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Natural Heritage Inventory of the East Bowl at Mount Sunapee State Park

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

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

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

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

The Natural Heritage Bureau has three facets:

Inventory involves identifying new occurrences of sensitive species and classifying New Hampshire's biodiversity. We currently study more than 600 plant and animal species and 120 natural communities. Surveys for rarities on private lands are conducted only with landowner permission.

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

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

cover: Old Forest in the East Bowl of Mount Sunapee State Park.

All photos in this report were taken by Stephanie Neid

This project was funded by Okemo Mountain, Inc.

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SUMMARY

On June 6, 2001, through a Memorandum of Agreement between the Mount Sunapee Resort and the NH Department of Resources and Economic Development, the NH Natural Heritage Bureau (NH Heritage) initiated an ecological assessment of the forest in the East Bowl of Mount Sunapee in order to (1) determine the extent and locations of exemplary natural communities in the East Bowl with an emphasis on old forests, (2) determine the ecological significance of Mount Sunapee's forest communities state- and region-wide, and (3) recommend Natural Area designations based on our findings.

The East Bowl Study Area is embedded within Sunapee State Park, which is at the northern edge of a 30,000 acre continuously forested land area that extends from the southeastern edge of the town of Sunapee south through Goshen and Newbury and into Bradford and Washington. Sunapee State Park itself covers approximately 2500 acres of forested and developed land primarily on the northern slopes of Mount Sunapee. Approximately 39% of Sunapee State Park is currently leased to Vermont-based Okemo Mountain, Inc. for management as a premier ski area in New Hampshire. The East Bowl study area straddles the ski lease area boundary on its east side.

Mount Sunapee has been a cultural and environmental resource in southwestern New Hampshire for centuries, beginning long before European settlement of the area. Adjacent to Lake Sunapee (a notable tourist destination since the early 1870's), Mount Sunapee's stature and mystique was well known to residents and visitors alike. In 1911, after a successful campaign by year-round and summer residents of Lake Sunapee to protect the forest on Mount Sunapee, 656 acres on the summit and ridges were purchased by the Society for the Protection of New Hampshire Forests. This was soon followed by additional land acquisitions that included the East Bowl. Historical documentation from this period describes remnant patches of "primeval forest", particularly in the areas of the South Peak, the North Peak, and the East Bowl. In New Hampshire, primeval or primary forest (i.e., old growth) is rare, and a majority of the known acreage occurs within and north of the White Mountains. Old growth forests are a result of time and natural ecological processes. They result from a lack of or at least very minimal anthropogenic disturbance. Old growth areas harbor a wealth of biological diversity and legacies that do not occur in managed forests. The continued presence of old growth in the East Bowl was strongly supported by our assessment.

The forest in the East Bowl of Mount Sunapee is ecologically significant and has been designated as exemplary by NH Heritage as one of the best remaining examples in the state. Containing higher elevation communities (northern hardwoods and northern-hardwood-spruce-fir), it is the only exemplary site for this combination of forest types in southern New Hampshire. The East Bowl contains a substantial area that is in old growth condition, which is also very rare, especially for southern New Hampshire. To date, the old growth stands on Mount Sunapee are the only old growth forest remnants known in Merrimack County.

Based on its findings, the NH Natural Heritage Bureau recommends that the East Bowl (including polygon 20 and the remainder of polygon 23 within the ski lease area) receive special conservation status as a formally designated Natural Area, to protect the inherent legacies that have survived at this site through the centuries.

INTRODUCTION

The New Hampshire Department of Resources and Economic Development, through its Division of Forests and Lands and Division of Parks and Recreation, is responsible for managing state forests and state parks for timber production, recreation, and conservation. This responsibility requires the two divisions to consider and balance these activities based on site-specific characteristics and needs of each property. The NH Natural Heritage Bureau (NH Heritage) performed an ecological assessment of the forest in the East Bowl of Mount Sunapee in order to (1) determine the extent and locations of exemplary natural communities in the East Bowl with an emphasis on old forests, (2) determine the ecological significance of Mount Sunapee's forest communities state- and region-wide, and (3) recommend Natural Area designations based on our findings. This report was compiled in part to fulfill a requirement invoked by the Commissioner of the Department of Resources and Economic Development on September 19, 2000 in response to the anticipated effects of the construction of a new chair lift and ski run in the Mount Sunapee Ski Resort.

LANDSCAPE CONTEXT

Sunapee State Park is at the northern end of a 30,000-acre continuously forested area in southwest New Hampshire. This area, or block of contiguous forest, is one of the three largest contiguous forests in southwest New Hampshire that are not bisected or fragmented by roads. It extends from the southeastern edge of the town of Sunapee south through Goshen and Newbury and extends into Bradford and Washington (Figure 1). This forest block straddles the watershed divide between the Connecticut and Merrimack Rivers, encompassing the upper watersheds of the Sugar and Upper Ashuelot rivers (Connecticut) and Beards Brook and the Warner River (Merrimack). Pillsbury State Park lies to the south of Sunapee State Park and is connected via the Pillsbury-Sunapee Corridor and associated conservation easements.

The bedrock geology and glacial history of southwest New Hampshire are responsible for the numerous, rolling, rocky hills and mountains of the region. In addition to Mount Sunapee and its associated ridge, nearby peaks include Bald Sunapee to the east, Goves Mountain to the south, Thompson and Chandler Hills to the west, and Blueberry Mountain to the north. The dominant bedrock type is Kinsman granodiorite, which is comprised of an assortment of foliated granite and quartz diorite (Lyons et al. 1997). It is an igneous rock from the early Devonian period (~400 million years old) that is highly resistant to weathering and typical of central New Hampshire. Formed deep under the earth's surface, this bedrock was only exposed relatively recently through uplift and erosion. During the most recent glaciation (~18,000 years ago), bedrock surfaces were smoothed, and a thin coating of glacial till was left on the slopes and valleys.

Within the large forested block (Figure 1), Mount Sunapee is a unique landscape feature because of its size. The stature of Mount Sunapee, 2743 feet at the summit (831 m), is such that an elevational/climatic transition is apparent in the forest vegetation, which is very rare south of the White Mountains in New Hampshire. Toward the base and mid-slopes of Mount Sunapee, northern hardwood tree species, including sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), and yellow birch (*Betula alleghaniensis*) are common and abundant in the

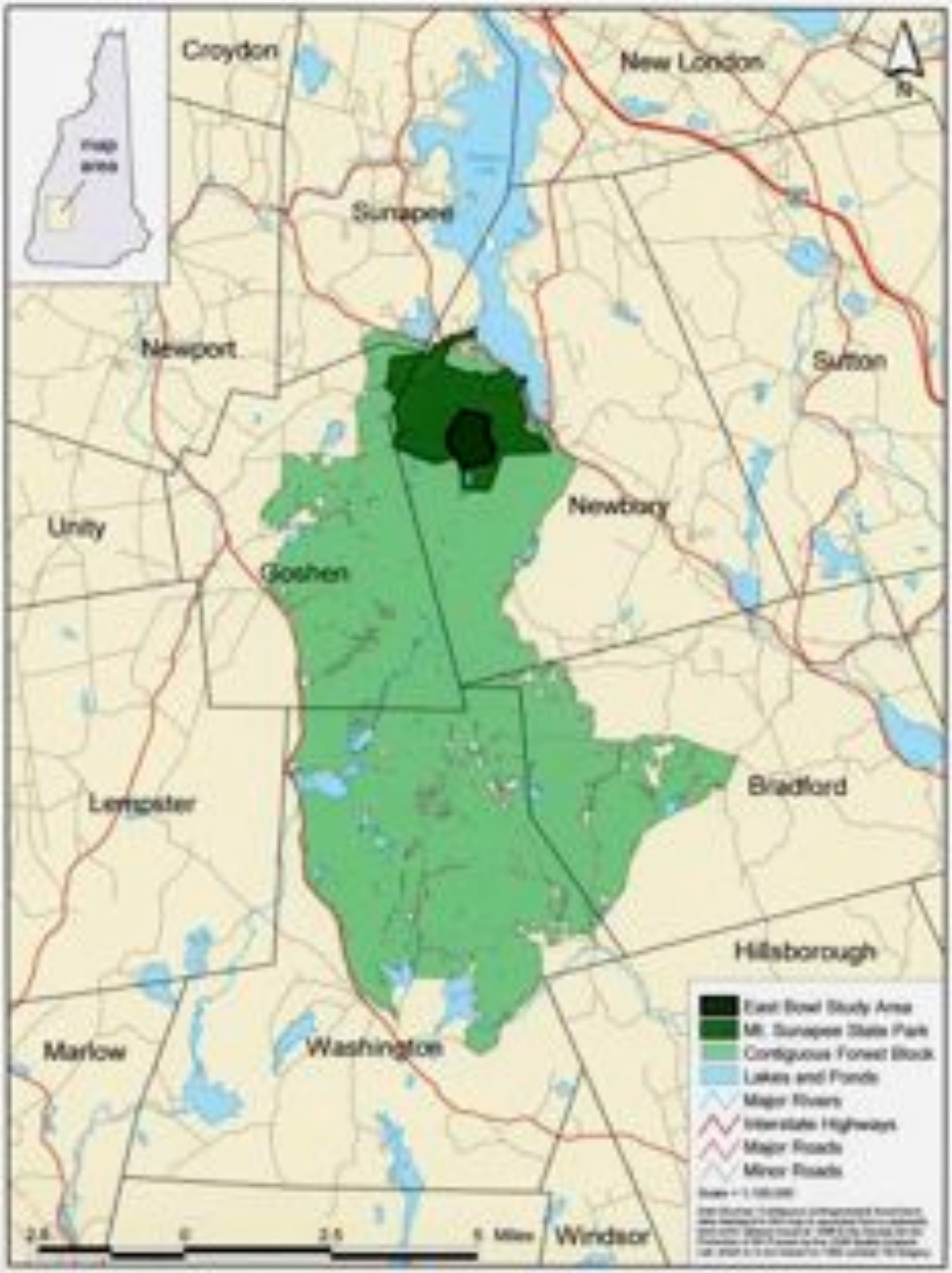


Figure 1. Regional context of Sunapee State Park and the East Bowl study area.

canopy, with hobblebush (*Viburnum alnifolium*) and striped maple (*Acer pensylvanicum*) as common shrubs in intact stands. Typical forest herbs include Canada mayflower (*Maianthemum canadense*) and intermediate wood fern (*Dryopteris intermedia*). At higher elevations, red spruce (*Picea rubens*) becomes a major forest component, and above 2500 feet (762 m), stunted red spruce and balsam fir (*Abies balsamea*) are the dominant forest canopy species. Sub-canopy and herbaceous species in these high elevation forests include heartleaf birch (*Betula papyrifera var. cordifolia*), mountain ash (*Sorbus americana*), bunchberry (*Cornus canadensis*), and goldthread (*Coptis trifoliata*) along with abundant bryophytes and lichens carpeting the tree bases and ground surface.

Sunapee State Park itself covers approximately 2500 acres of forested and developed land primarily on the northern and northeastern slopes of Mount Sunapee in Newbury and Goshen (Figure 2). These slopes extend from the summit directly to the southwestern shore of Lake Sunapee, except for the spur ridge from South Peak that encloses the East Bowl study area. A large portion (approximately 39%) of Sunapee State Park is currently leased to Vermont-based Okemo Mountain, Inc. for management as a premier ski area in New Hampshire. The ski lease area boundary contains extensive ski trails and associated lifts and infrastructure. The state park campground is immediately east of the ski lease area on a mid-elevation plateau. The remainder of the park is comprised of hiking recreation areas including Lake Solitude and the ridge from Sunapee summit proper to South Peak north and east toward the village of Newbury. The East Bowl study area straddles the ski lease area boundary on its east side.

The study area is the East Bowl of Mount Sunapee (Figure 2), also historically known as the Johnson Bowl. It is a steep amphitheater-shaped area located immediately east of the main Sunapee summit. Extending for approximately 350 acres, it includes most of the headwaters of Johnson Brook, from an elevation of 1673 feet (510 m) up to the ridge above White Ledges at 2700 feet (822 m). It is just east of the Sunbowl ski lift and associated trails. Only the Williamson ski trail/access road, built in 1967, cuts through the East Bowl on the west side. Hiking trails skirt the ridge including one trail that angles down from the saddle in the ridge north of Lake Solitude directly to the Williamson run.

OLD FORESTS IN SOUTHERN NEW HAMPSHIRE

Mount Sunapee, especially the summits, ridgelines and the East Bowl, have a history of protection for the primary purpose of maintaining old forest. In 1915, Philip Ayres of the Society for the Protection of New Hampshire Forests (Forest Society) described sections of the forests on Mount Sunapee as "primeval":

> Small areas of primeval forest may be seen across the middle of the valley, between the hills, and high up on the mountain. This is marked by the tops of large, dark spruces that protrude from among the hardwood trees. Wherever large spruce trees are found, either in pure stands or mingled with large hardwood trees, one may realize that he is in a primeval forest.

Of the total forested acreage in the Northeast, only 0.4% remains uncut or as primary forest (Davis 1996). In New Hampshire, primeval or primary forest (i.e., old growth) is rare, and a majority of the known acreage occurs within and north of the White Mountains. Old growth

Figure 2. Sunapee State Park.

forests are a result of time and natural ecological processes. They result from a lack of or at least very minimal anthropogenic disturbance; they are sculpted primarily by the ebb and flow of succession and natural disturbance.

Succession is the natural process of change in species composition over time; these changes are set back by natural disturbance. At elevations between 1000-2500 feet in southwest New Hampshire, northern hardwoods are the primary canopy species in late-successional forests (e.g. forests that have only been subjected to natural processes for a relatively long period of time). These species are long-lived and are able to persist in the forest canopy long after other species and they are able to regenerate under the deep shade of a closed canopy forest. At higher elevations, red spruce will also occur. Red spruce is also a long-lived tree and as an evergreen species is adapted to the harsher climate and soil conditions generally found at higher elevations in New Hampshire. One characteristic of old forests is the presence of old trees. When trees age in the forest, old specimens tend to have thicker bark, large gnarled branches that often have asymmetrical shapes, trunk cavities and other signs of decay, large diameters, large root structures, and relatively long, little tapered, and often twisted trunks (Leverett 1996; Figure3).

The primary natural disturbance processes or agents in southwest New Hampshire are wind and ice/snow loading. Wind events occur at various scales. Large-scale wind events, like hurricanes, are infrequent in New England with a return interval between 125 to >380 years (Boose et al. 2001). These wind events cause catastrophic blowdowns in New England, knocking down or damaging entire forest stands. Hurricanes that significantly impacted New England forests in recent centuries include those in 1815 and 1938. Small-scale wind events, like those of major winter or summer storms, occur when wind is strong enough to knock down trees singly or in small groups. These events are by far the most common and result in relatively small canopy gaps in the forest. When falling trees are also uprooted, the upended roots carry soil with them leaving a pit. As the downed wood decays, the soil falls away leaving a mound adjacent to the pit, often called a tip-up mound. Pit and mound microtopography can last for centuries and is common in old growth forests (Wessels 1997). Newly uprooted soil from a tree blowdown, combined with the gap created in the tree canopy, creates prime growing conditions for tree seedlings, thus beginning a new generation within the forest. Several series of these small-scale canopy gaps, occurring over time, result in multiple age classes as various waves of tree seedlings grow into saplings, mature into canopy trees, and age to become large, old specimens in a forest stand.

Ice and snow loading are another factor that alters the forest canopy. The weight of snow and ice breaks limbs, primarily trimming branches in the upper canopy. This happens most frequently in hardwood trees. Evergreen trees, with their more flexible and often downward drooping limbs, are affected less by this disturbance process as snow and ice are shed from them more readily. Moderate to severe ice damage tends to cause an uneven, ragged canopy. The most recent significant "ice storm" that impacted large areas of forest in southern New Hampshire occurred in January 1998.

Figure 3. Features of old forest at Sunapee; clockwise from top left: cavity high within a live yellow birch; twisted trunk of paper birch on steep, rocky slopes; branches turned to upright trunks of downed, but living, yellow birch; part of extensive root system of a large red spruce.

A consequence of blowdowns and natural tree death is a legacy of dead and decomposing wood, also called coarse woody debris. Coarse woody debris data are used to reconstruct forest history; the decomposition of wood follows a rough sequence and the degree of decomposition can be used to age tree or limb fall. Decomposition of wood takes decades or centuries and requires a whole host of organisms including fungi, invertebrates, and bacteria. These organisms recycle the nutrients and organic matter once held within the tree, returning these elements to the forest soil. Additional features of coarse woody debris are also useful for reconstructing forest history. Structural diversity, (i.e. standing or downed dead wood), the direction of fall once downed, and new tree cohorts (age classes) established on mounds all give clues to past forest dynamics and disturbance events (Figure 4). In turn, the variety of coarse woody debris influences abiotic factors in ecosystem dynamics, including physically slowing runoff and erosion, retaining moisture, and providing a long-term source of nutrients (Hagan and Grove 1999).

In addition to the hundreds of invertebrate and fungi species that comprise the bottom of the food chain, the structural diversity of coarse woody debris is important for wildlife. In the Northeast, 28 bird species, 18 mammal species, and 23 species of reptiles and amphibians have been documented using coarse woody debris as primary habitat (DeGraaf et al. 1992). Snags, or standing dead trees, are important for cavity-nesting and -roosting birds (e.g., woodpeckers, nuthatchs, and flickers), with certain species requiring snags >14 inches (35.6 cm) in diameter. Also, some species require old snags of softwoods rather than hardwoods. Downed logs provide dens for forest-dwelling mammals, including American marten and other members of the weasel family. When large enough, downed logs also provide denning opportunities for larger mammals like bear (Pelton 1996). In total, the structural diversity of both live and dead wood in addition to the innate natural processes in old forests provides food and habitat for a wide array of biodiversity. Further, old growth forests have been shown to harbor significantly different compositions of birds (Haney and Schaadt 1996), beetles (Chandler 1986), and lichens (Selva 1996).

EXEMPLARY FORESTS AND OLD GROWTH

Exemplary natural communities, as designated by Heritage programs and conservation data centers around the world, represent the best remaining examples of particular community types in a state, province, or country. Exemplary forests in New Hampshire are the best known examples of particular forest types and they occur where natural succession and disturbances have prevailed uninterrupted by humans or where human influence is minimal or has diminished substantially with the passage of time (see Appendix 1 for further discussion of size and landscape context components). Thus, exemplary forests include three possible types of conditions:

- Old growth forests are defined for the purpose of this report to mean structurally mature forests that have developed under natural processes of succession and natural disturbance and have had all but a very minimal level of anthropogenic disturbance.

Figure 4. Features of coarse woody debris at Sunapee; clockwise from top left: snag; decomposed, downed log; fungal fruiting bodies on yellow birch snag; paper birch growing from a "nurse" stump.

- Old growth forests that have been impacted by catastrophic natural disturbance (such as hurricanes, downbursts, and severe snow or ice storms), as long as material was not artificially removed from the forest ecosystem (e.g. no logs salvaged from the forest floor). These forests contain an important, and extremely rare, naturally dynamic condition in the landscape that has intrinsically valuable biological legacies.

- Structurally mature forests that have had little recent human disturbance and minimal historic disturbance (i.e., minimal, partial harvesting more than a century ago), such that the impact of this disturbance has diminished substantially with the passage of time. Since true "old-growth" occupies such an extraordinarily small part of the landscape, protecting only these patches will fail to protect the full range of biological legacies and processes associated with natural forests.

METHODS

STUDY AREA BOUNDARY

The East Bowl study area was defined using both natural and anthropogenic features on the landscape. To the south and east the study area was delineated using the watershed boundary that follows the ridge that runs from the main Sunapee summit east to South Peak and then extends northward. To the west, the Sunbowl Quad chair lift bounds the study area, and finally, a straight line from the base of the chair lift to the watershed boundary defines the study area to the north (Figure 2).

LANDSCAPE ANALYSIS

The first step of the Sunapee East Bowl inventory was a process called landscape analysis, which involved consulting a wide variety of resources to identify and prioritize survey areas and to provide an overall context for these areas. To identify ecological processes that may influence site characteristics as well as plant species occurrence and natural community patterns, Heritage staff consulted National Wetland Inventory maps, surficial (Goldthwait 1950) and bedrock (Lyons et al. 1997) geological maps, and U.S. Geological Survey (USGS) topographic quadrangles. Recent and historical aerial photographs were reviewed to determine broad vegetation patterns and conditions. A review of the NH Heritage database identified rare species and natural communities that are known to occur nearby and may be present within the study area. Historical land use information was assessed as described below.

FIELD SURVEY

We performed field surveys for the Sunapee East Bowl project in September and October of 2002 and May 2003. First, a rapid assessment reconnaissance was performed on the entire 350-acre study area. Data were collected at specific locations (observation points) throughout the study site. The following information was collected at a general level at most observation points:

1. natural community type, following Sperduto and Nichols (in press);
2. percent cover estimates for plant species;

3. average 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 or natural disturbance, and wildlife evidence.

At some observation points, more detailed ecological data were collected in releve plots (400 m^2), including estimated percent cover of all plant species by strata and growth form (canopy trees, subcanopy trees, shrubs, tree seedlings, vines, herbs, ferns, and graminoids). Most plants were identified in the field during the inventory or collected and keyed out. Vascular plant nomenclature follows Gleason and Cronquist (1991) and occasionally Fernald (1950), with common names generally following George (1998).

The rapid assessment formed the basis for selecting sites for more intensive forest sampling in areas with old forest characteristics. Data were taken in seven 0.1 ha (20x50 m) plots following a modified-Whittaker method (C. Cogbill, personal communication, November 2003). Soil pits were dug at each plot to collect soil pH, soil color, mottling characteristics, and a description and depth of all soil horizons. Microtopography of the ground surface was also noted. Within each plot, we collected species composition in nested $1m^2$, 25 m^2, and 100 m^2 subplots to acquire a species-area curve. Vegetation cover data were taken in twenty $1m^2$ plots along the centerline of the 0.1 ha plot. We recorded the dbh of all live trees greater than 10 cm in diameter throughout the plot. All dead wood, standing and downed, was recorded and its degree of decomposition noted following Cogbill's methodology for coarse woody debris. All dead and downed wood greater than 5 cm were measured (approximate dbh) and assigned a structural class:

1. standing dead (plus crown)
2. high snap/snag (>1.5m); noting the height of break
3. low snap/stump (<1.5m)
4. butt snap or root failure (snap at ground level)
5. tip-up; noting direction of tree fall
6. branch (log, no stump)
7. cut stump and no log

Further, the degree of decomposition was noted for each piece of recorded dead wood. Each piece of deadwood was assessed on a scale of 0 to 8:

D0 foliage still remaining
D1 twigs remaining
D2 medium-sized branches remaining
D3 bark remaining, hard sapwood
D4 punky (spongy) sapwood
D5 punky to core
D6 sagging wood structure (will not hold a person's weight)
D7 lump (above ground evidence of highly decomposed log)
D8 buried

Lastly, NH Heritage prepared natural community descriptions to summarize important ecological information, including existing threats and management recommendations. The study site was mapped using ArcView GIS version 3.3. A Garmin Global Positioning System (GPS) was used to determine the location of plots. The accuracy of the data collected by the GPS was generally plus or minus 5 m. Field data and locations of exemplary natural communities were catalogued and mapped in the NH Heritage database (see Appendix 1).

LIMITATIONS OF STUDY

The primary goal of this project was to survey the East Bowl of Sunapee State Park. As mentioned above, the East Bowl is at the north end of an extensive forest tract; it is merely a small part of a whole. The natural community boundaries were delineated only for the East Bowl; they continue over the ridge to the south, outside of the study area. Their full extent cannot be determined without additional field survey in these areas. Future field work at Mount Sunapee should also involve expert inventories for specific elements of biodiversity associated with old forests, such as studies of lichens, fungi, bryophytes, invertebrates, as well as birds, mammals, reptiles, and amphibians.

RESULTS AND DISCUSSION

LAND USE AND VEGETATION HISTORY

Land use history of Mount Sunapee is of particular interest given earlier reports and recent rediscoveries of old forest on the upper slopes of the mountain (Ayres 1915; Bechtel 1999; C. Kane to K. Desmarais, letter, 1 December 1997, NH Division of Forests and Lands, Concord, NH [NH DFL]; C. Cogbill to T. Miner, letter, 28 November 1997, NH DFL). There are two basic types of evidence for evaluating old forest: (1) the historical records of human activities; and (2) the evidence contained in or reconstructed from the forest itself. Direct observation may indicate that a forest is old, but it does not preclude the possibility of some past land use activities that may be revealed by historical documentation. When available, written historical records are useful both in directing field study and in supplementing information obtained through a direct study of the forest. Prior to our field inventory of the East Bowl, we reviewed several overview documents and primary source materials that describe past land use activities in the Sunapee area.

BRIEF HISTORY AND OVERVIEW OF OLD FORESTS AT MOUNT SUNAPEE

Mount Sunapee has a long history as a cultural and environmental resource in southwest New Hampshire. Sunapee Lake and its environs were prime fishing and hunting grounds of the Pennacook tribe, the Native Americans of the area, who frequently wintered on the lakeshore. The first European settlement in the area was the village of Fisherfield at the southern tip of Lake Sunapee in 1753. Earliest records report the area to be densely forested (MacAskill 1981). Fisherfield was chartered in 1772 and incorporated in 1778 (Town of Newbury 1978). The name of the town was changed to Newbury in 1837.

In the 1850’s the first farm was established at the base of Mount Sunapee on the north side. The Johnson farm was the sight of one of the first hotels in the area, taking in boarders and tourists as early as 1868. The Sugar River railroad, extending from the Connecticut River valley to Lake Sunapee, was finished in 1871. The completion of the railroad marked the advent of the steamboat era on Lake Sunapee and catapulted the Sunapee region into the tourist trade. People could board a steamboat upon disembarking from the train and be taken to various hotels on the lakeshore. Hiking up Mount Sunapee was a common outing, in order to picnic at White Ledges and take in views of the lake and of the Presidential Range. In the late 19th century, a lake tourism publication spoke of the mountain as

> "…completely forest clad, stern and savage of aspect except when touched by the tender lights of evening, it is not merely a mighty mountain, but a remnant of the primeval wilderness. At one point, only, has civilization encroached upon it. On a little knob of the northern slope…[is] a very large farmhouse…" (W. Young, 1896, The Lakes of New England: Sunapee, The Lake Publishing Company, Palmer, MA; in MacAskill 1981)

However, the Johnsons left the mountain farm in 1906 selling the land to the Draper and Emerson timber companies. Between 1906 and 1910 the north side of Mount Sunapee was extensively logged. Ayres (1915) states "most of the spruce trees had been removed [prior to 1909]…" but some of the original forest did remain, particularly at high elevations on the north slope of the main mountain and on the North Peak (Figure 5). The remnant old spruce and hardwood trees were present in small areas upslope from the North Peak, on the ridges, and in the East Bowl ("the tops of large, dark spruces that protrude from among the hardwood trees," Ayres 1915). These remaining trees were considered original (primeval) forest and were preserved from cutting through land purchase.

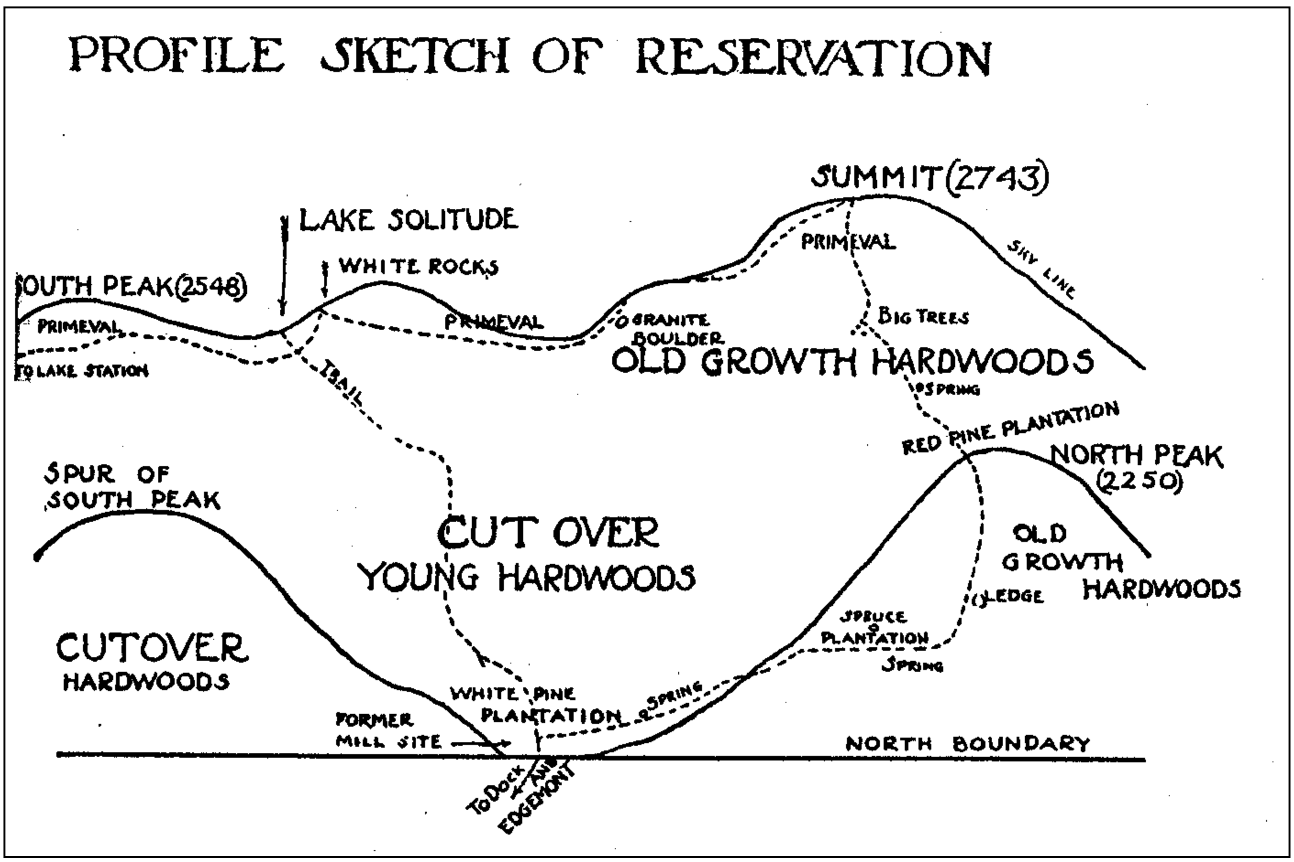


Figure 5. Profile sketch of reservation (Ayres 1915).

In 1911, the Forest Society made initial purchases of 656 acres at Sunapee with the help of Herbert Welsh, a long-time summer resident of Lake Sunapee. Herbert Welsh organized the year-round and summer residents of the area, obtaining enough contributions for the initial land purchases that were subsequently transferred to the Forest Society (Ayres 1915; Appendix 2). These original purchases included much of the North Peak, the main mountain, White Ledges, Lake Solitude, the South Peak (and spur), and the East Bowl (Figure 6). By 1934, the Forest Society owned 1,185 acres, including cut-over and old forests. In 1948 and 1949, the Forest Society transferred their acreage on Mount Sunapee to the state for public stewardship of the land and the fledgling ski area established by a local ski club on the north side of the mountain (Conroy and Ober 2001). Mount Sunapee State Park was opened in 1948 (MacAskill 1981).

Over the years, the presence of old forest on the mountain was largely forgotten until brought to the attention of NH DFL by Chris Kane (C. Kane to K. Desmarais, letter, 1 December 1997, NH DFL). Additional inventory by NH Heritage and NH DFL in 1998 and 1999 confirmed areas of old forest within the ski lease area (Bechtel 1999; K. Desmarais to D. VanLuven, letter, 21 October 1999, NH Heritage). Photos of the East Bowl also show large red spruce trees extending above the hardwood canopy, supporting the presence of additional areas of old forest in the East Bowl outside of the ski lease area (Bechtel 1999).

DETAILED HISTORICAL ASSESSMENT

To investigate the land use history of the East Bowl study area, we examined several types of documentation for information regarding historical forest condition and land use activities. These sources included: property, town, and county histories (Ayres 1915; Town of Newbury 1978; Hurd 1885); the NH State Papers (Batchellor 1896); Newbury town records (Town of Newbury records, 1793-1820, NH State Library microfilm); the 1880 NH Agricultural Census (NH State Library microfilm); 1858 and 1892 maps of Newbury (Smith & Peavey 1858; Saco Valley Printing 1981); miscellaneous town papers, including land surveys and letters (NH Division of Records and Archives, Concord, NH [NH Archives], Miscellaneous Town Records, Town of Newbury, 1832-1856); and property deeds (Merrimack County Registry of Deeds, Concord, NH [MCRD] 1853-1924).

Much of the information in these documents and maps can be placed geographically based on the original plans for the town of Fisherfield by Zephaniah Clark (1775) and Allen Willey (1809; Figure 7). We digitized Willey's 1809 map in ArcView in order to overlay the East Bowl study area (Figure 8). The Mount Sunapee peaks and the East Bowl are primarily located within Lot 61, Lot 62, Lot 97, the southern portion of Lot 100, the western portion of Lot 63, and the eastern portion of Great Lot 10. Figure 8 also exhibits the additional lots within current park boundaries and study area.

Land surveys in Fisherfield from the early 1800's describe the condition of the mountain lots within and adjacent to the East Bowl, in some cases assessing the usefulness of this land for timber or pasture. These lots were generally considered very difficult to access. Early surveyors considered Lot 62 "poor and [with] little timber" (M. Wadley and S. Gunnison, land survey, March 1832 and S. Peasley to M.W. Pierce, letter, 27 March 1832, NH Archives, Miscellaneous Town Records, Town of Newbury; Appendix 3). Lot 62 was considered of higher quality than Lot 61, however, for which "...perhaps half or more is very rough and thinly timbered very bad

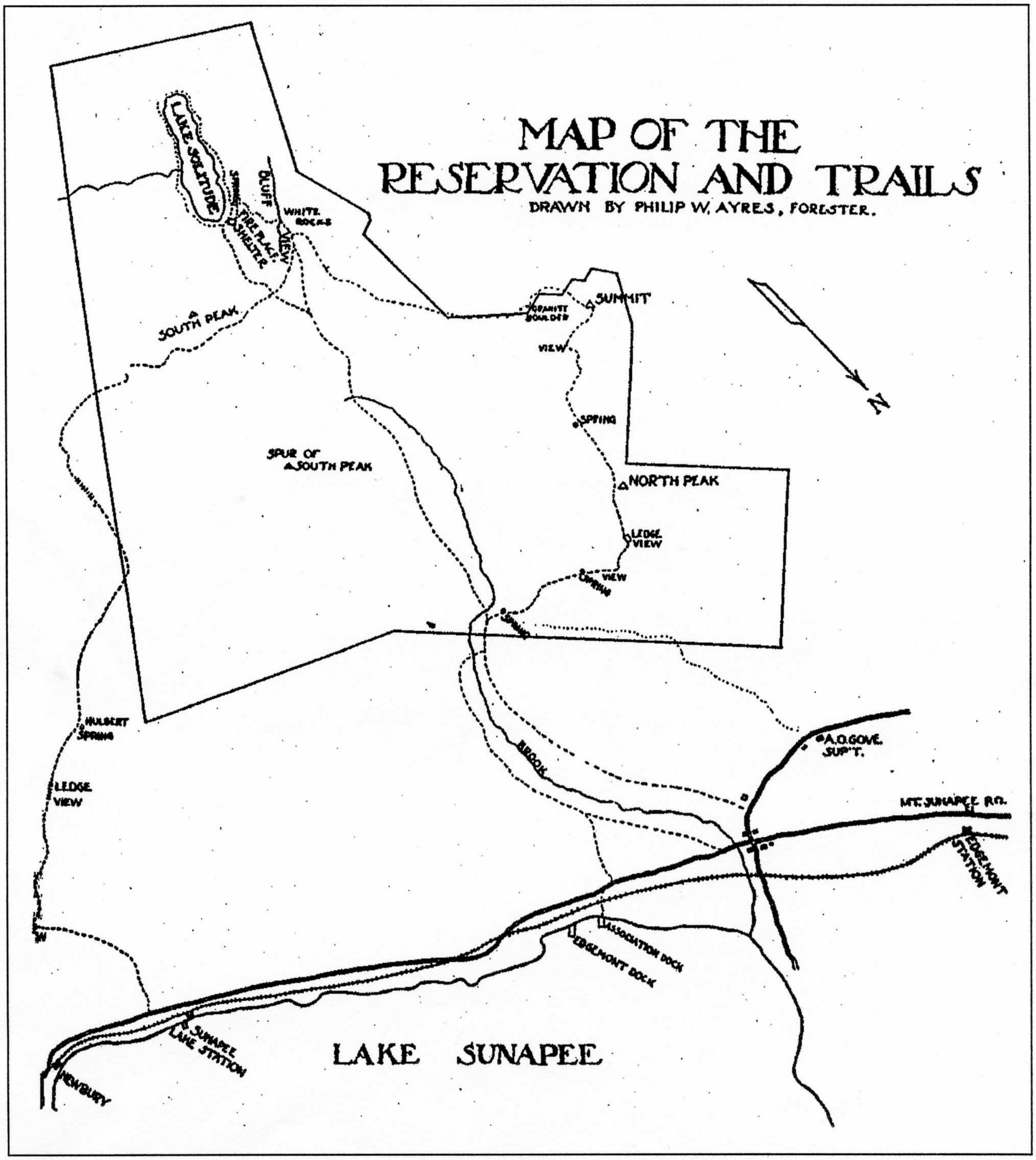


Figure 6. Map of Reservation and Trails (Ayres 1915).

to be got off. The westerly Side is mostly very well timbered with beach [sic] Birch Spruce hemlock &, Soil tolerably good for Pasture, the timber being quite a distance from any road or Settlement it is hard to be got off for use" (M. Wadley and S. Peasley to M.W. Pierce, letter, 20 July 1836, NH Archives, Miscellaneous Town Records, Town of Newbury). Similarly, Wadley and Peasley (1836) considered Lots 97 and 98 (within the current ski lease area boundary) "rather rough lots with a considerable growth of timber but mostly hard to get off," although the northern part of Lot 97, where lower in elevation and slope, might be suitable for plowing or mowing. Given the difficult access and poor timber resources, some tracts of old forest appear to have been left intact at that time.

In contrast, farther downslope and to the north of Lots 97 and 98 (Figures 7 and 8), Lots 99 and 100 had been partially cleared by 1832 and were considered suitable for farming or pasture (M. Wadley, under the employ of S. Peasley, land survey, 26 March 1832 and M. Wadley and S. Peasley to M.W. Pierce, letter, 20 July 1836, NH Archives, Miscellaneous Town Records, Town of Newbury). Nathan S. Johnson purchased Lots 99 and 100 in 1853 and 1857 (MCRD 1853: Deed Book [DB] 116:101; MCRD 1857: DB 145:33) and established a farm on the site. By 1880, 50 acres remained in woodland and forest (NH Agricultural Census, 1880, NH State Library microfilm), but most of this land was tilled or maintained in pastureland, orchard, and other agricultural uses.

Similarly, the original Great Lot 10 (Figures 7 and 8) was later divided into five 100-acre lots, which have a complex history of land ownership.[1] Some of the deeds for lots in the western portion of Great Lot 10 refer to specific signs of land use, including a barn on Lot 1 and the "Sholes Pasture" on Lot 2 (MCRD 1907: DB 385:175; MCRD 1924: DB 470:123). For the eastern portion of Great Lot 10, however, we did not find specific signs of land use in the deeds we reviewed for the years prior to timber company ownership.

In light of the historical land surveys for the area, the principal assessed land use for the higher elevations on Mount Sunapee appears to have been timber harvest. Otherwise, historical reports suggest tourism was a primary use of Mount Sunapee (MacAskill 1981). In 1907 and 1908, the Emerson Paper Company (Emerson) took ownership of Lots 61, 62, 97, 98, and Lots 1-3 of Great Lot 10 (MCRD 1907: DB 385:175; MCRD 1908: DB 383:403; MCRD 1908: DB 379:252). Also in 1908, Emerson released timber rights on these lots to the Draper Company (Draper), including all standing hardwood timber on Lots 1-3 of Great Lot 10; all standing hardwood timber, and the softwood timber greater than seven inches, on Lots 61, 62, and 97; and all standing hardwood timber and the softwood timber in the eastern portion of Lot 98 (MCRD 1908: DB 383:418; MCRD 1908: DB 383:420).

Because of the efforts of Herbert Welsh and the Forest Society, these transfers of land and timber rights did not result in comprehensive logging of the Mount Sunapee area (Ayres 1915). In 1911, the Forest Society obtained the timber rights and land ownership for Lots 61, 62, 97, and 98 from Draper and Emerson, and Welsh transferred to the Forest Society the ownership of Lots

[1] We were not able to locate a plan showing the boundaries of these five lots, and our knowledge of their locations within Great Lot 10 is therefore approximate.

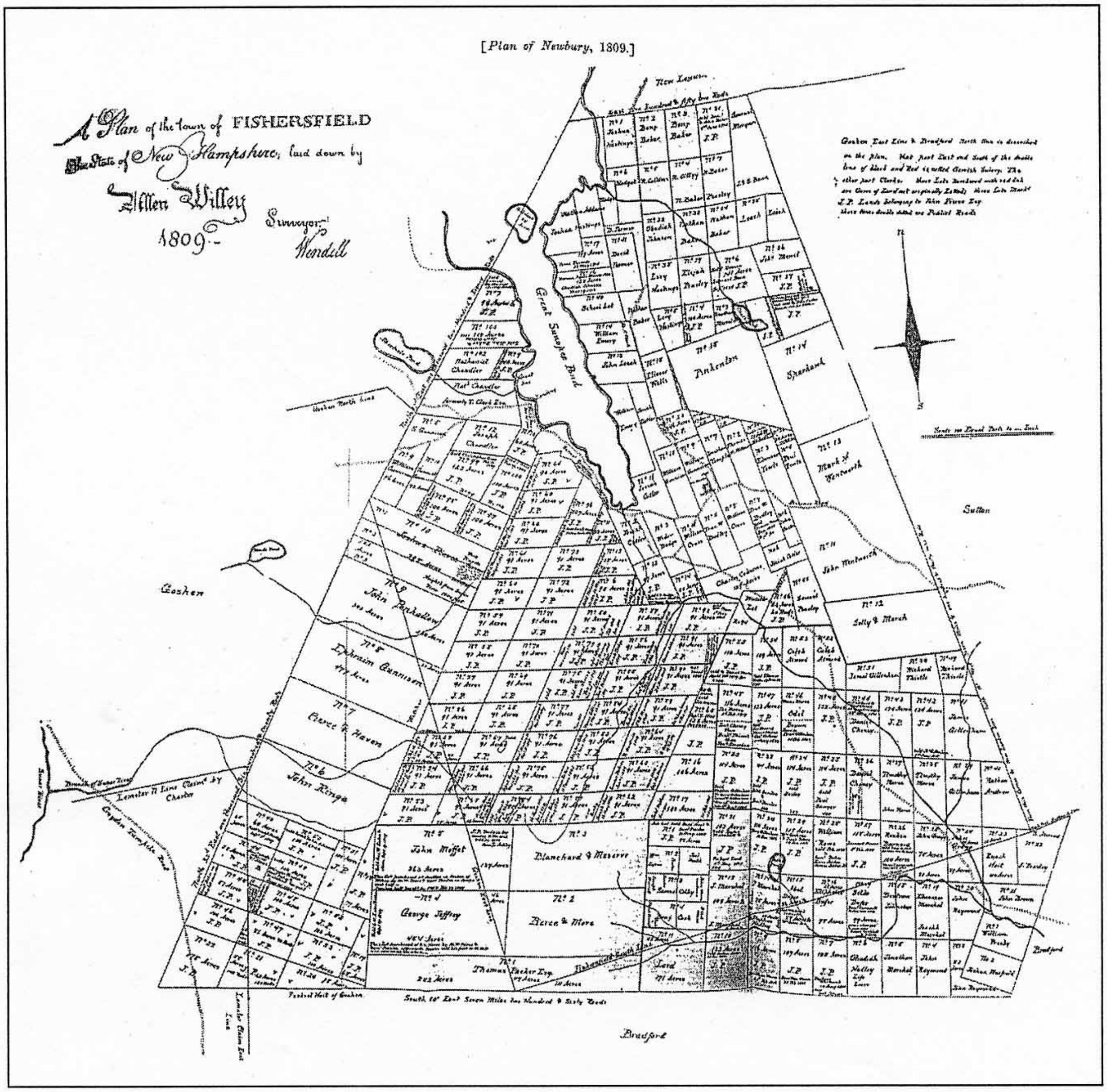


Figure 7. Fisherfield town plan (Willey 1809).

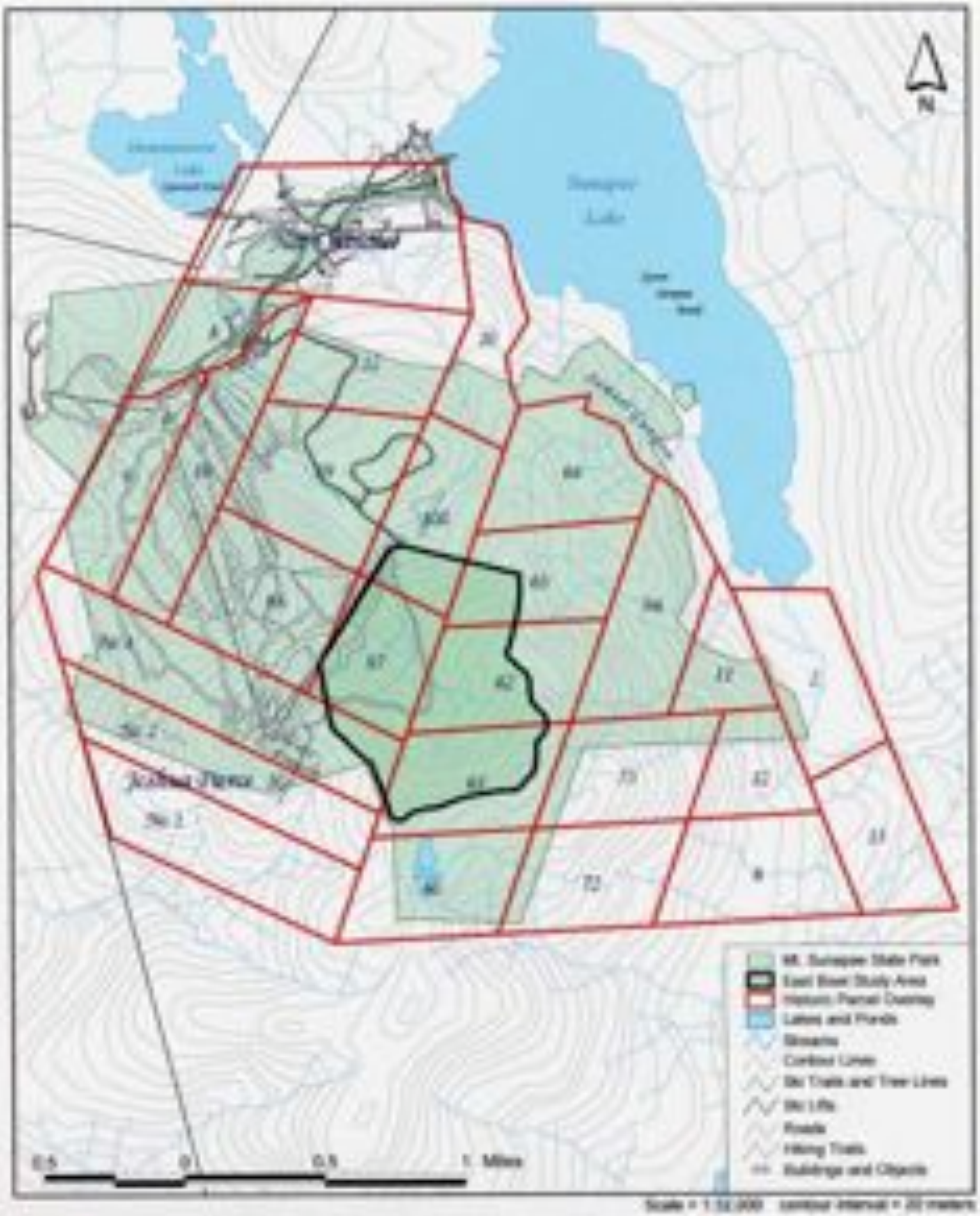


Figure 8. Digitized lot boundaries based on Willey (1809; Figure 7).

58, 59, 60, and 4 and 5 of Great Lot 10 (MCRD 1911: DB 396:360). In 1924, SPNHF purchased Lots 1-3 of Great Lot 10 from Emerson (MCRD 1924: DB 470:123). Together, these lots make up much of what is now Mount Sunapee State Park, including the East Bowl.

While they do not provide a complete picture, the deeds for these land purchases suggest a potential extent of logging activities on Mount Sunapee prior to Forest Society ownership. For Lots 61, 62, 97, and 98, Draper transferred the timber rights to the Forest Society exactly as described in the deeds that had originally transferred to them from Emerson (MCRD 1911: DB 399:213; MCRD 1908: DB 383:418; MCRD 1908: DB 383:420). For Lots 1-3 of Great Lot 10, however, the deed released to the Forest Society "...all of the *remaining* rights and privileges conveyed to the said Draper Company..." (emphasis added) (MCRD 1911: DB 399:213). This suggests that cutting may already have occurred on Lots 1-3 at the time of the transfer, but possibly not on Lots 61, 62, 97, or 98. Emerson reserved the softwood on the west side of Lot 98, away from the East Bowl, for harvest within a period of 25 years, suggesting that the company intended to cut this timber after the transfer (MCRD 1911: 397:391; MCRD 1911: 399:213). Other timber rights on Lots 61, 62, and 97 appear to have been transferred to the Forest Society intact.

This historical documentation supports Ayres' descriptions (1915) of old forest at Sunapee, particularly in the areas of the South Peak, the North Peak, and the East Bowl. Recent observations and data collection also confirm the presence of old forest in the East Bowl as well as within the ski lease area on the east side (Bechtel 1999; C. Kane to K. Desmarais, letter, 1 December 1997, NH DFL; C. Cogbill to T. Miner, letter, 28 November 1997, NH DFL). Further remnants may exist to the south in the vicinity of Lake Solitude as well.

NATURAL DISTURBANCE HISTORY

Major hurricanes in 1635, 1788, 1815, and 1938 have been documented as having caused widespread damage throughout central New England. The most recent of these, the hurricane of 1938, caused catastrophic blowdowns in New England forests. The prevailing winds of the hurricane were from the southeast. Consequently, the most severe damage occurred on ridgetops and on south- to southeast-facing slopes with little disturbance occurring leeward of broad hills or in valleys (Foster 1988). The north-facing East Bowl study area was leeward of the ridge between the Sunapee summit proper and South Peak; thus the East Bowl was largely protected from the full force of the damaging winds. Eyewitness accounts corroborate the pattern of impact of the 1938 hurricane on Mount Sunapee; the ridgeline was a tangle of downed wood, whereas the East Bowl, although affected, was not impacted severely. Downed limbs and trees were cleared the following summer, by hand, from the hiking trails, but they were not salvaged from the mountain. Major wildfires resulted from the excessive storm debris throughout the region and one occurred to the south of the Sunapee ridge, along what is now the Pillsbury-Sunapee corridor. However, this fire did not affect the Sunapee ridge or the East Bowl (D. Parker, personal interview, 2 December 2003).

Although spared from the 1938 hurricane, Mount Sunapee was impacted by the January ice storm in 1998. Statewide aerial reconnaissance and assessment estimated 800,000 acres were damaged in New Hampshire (NH Division of Forests and Lands 1998). The aerial assessment identified the area south-southwest of Lake Sunapee, including Sunapee State Park, as receiving moderate to heavy damage. The ice storm coated trees with as much as three inches of ice. Upland hardwood forests were the most severely affected with forests incurring widespread crown damage, broken branches, plus leaning and bending of individual trees. In southern New Hampshire, trees on south- and southeast-facing slopes and at elevations above 1300 feet (~400m) were most severely impacted. The entire East Bowl study area is north- to northwest-facing, but is above 1600 feet (~490m). It will be years before we will fully understand the impact of the 1998 ice storm on forest health and dynamics, but recovery is occurring. Current forest condition in the East Bowl study area, including impacts from the 1998 ice storm, is discussed below.

RESULTS OF LANDSCAPE ANALYSIS

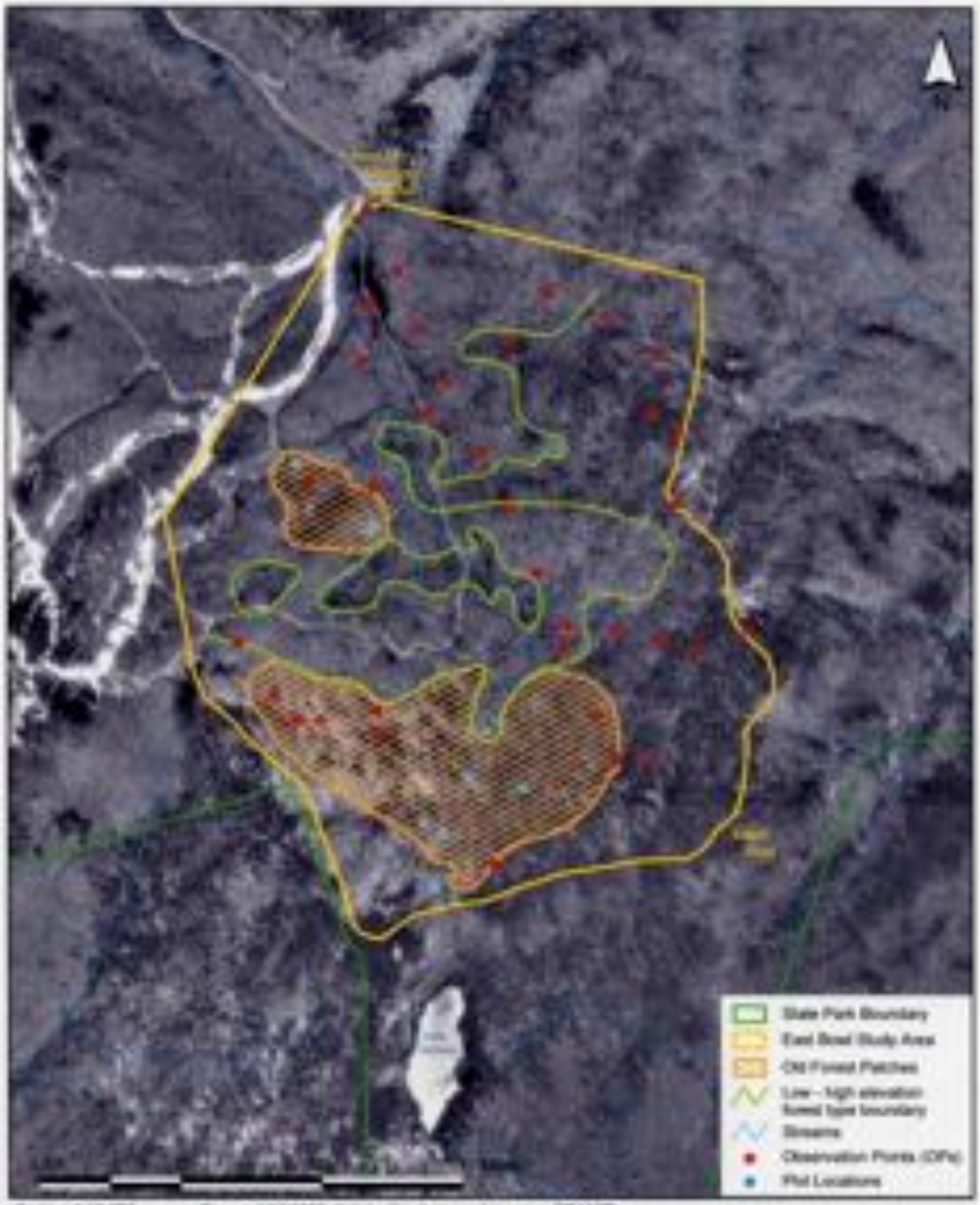
Mount Sunapee is composed of Kinsman granodiorite, a relatively slow weathering granitic bedrock type composed of base-poor silicate, felsic rocks (Lyons et al. 1997). The lack of minerals such as calcium and other plant nutrients in this bedrock type leads to relatively infertile soils. There are no delineated NWI wetlands in the East Bowl study area, although several intermittent streams tumble down the steep slopes. A permanent emergent marsh occurs adjacent to the study area near the base of the Sunbowl chair lift and a relatively small, linear forested wetland occurs nearby within the ski lease area. The soil type of the East Bowl is Hermon extremely stony sandy loam on 25-60% slope. The ridge above the bowl has Canaan-Hermon extremely rocky sandy loam also on 25-60% slopes. Hermon and Canaan-Hermon soils are excessively-drained to well-drained, very strongly acidic, and sandy. As noted in their title, the soils occur on steep slopes. They are derived from glacial till. These soil types are restricted to the higher elevations of this area of Merrimack County (USDA-SCS 1965). No rare species have been documented in the study area to date.

NATURAL COMMUNITIES OF THE SUNAPEE STUDY AREA

PLANT SPECIES AND NATURAL COMMUNITY COMPOSITION

The plant species observed in the East Bowl are typical for acidic, montane environments in the state and region. Soil pH from the plots falls mostly around 5.0, with the highest only 5.2 and the lowest 4.6. Mild enrichment indicators, such as jack-in-the-pulpit (*Arisaema triphyllum)*, alternate-leaved dogwood (*Cornus alternifolia*), and Christmas fern (*Polystichum acrostichoides*) were very rare. The East Bowl's northerly aspect and higher elevations provide good growing conditions for montane species, like large-leaved goldenrod (*Solidago macrophylla*), mountain wood fern (*Dryopteris campyloptera*), and red spruce and balsam fir. This physiographic setting also leads to very restricted hemlock distribution. Red oak is even more scarce; one maturing oak plus a couple seedlings were noted along the Rim Trail at around 2120 feet (645 m) elevation. Another unusual aspect of the East Bowl is its paucity of seeps, which are often a common small patch community within northern hardwood type forests. While a very narrow seepage zone was observed along some of the lower reaches of streams, very few other seeps were seen on slopes or benches elsewhere.

The East Bowl is completely forested except for some very minor (less than one-quarter acre) openings associated with rock outcrops or blowdowns. It contains two primary matrix forest



Scale = 1:12,000 Base = 4/13/1998 digital orthophotoquad (source: GRANIT)

Figure 9. East Bowl study area. High-elevation forest types (montane spruce-fir and northern hardwood-spruce-fir) occur above the low elevation-high elevation forest boundary (south and east of dashed line) and within polygons, whereas low elevation forest type (sugar maple-beech-yellow birch) occurs below the boundary and outside the polygons (north and west of dashed line). Plot locations are where intensive forest sampling occurred.

photos taken May 2003

Figure 10. Forest community types at Sunapee; (clockwise from top left) northern hardwood forest (Lake Sunapee in background); northern hardwood-spruce-fir forest around Lake Solitude; spruce-fir forest along ridge; yellow birch glade on upper slopes.

types, northern hardwood-spruce-fir forest and sugar maple-beech-yellow birch forest (northern hardwood forest), which roughly correspond to the elevational gradient at the site. The former occupies the higher and generally rockier terrain while the latter dominates the deeper soils at lower elevations (Figures 9 and 10). The yellow birch variant of the northern hardwood-spruce-fir forest occurs intermittently along ridges and in small talus areas (Figure 11). In addition to these matrix natural communities there are several large and small patch communities in or immediately adjacent to the East Bowl. On the ridge, spruce-fir forest is prevalent, especially on the lesser summits (Figure 10). In addition to red spruce and fir, the canopy often contains a significant proportion of paper birch (*Betula papyrifera*). Bryophytes, especially *Bazzania trilobum, Pleurozium schreberi,* and *Hylocomium splendens*, cover the rocky terrain at these higher elevations. On the lowest slopes a hemlock-spruce-northern hardwood forest (typic hemlock-red spruce-yellow birch variant) occurs on a very steep slope along lower Williamson, elevation 1700-2400 feet (520-570 m). A semi-rich mesic sugar maple forest occurs on deep soils (typic sugar maple-beech till variant). The presence of white ash (*Fraxinus americana*) in the canopy is one indicator used to identify this community in the East Bowl. Another example of a semi-rich forest occurs on a bench at 2300 feet (700 m). A canopy and regeneration layer heavy to sugar maple, deep Oa-A horizon (including some alluvial deposition) and Christmas fern are all indicators of enrichment in this bench forest. Perched above Lake Solitude, White Ledges is a small example of an acidic cliff natural community.

Site-scale variability produces an interlaced spatial arrangement of natural communities in the East Bowl. Better site conditions (e.g. small, concave pockets or benches that accumulate soil nutrients and moisture) allow northern hardwood forest to reach higher elevations in some parts of the East Bowl. Likewise, northern hardwood-spruce-fir forest primarily occurring at the higher elevations of the ridge and summits occurs in small patches in steeper, rockier soils and rock outcrops at certain lower elevations.

SUGAR MAPLE-BEECH-YELLOW BIRCH FOREST

The sugar maple-beech-yellow birch forest is the matrix community that dominates the lower and gentler slopes of the East Bowl. It grades into northern hardwood-spruce-fir forest higher on the slopes. This forest type generally occurs below the low/high elevation forest boundary line (Figure 9), but it also occurs in more favorable locations at higher elevations, especially on concave slopes where the soil is deeper and moister. The flora is typical for this natural community type and contains no rare or unusual species. The canopy is strongly dominated by the nominal species, sugar maple, beech, and yellow birch. Additional species occasionally found in the canopy include red maple (*Acer rubrum*), with striped maple (*Acer pensylvanicum*) and mountain maple (*Acer spicatum*) in the subcanopy. Shrubs include dense hobblebush (*Viburnum alnifolium*), plus occasional skunk currant (*Ribes glandulosum*) and strigose red raspberry (*Rubus idaeus* ssp. *melanolasius* var. *strigosus*). Herbs are variable but include hay-scented fern (*Dennstaedtia punctilobula*), mountain wood fern (*Dryopteris campyloptera*), shining clubmoss (*Huperzia lucidula*), northern wood sorrel (*Oxalis acetosella*), Canada mayflower (*Maianthemum canadense*), blue-bead lily (*Clintonia borealis*), sessile-leaved bellwort (*Uvularia sessilifolia*), whorled aster (*Aster acuminatus*), large-leaved goldenrod (*Solidago macrophylla*), starflower (*Trientalis borealis*), drooping woodreed (*Cinna latifolia*), inflated sedge (*Carex intumescens*), beech-drops (*Epifagus virginiana*), partridge-berry (*Mitchella repens*), and Christmas fern (*Polystichum acrostichoides*). In the very best soil situations, semi-rich sugar maple-beech forest (typic variant) occurs in very restricted pockets within the sugar maple-beech-birch forest, which has additional species like cinnamon fern (*Osmunda cinnamomea*), long beech fern (*Phegopteris connectilis*), and New England sedge (*Carex novae-angliae*) among others.

NORTHERN HARDWOOD-SPRUCE-FIR FOREST

The northern hardwood-spruce-fir forest is a matrix community that dominates the higher and steeper slopes of the East Bowl. It grades into sugar maple-beech-yellow birch forest on the lower slopes and in better soil conditions at higher elevations, and grades into spruce-fir forest on the ridge. It occurs in pockets at lower elevations where slopes are convex and/or especially rocky. The flora is typical, containing no rare or unusual species. The canopy is dominated by sugar maple, yellow birch, beech, and red spruce with lesser amounts of showy mountain ash (*Sorbus decora*), mountain maple, and balsam fir. Paper birch can occasionally be an important canopy species. Shrubs include abundant hobblebush, striped maple, mountain maple, and saplings of canopy trees. The herbaceous layer has abundant northern wood sorrel and intermediate wood fern, with lesser amounts of mountain wood fern, shining clubmoss, and tree seedlings, and occasional blue-bead lily, whorled aster, sessile-leaved bellwort, and Canada mayflower.

The summits, ridgeline, and upper slopes above the East Bowl have shallow soils over very steep, rocky slopes that are generally convex. This landscape position on the mountain is more exposed to wind and ice. The composition generally varies between glades dominated by yellow birch (yellow birch variant), especially where it is excessively rocky, to predominantly spruce and fir. The forests in these landscape positions appear youthful with small dbh measurements, however, in places these stunted trees may actually be very old. No large trees, living or dead, appear in this forest and a lack of forest dynamics also suggests a young forest in recovery from the impacts of the 1938 hurricane.

FOREST CONDITION

The condition of the forest in the East Bowl is variable, reflecting both natural and human disturbance events over the past several hundred years. Based on our field surveys, the 1998 ice storm, the most recent natural disturbance event at Mount Sunapee, had a moderate impact on the forest; twisted trunks and broken branches are evident. Damage varied from light to heavy (e.g., heavily damaged areas had large portions of tree canopies knocked down creating a very broken canopy in the some areas). From around 1900 feet (580 m) elevation up to the ridge and summit, small to medium size (up to ± 4 in. [10 cm] diameter) limb snaps are frequent, leading to a more broken canopy than was likely present prior to the storm. In addition to this natural disturbance, logging likely took place in part of the bowl. Much of the East Bowl, especially lowest elevations (below 2200 feet or 670 m), has an even-sized structure of moderately mature forest. Canopy trees are 8-16 in. dbh (20-40 cm) and trees larger than 19.7 in. (50 cm) are absent or very rare. Likewise deadwood greater than 16 in. dbh is essentially absent in these areas. Even though stumps from logging were very rare in these areas, the forest structure, including deadwood stems, imply a logging history. The lack of stumps suggests that the logging must have taken place a long time ago, likely more than 50 years before present, which was substantiated by our land use history research.

The forest along the ridge has a similar even-aged structure to the lower elevation forest. Poor growing conditions in the shallow, rocky soils and exposure to severe weather along the ridge keep the canopy ragged and trees stunted. Eyewitness accounts depict the ridge forest as being leveled by the 1938 hurricane (D. Parker, personal interview, 2 December 2003). Also, a map from 1939 by an unidentified author (initials W.P.H.) suggest that the Sunapee ridge and summit suffered 50-100% blowdown from the 1938 hurricane, while the majority of the East Bowl and ski area had 0-25% impact. Historical documents spoke of a fire that occurred to the south and east of the Sunapee ridge (E. Dodge to J Pierce, letter, Nov. 24, 1856, NH Archives, Miscellaneous Town Records, Town of Newbury). The same ridge area south of the Sunapee ridge burned in a large fire in the years following the 1938 hurricane, but the Sunapee ridge was not affected by this fire (D. Parker, personal interview, 2 December 2003). Alternatively, the even-aged structure could suggest a logging history, although no cut stumps were found. However, the inaccessibility of the ridge and low timber value of its trees also reduce the likelihood that logging occurred on the ridge.

Towards the center of the East Bowl is an area of old-growth forest. It is largely restricted to the backslope on both sides of the East Bowl Trail above 2260 feet (690 m). This corresponds to the steepest portion of the bowl slopes and likely covers less than or equal to 50 acres (~20 ha). Tree cores from plots in this old-growth area show a significant number of trees, both spruce and yellow birch, to be over 200 years old. A 323 year-old yellow birch, 30 in dbh (75 cm), is the oldest tree documented in the plots. Another 8 hectares on the steepest portion of the slope within (west of) the Williamson trail, elevation 1970-2260 feet (600-690 m), might also be old-growth, though there were fewer large trees in this. There is, however, some large diameter deadwood in this area. An old white pine stump, which appeared to have been from cutting many years ago, occurs in this area within the Williamson trail (plot 1). This is curious not only because it was one of just a handful of cut stumps noted in the East Bowl, but also because it is the only evidence of white pine in the East Bowl. Analysis of tree ring data revealed evidence of a large, local disturbance ca. 1827 (175 years before present); five cores from four different points up to half a kilometer apart showed releases around this time. Tree ages (rough germination dates) and releases from previous inventories might reveal this same event date if analyzed carefully. It is difficult to assess what type of natural disturbance could have invoked the 1827 release without further spatial information to determine the scale of the event. However, damage from a wind event or ice storm, the two most common natural disturbance events, could have instigated the release. There are no hurricanes recorded for 1827, however the hurricane of 1815 passed directly over the Sunapee area, while another hurricane in 1821 passed through eastern Vermont, so the storm was likely of smaller magnitude and perhaps more local in scale.

The Significance of Sunapee East Bowl in Relation to Other Forests in New England

As one of the best remaining examples of northern hardwood (sugar maple-beech-yellow birch forest) and northern hardwood-spruce-fir forest in the state, NH Heritage has designated the entire forest area of the East Bowl as exemplary (See Appendix 1). While these forest types are common in New Hampshire, old or very large, mature and little-disturbed examples are not - in fact they are quite rare. The intact and mature forest in the East Bowl, with its sizeable remnant patches of old growth, is equivalent or better in terms of size and condition when compared to other exemplary forests of this type in the state. In addition to the East Bowl, NH Heritage has documented 13 sugar maple-beech-yellow birch forest and 17 northern hardwood-spruce fir exemplary occurrences in New Hampshire (Figure 11). All but one of these, the Williams Forest in Stoddard, occurs in the White Mountains or the immediate vicinity. The Williams forest is different than the Sunapee East Bowl forest in its narrower range of elevation. It does not contain northern hardwood-spruce-fir and spruce-fir forest types; it only has northern hardwoods. Thus, Sunapee is unique in New Hampshire as the only exemplary northern hardwood and northern hardwood-spruce-fir forest system south of the White Mountains.

Forest stand characteristics collected in eight plots in the East Bowl (one of which was established by Charlie Cogbill for prior research and revisited in this study) indicate that forests here are equivalent in many respects to documented old growth northern hardwood sites elsewhere in New Hampshire and the region (Table 1). Deliberately located in old or mature stands within the East Bowl, the data from these plots support the contention that old growth or old forest conditions exist in the East Bowl. This assessment is also supported by land use history research performed for the project as well as by expert opinion (Cogbill 1997; C. Cogbill, personal communication, November 2003). The old growth sites in Table 1 represent those available in the literature that contain equivalent forest types (northern hardwoods or northern hardwood-spruce-fir) measured using similar metrics to the Sunapee East Bowl study (Tyrrell et al. 1998). Additional old growth studies in the literature were not included in this table because they lacked similar metrics, were conducted on different forest types, or were averaged across many sites or studies.

The Sunapee plot data indicate that these forests are comparable to other old growth sites in terms of basal area, total number of stems and number of large stems (>19.7 in. [50 cm]), maximum tree ages and diameters, number of snags/ac, number and basal area of snags/ac, and uneven-sized diameter distribution (calculated q ratios of 1.3 to 1.5; Leak 1987). These results indicate old, late-successional forest with a considerable numbers of large trees and large amount of deadwood, a condition that is not characteristic of younger or managed forests.

The average basal area of the Sunapee plots was 29 m^2/ha (126 ft^2/ac), equivalent to these other studies. Keddy and Drummond (1996) reported a mean basal area of 29 m^2/ha for 10 old eastern hardwood forests. They suggest that while lower basal area/ha numbers do not necessarily presume human alteration and exclude a stand from being old, values above 29 may often indicate little human alteration; values of 20-29 m^2/ha (87-126 ft^2/ac) may indicate moderate levels of human alteration, and less than 20 m^2/ha indicative of high levels of human alteration.

There is substantial deadwood (snags and downed logs) in the Sunapee plots, with total basal area of snags at 24% of live tree basal area. Thirty-seven percent of the snag basal area was contributed by large snags (>50 cm or 19.7 in.). McGee reports that large snags (>50 cm) in the Adirondacks contributed 70% of the snag basal area in old growth, 0% in partially cut stands, and 5% in maturing stands. The basal area of all dead wood (snags and downed logs) is 80% of that of live basal area at Sunapee, indicating a large amount of deadwood in these forests. Cogbill (1996) reports a similar pattern for old growth spruce forests in the region, which contain nearly as much (or more) total deadwood as live wood on a basal area basis.

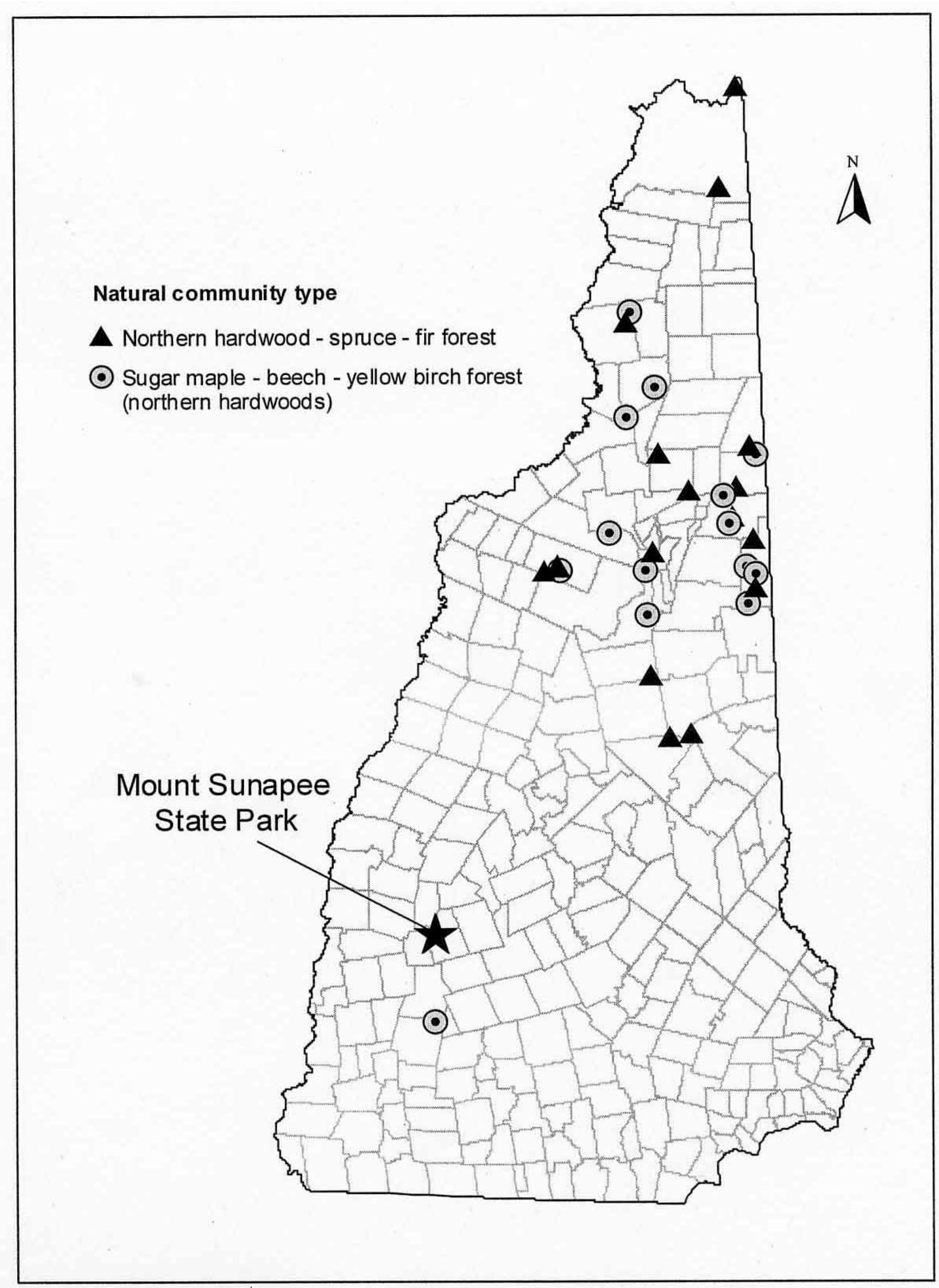


Figure 11. Exemplary northern hardwood-spruce-fir and sugar maple-beech-yellow birch forests in New Hampshire documented in the NH Heritage Bureau database.

Table 1. Comparison of Sunapee stand characteristics with other old forest stands in New England (Tyrrell et al. 1998).

Site	N	Live tree BA > 10 cm (m2/ha)	# Live trees/ha (>10 cm)	# Live trees/ha (>50 cm)	Max tree age Spp 1	Max tree age Spp 2	Max diameter (cm) - Hwd[a]	Max diameter (cm) - Soft[b]	Snags (#/ha)	# Snags per ha/# dead + live per ha	Snags (#/ha > 50 cm)	Snags (BA[c])	Snag BA/Live BA	Total Dead BA/live BA	q[d]
Sunapee (NH) [1]	8	29.27	438	38	YB 323	RS 244	YB 96		31	0.07	8.8	7.17	0.24	0.80	1.30
Charcoal Hearth (NH) [2]	2-7	25.70	417		YB/SM 250-350		YB 85		33	0.07		2.70	0.11		
Eagle Cliff (NH) [2]	2-7	43.30	380		YB/SM 250-350		YB 85		60	0.14		5.10	0.12		
Mountain Pond (NH) [2]	2-7	37.60	450		YB/SM 250-350		SM 95		50	0.10		4.20	0.11		
Mountain Pond (NH) [3]		30.59					SM/WA 91	RS 35.56							1.34
The Bowl (NH) [2]	2-7	28.20	566		YB/SM 250-350		SM 95		54	0.09		4.40	0.16		
The Bowl (NH) [3]		30.54			YB 250	AB 230	YB 86.36	HE 66.04							1.36
Williams (NH) [2]	2-7	27.70	379		YB/SM 250-350		SM 85		36	0.09		2.90	0.10		
Williams (NH) [3]		25.29					SM 91.44	HE 40.64							1.44
Cold River (MA) [4]	3	35.77	327		SM 214	AB 177	SM 92	HE 72	34	0.09		4.97	0.14		
Fife Brook (MA) [4]	2	37.55	355		SM 177		SM 103		10	0.03		0.15	0.00		
Ampersand Mountain (NY) [5]	2	39.60	380	85	SM ave age 175 (n=5)		SM 84	HE 38	30	0.07		11.40	0.29		
Catlin Lake (NY) [5]	2	28.30	415	55	SM 218		SM 72	RS 52	60	0.13		9.70	0.34		
Gill Brook (NY) [5]	2	31.20	405	55	HE 274	RS 254			50	0.11		12.50	0.40		
Mason Lake (NY) [5]	2	33.20	370	55	HE 247	WA 157	SM 83	HE 68	15	0.04		4.40	0.13		
Moose Mountain (NY) [5]	2	39.00	405	70	SM ave age 142 (n=4)		SM 94	HE 42	20	0.05					
Sucker Brook (NY) [5]	2	31.90	470	30	YB 250	RS 141	YB 93	RS 37	25	0.05		5.40	0.17		
Whalestail Mountain (NY) [5]		38.20	345	60	SM ave age 125 (n=5)	RS 176	SM 88	RS 39	25	0.07		8.40	0.22		
Big Reed (ME) [6]			645	29					91	0.12					
Big Reed (ME) [7]		24.50			RS >161							3.80	0.16		

[a] Deciduous
[b] Coniferous
[c] Basal area
[d] Ratio assessing size cohorts within a forest stand

[1] Sunapee 125 snags/ha including high snaps
[2] Carbenneau 1986; a range from all 5 plots
[3] Leak 1987; dbh >5 cm (not >10 cm as with others)
[4] Dunwiddie 1993; plots averaged at Cold River and Fife Brook
[5] McGee 1999
[6] Widoff 1985
[7] Cogbill 1996

Species abbreviations:
AB American beech
HE hemlock
RS red spruce
SM sugar maple
WA white ash
YB yellow birch

The Sunapee plots had 8.8 snags/ha > 50 cm (3.6/ac > 19.7 in.). This is equivalent to the 8.6 snags/ha (3.5/ac) snag densities reported by McGee et al. (1999) in six old growth hardwood forests in the Adirondacks. In the same study, McGee et al. (1999) found considerably less snags/ha in non-old growth maturing and partially cut stands (4.1/ha and 1.2/ha, respectively). In addition to standing dead trees, the Sunapee plots also had 29 large (>50 cm or 19.7 in.) dead and downed trees per ha (or 11.6/ac.).

Within the ski lease area, polygons 20 and 23 (see Figure 12; Bechtel 1999) are mature forests, each documented as containing old forest characteristics (Appendix 4; also this study). Earlier research conducted by the Division of Forests and Lands' Land Management Bureau recorded trees over 200 years of age in parts of Polygon 23, and that compared to second growth portions of this polygon, old growth areas had greater stem densities (46 vs. 41 stems/ac) and more coarse woody debris (21.1 vs 14.0 cu. ft./ac).

MANAGEMENT CONSIDERATIONS AND RECOMMENDATIONS

The NH Natural Heritage Bureau recommends that the East Bowl receive special conservation status as a Natural Area that would include no tree harvest or any artificial manipulation of the land and its vegetation. Recommendations for Natural Area boundaries are shown in Figure 12. They include the East Bowl study area east of the Williamson ski run/access road, much of the remainder of the East Bowl study area between the Williamson and Wingding ski runs (polygon 20 within the ski lease area), as well as what will be the remainder of polygon 23 within the ski lease area (following the approved construction of a new ski lift and glade thinning at the southern end of the polygon). This proposed Natural Area boundary includes a ridgeline buffer, which is recommended to ameliorate high winds common to Sunapee Mountain (AWS Scientific, Inc. and Plymouth State College 2003). If the surrounding lands to the south were cut or made bare, there would be significant wind stress on the ridge that would likely spill into the East Bowl. A ridgeline buffer is therefore needed to protect the structural integrity of the East Bowl.

The East Bowl of Mount Sunapee is ecologically significant and has been designated as exemplary by NH Heritage for several reasons. First, the forest consists of higher elevation communities (northern hardwoods and northern-hardwood-spruce-fir); it is the only exemplary site for this combination in southern New Hampshire. A few other examples of this natural community continuum occur in this part of the state, but they have not been designated as exemplary due to significant anthropogenic disturbance (Nichols 2002). Second, East Bowl contains a substantial area that is in old growth condition, nearly 65 acres, which is very rare, especially for this part of New Hampshire. To date, these old growth stands are the only old growth forest remnants known in Merrimack County. The biological legacies found in these areas are invaluable. Old growth stands also provide reference points as benchmarks for original forest condition and for informing forest management. Third, the mature forest surrounding these patches of old growth is significant in and of itself, and is an essential and integral part of the exemplary forest in the East Bowl. It contributes critically to the long-term integrity and viability of the old growth, and over time will acquire certain old forest characteristics as well. Polygons 20 and 23 within the ski lease area are included in the exemplary forest designation and proposed Natural Area for their old growth characteristics (see section above and Appendix 4). Although their fragmentation from the rest of the East Bowl forest is not ideal, these areas

Figure 12. Natural Area boundary recommendations for Mount Sunapee State Park.

contain patches of old growth forest, provide wildlife habitat, and contain biological legacies and elements of forest history that are valuable for scientific study.

Old growth forests are our legacies; they represent the natural heritage of a state that was once almost completely forested. New Hampshire is once again nearly completely forested, but the vast majority represents forests in various stages of recovery from human influences, such as logging and clearing for pasture. Old growth and other exemplary forests in New Hampshire are special and they are rare. They harbor a wealth of biodiversity that can be lost if the forests are unnaturally altered. Further, the old growth at Sunapee is on public land; it belongs to everyone in the state of New Hampshire. It is also easily accessible, unlike other areas of old growth in New Hampshire, and is thus available for education and outreach. If left intact, it will be an enduring inheritance for future generations.

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APPENDIX 1. NH HERITAGE ECOLOGICAL APPROACH

NATURAL COMMUNITIES

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

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

NATURAL COMMUNITY CLASSIFICATION

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

The classification of natural communities in New Hampshire is based on data from more than 10 years of ecological research by ecologists with NH Heritage and The Nature Conservancy, plus extensive reviews of scientific literature (Sperduto 1994, 1997a, 1997b, 2000). These data have been compiled and used to define natural community types in part through the application of ordination and classification techniques. Most state natural heritage programs continually update their classifications and cooperate with The Nature Conservancy's regional and national ecologists to ensure that natural community types are comparable across state lines.

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

EXEMPLARY NATURAL COMMUNITIES

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

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

PROTECTING NEW HAMPSHIRE'S BIODIVERSITY

WHAT IS AND WHY SHOULD WE PROTECT BIODIVERSITY?

WHAT IS BIODIVERSITY?

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

WHY SHOULD WE PROTECT BIODIVERSITY?

Reasons for biodiversity protection include the following:

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

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

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

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

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

WHY FOCUS BIODIVERSITY PROTECTION ON NATURAL COMMUNITIES?

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

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

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

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

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

PROTECTING NEW HAMPSHIRE'S BIODIVERSITY

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

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

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

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

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

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

NH NATURAL AREAS

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

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

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

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

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

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

E. Sites with special geological or paleontological significance.

RARITY

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

QUALITY RANKS

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

<u>Rank</u> <u>Description</u>

A **Excellent Occurrence:** An A-ranked natural community is a large example nearly undisturbed by humans or which has nearly recovered from early human disturbance and will continue to remain viable if protected. An A-ranked rare species occurrence is large in both area and number of individuals, is stable, exhibits good reproduction, exists in a natural habitat, and is not subject to unmanageable threats.

B **Good Occurrence:** A B-ranked community is still recovering from early disturbance or recent light disturbance by humans and/or may be too small in size to be an A-ranked occurrence. A B-ranked population of a rare species occurrence is at least stable, grows in a minimally human-disturbed habitat, and is of moderate size and number.

C **Fair Occurrence:** A C-ranked natural community is in an early stage of recovery from disturbance by humans and/or a small sized representative of the particular type of community. A C-ranked population of a rare species is in a clearly human-disturbed habitat and/or small in size and/or number, and possibly declining.

D **Poor Occurrence:** A D-ranked natural community is severely disturbed by humans, its structure and composition are greatly altered, and recovery is unlikely. A D-ranked occurrence of a rare species is very small, has a high likelihood of dying out or being destroyed, and exists in a highly human-disturbed and vulnerable habitat.

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

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

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

SIZE

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

CONDITION

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

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 beyond the relevant watershed receives the least consideration. The actual size applied for a natural community varies according to the characteristics of the particular natural community and the specific context of the occurrence in the landscape.

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.

APPENDIX 2. TRANSFER HISTORY OF LOTS FROM FISHERFIELD TOWN PLAN (WILLEY 1809) FROM MERRIMACK COUNTY REGISTRY OF DEEDS, CONCORD, NH, 1853-1924.

Lot	Emerson Paper Co. to SPHNF	Draper Co. to SPNHF	Emerson Paper Co. to Draper Co.	Other transfer history
Great Lot 10: 1-3	Emerson Paper Co. to SPNHF 2/28/1924 (470:123)	Draper Co. timber rights to SPNHF 12/14/1911 (399:213). NOTE: "Remaining" rights and privileges of those conveyed to Draper by Emerson.	Emerson Paper Co. timber rights to Draper Co.12/28/1908 (383:418; 383:420). All standing hardwood timber and softwood >7 inches.	Lot 1: S.W. Dodge to Emerson 4/8/1907 (386:175). Lot 2: D. Barton to Emerson 10/17/1907 (379:252). Lot 3: H. Bailey to Emerson 10/5/1908 (383:403).
Great Lot 10: 4-5				Champlain Realty Co. to H. Welsh 7/28/1911 (399:81) to SPNHF 10/11/1911 (396:360)
60				Champlain Realty Co. to H. Welsh 7/28/1911 (399:81) to SPNHF 10/11/1911 (396:360)
61	Emerson Paper Co. to SPNHF 3/27/1911 (397:391)	Draper Co. timber rights to SPNHF 12/14/1911 (399:213). In full? No caveats.	Emerson Paper Co. timber rights to Draper Co.12/28/1908 (383:420). All standing hardwood timber and softwood >7 inches.	J.W. & D.H. Peirce to A. Runals 7/28/1868 (192:199) to Lowe & Sawyer 5/7/1874 (230:113) to G.H. Collins 10/31/1874 (223:498). H. Bailey to Emerson 10/5/1908 (383:403)
62	Emerson Paper Co. to SPNHF 3/27/1911 (397:391)	Draper Co. timber rights to SPNHF 12/14/1911 (399:213). In full? No caveats.	Emerson Paper Co. timber rights to Draper Co.12/28/1908 (383:420). All standing hardwood timber and softwood >7 inches.	Lowe & Sawyer to G.H. Collins 10/31/1874 (223:498). Bailey to Emerson 10/5/1908 (383:403)
97	Emerson Paper Co. to SPNHF 3/27/1911 (397:391)	Draper Co. timber rights to SPNHF 12/14/1911 (399:213). In full? No caveats.	Emerson Paper Co. timber rights to Draper Co.12/28/1908 (383:420). All standing hardwood timber and softwood >7 inches.	H. Bailey to Emerson 10/5/1908 (383:403)
98	Emerson Paper Co. to SPNHF 3/27/1911 (397:391). NOTE: softwood timber W side: reserved for 25 yrs.	Draper Co. timber rights to SPNHF 12/14/1911 (399:213). In full? No caveats.	Emerson Paper Co. timber rights to Draper Co.12/28/1908 (383:420). All standing hardwood timber and softwood >7 inches, east side of lot only.	H. Bailey to Emerson 10/5/1908 (383:403)

Lot	Emerson Paper Co. to SPHNF	Draper Co. to SPNHF	Emerson Paper Co. to Draper Co.	Other transfer history
99				C. Cross to N.S. Johnson 3/1/1853 (116:101) & 6/10/1857 (145:33). E. A. Johnson to A. H. Johnson 6/18/1908 (377:405). Couldn't trace farther; possible marriage & name change before transfer to Emerson?
100				C. Cross to N.S. Johnson 3/1/1853 (116:101) & 6/10/1857 (145:33). E. A. Johnson to A. H. Johnson 6/18/1908 (377:405). Couldn't trace farther; possible marriage & name change before transfer to Emerson?

APPENDIX 3. LAND SURVEY NOTES ON LOTS DELINEATED IN FISHERFIELD TOWN PLAN (WILLEY 1809) FROM NH DIVISION OF RECORDS AND ARCHIVES, CONCORD, NH.

Lot	March 26, 1832[1]	March 27, 1832[2]	July 20, 1836[3]	Nov. 24, 1856[4]
61			"...perhaps half or more is very rough and thinly timbered very bad to be got off. The westerly Side is mostly very well timbered with beach Birch Spruce hemlock &, Soil tolerably good for Pasture, the timber being quite a distance from any road or Settlement it is hard to be got off for use."	
62		"poor and but little timber"	"Lot No. 62 would be called rather a better Lot than No. 61, especially the Northerly part of it."	
63		"good and well timbered"	"Lot No. 63 has quite a growth of timber on most part of it of Something the Same kind of growth of the two Lots last mentioned [61 & 62]. Can hardly be said to have any tillage land on it although there might be fifteen acres that might be tilled in different Spots but mostly fit for pasture or grazing Land. The timber might be taken off of most parts of it tolerably well considering the distance, the nighest road is that which passes by the Lake."	
64		"ledgy but some good land"	"...mostly tolerably well timbered except the easterly Side which is quite ledgy and but thinly timbered. The Lot is rather a rough Lot, except perhaps about ten acres on the westerly Side which lyes [sic] very hansome [sic] and to appearance if cleared might be good grass land, might be hay cut from it, perhaps 1/3 of the Lot is not of much use only for the present growth which lying still nigher the road might be got off, though the way is rather rough not any tillage"	
72			"...mostly a rough Ledgy Lot although where it is not all Ledge there is a tolerable growth of timber of beach birch Maple hemlock Spruce the which on most part of it may be got off but must be hauled a considerable distance over some quite steep hills. There might be a few acres tillage say 8 or 10 but neither presents 3/4 of the Lot pasture or grazing land, the remainder ledge after it was cleared."	

Lot	March 26, 1832[1]	March 27, 1832[2]	July 20, 1836[3]	Nov. 24, 1856[4]
73			"Likewise Lot No 73 lying mostly on the north part of the top of the mountain very rough Steep and Ledgy most of it we think - hardly worth clearing. Some part of it has a considerable timber on it mostly Spruce but to appearance most impossible to be got off."	(partly?) burned; unclear if other parts of mountain were burned also, between 57/69 and 73? "...a part of 56 & 57 & on north and Mountain on 73 Lot."
97		"tolerably good land but rough"	"...97 & 98...it was near night when we went on to them we had not time to make a very thorough examination. There is some very good land on the northerly side of said lot No. 97, which part of it we think would make natural mowland and a small piece of plow land but as far as I Could See I considered them rather rough lots with a considerable growth of timber but mostly hard to get off."	
98		"tolerably good land but rough"	(see 97)	
99	~15 acres cleared: ~10 acres a trespass by Thane [Shane?], ~5 acres felled by Oliver Gunnison (see survey plan). "...south west corner of Said lot containing 10 acres and 20 [? - part of an acre?] is principally what we call fell trees the wood and timber having been cut down last June or July and now lies on the ground, the piece plotted on the easterly line of said lot wich [sic] contains 4 acres and 95 [?] is mostly into grass and I think usually been mowed, and in regard to the residue of this lot there has from a great part of it been a considerable timber and wood cut and carried off from it although there are quite a number of large hemlock trees fell and the bark peeled off and the trees now lie on the ground much of wich [sic] has	"some pretty good land but ledgy & rough"	"Lot No. 99 would mostly make decent pasture Land it is pretty well wooded except what was Cleared at the time of my previous Survey though the wood has been quite thinned out by the inhabitants in former times which was pretty easy got off. There is on this Lot perhaps 15 acres that might be plowed."	

Lot	March 26, 1832[1]	March 27, 1832[2]	July 20, 1836[3]	Nov. 24, 1856[4]
	been done recently."			
100	"...on the North westerly side of said lot containing 13 acres and 62 [? - part of an acre?] and likewise the piece at the corner containing 1 acre and 64 [?] is cleared and into grass and I think usually has been pastured, the remainder of said lot is principally well-timbered and not much wood or timber has been cut off for some years, as I perceived."	"good and well timbered although some poor land yet I think it much the best lot." Mr. John Shaw [Straw?] wishes to purchase.	"...mostly a very good lot we think 1/3 of it would make tolerable plow land, perhaps for 10 acres of natural mowland, and the remainder quite good pasture land if cleared. Should think if it [?] to any road it might make a decent farm. It is now well timbered except what was cleared when I previously Surveyed it of beach birch Maple hemlock Spruce and some Ash with other timber very good getting off for a mountain Lot Mostly."	

[1] M. Wadley and S. Gunnison, land survey, 26 March 1832
[2] S. Peasley to M.W. Pierce, letter, 27 March 1832, NH Archives, Miscellaneous Town Records, Town of Newbury
[3] M. Wadley and S. Peasley to M.W. Pierce, letter, 20 July 1836, NH Archives, Miscellaneous Town Records, Town of Newbury
[4] E. Dodge to J Pierce, letter, Nov. 24, 1856, NH Archives, Miscellaneous Town Records, Town of Newbury

APPENDIX 4. EXCERPT FROM BECHTEL (1999; PP. 9-10) DESCRIBING POLYGONS 20 AND 23 WITHIN THE SKI LEASE AREA.

Polygons with high proportion of exemplary old growth

Polygon 23 / North Peak Area

This polygon coincides closely with the North Peak area identified by Chris Kane (1997) as containing areas of old growth (Appendix 7). It is a relatively large polygon that extends from the Sun Bowl chairlift's maintenance road (approximately 1700' elevation) to the North Peak (2250' elevation). The central portion of the polygon, a northeast facing steep band between 1700' and 2050' elevation, supports a semi-rich mesic sugar maple-beech forest.

Large, old trees grow along this steep section, with fewer old trees and more acidic conditions on the northwest portion of the polygon. Indicators of enrichment include dominance by white ash and sugar maple, with black cherry (*Prunus serotina*) also in the canopy, alternate leaf dogwood (*Cornus alternifolia*) in the shrub layer, and a relatively high species richness of herbaceous plants, including Christmas fern (*Polystichium acrostichoides*), sweet cicely (*Osmorhiza claytoni*), and doll's-eyes (*Actaea pachypoda*). Other old growth characteristics in this portion of polygon 23 include evidence of previous crown damage, abundant standing snags and coarse woody debris, and pit and mound microtopography. This polygon was heavily damaged by the January 1998 ice storm, and there are many broken tree limbs and shattered canopies throughout the polygon.

Superlative tree sizes (DBHs) include sugar maple with 29–36" DBHs, a 30" yellow birch, and a 34" white ash. Some of the oldest cored trees revealed ages for sugar maple (90, 108, 153, 178 years old) and a 31" tree with a rotten core that we estimated close to 330 years old, white ash (90 years old), red spruce (103 years old), and an estimate of 150–165 years old for other hardwoods (Appendices 6 & 7).

Ayres (1915) also mentions the North Peak area as containing "some of the original hardwoods, trees sixty to seventy feet tall, very large, and standing thick together." In addition, "one passes through a fine bit of primeval forest in climbing the steep ascent after leaving North Peak" (Ayres 1915).

Polygon 20 / East Bowl Area

The East Bowl, the "amphitheatre" described by Ayres (1915) below the South Peak, also contains "primeval" forest. Polygon 20 represents the portion of the East Bowl within the ski lease area. It is cradled between the two straight sections of the Williamson Trail (formerly the Porky Trail) and extends from the end of the Sun Bowl chairlift's maintenance road (1660' elevation) up to 2450', only 300' below the summit. The oldest sections we encountered were near the middle of the polygon on steep northeast facing slopes. The relative scarcity of semi-rich indicator species, as well as the presence of red spruce in the canopy, classified this polygon as primarily a northern hardwood-spruce-fir forest.

Typical northern hardwood species (sugar maple, beech, yellow birch) and red spruce were the dominant canopy species, with beech and red spruce the most common regenerating species. Hobblebush and striped maple were common shrubs, while intermediate wood fern, blue-bead lily (*Clintonia borealis*), whorled aster (*Aster acuminatus*), and wood sorrel (*Oxalis acetosella*) were among the common woodland herbs.

Among the larger (DBH) and older trees in the East Bowl area (including areas not within the ski lease area but still on state land) were yellow birches of 41" and 30" (228 years old from only 8" of intact core), and a 29" red spruce (249 years old) (Appendix 3 &7). Tree cores from polygon 20 included an 85 year old sugar maple and a 160 year old red spruce (Appendix 6).