountain holly (*Nemopanthus mucronatus*), sheep laurel (*Kalmia angustifolia*), and other shrubs continue to encroach on the summit, habitat suitable for the shade-intolerant rare arctic-alpine species (boreal bent-grass (*Agrostis mertensii* [=*A. borealis*]), highland rush (*Juncus trifidus*), mountain sandwort (*Minuartia groenlandica*), and Appalachian fir clubmoss (*Huperzia appalachiana*)) will be reduced. Baldwin (1977) determined that the extent of arctic-alpine species have contracted since the time of Thoreau's visits (1844–1860) as woody plants reinvaded the mountain's flanks. Since this process of reforestation has greatly slowed in recent decades on the remaining, more exposed areas around the summit, no immediate management is needed other than controlling direct trampling of rare plants. In the future, if ever the summit nears a state of reforestation, fire management would be required (under current fire suppression practices) to maintain smaller extents of rocky ridge (like that which probably existed historically) and the arctic-alpine plants dependent on this habitat. During the survey, we took several photographs that can be used in the future to reference gross change in plant cover in areas that are currently sparsely vegetated. Information collected for each reference photograph (stored at NH Natural Heritage) includes GPS location data and the compass bearing in which each picture was taken.

Hiker impacts: Another important consideration is the large number of hikers that visit the mountain. Mt. Monadnock is believed to be the second most climbed mountain in the world, with more than 125,000 hikers visiting each year. It is likely that the summit will never completely reforest at current levels of hiker visitation. Trampling and soil erosion resulting from current levels of hiking activity will prevent any significant growth of woody plants in the most heavily used areas. Although the rare arctic-alpine plants on the mountain require open habitat, as most areas around the summit slowly reforest, foot traffic likely will have a more significant impact on these plants since hiker activity will be more concentrated in the remaining open habitat otherwise suitable for these plants. Educating hikers to avoid vegetated areas and areas with mineral soil (i.e., a "stay on the rocks" message) through brochures, trail guides, and trail signs would be one way to minimize hiker impact. Foot traffic should also be discouraged from entering or crossing any of the small montane poor fens on the mountain's higher slopes.

Forest Communities: In general, for all the forested communities on the mountain, the extent of hiking activity should be closely monitored and its impacts to the local flora and fauna minimized. There are no other specific *active* management needs that would relate to the exemplary and locally significant forests we identified, although there are important considerations to note in the context of managing these forests and the surrounding landscape, and in terms of the role of old forest core areas within a larger working forest. This is relevant for locally significant as well as currently exemplary forests because if the forests are protected with the intent of restoring or increasing ecological integrity, they will eventually become exemplary at a statewide scale.

Minimally managed old forests (more than 150 years) are associated with ecological characteristics and "biological legacies" not found in younger and more heavily managed forests. Examples of these characteristics include old trees, large snags, and large coarse woody debris in various stages of decay, undisturbed soils, and biota that are dependent on late successional conditions and disturbance dynamics. In northern hardwood and spruce–fir forests, relatively small scale (e.g., single tree) gap dynamics are the dominant pattern of disturbance over the course of decades. Over longer time frames, however, disturbance patch sizes occur at a scale of hundreds and, in some areas, thousands of acres, particularly in spruce–fir forests. Major disturbances may include windthrow from hurricanes, crown damage from major ice storms, and insect outbreaks. Thus, since the old forests identified in the exemplary yellow birch talus forest woodland and the locally significant montane spruce-fir communities (see Figure 3) are relatively small in size they are more vulnerable to large-scale catastrophic disturbances. This vulnerability can be mitigated to an extent by retaining a minimally disturbed buffer around these forest communities, or by protecting these communities as pieces within a larger protected forest matrix.

Principles of conservation biology tell us that, in general, the larger and more varied a protected forest tract is, the more biodiversity it will contain, and the more buffered it will be from disturbance. Large tracts with a diverse array of topography, aspect angles, forest types, successional stages, and age and size structures are less likely to have the entire tract affected by a major disturbance event, and more likely to contain patches of dynamic, late-successional forest somewhere in the tract. A major blowdown of the old trees identified in the exemplary yellow birch talus forest woodland and locally significant montane spruce-forest natural communities would not eliminate the ecological value of these communities, but it might eliminate the prevailing late-successional condition with the signature old trees and other characteristics that we recognize as unusual and ecologically significant. The communities would still be an inherently valuable, albeit less dramatic and diverse, expression of dynamic forest conditions (e.g., biological legacies associated with soil and diverse woody debris dynamics, and the remaining young to middle aged trees), but would lack the present 200 year age structure. However, in a scenario where the old forest communities are part of a larger protected forest, the younger forest communities that surround them would become the late successional “old forests” of the future. This would ensure the continued presence of old (200+ years) trees in these forests, regardless of whether a major natural disturbance brings down the old trees that are there currently. In this manner, a "shifting mosaic" of dynamic forest conditions is created, maintained by a natural disturbance regime.

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Appendix 1. 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 2. Explanation of state listing codes.

In 1987, the New Hampshire state legislature passed the Native Plant Protection Act (RSA 217-A) and formally recognized that "for human needs and enjoyment, the interests of science, and the economy of the state, native plants throughout this state should be protected and conserved; and . . . their numbers should be maintained and enhanced to insure their perpetuation as viable components of their ecosystems for the benefit of the people of New Hampshire." To compile a list of the species requiring protection, the NH Natural Heritage Program collaborated with knowledgeable botanists and identified the most imperiled taxa as "endangered" and those likely to become endangered as "threatened." A total of 288 taxa were listed, 144 as endangered and 144 as threatened.

In addition to endangered and threatened categories, a state watch category exists for taxa appearing vulnerable to extirpation where current information does not justify designating them endangered or threatened.

Endangered
Native plants documented as having five or fewer natural occurrences in the state observed within the last 20 years, or plants with more than five occurrences that are, in the judgement of experts, critically imperiled by extirpation due to other important rarity considerations (number of individuals, area of population occupancy, restrictiveness and distribution of species' geographic range, habitat rarity, population trends, population viability, and degree of protection).

Threatened
Native plants documented as having 6-20 natural occurrences in the state observed within the last 20 years, or plants with more than 20 occurrences that are, in the judgement of experts, imperiled by extirpation due to other important rarity considerations (number of individuals, area of population occupancy, restrictiveness and distribution of species' geographic range, habitat rarity, population trends, population viability, and degree of protection).

Watch
Native plants documented as having 21-100 natural occurrences in the state observed within the last 20 years, or plants that are, in the judgement of experts, vulnerable to extirpation due to other important rarity considerations (number of individuals, area of population occupancy, restrictiveness and distribution of species' geographic range, habitat rarity, population trends, population viability, and degree of protection). Native plants whose status is uncertain, but are possibly in peril, may be designated state watch as well.

Appendix 3. Tree core data.

NH Natural Heritage collected tree cores and assessed red spruce stumps in 2002 as part of this study. These data are summarized below.

OP	Species	DBH	Date	Type	Count-able Rings	Est. Rings to Pith	Est. Age	Release Dates (YBP)	Restric-tion Dates (YBP)	Comments
25c	Tsuga canadensis	29.50	10/5/01	S	190	0	215			Count on trunk that was 25' up but snapped and was cut from trail; 22.5" dia at 25'.
51	Acer sacharrum	29	9/20/02	C	111		111			No bark; center rot.
53	Betula alleghaniensis	16	9/20/02	C	118		118		97, 78	Center rot.
53	Picea rubens	14	9/20/02	C	184	4	188	20	62, 33	On streambank.
57	Betula alleghaniensis	20	9/20/02	C	132		132	116	92, 72	Center rot.
57	Picea rubens	15	9/20/02	C	116	5	121		95, 53	
58	Picea rubens	14	9/20/02	C	112	4	116		62	
63	Picea rubens	7.50	9/24/02	S	110	0	115			Cut stump on trail 50 meters east of OP 63; stump 3" high.
63	Picea rubens	19	9/24/02	C	130	5	135		50	Spruce Link Trail.
64	Picea rubens	17	9/24/02	C	124	6	130	45	60	
64	Quercus rubra	13	9/24/02	S	75	0	80			Cut stump on trail at junc of Spruce Link and White Cross; stump 3" high.
66	Betula alleghaniensis	22.50	9/24/02	C	164		164	164		Knot at 1838.
66	Quercus rubra	26	9/24/02	C	105	4	109	24	59	
68	Picea rubens	14	9/24/02	C	59	4	63		28, 19	In headwater drainage.
70	Betula alleghaniensis	7.50	9/24/02	S	65	0	70			Cut stump on trail; stump 3" high.
70	Picea rubens	6	9/24/02	S	82	0	87			Cut stump on trail; stump 3" high.
70	Picea rubens	13	9/24/02	C	67	7	74			Trailside.
72	Betula papyrifera	4	9/24/02	C	42	1	43			
72	Picea rubens	9.75	9/24/02	C	60	1	61		52, 24	
75	Picea rubens	15	9/24/02	C	37	21	58			Knot at 1965 .

OP	Species	DBH	Date	Type	Count-able Rings	Est. Rings to Pith	Est. Age	Release Dates (YBP)	Restric-tion Dates (YBP)	Comments
76	Betula alleghaniensis	12.50	9/24/02	C	174	5	179	110	70	Cored 6' up.
76	Betula alleghaniensis	15	9/24/02	C	161		161			Center rot.
76	Quercus rubra	17.50	9/24/02	C	194	0	194			
77	Picea rubens	16	9/24/02	C	88	6	94	119, 95, 69	61	
82	Quercus rubra	22	9/24/02	C	97	6	103			
112	Picea rubens	2.50	9/25/02	S	45	0	60			Cut stump on trail; stump cut at DBH.
112	Picea rubens	4.50	9/25/02	S	54	0	59			Cut stump on trail; stump 3" high.
112	Picea rubens	5	9/25/02	S	63	0	68			Cut stump on trail; stump 3" high.
112	Picea rubens	5	9/25/02	S	65	0	70			Cut stump on trail; stump 3" high.
112	Quercus rubra	8	9/25/02	S	102	0	107			Cut stump on trail; stump 3" high.
113	Picea rubens	1.75	9/25/02	S	32	0	37			Cut stump on trail; stump 3" high.
113	Picea rubens	3	9/25/02	S	46	0	51			Cut stump on trail; stump 3" high.
114	Picea rubens	3	9/25/02	S	56	0	61			Cut stump on trail; stump 3" high.
118	Picea rubens	4.50	9/25/02	S	60	0	65			Cut stump on trail; stump 3" high.
122	Picea mariana	4	9/25/02	C	65	4	69	43		Cored at 1'.
122	Picea mariana	4.75	9/25/02	C	51	2	53	42	19	Cored at 1'.
123	Picea rubens	4.50	9/25/02	C						Dead when cored.
123	Picea rubens	4.75	9/25/02	C	58	4	62			
123	Picea rubens	6.50	9/25/02	S	80	0	85			Cut stump on trail; stump 3" high.
127	Betula alleghaniensis	16	9/26/02	C	164	5	169	102		
127	Betula alleghaniensis	19	9/26/02	C	98		98			Center rot.
127	Picea rubens	9.50	9/26/02	C	75	7	82		60, 47	
127	Picea rubens	15	9/26/02	C	97	5	102		43	Two trunks at 8'.
127	Quercus rubra	13.25	9/26/02	C	202	5	207	62	59	50 meters upslope from GPS pt.

OP	Species	DBH	Date	Type	Count-able Rings	Est. Rings to Pith	Est. Age	Release Dates (YBP)	Restric-tion Dates (YBP)	Comments
128	Picea rubens	11	9/26/02	C	96	0	96	57, 31	40	
129	Betula alleghaniensis	21	9/26/02	C	172		172			Short of center.
134	Quercus rubra	10.50	9/26/02	C	84	5	89	48		Cliff summit.
135	Quercus rubra	7	9/26/02	C	46	0	46		10	
135	Quercus rubra	12	9/26/02	C	36	4	40			
141	Picea rubens	12.50	10/1/02	C	73	3	76	32, 15	61	
141	Picea rubens	21.50	10/1/02	C	125	3	128		88, 61	
142	Betula alleghaniensis	22	10/1/02	C	132		132	114	63	Short of center.
142	Betula alleghaniensis	26	10/1/02	C	202		202	78	65	Center rot.
143	Picea rubens	7	10/1/02	C	74	0	74			
143	Picea rubens	10.75	10/1/02	C	66	0	66		38	
143	Picea rubens	11	10/1/02	C	72	3	75			
145	Picea rubens	5.25	10/1/02	S	68	0	83			Snag on trail; snag snapped at DBH.
145	Picea rubens	8.50	10/1/02	C	78	4	82			
145	Picea rubens	18	10/1/02	C	67	3	70			
148	Betula alleghaniensis	21.50	10/1/02	C	152	18	170	60, 33	106	
148	Quercus rubra	24	10/1/02	C	157	6	163		81	
155	Betula alleghaniensis	20	10/2/02	C	169	8	177	69		
159	Picea rubens	16.50	10/2/02	C	132	10	142			
160	Quercus rubra	13	10/2/02	C	63	3	66			
161	Quercus rubra	26	10/2/02	C	59		59	39		Center rot.
162	Quercus rubra	24.50	10/2/02	C	109	6	115	65	59	
164	Picea rubens	7.75	10/2/02	C	87	1	88	11		
164	Picea rubens	8.50	10/2/02	C	73	4	77		34, 5	
164	Quercus rubra	14.50	10/2/02	C	113	7	120	54		
165	Quercus rubra	17.50	10/2/02	C	144	8	152			
170	Quercus rubra	22	10/3/02	C	97		97			Center rot; see other core at 7'.
170	Quercus rubra	22	10/3/02	C	148		148	123	132	Center rot, see other core at dbh.
171	Picea rubens	21	10/3/02	C	94	6	100			
174	Picea rubens	4.50	10/3/02	S	98	0	103			Cut stump on trail; stump 3" high.

OP	Species	DBH	Date	Type	Count-able Rings	Est. Rings to Pith	Est. Age	Release Dates (YBP)	Restric-tion Dates (YBP)	Comments
174	Picea rubens	17	10/3/02	C	131	5	136		62	
174	Picea rubens	18	10/3/02	C	156	10	166	72	122, 59	
176	Picea rubens	6	10/3/02	C	35	4	39			Cored at 2'.
176	Picea rubens	8	10/3/02	C	73	0	73	15	36	
179	Betula alleghaniensis	18	10/3/02	C	126		126			Center rot.
180	Picea rubens	6	10/3/02	C	49	6	55	32	19	Cored at 2'.
181	Picea rubens	5	10/3/02	S	100	0	105			Cut stump on trail; stump 3" high.
181	Picea rubens	11	10/3/02	C	182	0	182		67	
185	Picea rubens	12	10/8/02	C	136	3	139	43		Cored at 2'.
189	Picea rubens	6.50	10/8/02	S	120	0	125			Cut stump on trail; stump 3" high.
196	Picea rubens	5.50	10/8/02	C	35	2	37			Cored at 2'.
200	Picea rubens	8	10/8/02	C	51	5	56			Cored at 2'.
200	Picea rubens	10.25	10/8/02	C	53	4	57		23, 5	Cored at 2'.
201	Picea rubens	15	10/8/02	C	66	6	72		62	Cored at 2'.
202	Picea rubens	7.50	10/8/02	C	90	3	93			Cored at 2'.

Columns are as follows:
OP: Observation Point (numbers correspond to OP numbers shown in Figure 2).
Species: Tree species assessed.
DBH: Tree diameter at breast height or at height noted in "Comment" column. DBH measured either to the nearest inch or nearest 0.25 inches.
Date: Date that core was collected or stump assessed.
Type: C = core; S = stump.
Countable Rings: Number of rings counted on tree core or stump.
Est. Rings to Pith: When core missed pith, estimated number of rings to pith.
Est. Age: Estimated age of tree based on countable rings, and when applicable estimated rings to pith, estimated years to DBH (10 yr. default), and years since cut (5 yr. default).
Release Dates (YBP): Years before present (YBP) when tree growth was rapid, as indicated by wide rings.
Restriction Dates (YBP): Years before present (YBP) when tree growth was slow, as indicated by narrow rings.
Comments: Miscellaneous comment field.

Appendix 4. Pictures of selected locations on Mt. Monadnock.

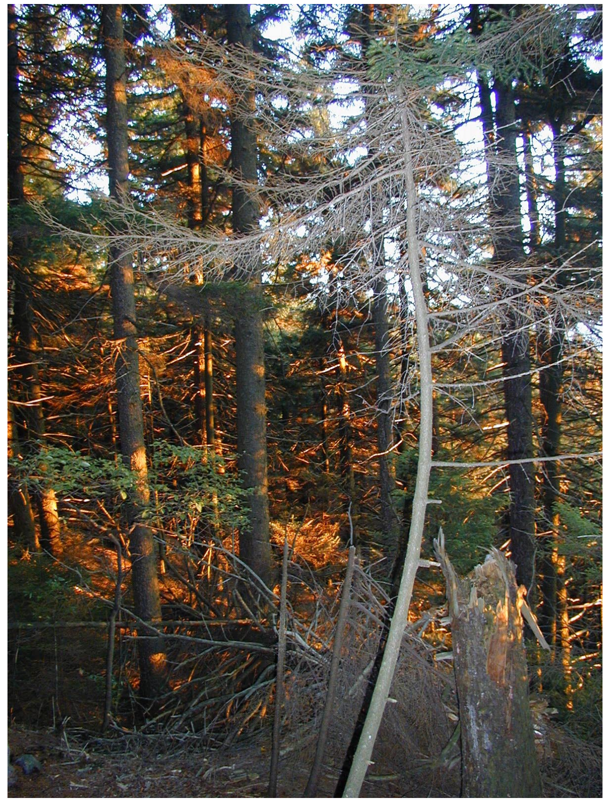
All photographs by Bill Nichols, 2002.

Yellow birch talus forest/woodland at base of a slope.

Red spruce regeneration in the understory of the red oak forest.

Yellow birch talus forest/woodland near a small talus field.

A large, old red oak in the yellow birch talus forest/woodland.



The sun's last light in the montane spruce–fir forest.

Summit in a lingering cloudbank after a storm.

The transition between red oak forest on lower slopes (lower right) and montane spruce–fir forest (upper left) on higher slopes is often characterized by a talus forest/woodland at the slope break (center).

Red spruce/heath/cinquefoil rocky ridge community on the mountain's higher slopes.

One of several montane poor fen/bogs on the mountain's higher slopes.

The subalpine rocky bald around the mountain's summit.

The regeneration of red spruce and other plants in the most protected hollows on the mountain's higher slopes.

A small example of a montane poor fen/bog. Cotton-grass lies in the foreground; the pale-leaved shrub rhodora dominates most of the wet pocket.

From the summit, looking downslope at the subalpine rocky bald and the red spruce/heath/cinquefoil rocky ridge community.

A gnarly, old yellow birch in the yellow birch talus forest/woodland.