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Vegetation of Forested Uplands in the Massabesic Experimental Forest

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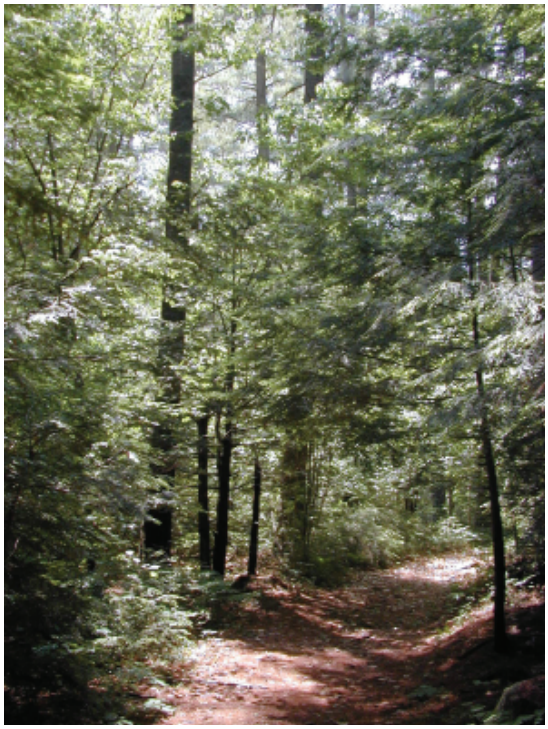

Abstract

A summary of an inventory of vascular plants in the 3,700-acre Massabesic Experimental Forest in York County, Maine. On a grid of 399 permanent sample points, trees 4.5 inches diameter breast height or greater were tallied using variable radius plot sampling. Sample points also served as centers of 0.01-acre plots on which smaller trees and all other plants were recorded. We identified about 500 species and subspecies. The most common overstory trees were eastern white pine, eastern hemlock, northern red oak, and red maple. Hemlock was the most abundant tree seedling. Shrub density was greatest for beaked hazlenut, followed by several viburnum species, highbush blueberry, and winterberry. The most common herb was starflower. We found nine listed rare plants, including a federally threatened orchid, small whorled pogonia. A geographic information system was developed and includes inventory data, forest type, soils, fire history, topography, roads, and streams.

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Introduction

The plant species composition found in a forest is the result of a complex interaction among climate, site characteristics, and natural and human-caused disturbances. This report describes the history and site conditions of various parcels of land that make up the 3,700-acre Massabesic Experimental Forest (MEF) in York County, Maine. We detail the systematic sampling procedures used to describe the vegetation of the forest, summarize tree composition and distribution, shrub density, and understory plant distribution, and list the vascular plants found in the various parcels.

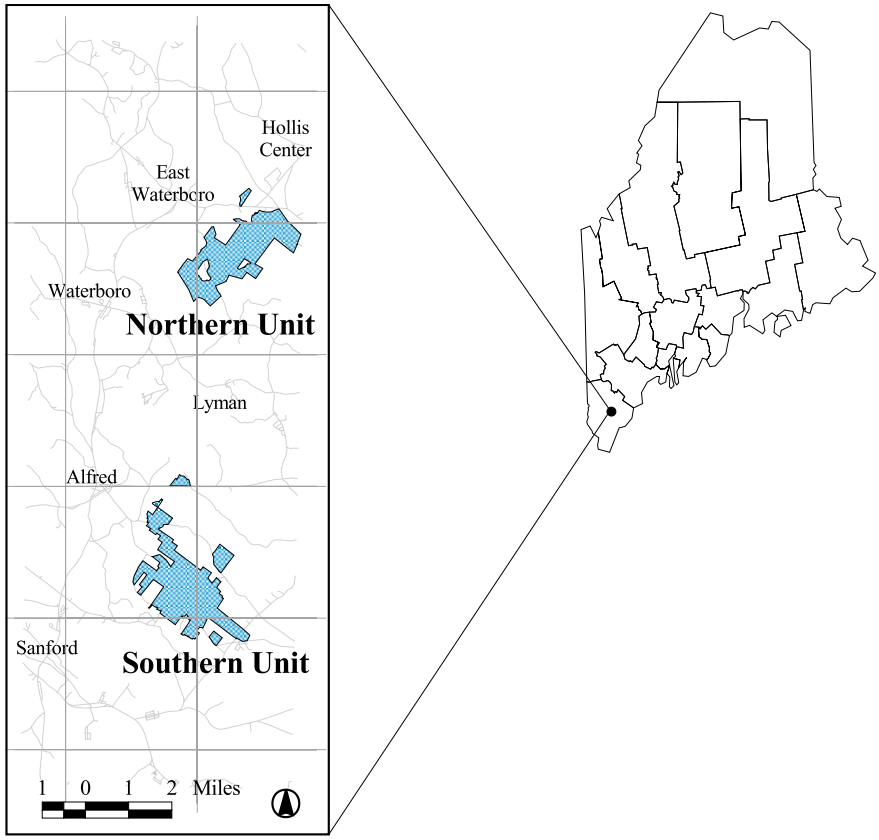

Figure 1.—Location of the Massabesic Experimental Forest, York County, Maine.

The MEF is a unique resource for forest ecology and management research. The Northeastern Research Station of the United States Department of Agriculture Forest Service currently manages eight experimental forests. Four are on national forests and three are on lands owned by a state, forest industry, or a university. The Station owns the MEF. The property consists of northern and southern units of nearly equal area and an administrative site located near the southern unit (Fig. 1). The MEF has a number of special ecological features, including some of the largest wetlands in northern New England that are dominated by Atlantic white-cedar (*Chamaecyparis thyoides*; full scientific names are in Appendix I). It also has a high density of seasonal wetlands or vernal pools, and numerous species of plants and animals that are rare or uncommon. The history of the MEF (detailed by parcel below) includes clearing for farms that were subsequently abandoned to be replaced with a successional forest. A fire that burned 150,000 acres in southwestern Maine in 1947 destroyed 80 percent of the timber in the forest (McConkey and Smith 1958). The forest has grown back and is the largest single block of federal land in southern Maine. The MEF is valued for open space and wildlife habitat in a rapidly developing part of the state, is popular among local residents for some types of recreation, and is an ideal location for demonstrating good forest management.

The forests of which the MEF is a part have been classified in a number of ways. Braun (1950) included all of Maine, New Hampshire, Vermont, and much of Massachusetts as the New England Section of the Northern Appalachian Highland Division, which in turn is part of the hemlock—white pine—northern hardwoods region. The predominant forest-cover type is white pine—northern red oak—red maple and there may be white pine—hemlock in places (Baldwin and Ward 1980, Powell 1980). Keys and others (1995) classify that part of Maine and adjacent New Hampshire as the Gulf of Maine Coastal Plain subsection (221Ai) of the Southern New England Coastal Hills and Plain Section of the Eastern Broadleaf Forest province. The southern unit of the MEF is near the boundary of the Gulf of Maine Coastal Lowland subsection (221Ak) and has some elements of that subsection, especially the Atlantic white-cedar swamps. Eastern hemlock (*Tsuga canadensis*), eastern white pine (*Pinus strobus*), and northern red oak (*Quercus rubra*) are important species of the dominant potential vegetation in both subsections.

Most of the northern unit burned in the 1947 forest fire. The area regenerated to a forest dominated today by white pine and red oak with dense patches of sapling-size hemlock. Plantations of white pine and mixed plantings of white and red pine (*P. resinosa*) were established after the fire by the Forest Service on some of the most severely burned areas and on areas that were poorly stocked before the fire. There are extensive areas of open

water in the unit, including Tarwater Pond, which is surrounded on three sides by mixed woods, pine plantations, a tamarack (*Larix laricina*) swamp, and a shrub heath. Except for a portion on the east side, this 11-acre pond is within the boundary of the MEF. It drains into Roberts Pond, an impoundment that provides extensive shoreline and shallow water, and is part of the Saco River drainage. Cooks Brook crosses the northern unit. Numerous small seasonal wetlands are scattered throughout the unit.

The southern unit contains some upland areas that did not burn in 1947 and that appear to be relatively free of disturbance during the past 100 years. Some burned areas on this unit were planted to white and red pine, while the remainder regenerated to hardwoods or mixed stands of hardwoods and conifers. Areas of sandy loam support mature stands of white pine and hemlock, or of white and red pine (probably planted). Pitch pine (*P. rigida*) naturally occurred on an area of loamy sand and a few small populations remain. Some of this area was planted with white and red pine, and in the 1960s genetic test plantings of hybrid poplars (*Populus* spp.) were established there. There are complex drainage patterns across a large portion of the southern unit that includes the Atlantic white-cedar swamps. One observer reported that these swamps did not burn extensively in 1947.[1] The unit contains numerous small ponds and seasonal wetlands, and borders Estes Lake, an impoundment of the Mousam River.

The current composition and structure of plant communities found in the MEF are the result of a complex interaction among climate, topography, soils, natural disturbances, and human land use, including research activities since the 1940s.

Climate

Both units of the MEF are 15 to 20 miles northwest of the Atlantic Ocean and the climate of the region is greatly influenced by the ocean's moderating effect. The forest is in Plant Hardiness Zone 5a (cold hardy, -15 to -20 °F) (Cathey 1990), while a few miles farther inland is Zone 4b (hardy, -20 to -25 °F). The closest weather station to the MEF with long-term data published by the National Oceanic and Atmospheric Administration (NOAA) is at the airport in Sanford (43°26′ N, 70°47′ W; elevation 280 ft), about 3 miles southwest of the southern unit. NOAA uses a 30-year period, updated each decade, to establish "normal" conditions. The period 1961-90 defined normal or average conditions

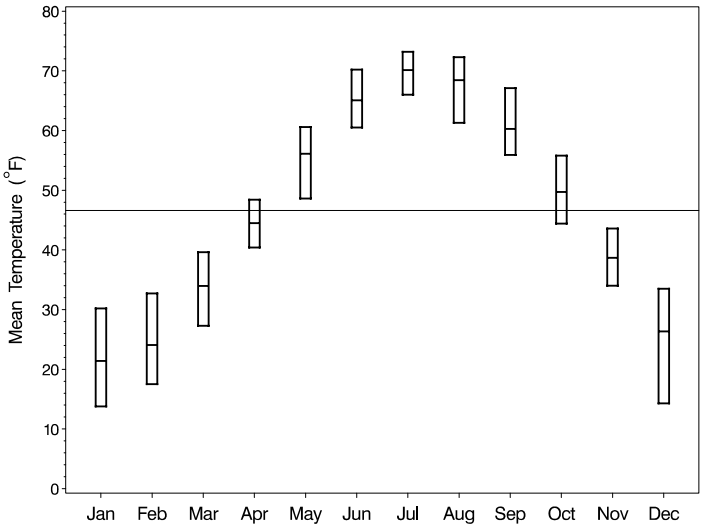

Figure 2.—Monthly mean temperatures at the Sanford, Maine airport for the 30-year period 1961-1990. The horizontal line is the mean annual temperature (46.6 °F) for the period. For each month, center line is normal temperature (overall mean), upper and lower lines are maximum and minimum means over the 30-year period.

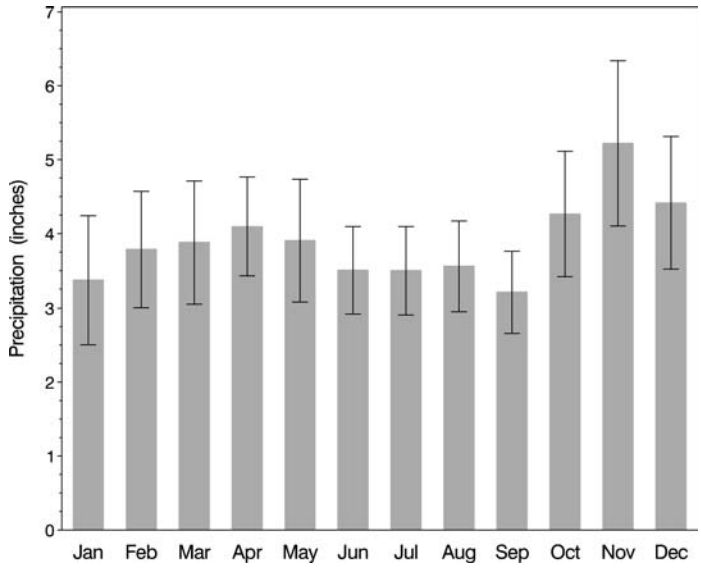

Figure 3.—Monthly mean total precipitation at the Sanford, Maine airport for the 30-year period 1961-1990. Vertical lines are the 95 percent confidence limits for the period.

when the inventory was conducted. The average annual temperature for the period was 46.6 °F, during which July was the warmest month (70.2 °F) and January the coldest (21.5 °F) (Fig. 2). The average high temperature was 94.7 °F and the average low was -17.1 °F. The extremes were 101 °F on August 2, 1975 and -27 °F on January 11, 1968. Annual precipitation for the period averaged 46.85 inches. September was the driest month (3.21 inches) and November the wettest (5.22 inches) (Fig. 3). The growing season, or period between killing

[1]Swett, Charles E. 1999. Personal communication. Retired, USDA Forest Service.

frosts (i.e., ≤ 28 °F), averaged 157 days. May 4 was the average date of the last killing frost in the spring, and October 8 was the first in the fall (Fig. 4).

Topography and Soils

The terrain in the MEF is flat to gently rolling with elevation between 200-450 ft above sea level. Noteworthy topographic features that contribute to the diversity of habitats include sandy flats, rocky hills, and ledge outcrops interspersed with numerous areas of peat and muck. There are small horsebacks, kames, possible kettleholes, and pocket wetlands that were sculpted by the receding Wisconsin glacier about 16,000 years ago. Underlying bedrock is granite composed especially of muscovite-biotite, though feldspar and quartz could be more abundant.[2] Major soil taxa in the Gulf of Maine Coastal Plain subsection are Dystrochrepts, Udothents, and Udipsamments (Keys et al. 1995). Soils of the MEF are primarily stony to very stony sandy loams, ranging to sandy soils on outwash plains. The relatively few glacial erratics and rocky outcrops are granite.

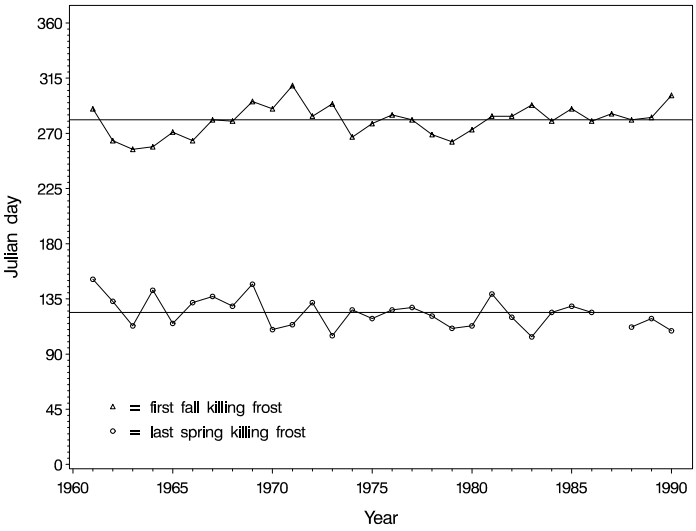

Figure 4.—Dates of last spring and first fall killing frosts (≤ 28 °F) at the Sanford, Maine airport for the years 1961-1990. Horizontal lines are the average dates, May 4 and October 8, respectively. The interval between is considered the growing season and averaged 157 days for the 30-year period. Note that the datum for the last killing frost in the spring of 1987 is missing.

Land Use History

Presettlement use of the area that is now the MEF is largely unknown. It can be assumed that the Massabesic Indians, who lived in the area when the first European colonists arrived, probably traveled through, hunted, and camped within the forest, especially along rivers and streams. It is likely that these Native Americans used fire to enhance hunting habitat in or near the area, as was common throughout much of coastal New England into the 1600s (Cronon 1983). Because of good harbors on the Atlantic coast and relatively good, light textured soils, European settlers were attracted to York County early in the 1600s. The area was heavily forested with both softwoods and hardwoods and lumbering was an important industry in the region by the 1630s (Carroll 1973). Colonial and early American farms once occupied what is now the MEF, as evidenced by old foundations, family cemeteries, quarries, and stone fences that are found throughout the forest. These farms created a patchwork of fields and woodlots. After the Civil War, farm abandonment began and continued through the Great Depression. White pine is well adapted to conditions following clearing and abandonment and became the dominant tree species in parts of the MEF, as it did elsewhere in the region.

About two-thirds of the area that is now the MEF was purchased in the late 1800s by Benjamin Clark Jordan, a local lumberman. He willed this property to Bates College of Lewiston, ME in 1912 for the purpose of establishing a forestry program. Bates College discontinued its forestry program due to financial hardship during the Depression. This change, combined with the tax burden, led Bates College to sell the land in the late 1930s (Coolidge 1963).

Establishment of the MEF

The parcels that make up the MEF were bought by the Northeastern Forest Experiment Station (now Northeastern Research Station) under authority of the Weeks Act between 1937 and 1942 (McConkey and Smith 1958). A number of old farms were purchased in addition to the land bought from Bates College. The land was acquired to conduct timber management research, focusing on white pine. Because this species was the dominant tree across previously farmed landscapes in central and southern New England, important management questions could be addressed in the MEF. However, soon after the purchases were completed, the new experimental forest was closed during World War II. In 1946 the MEF reopened with design of the first experiments and initiation of treatments. As land was acquired for the MEF, a grid of permanent plots was established across the forest. Unfortunately, between the forest fire in 1947 and storms in the early 1950s, most of these plot locations were lost.

[2]Leak, William B. 1999. Personal communication. Research Forester, USDA Forest Service, Durham, NH.

1947 Fire and its Aftermath

Following a prolonged drought, wildfires erupted across Maine in October 1947 before leaf fall had completed in southern and coastal sections. Statewide, more than 200,000 acres burned, resulting in the death of 16 people and the loss of entire villages. About 3,025 acres of the MEF burned. In some places the fire crowned, causing stand-replacing disturbance; in other areas only part of the forest floor was consumed. The fire skipped some areas entirely. Immediately following the fire, a map of the burn was prepared with a report on quantity and size of remaining timber (USDA Forest Service 1947). Many of the trees killed in the fire, especially in the northern unit, were harvested the following year. Nearly 4.5 million board feet of timber was salvaged (McConkey and Smith 1958). The fire killed only some of the trees outright, but it reduced stand density and left many surviving trees weakened, leaving the stands more vulnerable to subsequent disturbances. Consequently, a substantial number of trees blew down in the gale of November 1950 and during Hurricane Carol in 1954. Another 1.75 million board feet of mostly white pine was salvaged. After the fire and storms, 990 acres had merchantable or potentially merchantable stands, and 580 acres were considered "nonproductive land" (USDA Forest Service 1955). Of these "nonproductive" areas 330 acres were considered to be in need of planting and much of this total was thought to require site preparation. In the 1950s, plantations of white and red pine were established primarily for rehabilitation, though some were designed with research objectives.

The Research Program, 1946 to 1996

Experiments from the early years also have influenced the current structure and composition of the forest. In 1950, a program of management studies was started in the unburned portion of the MEF, based on a design similar to other silvicultural studies initiated throughout the Forest Service around that time. The goal of these Compartment Management studies was to compare an array of long-term management treatments at the stand level, and thus to evaluate quantity and quality of timber yields, changes in growing stock conditions, and costs of labor and materials. Treatments included diameter-limit cutting, shelterwood, and patch and strip clearcutting (McConkey and Smith 1958).

Other research started in the 1950s included artificial regeneration of white and red pine by planting and direct seeding (Graber 1965, 1968); chemical pest control, primarily for white pine weevil (*Pissodes strobi* Peck) (McConkey and Swett 1967); woodlot management; and early stand management techniques, such as release using herbicides and precommercial thinning.[3] Some of the burned areas in the northern unit regenerated to stands dominated by paper birch (*Betula papyrifera*). To provide management prescriptions for paper birch stands, an experiment was established to study the effects of thinning, with and without fertilizer application (Safford 1989). Except for an occasional small salvage operation, there has been no commercial harvesting in the MEF since the mid-1960s. Harvesting of firewood, including standing hardwood trees, was allowed by permit for many years, but most of that activity was confined to a narrow band along forest roads. Firewood harvesting was halted by the early 1980s. The last Northeastern Research Station employee located in the MEF retired in 1983.

Forest genetics experiments have been an important extension of the artificial regeneration research in the MEF. In 1959-60 four white pine provenance studies were planted on old fields owned by Chadbourne Lumber Company. These lands border the northern unit and their use made clearing additional land in the MEF unnecessary. Genetics studies in the southern unit evaluated weevil resistance in selected half-sib progeny of western white pine (*P. monticola*) and local eastern white pine.

Soil processes were studied at the Littlefield farm on Ida Jim Road. This farm was in operation from at least 1842, perhaps earlier, until the 1920s, then was abandoned, and burned in the 1947 fire. During World War II, it was under cultivation for a few years. Soil pH, concentrations of total carbon (C) and nitrogen (N), C:N ratio, and percentage organic matter were influenced more by agricultural history of the landscape than by the 1947 fire (Soulia 1997).

Currently, there are no studies in the MEF that require manipulating plant community composition or structure. Ongoing research includes owl surveys in the southern unit and aquatic insect ecology and stream chemistry monitoring of Cooks Brook in the northern unit. Since 1998, the Massabesic Experimental Forest Education Project partners have been involved in developing and promoting the MEF as a location for conservation education and demonstration. These partners include the Forest Service's Northeastern Research Station, Maine Forest Service, the town of Alfred Conservation Commission, the York County Soil and Water Conservation District, the Small Woodlands

[3]Massabesic Rehabilitation Journal. 1956-1959. On file at USDA Forest Service, Northeastern Research Station, Louis C. Wyman Forestry Sciences Laboratory, Durham, NH. Typed log.

Owners Association of Maine (SWOAM), LaValley Lumber Company, and the Threshold to Maine Resource and Conservation District. The MEF Education Project developed interpretative trails on the forest with accompanying brochures and conducts tours for schools and other local organizations. Among these partners, the Maine Forest Service and SWOAM strongly advocate a Forest Service research program focusing on the needs of private owners of smaller forest lots.

The Inventory, 1997-2000

The MEF mission is to provide a location for conducting long-term ecological and management research, and for demonstrating sustainable forest management in central New England. The primary goal is to provide research results that develop a better understanding of the effects of management practices on forest structure, composition, and function. A secondary goal is to provide a setting where ecological principals and management techniques can be presented to professional and educational groups and the public. Given the location and history of the forest, and the interest of stakeholders in managing small forest properties, the MEF is an ideal outdoor laboratory for conducting ecology and management research on old-field sites typical of New England. To provide the critical knowledge needed by landowners and land managers, experiments that harvest overstory trees must be designed and implemented. Such experiments change the composition and structure of the overstory and understory. Before a comprehensive research program can be put into effect, it is necessary to know the composition and structure of the plant communities that will be altered when the manipulative experiments are conducted.

Thus in 1997 we developed a plan to obtain a floristic description of the MEF and we tested aspects of data collection. The plan called for a grid of permanent sample plots across the upland portions of the forest and a protocol to measure herbaceous and woody plants. Anecdotal observations of non-vascular plants, lichens, fungi, and some species of animals also were included. However, the primary focus was on upland vascular plants because we were interested in conducting manipulative experiments on well-drained sites, not wetlands. We established permanent plots and took measurements over three field seasons, 1998-2000.

Objectives

The inventory was designed to: 1) gather information needed to plan experiments in upland habitats that will answer questions about regeneration, individual tree and stand growth, productivity, and wildlife habitat; 2) provide information about forest structure and composition that could serve as a baseline for comparing the effects of change due to management practices, natural disturbance, and ecological succession; and 3) develop a geographic information system (GIS) database that can be queried to locate areas that meet defined criteria, such as tree size or species composition, so that experiments can be established in the most appropriate areas of the forest.

Methods

Failing in our attempt to relocate the original plot system, we established a new grid of plots. To facilitate the inventory, we used a pre-existing set of 10 arbitrary parcels plus the administrative site (Figs. 5 and 6). Parcel boundaries were based primarily on land tenure and to some extent on municipal boundaries, roads, and natural features. Consequently, parcels differ in size, topography, and soils. Parcels are administrative designations rather than management compartments or forest stands. They are described below and summarized in Table 1. All soils information is from Flewelling and Lisante (1987) and U.S. Department of Agriculture, Natural Resources Conservation Service, MUIR Database (USDA Natural Resources Conservation Service 1994). Wetland information is from Cowardin et al. (1979) and National Wetlands Inventory (USDI Fish and Wildlife Service 2002).

Prior to the start of any field work, we familiarized ourselves with the rare plant list for Maine, which is an administrative list maintained by the Maine Natural Areas Program (Maine Department of Conservation 1999), and a checklist that provided a county-by-county listing of herbarium records (Campbell et al. 1995), so that we could better document rare plant populations while collecting field data.

Description of parcels

Northern Unit

Parcel N1 (36 acres) is a narrow, isolated parcel north of Maine Route 5 in Lyman (Fig. 5). The west boundary is Cooks Brook, which is in the Saco River drainage. An abandoned railroad bed crosses the parcel at the south end near Route 5. Forested wetlands associated with Cooks Brook bound the parcel at the southwest with another small wetland near the center of the parcel. At the north end of the parcel there is a stand of mature northern hardwoods with sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*), a few white ash (*Fraxinus americana*), red oak, hemlock, and white pine. Within the recent past, the private woodlot west of this stand was clearcut to the MEF boundary. Soils are

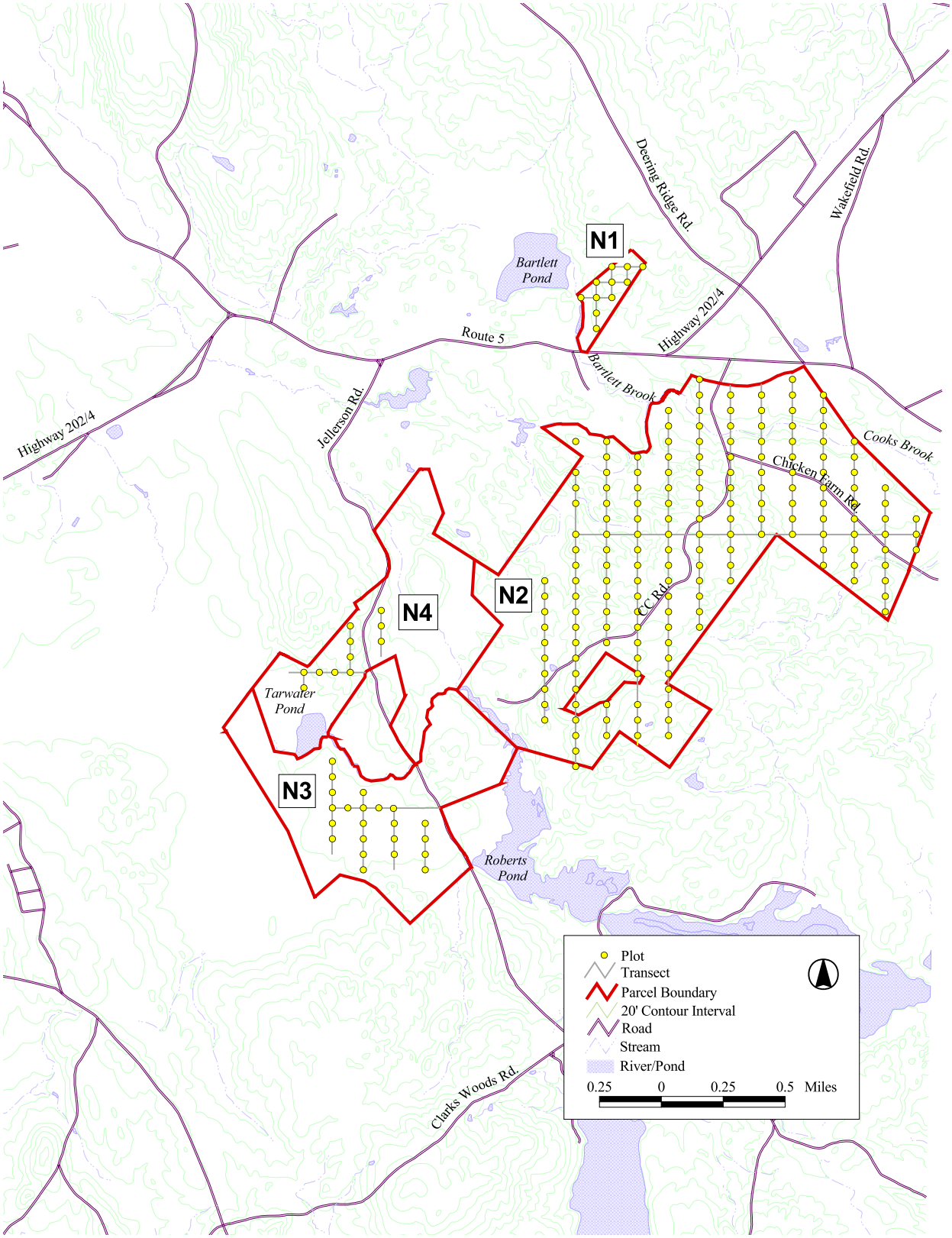

Figure 5.—Location of permanent sample points in the northern unit, Massabesic Experimental Forest, and parcels used for summarizing data.

Table 1.—Total area, area sampled, and numbers of sample points and meander transects in the inventory of upland vascular plants in the Massabesic Experimental Forest, by parcel.

Parcel	Total area	Area sampled	Sample points	Transects
	acres			
N1	36	36	11	10
N2	979	881	170	176
N3	335	91	22	25
N4	318	35	11	12
Total, northern unit	1,668	1,043	214	223
S1	167	37	13	13
S2	167	107	22	24
S3	1,336	593	114	135
S4	58	54	17	12
S5	36	25	8	8
S6	192	36	15	12
S7 (Admin site)	52	0	0	0
Total, southern unit	2,008	852	189	204
Total	3,676	1,895	403	427

mostly stony, very fine sandy loams, well to somewhat excessively drained Skerry and Hermon, with a small proportion of poorly drained Brayton and some excessively drained, gravelly, loamy sand (Colton). Hydric soils include small areas of Naumburg sand and Chocorua peat.

Parcel N2 (total area 979 acres, area sampled 881 acres) is located at the northern end of the unit (Fig. 5) in the towns of Lyman, Hollis, and Dayton. Topography is varied with elevation ranging to the highest point in the MEF at about 450 ft above sea level, with large and small forested wetlands, vernal pools, and the swell and swale undulations left by glaciation. Cooks Brook flows easterly across the northern part of the parcel, eventually to the Saco River. The southern boundary includes frontage on Roberts Pond, which is an impoundment of Tarwater Stream, and wetlands associated with that body. Small pockets of scrub shrub and forested wetlands are found throughout this parcel.

A flat, sandy outwash area where Chicken Farm Road extends east to the MEF boundary was abandoned farmland that was harvested prior to the 1947 fire. This area, which burned intensively in 1947, was "mostly brush land prior to the fire, with a fair scattering of white pine saplings."[3] A salvage harvest was conducted here following the fire. The area was converted to pine plantations in the 1950s. The riparian zone of Cooks Brook broadens to the east of CC Road, the main north-south forest road, with a ravine up to 70 ft deep and about 500 ft wide. Some pitch pine and bear oak (*Q. ilicifolia*) are present near CC Road, which may be remnants of the presettlement forest. A 0.5-acre jack pine (*P. banksiana*) plantation was established in 1951 near a borrow pit off Chicken Farm Road. The Civilian Conservation Corps, after which CC Road was named, established this pit in the 1930s and the deposits probably were used to build the road system in the unit. In 1954, about 4 acres were rototilled and in 1955 white and red pine were planted. The red pine was replanted in 1956 due to poor survival. West of the access road to the borrow pit is an area that was treated with an aerial spray of 2,4,5-trichlorophenoxy acetic acid (2,4,5-T) in 1954 and planted with white pine, but details of this planting are not included in the MEF Journal.[3] Most of the planted strip between Chicken Farm Road and the southern boundary of the parcel was treated with an aerial application of 2,4,5-T in 1956. On the southern boundary of the treated area, 7 acres were planted with white pine in 1958.

In the southeast part of this parcel are stone walls, dug wells, and cellar holes from earlier farms. This area,

which is known locally as Thirteen Cellar Holes, is located on a forested hill that is most easily accessed from the settlement at Roberts Pond. Soils support a small population of sugar maple and shagbark hickory (*Carya ovata*); the former is unusual in the MEF and the latter is known only from this one locale. An inholding on the east side of the parcel is near the summit of the highest promontory in the MEF. A narrow ravine among granitic ledges seems to have remained unburned when the 1947 fire consumed the humus layer on the slope to the west of the ravine.

Soils in Parcel N2 are predominantly stony, fine sandy loams, including somewhat excessively drained Hermon and poorly drained Brayton. Loamy sands are also important components including well-drained Adams, moderately well-drained Croghan, and small amounts of excessively drained Colton. A small amount of granitic rock outcrop has been mapped. Hydric soils include small amounts of Naumburg sand, and Chocorua and Sebago peats. Some large glacial erratics are present but infrequent.

Parcel N3 (total area 335 acres, sampled area 91 acres) is located along Jellerson Road in Lyman (Fig. 5). It is bounded on the north by a wetland associated with the Tarwater Pond outlet, which feeds into Roberts Pond. A large scrub shrub wetland to the north and east (labeled "heath" on the USGS quadrangle) extends onto private land. Forested wetlands that are typically dominated by red maple (*Acer rubrum*) extend to the south and west. The sampled area burned in 1947, and pine was salvaged post-fire. Rehabilitation efforts included small plantations of white and red pine south of the woods road from Jellerson Road to Tarwater Pond in 1948 and 1949. Part of the area was sprayed with 2,4,5-T in 1955 and then white pine was planted in 1956. Moose Point Road crosses the parcel in the southeastern portion. Soils are mostly loamy sands including well-drained Adams and moderately well-drained Croghan. Hydric soils fringe the sampled areas and include peat types such as Chocorua, Vassalboro, and Sebago with a small amount of Naumburg sand.

Parcel N4 (total area 318 acres, sampled area 35 acres) is divided into east and west portions by Jellerson Road (Fig. 5). The south boundary includes part of Tarwater Pond and its associated drainage. An inholding of private land is in the southeast portion. Parcel N4 burned in 1947. In 1957 it was treated with an aerial spray of 2,4,5-T and then a part of the area was planted with white pine. Reforestation of the area east of Jellerson Road appears to have been successful, but efforts on the west side were not. Due to boulders, stumps, ledge outcrops, and boggy spots on the west side, this area was considered "not plantable."[3] The soil of this parcel is mapped as Hermon, a stony, very fine sandy loam. Small pockets of scrub shrub wetlands occur throughout the parcel, and a forested wetland is southwest of the sampled area.

Southern Unit

Parcel S1 (total area 167 acres, sampled area 37 acres) is north of Old Kennebunk Road in Alfred (Fig. 6). Old agricultural fields are now covered with second growth pine-oak in a rolling topography with many stone walls. Nearly all the soils in the sampled area are stony, very fine sandy loams, and include Hermon, which is somewhat excessively drained, and Brayton, which is poorly drained. The three plots on the western side of this parcel are in a forested wetland and are underlain by Naumburg sand, a hydric soil. There is a large sedge meadow along Old Kennebunk Road, the hydrology for which was probably influenced by the building of the road through the wetland. This wetland is noteworthy because despite its proximity to a residential area, it does not contain such invasive plants as purple loosestrife (*Lythum salicaria* L.), common reed grass (*Phragmites australis* [Cav.] Trin. Ex Steud.), or exotic shrubs, such as smooth buckthorn (*Frangula alnus*).

Parcel S2 (total area 167 acres, sampled area 107 acres) is an isolated parcel on the north side of Old Kennebunk Road in Lyman (Fig. 6). Second growth pine-oak dominates the uplands. Topography is especially diverse, with a steep 40-ft rocky ledge, rolling hills, and numerous small wetlands including vernal pools. The largest wetland (7.4 acres) is a red maple swamp that drains to the northwest into Carlisle Brook, and thence to the Kennebunk River. Old stone walls, several cellar holes, and a woods road were established in the 1800s or possibly earlier. This suggests that the upland soils were plowed or pastured. A family cemetery is adjacent to the southeast corner of the parcel. Prior to 1947, there was a stand of pine presumably planted around 1925 in the northwest corner of the parcel and an adjacent stand of natural pine, possibly on an old field, that grew on the slope along Old Kennebunk Road. In both areas, the 1947 fire damaged most of the pine. Four acres northeast of the woods road and along Old Kennebunk Road were planted with white and red pine in 1948. The remainder of the frontage along Old Kennebunk Road was treated with a basal spray of 2,4,5-T, followed by cutting stems within 1 foot of pine regeneration in 1954. A 15-acre area north of the woods road was part of a test aerial application of dilute 2,4,5-T amine. Poor coverage made treatment relatively ineffective. Soils are mostly stony, very fine sandy loams including a large proportion

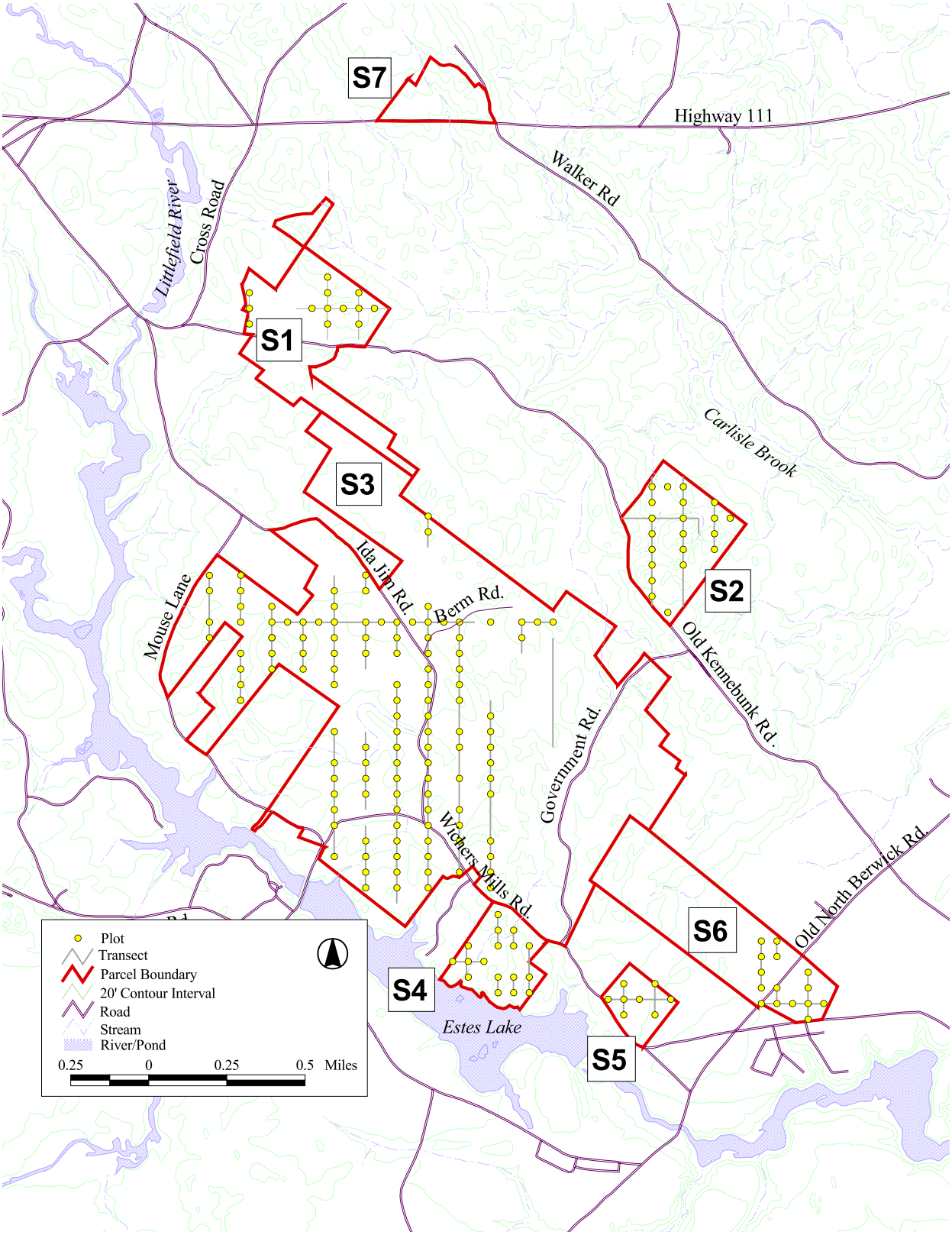

Figure 6.—Location of permanent sample points in the southern unit, Massabesic Experimental Forest, and parcels used for summarizing data.

of Hermon (somewhat excessively drained) with smaller amounts of Skerry (moderately well-drained), Becket (well-drained), and Brayton (poorly drained). Hydric soils occur in small amounts, including Sebago and Chocorua peats. Rock outcrops occur in a few places and feature some plant species usually not found elsewhere in the MEF.

Parcel S3 (total area 1,363 acres, sampled area 593 acres) is located in Alfred and Lyman (Fig. 6) on the north side of Estes Lake, an impoundment of the Mousam River. Access is from various local roads: Whichers Mills Road (southern portion), Mouse Lane (west), the unpaved Ida Jim Road, named after members of the Littlefield family who owned a farm (western portion), Old Kennebunk Road (northern portion), and the unpaved Government Road (eastern portion). Vegetation ranges from mature white pine and hemlock to red maple swamp. Topography is highly varied. Wetlands are numerous and include patches of forested wetland, streams, scrub shrub, vernal pools, and a swell and swale system of glacial outwash ridges, kames, and possible kettleholes. The largest wetland is an Atlantic white-cedar swamp complex that bounds the sampled area to the east and northeast.

Uplands east of Ida Jim Road burned in 1947. White and red pines were planted in 1948 on a 6-acre site of former farmland south of Bermed Road (which is perpendicular to and extending east from Ida Jim Road). Records show that the western portion of this site was a cultivated field in 1946; the remainder was old field.[3] Numerous small plantations of hybrid poplars were planted in 1948 and 1950 in addition to a 2.5-acre plantation of white and red pine established in 1948. At the end of Bermed Road, thinning was conducted on 23 acres in the early 1950s, but hurricanes blew down many of the remaining trees in 1954. This area was planted with red pine in 1956 and an additional 12 acres in the vicinity were treated with an aerial application of 2,4,5-T. Experiments using varying amounts of 2,4,5-T were conducted in 1957 in these same areas to either control hardwoods or prepare areas for planting. An application of 2,4,5-T was made to a 5-acre area at the northernmost boundary along Ida Jim Road to release pine seedlings overtopped by birch and red maple. A natural stand (0.7 acres) on the north side of Bermed Road was thinned in 1957 and then sprayed with DDT in 1958 to control white pine weevil. At the corner of Government Road and Whichers Mills Road, 3.5 acres of hardwood saplings were treated with a basal stem application of 2,4,5-T, then planted with white and red pine in 1955. The 1947 fire burned 130 acres northeast of the intersection of Ida Jim Road and Whichers Mills Road and killed white pine smaller than 4-6 inches diameter at breast height (dbh). In 1956, trees remaining in the stand were released to provide a future seed source. On the south side of Whichers Mill Road, Scotch pine (*P. sylvestris*) was planted to compare growth rate and form of selected families. Western white pine (*P. monticola*) and Himalayan blue pine (*P. wallichiana*) were planted nearby to compare growth rates and weevil resistance with eastern white pine.

The majority of soils in the sampled area are Hermon (somewhat excessively drained) and Skerry (moderately well-drained); both are stony, very fine sandy loams. These are generally found on the swells. Brayton, a poorly drained, stony, very fine sandy loam, is generally found in the swales. Present in smaller amounts are: Allagash, a well-drained, very fine sandy loam; Adams, a well-drained loamy sand; and Madawaska, a somewhat poorly drained, fine sandy loam. Hydric soils include small amounts of Chocorua peat, Sebago peat, and Naumburg sand.

Parcel S4 (total area 58 acres, sampled area 54 acres) is in Alfred (Fig. 6) on the south side of Whichers Mills Road and the northern shore of Estes Lake. The topography is gently sloping to the south and there are a few small, forested wetlands. There is evidence of granite quarry activity presumably from the 1800s. A 5-acre plantation of white pine was established on the western boundary. This area is described as a "…rather open, merchantable stand of white pine burned in 1947. There were indications of an earlier fire about 1920 - consistent rather long butt scars on the larger trees."[3] Soils are mostly mapped as rock outcrop with a small proportion of Croghan, which is a moderately well-drained loamy sand. Brayton, a poorly drained, stony, very fine sandy loam, can be found in areas of lower elevation. Wetlands are on two hydric soils: Chocorua peat and Naumburg sand.

Parcel S5 (total area 36 acres, sampled area 25 acres) is in Alfred (Fig. 6) on the north side of Whichers Mills Road and is crossed by Shackford Farm Road, an unpaved woods road that proceeds north to Old Kennebunk Road. Topography is moderately rolling with some forested wetlands at the northwest corner of the parcel and along the southeast boundary. A stream flows southeast and crosses Shackford Farm Road at an old homestead, then cuts deeply into the slope before entering a scrub shrub wetland. Natural stands are mostly pine-oak with hemlock and a small area of pitch pine on a ledge to the southeast. Prior to the 1947 fire, the parcel was stocked with 60-year-old white pine and a band of hardwood less than 10 inches dbh running north to south through the center of the parcel. Except for some pine in the northeast corner, most of the parcel burned in 1947. Many of the surviving trees blew down

in the hurricanes of 1950 and 1954. In 1948, white and red pines were planted on 1 acre near the northwest corner of the parcel along Whichers Mills Road. Five acres were released in 1954 by cutting competing trees and treating stumps with 2,4,5-T. In the plantation, hardwoods were girdled and ammate crystals applied to the wounds. A gypsy moth (*Lymantria dispar* [L.]) infestation in 1954 defoliated the red and white pines, slowing growth but not killing the trees. Further east on Whichers Mills Road, all hardwoods and pulpwood were salvaged on 4 acres and stumps were treated with ammate (2,4,5-T) in 1955. Three of the treated acres were planted with red pine in 1956. Soils in this parcel have been mapped as mostly rock outcrop with some Adams, which is a well-drained loamy sand, and a small amount of Brayton, a poorly drained, stony, very fine sandy loam. Hydric soils include a large proportion of Naumburg sand and some Chocorua peat.

Parcel S6 (total area 192 acres, sampled area 36 acres) is in Alfred (Fig. 6) along Old North Berwick Road, and is mostly flat with a scrub shrub and forested wetland complex to the northwest, including small remnants of long-dead Atlantic white-cedar. Logging was conducted between 1930 and 1940, and regrowth burned in 1947. A 3.5-acre area on the north side of Old North Berwick Road was planted with white and red pine in 1948. A strip of jack pine was planted on the north side of Old North Berwick Road in 1951. Seventeen acres north of that road were planted with white and red pine in 1955. The red pine was replanted in 1956. A 12-acre site north of these plantations was planted with white pine in 1958, but survival was poor. South of Old North Berwick Road, 20 acres were planted with white pine in 1958. Nearby, some burned areas have regenerated to pitch pine. Soils in this parcel are Adams and Croghan, which are mostly well-drained and moderately well-drained loamy sands. Smaller areas of two hydric soils, Chocorua peat and Naumburg sand, have also been mapped in this parcel.

Parcel S7 (52 acres) is the administrative site for the MEF. It is on the north side of Maine Route 111 in Lyman (Fig. 6). It includes Forest Service buildings that once served as MEF headquarters. Now state and county agencies occupy the buildings. Topography is rolling, with a few patches of forested wetlands and seasonal streams that flow into Carlisle Brook. Vegetation is pine-oak on former farm fields, with stone walls and cellar holes. Invasive shrubs and vines are more common here than elsewhere in the MEF. The area "…north of office planted with white and red pine in 1949 and 1954…a few Austrian pine and Scotch pine were also planted in 1955." [3] In 1956, white pine was planted on 2 acres west of the office and near Route 111. Soils in this parcel are stony, very fine sandy loams. Hermon, excessively well-drained, is the greatest proportion, followed by Brayton, which is poorly drained, and there is a small amount of moderately well-drained Skerry. There are a few small forested wetlands here and there in the parcel. One small scrub shrub wetland is mapped near the south boundary at Route 111. No sampling points were established in this parcel.

Field Data Collection

Field data were collected during the summers of 1998-2000 using methods developed in a reconnaissance survey in 1997. Variables are listed in Table 2. Common and scientific names for trees follow Little (1979). Names for all other plants follow Haines and Vining (1998) and unpublished updates supplied by these authors.

Grid of permanent sample points

Wetlands are extensive in some parcels, but sampling for this inventory was mostly in uplands because manipulative experiments will be conducted on higher ground. Thus sampling covered one small parcel completely (N1), but for most parcels only a portion of the total area was sampled (Table 1). A parcel may contain one or more stands and may eventually be divided into one or more research compartments. A 330 x 660 ft (5 x 10 chain) grid was established wherever sufficient upland forest was available. The grid was laid out from an east-west baseline established for each parcel at an easily identified corner, typically monumented with a pre-existing granite post or painted boulder (Figs. 5 and 6). Crews of three to five people used staff compass and tape to survey each sampling point, based on true north. We monumented each point with an 18-inch stainless steel stake topped with a yellow plastic cap.

Sampling procedures

Each sampling point served as a permanent location for variable radius plot sampling (VRP) (Schreuder et al. 1993) and as the center for a 0.01-acre fixed-radius plot (radius = 11.77 ft). We used VPR to tally trees 4.5 inches dbh or greater with a 10 basal area factor (BAF) prism. We identified trees to species, measured their dbh with a diameter tape to the nearest 0.1 inch, and recorded each as live or dead. Any dead snag 4.5 ft tall or more that we encountered using the prism was tallied as a dead tree if its dbh was 4.5 inch or greater.

In the 0.01-acre plots, trees between 0.5 and 4.5 inches dbh were tallied by species, diameter, and as live or dead. Woody stems were counted by species if taller than 1 ft but less than 0.5 inch dbh. Tree and shrub seedlings were identified to species and scored as "present" if less than 1

Table 2.—Variables measured or recorded in the inventory of upland vascular plants in the Massabesic Experimental Forest.

Sample method	Taxa and strata sampled	Variable	Measurement units
Variable radius plot	trees ≥ 4.5 inch dbh	name	species
		dbh	nearest 0.1 inch
		status	live or dead
Fixed area plot	trees ≥ 0.5 dbh <4.5 inch	name	species
		dbh	nearest 0.1 inch
		status	live or dead
	trees < 0.5 inch dbh but ≥ 1 ft tall	name	species
		stem count	number
	trees < 1 ft	name	species
		abundance	class
	shrubs ≥ 1 ft	name	species
		stem count	number
	shrubs < 1 ft	name	species
		abundance	class
	nonwoody plants	name	species when possible
		abundance	class
Meander transect	all	name	species when possible

ft. For example, if at least one red oak seedling less than1 ft was found, that species was noted as present in the plot. Abundance of each plant species was estimated in the 0.01-acre plot using percentage cover classes of Witham et al. (1993). This involved visualizing each plot as a cylinder rising through the canopy and classifying the relative abundance for each species within the cylinder. For species that occupied less than 5 percent of the plot, three classes were used: 1) Rare, 5 or fewer individuals; 2) Occasional, numerous individuals but not common; 3) Common, occurred more or less throughout the plot but with coverage less than 5 percent. For species that occupied 5 percent or more of the plot, classification was in four additional classes: 4) 5-25 percent; 5) 26-50 percent; 6) 51-75 percent; and 7) 76-100 percent. Height also was classified. If a woody stem was shorter than 0.8 ft, it was assigned to class 1, otherwise it was estimated and assigned to a class as follows: 2) 0.8-3.4 ft; 3) 3.5-17 ft; 4) 18-34 ft; and 5) taller than 34 ft.

We also tallied any species not inside the plot but outside and within sight of it (about 30 - 50 ft radius, depending on homogeneity of habitat) as being in the vicinity of the sample point. These off-plot data were used to develop a more complete plant list for the MEF, not for any quantitative analyses.

A disturbance category was determined for each sample point based on evidence within or near the plot (i.e., 50-ft radius). A plot was classified as "Agriculture" if there were stone walls or foundation holes, "Harvest" if there were cut stumps, "Fire" if there were fire scars and/or charcoal (with no further classification, i.e., recent vs. presettlement fire), "Plantation", or "None" if there was no obvious disturbance. We did not include evidence of wind throw, though we noticed this on occasion.

Meander transects

Although we assume that data from VRP sampling and fixed-area plots are representative of the upland vegetation in the MEF, we wanted a more complete picture of the flora of the MEF. To augment the VRP and plot inventory, a series of transects was established along the north-south lines between sample points. Between one fixed plot and the next (approximately 307 ft), all vascular plants were recorded within a transect width of about 15 ft for the herb stratum and about 100 ft for the tree stratum. Transects were not fixed in width. If a feature, such as a vernal pool, rocky outcrop, stream, or glade, could be seen from a transect, we visited the area and recorded all plant species. We included wetlands in these meander transects, while passing from one upland plot area to another. Abundances for all species were assigned according to methods of Palmer et al. (1995). Like the off-plot data, information collected along meander transects was used to develop a more complete plant list and was not used in any quantitative analysis.

GIS database development

To facilitate use of forest vegetation data gathered in the inventory with other available spatial data, we developed a geographic information system (GIS). By referencing VRP, fixed plot, and transect inventory data with the geographic location from which it was obtained, the vegetation data can be viewed and analyzed in the context of other geographic datasets, such as soils, hydrology, topography, and disturbance history. Many such datasets exist and are available from various federal, state, or private sources. The GIS for the MEF is made up of the following layers: a base map with boundaries, aerial photos, roads and trails, wetlands, streams, ponds, rivers, drainage divides, soils, 1947 fire map, forest cover types, permanent sample points, meander transects, and most of the data we gathered in the field.

Digital, raster based, U. S. Geological Survey 7.5 minute, 1:24,000 scale quadrangles were used as base maps (USDI Geological Survey 2000). Forest boundary layers were created as vector files and registered on the base map. True color aerial photographs were taken in June 1999 at a scale of 1:20,000. We obtained both photographs and digital (1320 dots per inch) stereo pair images from J.W. Sewall Company, Old Town, ME. We created a mosaic of the images to provide complete coverage of the two units. We used the Universal Transverse Mercator (UTM), North Atlantic Datum 83 (NAD83) projection for the photo mosaics and the boundaries so that they could be used most easily with data layers obtained from the Maine Office of Geographic Information Systems (MEGIS).

We obtained the National Wetlands Inventory (NWI) layer (USDI Fish and Wildlife Service 2002) through MEGIS. We created fields to translate the wetland codes provided so that wetlands could be sorted by system, class, and subclass (Cowardin 1979). This allows the user to easily identify polygons representing, for example: palustrine (system), forested (class), broad-leaved deciduous (subclass) wetlands. Data layers containing roads and streams as vectors came from MEGIS. Roads were categorized by type from interstate to trail. Stream segments were categorized as perennial or intermittent in the attribute tables. We obtained polygon data layers containing rivers, ponds, and drainage divides from MEGIS. In addition, we incorporated vector files containing coordinates taken with the use of a geographic positioning system (GPS) receiver on some of the trails and woods roads in the MEF.

Two other data layers were added to the GIS. The soils data were obtained as a polygon layer from the USDA Natural Resources Conservation Service, National Map Unit Interpretation Record (MUIR) Database (USDA Natural Resources Conservation Service 1994). Attributes available include soil texture, soil erodability factors, hydric soil ratings, seasonal ponding, likelihood of flooding, water table depth, bedrock depth, and site indices of common trees. A map of southwestern Maine showing an estimate of fire severity and remaining timber type and size class was prepared immediately following the fire of 1947 (USDA Forest Service 1947). Portions that featured the MEF were digitized and categorized by the type of fire sustained—ground, crown, or none. Despite its historical interest, we consider the resolution of the 1947 fire map to be too coarse to provide a detailed description of fire in the MEF.

We created the forest-cover type layer based on data collected in the upland areas, then combined with NWI data to determine wetland cover types. For each sample point we determined percent basal area (dbh ≥ 0.5 inch) of each tree species. Using an inverse distance-weighted method, we interpolated percentage cover for each major tree species across the forest. For each 10 m^2 pixel we determined a cover type by calculating percentage basal area from the interpolated values of the major tree species. Forest-cover types defined for the upland portions of the MEF follow the types recognized by Forest Inventory and Analysis (FIA).[4] Because part of our tree data was collected using VRP sampling, rather than exclusively in fixed area plots as is done by FIA, we used percentage basal area of each species as its stocking value rather than determine stocking as specified by FIA methodology.

Single species types included white pine, hemlock, red pine, and Atlantic white-cedar when those species accounted for more than 50 percent of the basal area at a sample point. Where softwoods dominated multiple-species composition, the white pine—hemlock forest type was most common. If hardwoods exceeded 50 percent total basal area, and the percentage of white pine plus red oak exceeded 25 percent, then the forest-cover type was classified as pine—oak. For samples where pine was not present with oak, cover type was classified as either red maple or red oak, depending on whether either species was more than 50 percent of the basal area. For the few points where red oak did not meet this

[4]Arner, S.L., Woudenberg, S.; Water, S. [and others]. Unpublished. National algorithms for determining stocking class, stand size class, and forest type for forest inventory and analysis plots. [Documentation available from the Northeastern Research Station, Forest Inventory and Analysis, 11 Campus Blvd., Newtown Square, PA 19073].

criterion but white oak (*Quercus alba*) was a significant component, the oaks were combined. If all oak species combined met the 50 percent threshold, they were classified as red oak. One mixed-hardwood type was present in the MEF: the maple—American beech (*Fagus grandifolia*)—yellow birch type. For some sample points, we added paper birch or sweet birch (*Betula lenta*) to the percentage basal area of maple (mostly red), beech, and yellow birch to determine this type. Because plot locations were biased toward the upland areas and the inventory avoided many of the wetlands, we incorporated the national wetlands inventory cover types into the upland coverage we had created and allowed the NWI-derived types to take precedence in the wetlands.

Approximate locations of sample points and transects were established in the GIS by using coordinates from the base map and boundary layer to determine the origin of the grid for each parcel. Inventory data can be accessed from the GIS by unit, parcel, or plot.

Data summary and analyses

Data from trees between 0.5 and 4.5 inches dbh collected in the fixed plots and from larger trees by VRP sampling, were summarized using forest inventory software (Brann and Solomon 2001). Number of trees, basal area, and volume/acre were summarized by species and for all species for each parcel. The inventory software calculated volume based on regional height to diameter relationships by species contained in the inventory software because no tree height measurements were taken as part of the MEF inventory. Abundance of seedlings taller than 1 ft but less than 0.5 inch dbh was summarized as seedlings/acre by species, by parcel. We summarized results of the inventory of live trees (≥ 0.5 in dbh) in a series of tables (Tables 3-12) and figures (Figs. 9-18) by 1-inch diameter classes by parcel. Species were ranked in order by number of trees/acre in the tables. Diameter distributions were plotted in stacked bar graphs by species. We used the four most abundant species and an "all other species" category, and inset the smallest diameter classes (1 - 4 inches) in each of the larger graphs (> 4 inches).

We summarized data for plants other than trees by frequency, or percentage of plots by parcel or unit in which a species occurred, regardless of height class. Plants recorded in the vicinity of sample plots and in the meander transects are included only as "present" in the overall list of plants (Appendix I). We used SAS ver. 8.2 — especially PROC MEANS, PROC FREQ, and PROC GCHART (SAS Institute Inc. 1999) — to summarize the understory plants and create most figures.

Results and Discussion

We collected and summarized data from 399 VRP points and their corresponding 0.01-acre plots. Of these, 211 plots are in the northern unit (Fig. 5) and 188 are in the southern unit (Fig. 6). An additional four plots were monumented but not incorporated in the data summaries for various reasons (Table 1). In addition, plants recorded from 223 meander transects in the northern unit and 204 in the southern unit were included in the overall plant lists for the parcels (Appendix I). We observed about 500 plant taxa, including subspecies. The number is approximate because some herbaceous plants could not be conclusively identified from the material at hand. A single plot contained as few as eight or as many as 67 species.

We found six forest cover types, discerned from GIS, in the uplands. This represents more than 2,500 acres (Figs. 7 and 8). The most common of these is the white pine type with more than 900 acres, followed by pine-oak with more than 800 acres and pine-hemlock with slightly more than 700 acres. The types differ between the two units in terms of tree species composition and forest structure. The northern unit contains much more pine-oak and scrub shrub than does the southern unit. Atlantic white-cedar swamp, a type that is rare in Maine, is relatively abundant in the southern unit with a total of 160 acres. Total acreage of plantations is a matter of interpretation because many of the early attempts at establishing plantations failed.

Vascular Plant Diversity

The inventory resulted in identification of 464 vascular plants in the MEF representing 82 families and 229 genera (Appendix I). We found very few invasive, exotic plants. In disturbed habitats in southern Maine, there can be dense local populations of non-native species, such as Japanese barberry (*Berberis thunbergii*), Asian honeysuckles (*Lonicera* spp.), Oriental bittersweet (*Celastrus orbiculata*), Russian olive (*Elaeagnus angustifolia* L.), autumn olive (*Elaeagnus umbellata* Thunb.), and purple loosestrife. These are troublesome because they displace native species, alter wildlife feeding behavior, offer different wildlife cover than native vegetation, have an overall adverse impact on biodiversity, and could affect fuel loads (Richburg et al. 2001). We interpret the low frequency of exotic weedy species in the MEF as an important indication of ecosystem integrity in spite of intense agricultural activity on some parcels since the 1600s and establishment of plantations with non-native tree species.

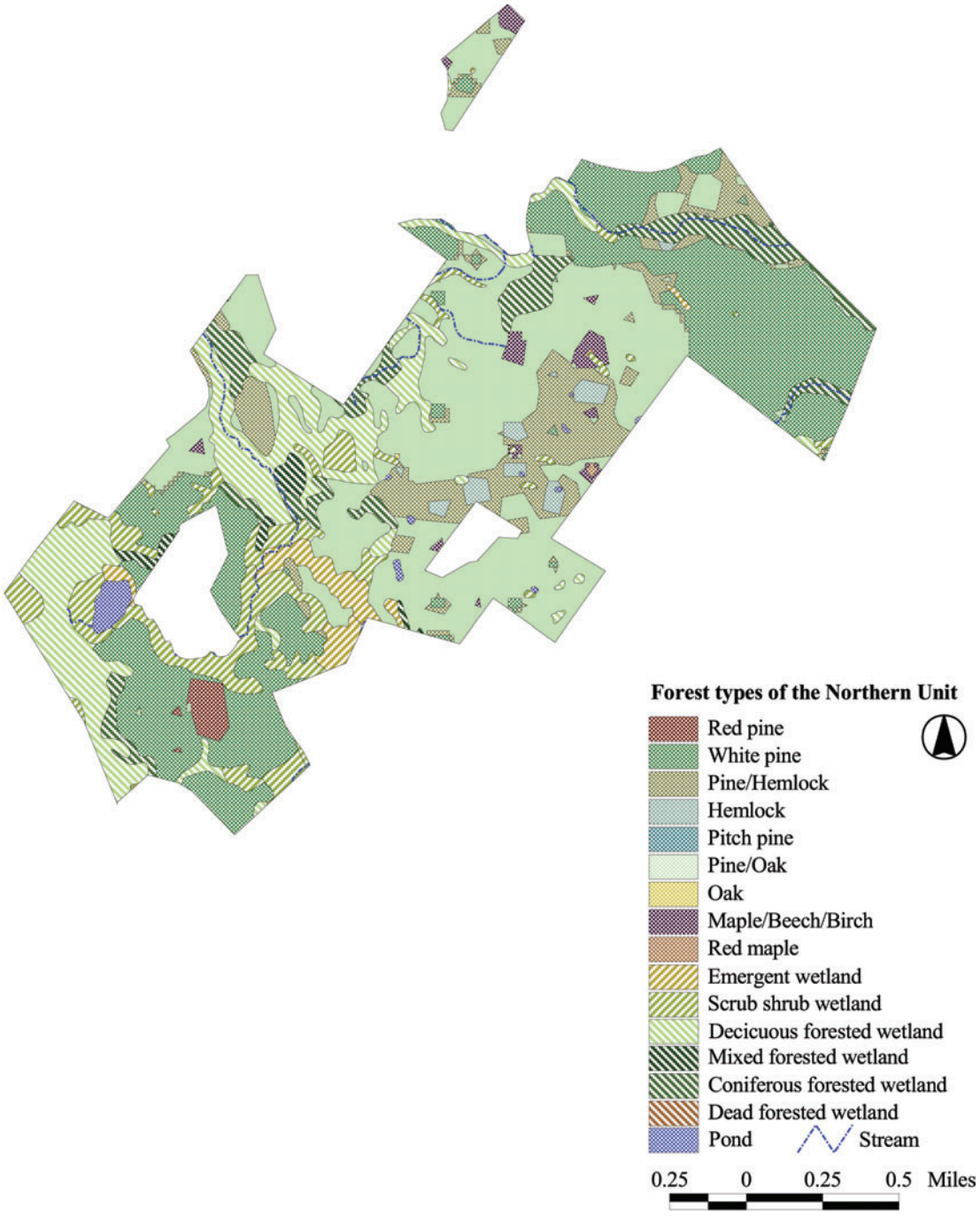

Figure 7.—Forest cover types, northern unit, Massabesic Experimental Forest.

The inventory includes 12 species of coniferous trees and 32 species of deciduous trees that were part of, or could potentially grow into, the overstory. In the understory, there are nine tree species that are unlikely to be found in the overstory except on unusual sites or following uncommon disturbances, including black gum (*Nyssa sylvatica*), shagbark hickory (*Carya ovata*), sugar maple (*Acer saccharum*), black cherry (*Prunus serotina*), eastern hophornbeam (*Ostrya virginiana*), and American hornbeam (*Carpinus caroliniana*). The understory vegetation includes 75 species of woody shrubs and subshrubs, 189 species of broad-leaved herbaceous plants, 47 species of grasses, 75 sedges and rushes, 39 species of ferns, horsetails, and clubmosses, and nine species of vines (Appendix I).

To get a sense of the diversity of vascular plants in the MEF, this inventory can be compared with the entire

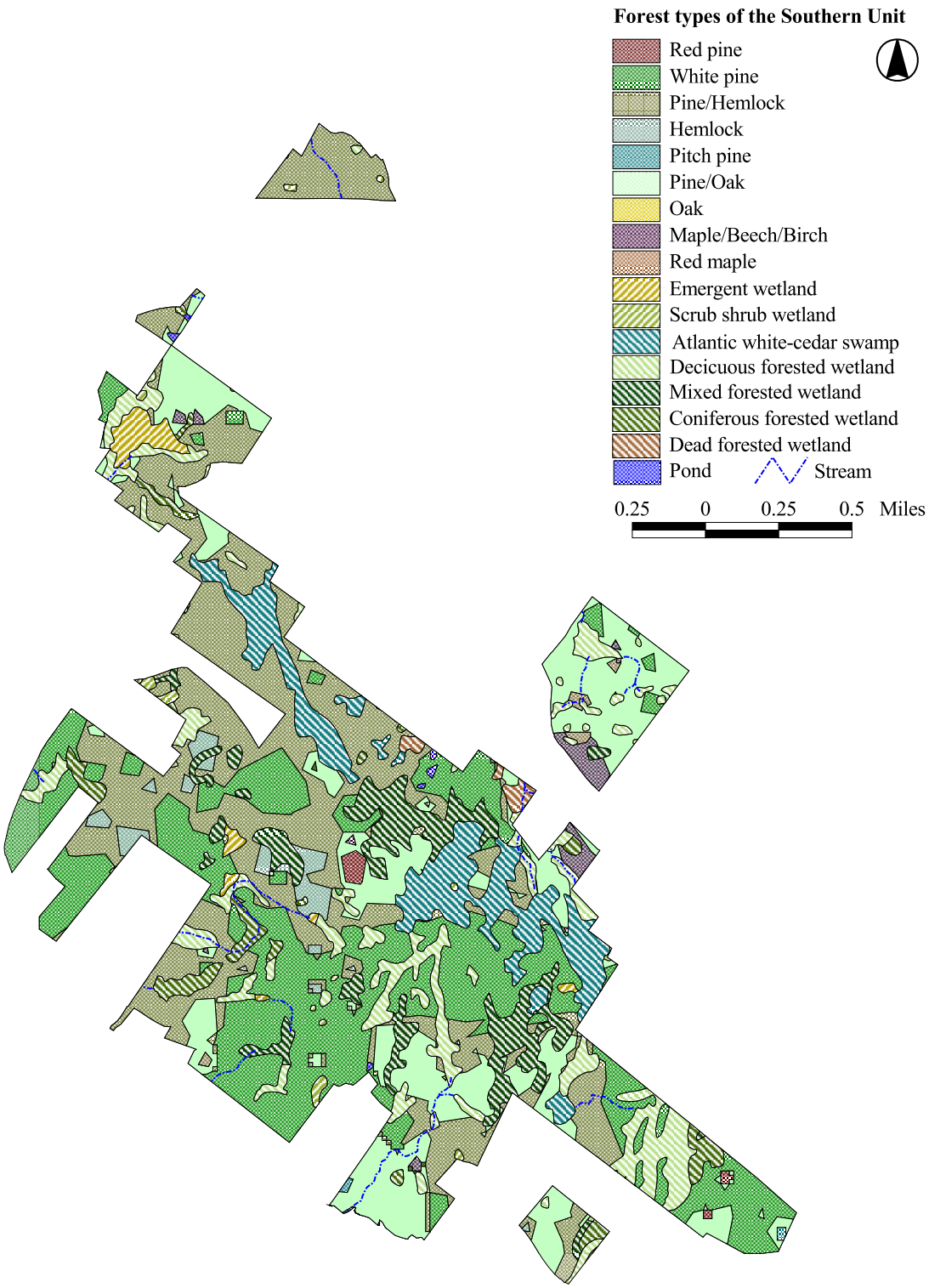

Figure 8.—Forest cover types, southern unit, Massabesic Experimental Forest.

Table 3.—Number of trees and basal area/acre for all live trees ≥ 0.5 inch dbh and gross volume/acre for all live trees ≥ 4.5 inch dbh by species and species group in Parcel N1, northern unit, Massabesic Experimental Forest.

Species	Number of trees	Basal area	Percent basal area	Volume
		ft²/acre		*ft³/acre*
		Softwoods		
Eastern hemlock	174	21.8	15.9	459
Eastern white pine	93	27.5	20.0	788
Balsam fir	5	0.9	0.6	17
Subtotal	272	50.2	36.5	1,264
		Hardwoods		
Red maple	346	28.7	20.9	692
American beech	266	8.0	5.8	165
Yellow birch	81	9.9	7.2	209
Paper birch	42	5.0	3.6	93
Northern red oak	39	28.4	20.6	998
White oak	36	1.7	1.2	—
Sweet birch	27	1.0	0.7	—
Moose maple	9	<0.1	<0.1	—
Gray birch	9	<0.1	<0.1	—
White ash	6	2.7	2.0	71
Sugar maple	4	0.9	0.6	19
Quaking aspen	2	0.9	0.6	28
Subtotal	867	87.2	63.5	2,275
Total	1,139	137.4	100.0	3,539

state of Maine where 139 families with 699 genera and 2,096 species of vascular plants have been identified (Haines and Vining 1998). The flora of Maine is not static and the numbers of taxa change over time. Furthermore, we sampled only half the area of the MEF in this inventory and think more plant species certainly occur within its boundaries. We think at least 25 percent of the vascular plant taxa that occur in Maine are found in the MEF.

Overstory Trees

White pine, hemlock, red oak, and red maple are the most abundant species in most parcels. Red maple was found on 94 percent of plots, white pine on 86 percent, and red oak on 84 percent. Gray birch (*Betula populifolia*) was found in all parcels, and paper birch in all but one. We found dense stands of young hemlock especially on slopes in stands that had burned in 1947. These thickets probably regenerated on intensely burned sites within a few years of the fire. The hemlock density data reflect these thickets but do not reveal their patchiness.

Parcel Summaries

Parcel N1 — The area sampled (36 acres) has 1,139 live trees/acre, basal area of 137.4 ft^2/acre, and volume of 3,539 ft^3/acre (Table 3). This parcel contains about one-third softwood species by basal area. Important softwoods include white pine and hemlock in terms of number of trees and basal area, and important hardwoods include red maple and red oak. These four species account for slightly more than three-quarters of the basal area. The larger trees in this parcel are red oak and white pine as shown by the relatively small number of trees (11.5 percent of total) compared to high timber volume (50.5 percent of total). This is also shown in Figure 9, which plots the number of trees/acre by 1-inch diameter classes. Without disturbance, red oak and white pine could gradually be replaced by red maple, hemlock, and American beech (which are lumped into "Other" in Fig. 9) in Parcel N1.

Parcel N2 — This is the largest parcel in the northern unit, 979 acres, and second largest in the MEF. The area sampled (881 ac) has 1,843 live trees/acre, basal area of

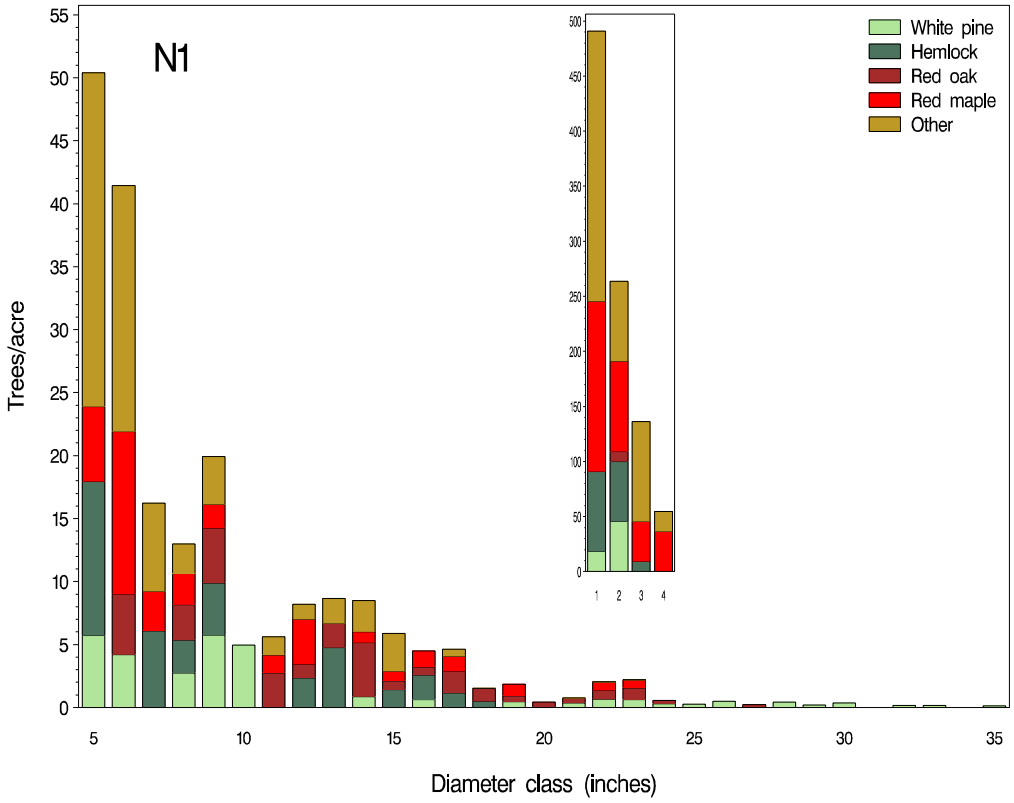

Figure 9.—Number of trees per acre by diameter classes and major tree species in Parcel N1, northern unit, Massabesic Experimental Forest.

155.2 ft^2/acre, and volume of 3,246 ft^3/acre (Table 4). This parcel is slightly more than half softwood species by basal area. Important softwoods are white pine and hemlock, in terms of numbers of trees and basal area. Important hardwoods, especially regarding basal area, are red oak and red maple. These four species account for more than 80 percent of the basal area. Large trees in this parcel are red oak and white pine as indicated by the relatively small number of trees (12.6 percent of total) compared to high timber volume (62.6 percent of total). Without disturbance, red maple and particularly hemlock will eventually represent a greater proportion of basal area and volume in this parcel but white pine and red oak are well represented in all diameter classes (Table 4 and Fig. 10).

Parcel N3 — Most of the area sampled (91 acres) is in white and red pine planted after the 1947 fire. The area sampled has 550 live trees/acre, basal area of 168.2 ft^2/acre, and volume of 4,073 ft^3/acre (Table 5). This parcel contains 94 percent softwood species by basal area. Important softwoods include planted white pine and red pine, in terms of number of trees and basal area. The small component of hardwoods (< 6 percent of basal area) consists of pioneer species such as gray birch. More than 90 percent of the basal area is pine. Ninety-five percent of the total volume is white and red pine with white pine comprising most. The diameter distribution of the parcel is characteristic of an even-aged planting (Fig. 11).

Parcel N4 — Much of the area sampled (35 acres) burned in the 1947 fire and was planted with pine. The plantation east of Jellerson Road survived but the plantation west of the road failed. This resulted in a mix of softwood plantation and pioneer hardwood species. Parcel N4 has 2,059 live trees/acre, basal area of 171.5 ft^2/acre, and volume of 2,872 ft^3/acre (Table 6). This parcel is slightly more than half softwood species by basal area. Important softwoods include white pine (mostly planted) and hemlock, in terms of number of trees and basal area, and important hardwoods include red maple and paper birch. These four species account for 80 percent of the basal area, of which white pine accounts for nearly half. More than half the volume in the parcel is white pine, while red maple, red pine, paper birch, and red oak account for most of the remainder. The mix of softwood plantations and natural, mixed wood stands has an effect on the diameter distribution of the parcel in that the larger trees (≥ 5 inch-diameter

Table 4.—Number of trees and basal area/acre for all live trees ≥ 0.5 inch dbh and gross volume/acre for all live trees ≥ 4.5 inch dbh by species and species group in Parcel N2, northern unit, Massabesic Experimental Forest.

Species	Number of trees	Basal area	Percent basal area	Volume
		ft²/acre		*ft³/acre*
		Softwoods		
Eastern hemlock	881	31.3	20.1	380
Eastern white pine	170	52.6	33.9	1,338
Balsam fir	32	1.5	1.0	20
Red spruce	7	0.1	0.1	2
Red pine	2	0.9	0.5	22
Pitch pine	<1	0.1	0.1	3
Subtotal	1,092	86.5	55.7	1,735
		Hardwoods		
Red maple	281	21.4	13.8	421
American beech	103	5.2	3.3	92
Sweet birch	78	1.9	1.2	9
Paper birch	75	6.8	4.4	82
Yellow birch	74	2.9	1.9	31
Northern red oak	62	21.8	14.0	695
Gray birch	34	1.6	1.0	6
White oak	14	3.9	2.5	112
Black cherry	7	0.3	0.2	3
White ash	4	1.0	0.6	25
Quaking aspen	4	0.7	0.4	13
Moose maple	4	0.2	0.1	—
Sugar maple	2	0.4	0.6	13
Black oak	2	0.2	0.1	3
Black gum	2	0.1	0.1	3
Hophornbeam	2	<0.1	<0.1	—
American elm	1	<0.1	<0.1	—
Serviceberry	1	<0.1	<0.1	—
Bigtooth aspen	<1	0.1	0.1	3
Subtotal	751	68.7	44.3	1,511
Total	1,843	155.2	100.0	3,246

class) on the parcel are mostly planted white pine while hemlock and red maple are dominant in smaller diameter classes (< 5 inches) (Fig. 12).

Parcel S1 — The area sampled (37 acres) has 3,220 live trees/acre, basal area of 178.9 ft²/acre, and volume of 2,629 ft³/acre (Table 7). This parcel contains about two-thirds white pine and hemlock, by basal area. Important hardwoods are red maple and red oak, in terms of number of trees and basal area. These four species account for more than 86 percent of the basal area. Nearly half of the volume in the parcel is white pine, while red oak, red maple, and hemlock account for most of the rest. Parcel S1 is former agricultural land that reverted to forest. Most of the hemlock trees are small. This species accounts for 74 percent of the total trees but only 37 percent of the basal area. Hemlock less than 6 inches dbh is especially well represented (Fig. 13).

Parcel S2 — This parcel burned extensively in 1947. There were a few small plantings of pine following the fire, but most of the area was left to regenerate naturally.

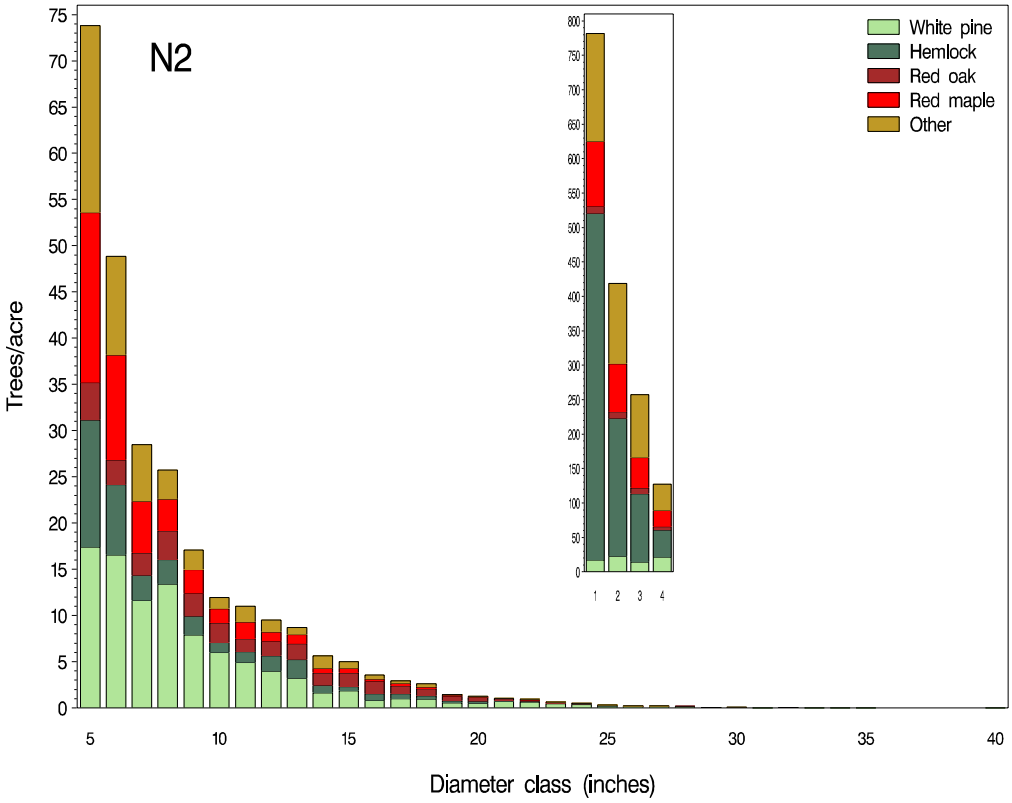

Figure 10.—Number of trees per acre by diameter classes and major tree species in Parcel N2, northern unit, Massabesic Experimental Forest.

Table 5.—Number of trees and basal area/acre for all live trees ≥ 0.5 inch dbh and gross volume/acre for all live trees ≥ 4.5 inch dbh by species and species group in Parcel N3, northern unit, Massabesic Experimental Forest.

Species	Number of trees	Basal area	Percent basal area	Volume
		ft²/acre		*ft³/acre*
		Softwoods		
Eastern white pine	306	116.1	69.0	2,960
Red pine	83	37.6	22.4	904
Red spruce	23	4.1	2.4	82
Black spruce	5	<0.1	<0.1	—
Tamarack	<1	0.4	0.2	11
Subtotal	417	158.2	94.1	3,957
		Hardwoods		
Gray birch	69	3.7	2.2	18
Red maple	43	2.7	1.6	28
Quaking aspen	14	2.3	1.4	38
Black cherry	6	0.9	0.5	19
Black gum	1	0.4	0.2	13
Subtotal	133	10.0	5.9	116
Total	550	168.2	100.0	4,073

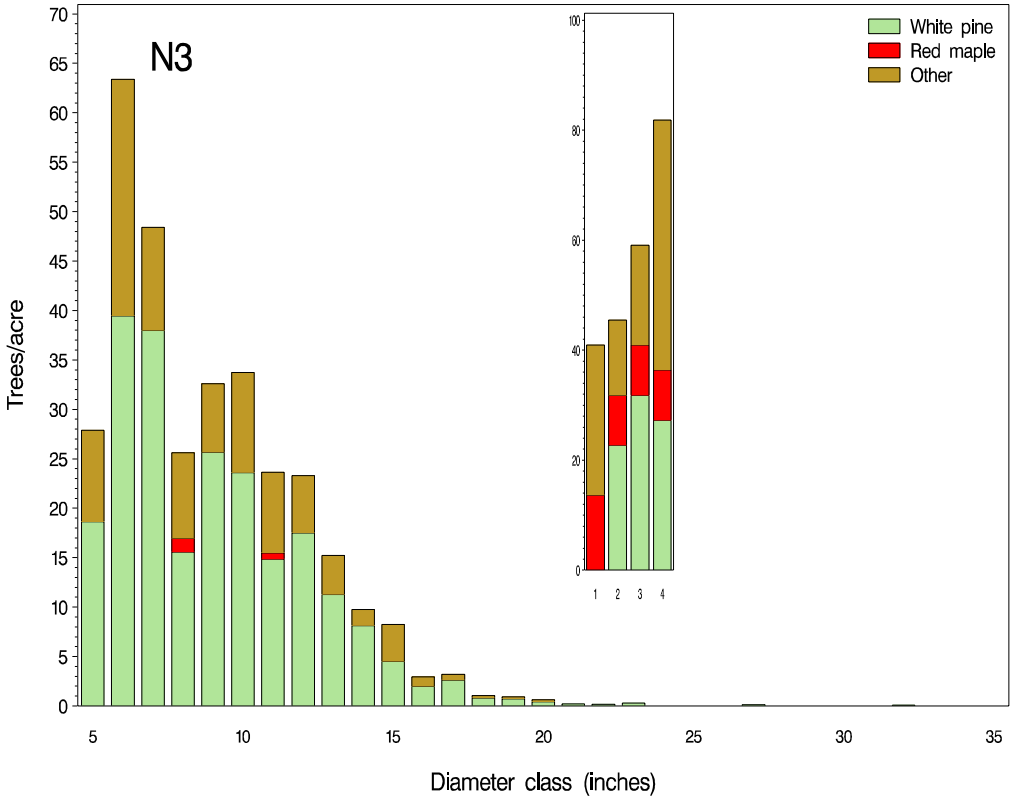

Figure 11.—Number of trees per acre by diameter classes and major tree species in Parcel N3, northern unit, Massabesic Experimental Forest.

Table 6.—Number of trees and basal/per acre for all live trees ≥ 0.5 inch dbh and gross volume/acre for all live trees ≥ 4.5 inch dbh by species and species group in Parcel N4, northern unit, Massabesic Experimental Forest.

Species	Number of trees	Basal area	Percent basal area	Volume
		ft²/acre		*ft³/acre*
		Softwoods		
Eastern hemlock	654	16.9	9.9	78
Eastern white pine	241	66.2	38.6	1,636
Balsam fir	155	5.2	3.0	—
Red pine	11	5.5	3.2	133
Red spruce	9	0.3	0.2	—
Subtotal	1,070	94.1	54.9	1,847
		Hardwoods		
Red maple	529	36.2	21.1	563
Paper birch	189	18.0	10.5	133
Yellow birch	82	2.6	1.5	—
American beech	76	5.0	2.9	33
Gray birch	56	5.3	3.1	74
Northern red oak	46	6.7	3.9	126
Quaking aspen	9	2.7	1.6	70
Black oak	2	0.9	0.5	26
Subtotal	989	77.4	45.1	1,025
Total	2,059	171.5	100.0	2,872

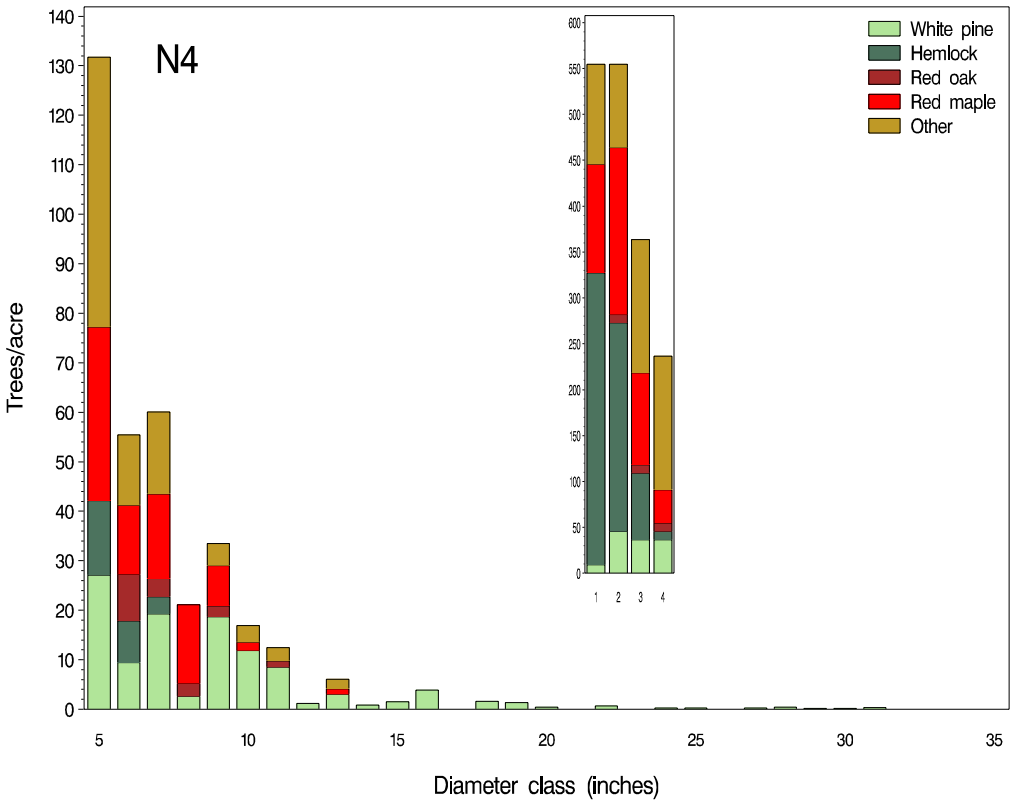

Figure 12.—Number of trees per acre by diameter classes and major tree species in Parcel N4, northern unit, Massabesic Experimental Forest.

In the area sampled (107 acres) there are 915 live trees/acre, basal area of 97.8 ft^2/acre, and volume of 1,887 ft^3/acre (Table 8). The parcel contains slightly more than a quarter softwood species by basal area. White pine is the major softwood species, in terms of number of trees and basal area, and important hardwoods include red maple, red oak, and paper birch. These four species account for more than 85 percent of the basal area. Sixty-two percent of the volume is red oak, red maple, and paper birch. There is a mix of hardwoods and pine across the diameter distribution (Fig. 14).

Parcel S3 — This is the largest parcel (1,363 acres) in the MEF but only 593 acres were suitable for sampling because of the presence of extensive wetlands. Parcel S3 is diverse in terms of topography, agricultural history, wetlands, fire history, and effects of hurricanes. It has had experimental plantings of softwoods and hardwoods, softwood plantings to replace stands lost to fire, and management interventions, such as thinning and herbicide applications, to encourage natural pine. Parcel S3 has 1,338 live trees/acre, basal area of 189.4 ft^2/acre, and volume of 4,610 ft^3/acre (Table 9). Almost three-fourths of the basal area is softwood species. Important softwoods are white pine and hemlock, in terms of number of trees and basal area, and important hardwoods include red maple and red oak. These four species account for more than 92 percent of the basal area. More than half of the volume is white pine; hemlock, red oak, and red maple account for most of the remainder. The diameter distribution shows that most species categories are represented over the range of classes. Both red oak and white pine are present in the 1 - 4 inch diameter classes (Fig. 15).

Parcel S4 — This parcel was a natural pine forest that partially burned in the 1947 fire. Although there were a few small plantings of pine, the area was largely left to regenerate naturally. In the area sampled (54 acres) there are 1,220 live trees/acre, basal area of 130.1 ft^2/acre, and volume of 2,666 ft^3/acre (Table 10). The parcel is half softwoods and half hardwoods by basal area. White pine and hemlock are the major softwood species, in terms of number of trees and basal area, and important hardwoods include red oak, red maple, and white oak. These five species comprise nearly 90 percent of the basal area and 88 percent of the volume. The diameter distribution indicates that most species are represented

Table 7.—Number of trees and basal area/acre for all live trees ≥ 0.5 inch dbh and gross volume/acre for all live trees ≥ 4.5 inch dbh by species and species group in Parcel S1, southern unit, Massabesic Experimental Forest.

Species	Number of trees	Basal area	Percent basal area	Volume
		ft²/acre		*ft³/acre*
		Softwoods		
Eastern hemlock	2,388	66.6	37.2	228
Eastern white pine	115	45.5	25.4	1,270
Subtotal	2,503	112.1	62.6	1,498
		Hardwoods		
Red maple	350	24.7	13.8	417
Paper birch	174	15.9	8.9	140
Yellow birch	67	3.3	1.8	12
Northern red oak	50	18.5	10.3	512
American beech	38	1.0	0.6	—
Sweet birch	15	0.5	0.3	—
Gray birch	15	1.0	0.6	—
White oak	8	1.9	1.1	50
Subtotal	717	66.8	37.4	1,131
Total	3,220	178.9	100.0	2,629

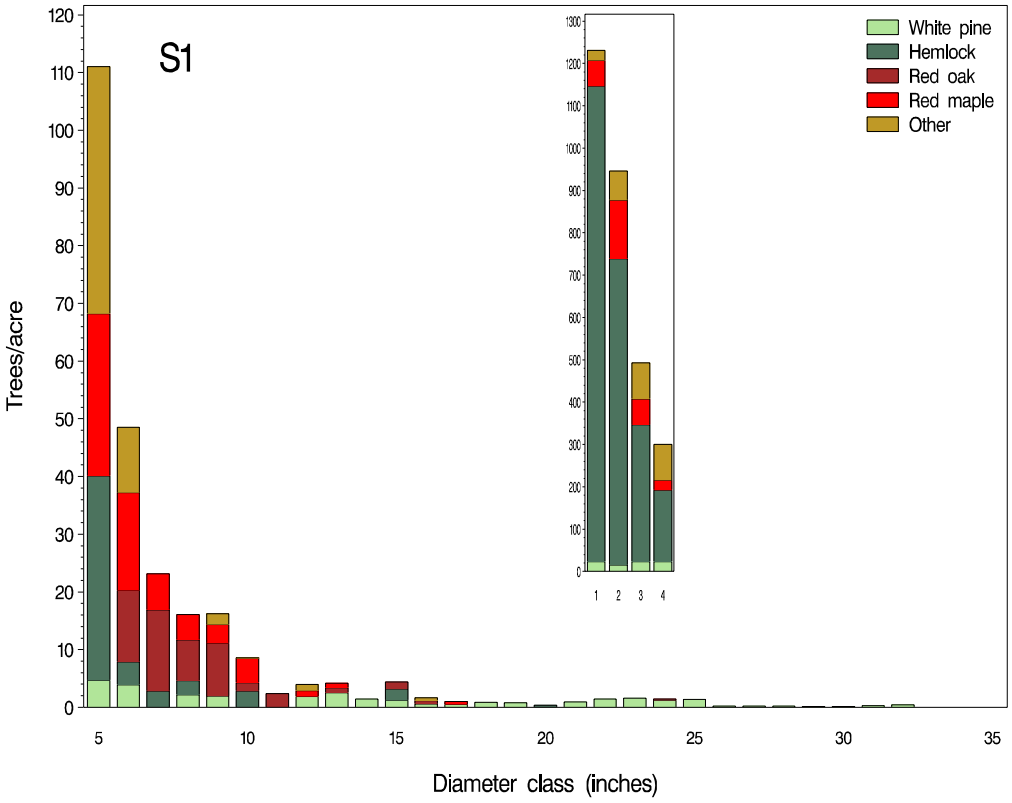

Figure 13.—Number of trees per acre by diameter classes and major tree species in Parcel S1, southern unit, Massabesic Experimental Forest.

Table 8.—Number of trees and basal area/acre for all live trees ≥ 0.5 inch dbh and gross volume/acre for all live trees ≥ 4.5 inch dbh by species and species group in Parcel S2 southern unit, Massabesic Experimental Forest.

Species	Number of trees	Basal area	Percent basal area	Volume
		ft²/acre		*ft³/acre*
		Softwoods		
Eastern white pine	126	25.9	26.5	591
Red pine	11	0.5	0.5	9
Subtotal	137	26.4	27.0	600
		Hardwoods		
Red maple	311	31.9	32.6	551
Sweet birch	157	3.9	4.0	9
Gray birch	93	4.2	4.3	38
Paper birch	88	12.0	12.3	206
Yellow birch	64	2.4	2.5	—
Northern red oak	42	13.6	13.9	413
White oak	9	1.8	1.8	34
Quaking aspen	5	0.6	0.6	13
Black cherry	5	<0.1	<0.1	—
American elm	3	0.5	0.5	8
Bigtooth aspen	1	0.5	0.5	14
Subtotal	778	71.4	73.0	1,287
Total	915	97.8	100.0	1,887

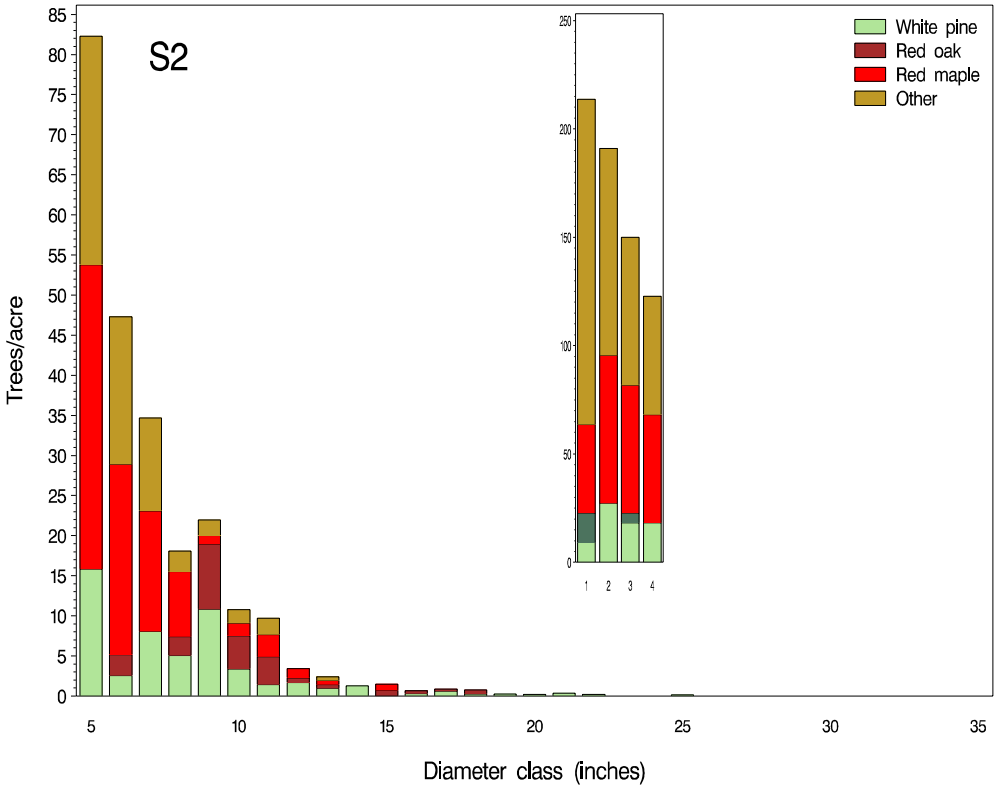

Figure 14.—Number of trees per acre by diameter classes and major tree species in Parcel S2, southern unit, Massabesic Experimental Forest.

Table 9.—Number of trees and basal area/acre for all live trees ≥ 0.5 inch dbh and gross volume/acre for all live trees ≥ 4.5 inch dbh by species and species group in Parcel S3, southern unit, Massabesic Experimental Forest.

Species	Number of trees	Basal area	Percent basal area	Volume
		ft²/acre		*ft³/acre*
		Softwoods		
Eastern hemlock	675	50.9	26.9	912
Eastern white pine	147	84.7	44.7	2,485
Balsam fir	16	0.4	<1	1
Red pine	3	3.4	1.8	97
Pitch pine	<1	0.1	<1	3
Subtotal	841	50.2	73.7	3,498
		Hardwoods		
Red maple	282	21.4	11.3	438
Northern red oak	87	17.5	9.2	454
Yellow birch	41	1.3	0.7	13
Paper birch	32	4.0	2.1	65
White oak	11	1.9	1.0	53
Sugar maple	10	0.7	0.4	10
White ash	9	0.7	0.4	13
American beech	8	1.1	0.6	34
Moose maple	6	0.2	0.1	—
Sweet birch	3	0.6	0.3	18
Bigtooth aspen	2	<0.1	<0.1	—
Gray birch	2	<0.1	<0.1	—
Black gum	2	<0.1	<0.1	—
Black cherry	1	0.1	<0.1	3
Quaking aspen	<1	0.3	0.1	8
Black ash	<1	0.1	<0.1	3
Subtotal	497	49.9	26.3	1,112
Total	1,338	189.4	100.0	4,610

over the range of diameter classes. Both red oak and white pine are present in the 1 - 4 inch diameter classes and red oak accounts for a large proportion of trees greater than 5 inches (Fig. 16).

Parcel S5 — Most of Parcel S5 burned in the 1947 fire and many of the surviving trees blew down in hurricanes in 1950 and 1954. Some white pine and red pine were planted, and hardwood competition was controlled by mechanical and chemical treatments. Most of the parcel was left to regenerate naturally. In the area sampled (25 acres) there are 2,856 live trees/acre, basal area of 169.0 ft^2/acre, and volume of 2,495 ft^3/acre (Table 11). This parcel contains more softwood (58 percent of basal area) than hardwood (42 percent). Hemlock and white pine are the major softwood species, in terms of number of trees and basal area, and important hardwoods include red maple, white oak, and red oak. These five species account for nearly 92 percent of the basal area. Almost 93 percent of the volume is from white pine, red oak, white oak, hemlock, and paper birch. The diameter distribution shows that hemlock in diameter classes smaller than 6 inches is very abundant (Fig. 17).

Parcel S6 — This parcel burned in 1947 and much of it was planted following the fire, mostly with white pine, red pine, and some jack pine. In the area sampled (36 acres) there are 699 live trees/acre, basal area of 160.5 ft^2/

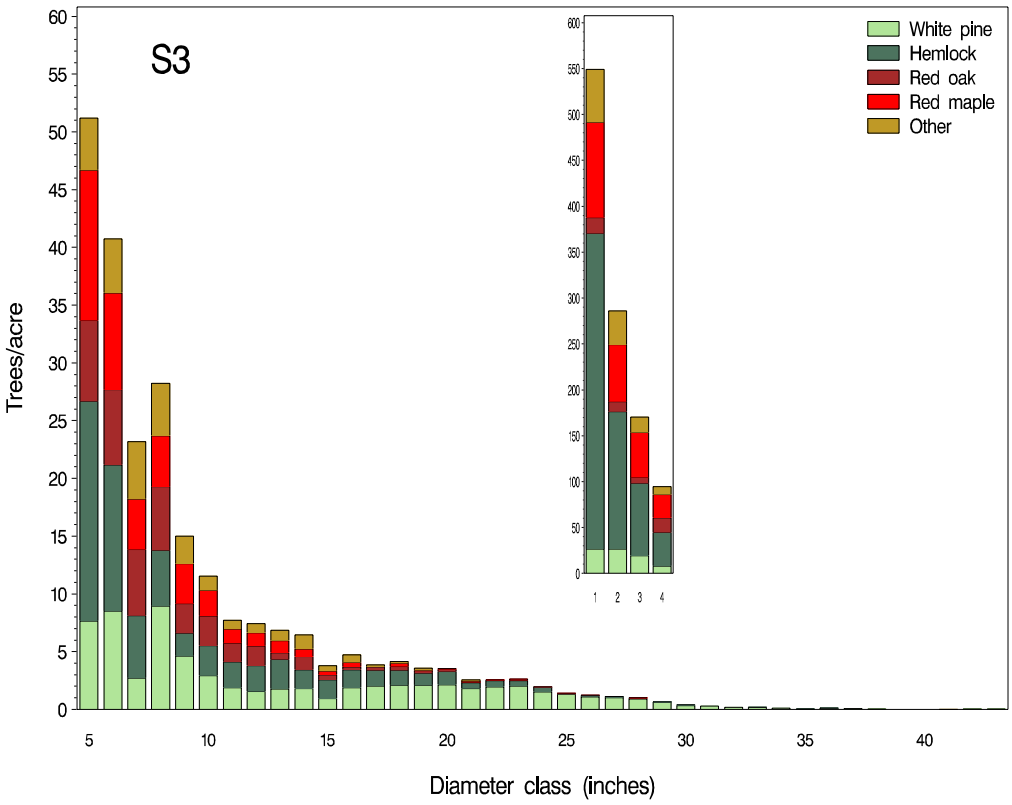

Figure 15.—Number of trees per acre by diameter classes and major tree species in Parcel S3, southern unit, Massabesic Experimental Forest.

acre, and volume of 3,566 ft^3/acre (Table 12). More than 80 percent of the basal area is softwood. Important softwoods include white pine and red pine (mostly planted) and pitch pine (natural), in terms of number of trees and basal area. The hardwood component (< 20 percent of basal area) is gray birch, red oak, and white oak. More than 58 percent of the basal area and nearly 60 percent of the total volume is white pine. The diameter distribution of the parcel is characteristic of an even-aged planting (Fig. 18).

Large live trees

Trees at least 18 inches dbh (large trees) are of particular interest because they often define the ecological character of a forest. Their importance to wildlife is well documented (DeGraaf and Yamasaki 2001, DeGraaf et al. 1992, Morrison et al. 1992). Because of their size and shape, large trees appeal to people aesthetically and spiritually. The southern unit contains the largest Atlantic white-cedar recorded in Maine. In 1999, it was 21.6 inches dbh, had a crown diameter of 19 ft, and was 63 ft tall.

We estimate that there are 14 live trees/acre that are 18 inches dbh or larger, or almost 27,000 on the area sampled. Of those measured, 66 percent are white pine, 16 percent hemlock, 11 percent red oak, 4 percent red maple, and 2 percent white oak (Table 13). The remaining 1 percent includes a few each of red pine, yellow birch, American beech, sugar maple, and paper birch. Parcel S3 has more large trees than average for the MEF, with 19.8 large, live white pines/acre. This abundance could be due to light harvest activity over the past century compared to the rest of the property, and because the parcel includes a relatively large area that did not burn in 1947. Northern red oak in this size class is most abundant in Parcel N1, with 4.4 large, live trees/acre.

Table 10.—Number of trees and basal area/acre for all live trees ≥ 0.5 inch dbh and gross volume/acre for all live trees ≥ 4.5 inch dbh by species and species group in Parcel S4, southern unit, Massabesic Experimental Forest.

Species	Number of trees	Basal area	Percent basal area	Volume
		ft²/acre		*ft³/acre*
		Softwoods		
Eastern hemlock	431	24.8	19.1	205
Eastern white pine	206	31.1	23.9	701
Pitch pine	10	6.5	5.0	187
Red pine	7	2.7	2.1	72
Subtotal	654	65.1	50.0	1,165
		Hardwoods		
Red maple	321	14.0	10.8	225
Northern red oak	124	34.0	26.1	902
White oak	50	12.5	9.6	326
Yellow birch	31	2.1	1.6	18
Paper birch	12	0.6	0.5	—
White ash	12	0.2	0.2	—
Gray birch	6	0.4	0.3	—
Black cherry	6	<0.1	<0.1	—
Quaking aspen	4	1.2	0.9	30
Subtotal	566	65.0	50.0	1,501
Total	1,220	130.1	100.0	2,666

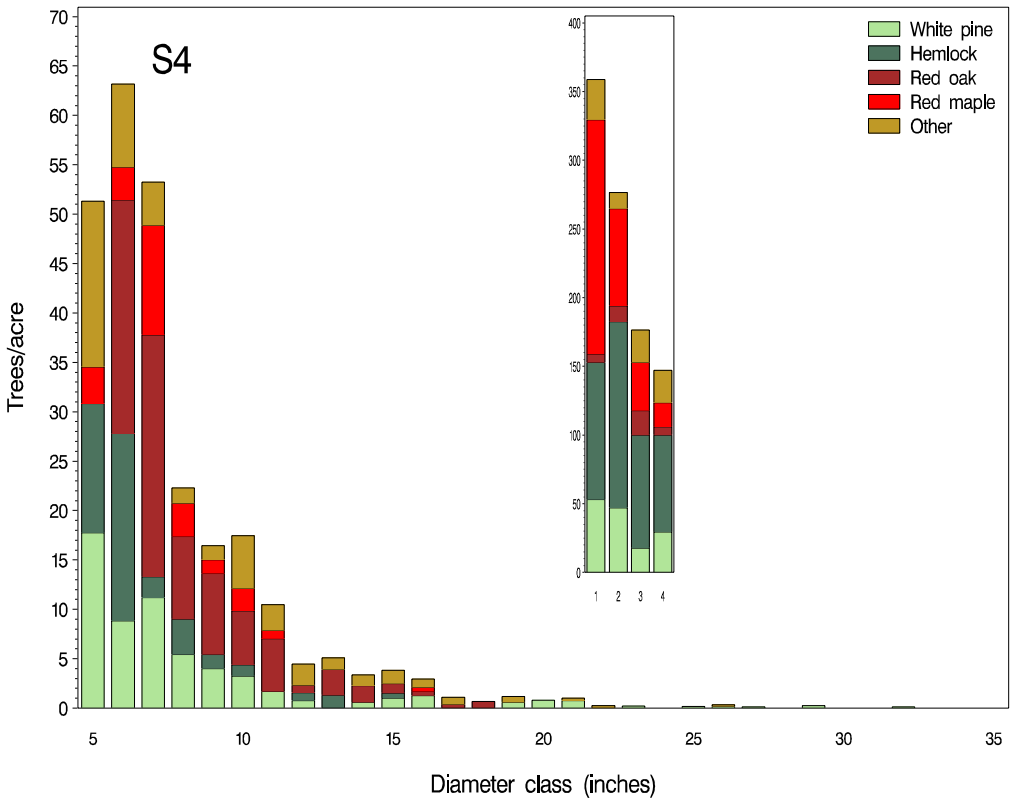

Figure 16.—Number of trees per acre by diameter classes and major tree species in Parcel S4, southern unit, Massabesic Experimental Forest.

Table 11.—Number of trees and basal area/acre for all live trees ≥ 0.5 inch dbh and gross volume/acre for all live trees ≥ 4.5 inch dbh by species and species group in Parcel S5, southern unit, Massabesic Experimental Forest.

Species	Number of trees	Basal area	Percent basal area	Volume
		ft²/acre		*ft³/acre*
		Softwoods		
Eastern hemlock	2,083	64.1	37.9	360
Eastern white pine	148	32.8	19.4	728
Balsam fir	25	0.7	0.4	—
Subtotal	2,256	97.6	57.7	1,088
		Hardwoods		
Red maple	272	14.0	8.3	159
White oak	131	21.8	12.9	419
Northern red oak	73	22.5	13.3	630
Paper birch	51	9.8	5.8	179
Yellow birch	50	1.6	1.0	—
Gray birch	13	0.4	0.2	—
Sweet birch	10	1.3	0.8	20
Subtotal	600	71.4	42.3	1,407
Total	2,856	169.0	100.0	2,495

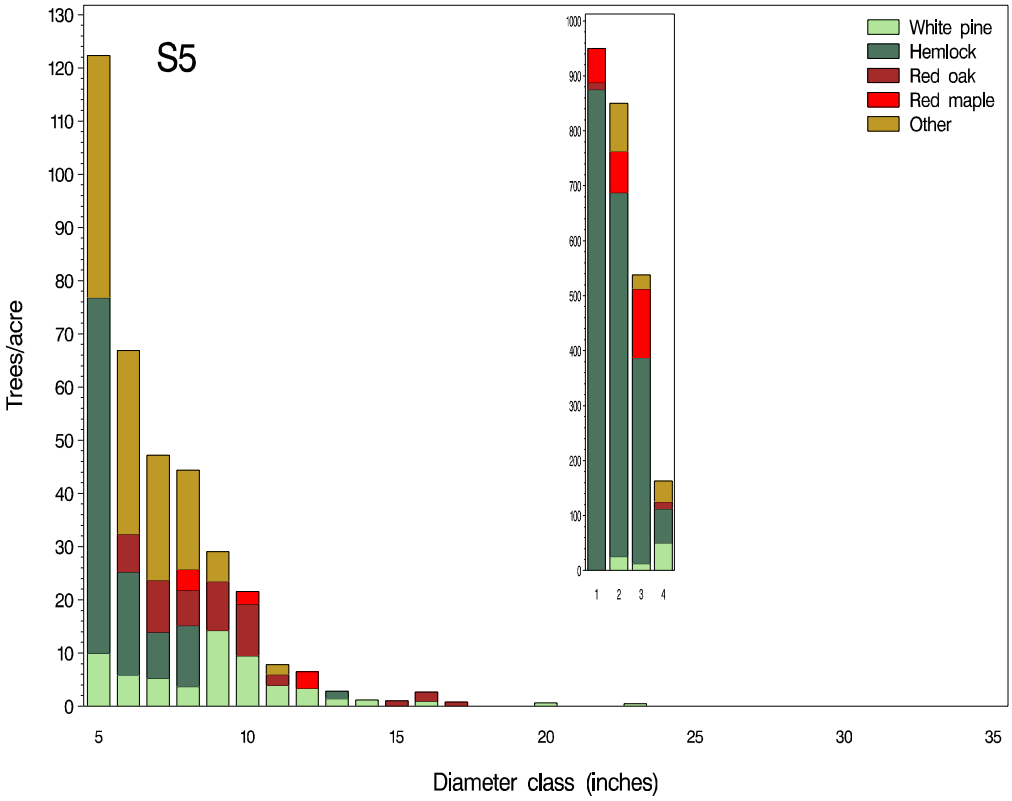

Figure 17.—Number of trees per acre by diameter classes and major tree species in Parcel S5, southern unit, Massabesic Experimental Forest.

Table 12.—Number of trees and basal area/acre for all live trees ≥ 0.5 inch dbh and gross volume/acre for all live trees ≥ 4.5 inch dbh by species and species group in Parcel S6, southern unit, Massabesic Experimental Forest.

Species	Number of trees	Basal area	Percent basal area	Volume
		ft²/acre		*ft³/acre*
		Softwoods		
Eastern white pine	403	93.9	58.6	2,124
Pitch pine	63	18.7	11.6	450
Red pine	50	16.4	10.2	351
Subtotal	516	129.0	80.4	2,925
		Hardwoods		
Gray birch	101	10.0	6.2	81
White oak	34	9.9	6.2	256
Northern red oak	31	10.7	6.7	290
Black cherry	10	0.7	<1	14
Red maple	7	0.2	<1	—
Subtotal	183	31.5	19.6	641
Total	699	160.5	100.0	3,566

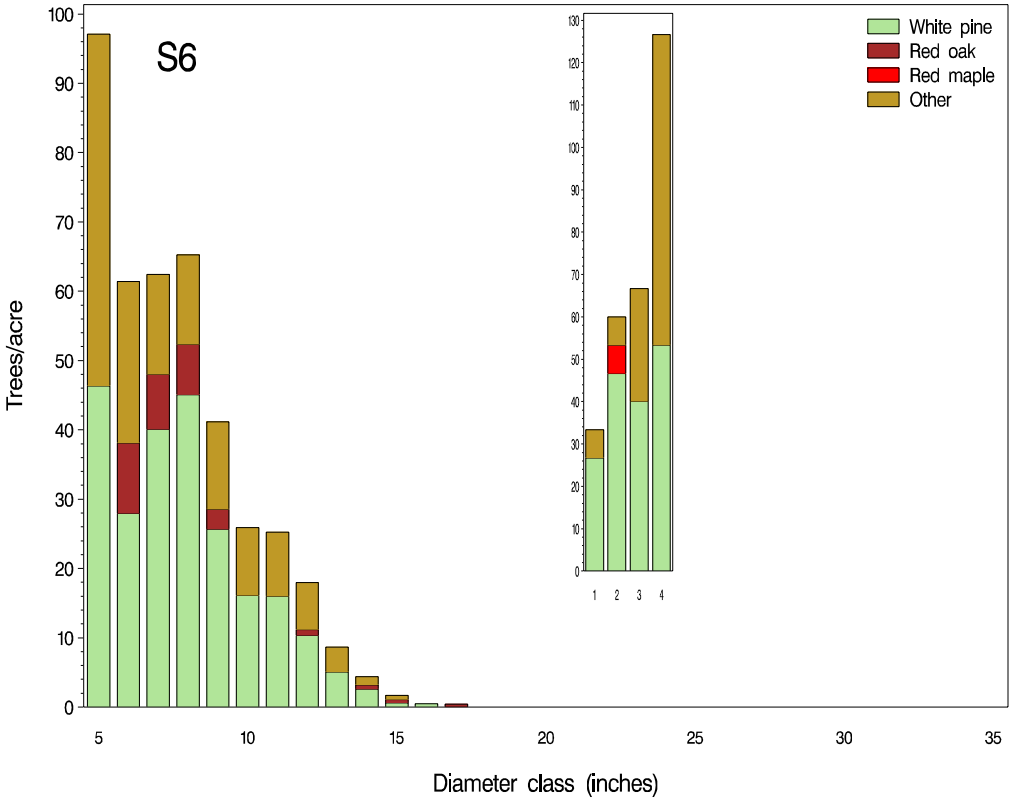

Figure 18.—Number of trees per acre by diameter classes and major tree species in Parcel S6, southern unit, Massabesic Experimental Forest.

Table 13.—Number of live trees/acre ≥ 18 inches dbh by species, parcel, unit, and total forest.

Parcel	Eastern white pine	Eastern hemlock	Red pine	Northern red oak	Red maple	White oak	Yellow birch	Sugar maple	American beech	Paper birch
N1	4.6	0.5	0.0	4.4	2.2	0.0	0.0	0.0	0.0	0.0
N2	5.1	1.0	0.1	2.4	0.5	0.4	0.1	0.1	0.1	<0.1
N3	2.8	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N4	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Northern unit	4.9	0.9	0.1	2.1	0.5	0.3	0.1	<0.1	<0.1	<0.1
S1	9.9	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
S2	1.4	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
S3	19.8	6.0	0.2	0.9	0.7	0.2	0.0	<0.1	0.0	0.0
S4	3.2	0.0	0.6	0.7	0.0	0.6	0.0	0.0	0.0	0.0
S5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Southern unit	14.6	4.2	0.2	0.8	0.5	0.2	0.0	<0.1	0.0	0.0
Forest	9.2	2.3	0.1	1.5	0.5	0.3	<0.1	<0.1	<0.1	<0.1

Dead trees

Dead trees are important as snags, which are used by wildlife, and as future downed coarse woody material that will remain on the forest floor for many years. They provide habitat, carbon and moisture storage, and a site for regeneration of tree seedlings.

Inventory data for standing dead trees includes trees 4.5 inches dbh or greater, not just large trees. We summarized these data by parcel, unit, species group, and size class (Table 14). Parcels N3 and S6 were largely replanted with softwood species after the 1947 fire, possibly explaining why we found no dead hardwoods 4.5 inches dbh or larger. There are no dead softwood trees 11.5 inches dbh or larger recorded for S6 but N3 has dead softwood trees in all size classes. The two largest compartments, N2 and S3, have dead trees in all three size-classes for both softwoods and hardwoods. Both the northern unit and southern unit have similar numbers of dead trees/acre in all three size-classes for both softwood and hardwood species-groups. The northern unit averages a total of 15.3 dead trees/acre and the southern unit 22.8 dead trees/acre.

Tree mortality, especially among smaller diameter classes, can provide clues to likely future composition of the overstory. For example, at a point in time one species in a stand may have more stems/acre than another, suggesting that without disturbance it will eventually dominate the overstory. However, if trees of the more abundant species die at a faster rate, the less abundant species may eventually dominate. These inventory results represent only one point in time so the mortality rates among species cannot yet be determined. Nevertheless, comparing the percentage of dead trees by diameter class provides insight into likely changes in species composition across the forest. Compared to other species, eastern hemlock has a relatively low percentage of dead trees in the 1 - 8 inch diameter classes (Table 15), suggesting that the proportion of hemlock will increase in the MEF, if it is not infested by hemlock woolly adelgid (*Adelges tsugae* Annand.). White pine has the greatest percentage of dead trees in both units, and in most diameter classes. Consequently, without disturbance or management that focuses on white pine, it could decline in importance. Overall, the percentage of dead trees is similar among species in the two units except for red oak, which has about 10 percent more dead trees in the southern unit than in the northern unit. Thus, like white pine, the prevalence of red oak might also decline, especially in the southern unit.

Table 14.—Number of dead trees/acre by parcel, unit, species group, and size class in the Massabesic Experimental Forest.

Parcel	Area *(acres)*	Softwood			Hardwood			Total
		Small[a]	Medium[b]	Large[c]	Small[a]	Medium[b]	Large[c]	
N1	36	2.3	1.0	0.2	7.8	1.7	0.3	13.3
N2	881	8.1	0.5	0.3	5.2	1.6	0.2	15.9
N3	91	2.3	0.4	0.3	0.0	0.0	0.0	3.0
N4	35	19.1	0.0	0.5	12.9	0.0	0.0	32.5
Northern unit	1043	7.8	0.5	0.3	5.1	1.4	0.2	15.3
S1	37	0.0	2.5	0.4	15.7	1.3	0.0	19.9
S2	107	3.7	0.0	0.0	15.8	0.4	0.1	20.0
S3	593	12.2	0.9	0.5	6.6	0.5	0.1	20.8
S4	54	9.3	0.0	0.0	31.2	0.0	0.0	40.5
S5	25	13.7	0.0	0.0	62.0	0.0	0.0	75.7
S6	36	4.9	0.0	0.0	0.0	0.0	0.0	4.9
Southern unit	852	10.1	0.8	0.4	11.1	0.4	0.1	22.8

[a]Small: 4.5 - 11.4 inches dbh
[b]Medium: 11.5 - 17.4 inches dbh
[c]Large: 17.5 inches dbh or larger

Table 15.—Trees in the sapling and pole size classes in the Massabesic Experimental Forest that were dead when sampled, by unit and species.

Unit	Species	Diameter class (*inches*)								
		1	2	3	4	5	6	7	8	Overall
		Percentage dead trees								
North	White pine	44.6	37.7	30.4	16.9	15.7	6.8	8.5	2.0	24.3
	Red maple	29.5	10.6	5.9	0	0	0	0	3.4	15.6
	Red oak	17.6	10.4	6.4	17.3	0	12.7	8.2	7.9	1.3
	Hemlock	9.6	3.1	0.9	1.8	0	2.4	0	0	6.6
South	White pine	23.8	26.4	27.0	19.0	20.5	8.4	13.0	6.2	21.8
	Red oak	30.6	25.8	27.2	19.3	26.9	10.3	0	9.2	21.2
	Red maple	27.1	23.2	11.5	4.4	3.3	0	0	0	18.8
	Hemlock	16.5	5.8	1.7	2.4	4.4	2.6	5.7	18.3	10.8

Tree Seedlings

Regeneration is the basis of the future forest. Tree seedlings greater than 1 ft tall and with dbh less than 0.5 inches are present on most but not all 0.01-acre plots. Among parcels, S3 has the greatest number of seedlings/acre, followed by S4, N1, and N2. Hemlock is the most abundant seedling, especially in S3, with an average of 1,091 seedlings/acre (Table 16). This species is also abundant in N2, S5, and N1. White pine seedlings are most abundant in N1, followed by S3 and N2. Red maple seedlings are most abundant in S4, followed by S2 and N1. Oaks, including red and white, are most abundant in S6, followed by S5, S2, S1, N1, and S4. Seedlings found in a high percentage of plots throughout the MEF include red maple, paper birch, white pine, trembling aspen (*Populus tremuloides*), black cherry, white oak, red oak, and hemlock.

Table 16.—Seedlings/acre, by parcel in the Massabesic Experimental Forest. Seedlings are defined as trees > 1 ft high and < 0.5 inch dbh.

Scientific name	Common name	Parcel									
		S1	S2	S3	S4	S5	S6	N1	N2	N3	N4
Abies balsamea	balsam fir			130.6	5.9	12.5			70.0		172.7
Acer pensylvanicum	striped maple			3.6				27.3	5.9		
Acer rubrum	red maple	133.3	235.3	121.6	641.2	75.0	93.3	236.4	92.9	9.1	54.5
Acer saccharum	sugar maple			3.6				9.1			
Betula alleghaniensis	yellow birch		29.4	12.6	11.8				14.1		18.2
Betula lenta	sweet birch		17.6	0.9					5.9		
Betula papyrifera	paper birch		5.9	8.1				18.2	8.8		
Betula populifolia	gray birch	8.3	23.5	7.2		37.5	73.3	9.1	25.9	68.2	72.7
Betula sp.	birch species							18.2			
Carpinus caroliniana	American hornbeam			0.9							
Crataegus sp.	hawthorn species			1.8				9.1	15.3		
Fagus grandifolia	American beech			17.1				127.3	53.5		
Fraxinus americana	white ash			13.5	70.6			9.1	4.7		
Juniperus communis var. depressa	common juniper			0.9					0.6		
Nyssa sylvatica	black tupelo			3.6					1.8		
Ostrya virginiana	eastern hophornbeam								2.4		
Picea rubens	red spruce			0.9					5.3	4.5	
Pinus rigida	pitch pine			0.9							
Pinus strobus	eastern white pine	50.0	64.7	255.9	164.7	12.5	60.0	418.2	164.7	4.5	
Populus tremuloides	quaking aspen		17.6	5.4	11.8				1.2	31.8	
Prunus serotina	black cherry		100.0	72.1	111.8		206.7		38.8	118.2	18.2
Quercus alba	white oak	183.3	23.5	36.9	317.6	12.5	186.7	81.8	63.5	27.3	
Quercus ilicifolia	bear oak								5.3		
Quercus rubra	northern red oak	158.3	182.4	97.3	147.1	212.5	293.3	154.5	80.0	31.8	9.1
Tsuga canadensis	eastern hemlock	91.7		1091.0	58.8	225.0		218.2	348.8		27.3
Ulmus americana	American elm								0.6		
Ulmus sp.	elm species		17.6						0.6		
Unknown dead hardwood	unknown dead hardwood			1.8							
Total		625.0	717.6	1888.3	1541.2	587.5	913.3	1336.4	1010.6	295.5	372.7

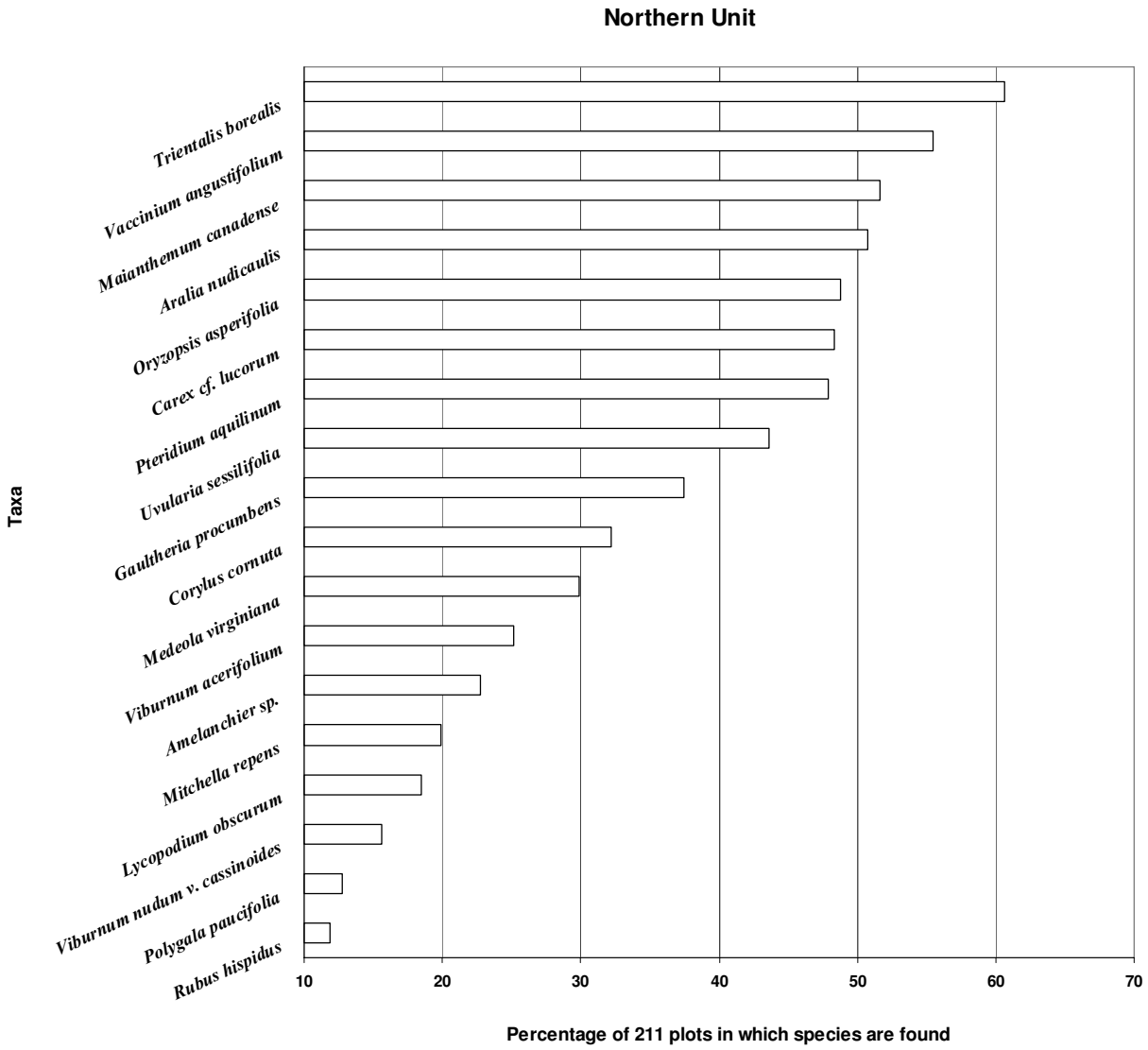

Figure 19.—Common understory plants in the northern unit, Massabesic Experimental Forest.

Understory Plants—Shrubs and Herbs

Density (stems/acre) of shrubs taller than 1 ft in 0.01-acre plots is greatest in Parcel N3, followed by S1 and N2 (Table 17). The most abundant shrub species in the MEF is beaked hazelnut (*Corylus cornuta*), especially in N3 and N2. The genus *Viburnum*, which includes here witherod (*V. nudum* var. *cassinoides*), arrowwood (*V. dentatum*), and maple-leaved viburnum (*V. acerifolium*), is common and abundant across the forest, especially in N3. Highbush blueberry (*Vaccinium corymbosum*) is most abundant in S1 and S6. Winterberry (*Ilex verticillata*), a facultative wetland species (Appendix II), is abundant in N1 and S1. Other shrubs that average more than 100 stems/acre on a single parcel include witch-hazel (*Hamamelis virginiana*), sheep laurel (*Kalmia angustifolia*), and speckled alder (*Alnus incana* ssp. *rugosa*), an obligate wetland species (Appendix II). Parcel N4 has no plots with shrubs taller than 1 ft, although shrub species shorter than 1 ft were present and shrubs were evident in the meander transects. We did not collect shrub data for parcels S2 and S5.

A common shrub, low sweet blueberry (*Vaccinium angustifolium*), is not represented in the stem count data (Table 17) because of its growth habit, which is usually shorter than 1 ft, yet it has a higher frequency than most other understory species (Table 18; Figs. 19 and 20). We found this species in 55 percent of the 211 plots in the northern unit and in 63 percent of those in the southern unit. The frequency of low sweet blueberry could be due to sandy soils, fire history, and seed longevity in the soil. Other common shrubs found in more than 10 percent of plots for one or both units are beaked hazelnut, maple-leaved viburnum, shadbush (*Amelanchier sp.*),

Table 17.—Shrub stems/acre found on fixed plots in eight parcels and by unit in the Massabesic Experimental Forest. Data for S2 and S5 are not available.

Scientific Name	Common Name	N1	N2	N3	N4	NU Total	S1	S3	S4	S6	SU Total
Alnus incana ssp. rugosa	speckled alder		7			5		27	6		16
Alnus sp.	alder species	18	0			1					0
Amelanchier sp.	shadbush species	18	13	27		14		33	82	53	31
Carpinus caroliniana	American hornbeam		0			0		<1			<1
Cornus alternifolia	alternate-leaved dogwood		<1			<1					0
Corylus cornuta	beaked hazlenut		360	568		344		79	18	147	61
Crataegus sp.	hawthorn species	36	16			14		2			1
Diervilla lonicera	bush-honeysuckle	9	0			<1					0
Gaylussacia baccata	black huckleberry		0			0		5		53	7
Hamamelis virginiana	witch-hazel		132			105		116			70
Ilex verticillata	winterberry	318	4			20	169	15			21
Juniperus communis v. depressa	common juniper		<1			<1		<1			<1
Kalmia angustifolia	sheep laurel		0			0	185			7	13
Lyonia ligustrina	maleberry		2			2	169	5	6		15
Nemopanthus mucronatus	mountain holly		<1			<1	77	2	6	13	8
Photinia melanocarpa	black chokeberry		1			1	8	2	18	47	7
Quercus ilicifolia	bear oak		5			4					0
Rhododendron canadense	rhodora		12			9					0
Spiraea latifolia	meadowsweet		0			0		4			2
Vaccinium corymbosum	highbush blueberry		23			18	354	8		180	44
Viburnum acerifolium	maple-leaved viburnum		42			33		<1			<1
Viburnum lentago	unknown seedling		1			1					0
Viburnum nudum v. cassinoides	witherod		2	477		52		6	6		4
Viburnum dentatum	arrowwood		1			1					0
	Total		622	1073		625	962	303	141	500	301

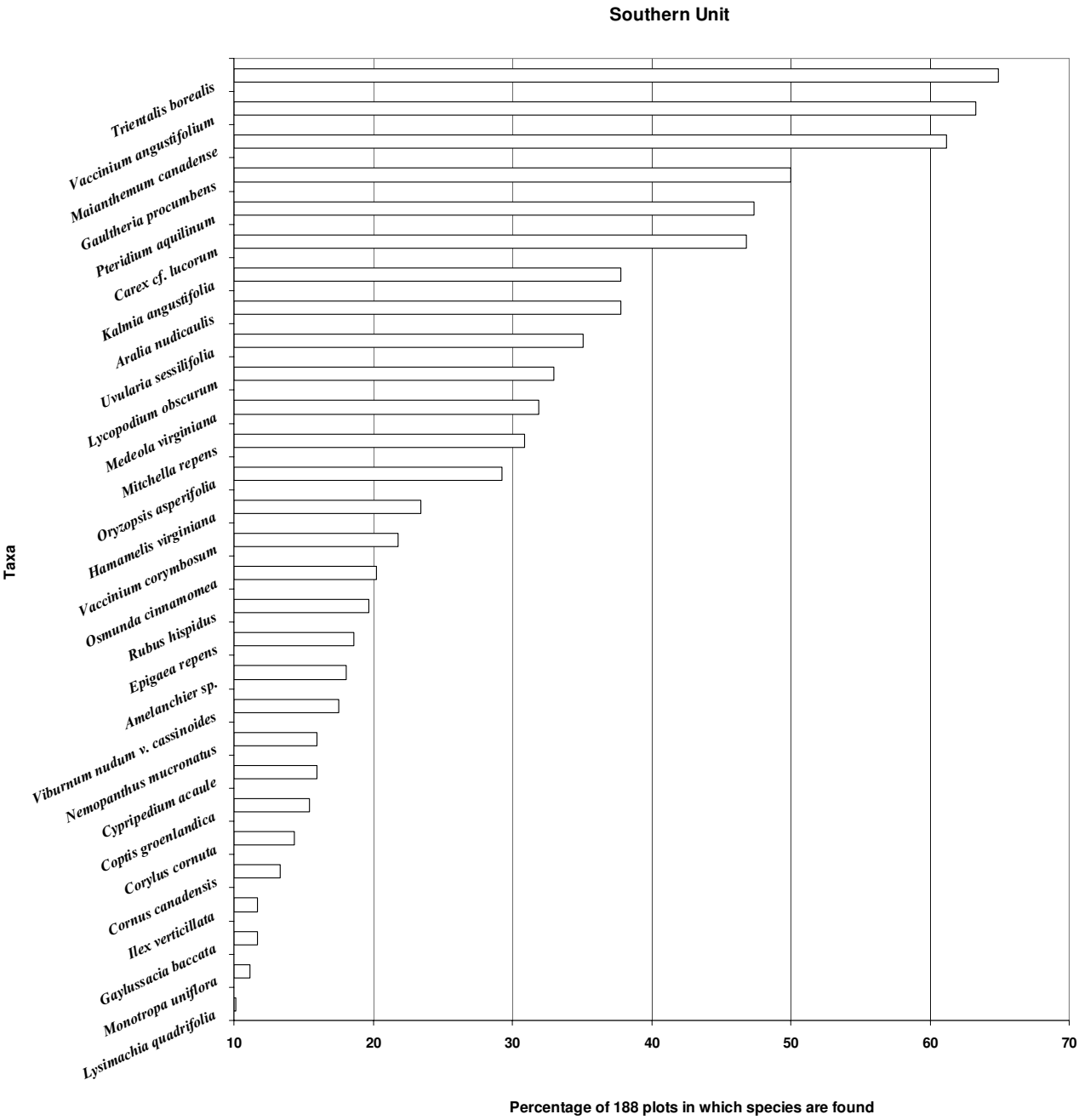

Figure 20.—Common understory plants in the southern unit, Massabesic Experimental Forest.

witch-hazel, highbush blueberry, mountain holly (*Nemopanthus mucronatus*), black huckleberry (*Gaylussacia baccata*), winterberry, sheep laurel, and witherod (Figs. 19 and 20).

One way to examine the frequency of understory plants is by the number of parcels in which they are found. In addition to low sweet blueberry, all 10 parcels have highbush blueberry, wintergreen (*Gaultheria procumbens*), mountain rice (*Oryzopsis asperifolia*), bracken fern (*Pteridium aquilinum*) and club moss (*Lycopodium obscurum*). Nine of ten parcels have wild sarsaparilla (*Aralia nudicaulis*), partridgeberry (*Mitchella repens*), swamp dewberry (*Rubus hispidus*), pink lady's slipper (*Cypripedium acaule*), Canada mayflower (*Maianthemum canadense*), and cow-wheat (*Melampyrum lineare*) (Figs. 19 and 20).

Another way to consider frequency is in the number of plots where a species was found (Table 18). The three most frequent understory species in each unit are the same and in the same order—starflower (*Trientalis*

Table 18.—Percentage of plots in which given species was found, by parcel.
No number indicates species was not found during survey.
Number of plots/parcel are shown in parentheses beside parcel name.

	Northern unit					Southern unit						
	N1 (11)	N2 (167)	N3 (22)	N4 (11)	Total (211)	S1 (13)	S2 (22)	S3 (113)	S4 (17)	S5 (8)	S6 (15)	Total (188)
Coniferous trees												
Abies balsamea	18.2	27.5	4.5	63.6	26.5			16.8	17.6	25.0		12.8
Larix laracina			4.5		0.5							
Picea rubens		1.8	9.1	9.1	2.8			1.8				1.1
Pinus resinosa		1.2	36.4	9.1	5.2		4.5	3.5	11.8		20.0	5.3
Pinus rigida		0.6			0.5				5.9		26.7	2.7
Pinus strobus	81.8	80.2	95.5	90.9	82.5	61.5	72.7	92.9	100.0	87.5	100.0	89.4
Pinus sylvestris		0.6			0.5							
Tsuga canadensis	72.7	63.5	13.6	72.7	59.2	76.9	4.5	83.2	58.8	87.5		64.9
Deciduous trees												
Acer pensylvanicum	9.1	7.8			6.6		4.5	0.9				1.1
Acer rubrum	100.0	96.4	72.7	100.0	94.3	92.3	90.9	95.6	100.0	87.5	80.0	93.6
Acer saccharum	18.2	1.8			2.4	7.7		2.7				2.1
Betula alleghaniensis	63.6	24.0		9.1	22.7	38.5	22.7	20.4	5.9	25.0		19.1
Betula lenta	9.1	7.8			6.6	7.7	31.8	6.2	5.9	12.5		9.0
Betula papyrifera	18.2	34.1	9.1	45.5	31.3	46.2	68.2	25.7	11.8	37.5		29.3
Betula populifolia	9.1	17.4	36.4	36.4	19.9	7.7	22.7	1.8	5.9	12.5	46.7	9.0
Betula sp.	9.1	2.4			2.4		9.1					1.1
Carpinus caroliniana					0.0			0.9				0.5
Crataegus cf. *macrosperma*	9.1				0.5							
Crataegus sp.	9.1	9.0			7.6			1.8	11.8			2.1
Fagus grandifolia	72.7	42.5		9.1	37.9	23.1		15.9				11.2
Fraxinus americana	27.3	7.8			7.6			8.0	5.9			5.3
Fraxinus nigra		0.6			0.5							
Fraxinus sp.										12.5		0.5
Malus sylvestris			4.5		0.5							
Nyssa sylvatica		1.2	4.5		1.4		4.5	0.9				1.1
Ostrya virginiana		1.8			1.4							
Populus grandidentata		1.8		9.1	1.9			0.9	5.9			1.1
Populus tremuloides		4.2	22.7	18.2	6.6		9.1	1.8	5.9			2.7
Prunus serotina		28.7	63.6	45.5	31.8		50.0	29.2	29.4	12.5	66.7	31.9
Prunus virginiana			4.5		0.5		4.5	0.9				1.1
Prunus sp.		0.6	4.5		0.9							

	Northern unit					Southern unit						
	N1 (11)	N2 (167)	N3 (22)	N4 (11)	Total (211)	S1 (13)	S2 (22)	S3 (113)	S4 (17)	S5 (8)	S6 (15)	Total (188)
Quercus alba	36.4	38.9	13.6	27.3	35.5	30.8	40.9	30.1	64.7	62.5	80.0	39.9
Quercus ilicifolia		1.2			0.9							
Quercus rubra	100.0	86.2	40.9	90.9	82.5	76.9	72.7	87.6	100.0	62.5	100.0	86.2
Quercus sp.								0.9				0.5
Quercus velutina		0.6			0.5							
Sorbus americana		1.2			0.9							
Ulmus americana		0.6			0.5							
Ulmus sp.		0.6			0.5		4.5					0.5
Shrubs												
Alnus incana ssp. *rugosa*		0.6			0.5		4.5	0.9	5.9			1.6
Alnus cf. *incana* ssp. *rugosa*							4.5					0.5
Alnus sp.	9.1				0.5							
Amelanchier sp.	18.2	22.8	36.4		22.7		22.7	10.6	52.9		53.3	18.1
Comptonia peregrina		4.8	22.7		6.2		13.6	0.9				2.1
Cornus alternifolia		1.2			0.9							
Cornus cf. *racemosa*							4.5					0.5
Cornus sp.		1.2			0.9						6.7	0.5
Corylus cornuta	54.5	33.5	18.2	18.2	32.2		22.7	13.3	11.8		33.3	14.4
Diervilla lonicera		3.0	9.1		3.3		4.5	1.8				1.6
Gaylussacia baccata		1.2	4.5		1.4	7.7	4.5	9.7	41.2	12.5	6.7	11.7
Gaylussacia cf. *baccata*							4.5					0.5
Hamamelis virginiana	81.8	26.3		9.1	25.6		4.5	33.6	29.4			23.4
Ilex verticillata	9.1	3.0	9.1		3.8	15.4	22.7	9.7	17.6		6.7	11.7
Juniperus communis var. *depressa*		0.6			0.5			0.9	5.9			1.1
Kalmia angustifolia	9.1	6.0	4.5		5.7	30.8	27.3	38.1	64.7	50.0	20.0	37.8
Lonicera canadensis		1.2	4.5		1.4							
Lonicera sp.								0.9				0.5
Lyonia ligustrina		2.4			1.9	15.4	9.1	8.0	11.8			8.0
Nemopanthus mucronatus		2.4	13.6	9.1	3.8	15.4	9.1	18.6	5.9		26.7	16.0
Photinia melanocarpa		1.8	18.2		3.3	7.7		4.4	17.6	12.5	13.3	6.4
Rhododendron canadense		0.6			0.5							
Rubus allegheniensis			9.1		0.9							
Rubus cf. canadensis							4.5					0.5
Rubus idaeus		0.6			0.5							
Rubus occidentalis			4.5		0.5			0.9				0.5

Continued.

Table 18.—Continued.

	Northern unit					Southern unit						
	N1 (11)	N2 (167)	N3 (22)	N4 (11)	Total (211)	S1 (13)	S2 (22)	S3 (113)	S4 (17)	S5 (8)	S6 (15)	Total (188)
Rubus sp.		1.2	18.2		2.8			2.7			13.3	2.7
Spiraea latifolia	9.1	2.4	18.2	0.0	4.3		36.4	5.3				7.4
Taxus canadensis		0.6			0.5							
Vaccinium angustifolium	81.8	51.5	72.7	54.5	55.5	38.5	77.3	56.6	88.2	50.0	93.3	63.3
Vaccinium corymbosum	18.2	2.4	4.5	18.2	4.3	23.1	45.5	19.5	17.6	12.5	6.7	21.3
Vaccinium myrtilliodes			9.1		1.4							
Viburnum acerifolium	27.3	29.9			25.1		4.5	10.6		12.5		7.4
Viburnum dentatum	9.1	2.4			2.4		4.5	0.9	5.9			1.6
Viburnum lantanoides	9.1	2.4			2.4							
Viburnum lentago		0.6			0.5							
Viburnum cf. *lentago*		1.2			0.9							
Viburnum nudum var. cassinoides	54.5	14.4	13.6		15.6	15.4	27.3	15.0	29.4		20.0	17.6
Viburnum sp.		0.6			0.5							
Subshrubs												
Aralia nudicaulis	63.6	56.9	4.5	36.4	50.7	38.5	45.5	45.1	17.6	25.0		37.8
Cornus canadensis	18.2	8.4	18.2	9.1	10.0	7.7	4.5	17.7	17.6			13.3
Epigaea repens	36.4	6.6		9.1	7.6		13.6	21.2	29.4	37.5		18.6
Gaultheria procumbens	81.8	38.3	18.2	18.2	37.4	23.1	45.5	50.4	70.6	50.0	53.3	50.0
Mitchella repens	63.6	18.6	13.6	9.1	19.9	7.7	13.6	44.2	17.6	12.5	0.0	30.9
Rubus hispidus	27.3	6.0	54.5		11.8		31.8	23.0	11.8	12.5	6.7	19.7
Rubus pubescens		4.8			3.8		13.6	4.4	5.9	12.5		5.3
Herbs												
Achillea millefolium	9.1				0.5							
Actaea pachypoda		0.6			0.5							
Anaphalis margaritacea		0.6			0.5		4.5					0.5
Anemone quinquefolia		0.6	4.5		0.9				5.9			0.5
Apocynum androsaemifolium		4.8	9.1		4.7		22.7				33.3	5.3
Apocynum sp.		0.6	18.2		2.4							
Arisaema triphyllum		3.6			2.8		13.6	0.9	5.9			2.7
Aster macrophyllus		1.8		9.1	1.9							
Aster sp.	9.1	2.4	13.6	9.1	4.3		22.7	1.8				3.7
Asteraceae sp.		7.2	13.6		7.1			0.9	5.9			1.1
Brassica sp.							4.5					0.5
Circaea alpina		0.6			0.5		4.5	0.9				1.1

	Northern unit					Southern unit						
	N1 (11)	N2 (167)	N3 (22)	N4 (11)	Total (211)	S1 (13)	S2 (22)	S3 (113)	S4 (17)	S5 (8)	S6 (15)	Total (188)
Circaea cf. *alpina*		0.6			0.5							
Clintonia borealis	9.1	7.2		9.1	6.6	7.7		5.3				3.7
Coptis trifolia	18.2	8.4	4.5	18.2	9.0	7.7	13.6	21.2	5.9			15.4
Cypripedium acaule		2.4		36.4	3.8	7.7	27.3	12.4	23.5	12.5	26.7	16.0
Desmodium sp.		0.6			0.5							
Eupatorium maculatum							4.5					0.5
Fallopia cilinodis							4.5					0.5
Fragaria virginiana		0.6			0.5		4.5					0.5
Fragaria cf. *vesca*			4.5		0.5							
Galium asprellum		0.6			0.5							
Galium sp.		0.6			0.5		4.5					0.5
Goodyera tesselata		9.0	9.1		8.1			8.0				4.8
Hieracium sp.		1.8			1.4							
Houstonia caerulea		0.6			0.5		4.5					0.5
Hydrocotyle americana		1.2			0.9		4.5					0.5
Hypericum sp.							4.5					0.5
Impatiens capensis							4.5					0.5
Iris versicolor	9.1	0.6			0.9		9.1					1.1
Lactuca sp.		0.6			0.5							
Lilium philadelphicum							4.5					0.5
Lycopus uniflorus	9.1	2.4			2.4		18.2	0.9				2.7
Lycopus sp.							4.5					0.5
Lysimachia quadrifolia		10.2	4.5		8.5		50.0	3.5	11.8		13.3	10.1
Lysimachia terrestris		1.2			0.9		18.2	0.9				2.7
Maianthemum canadense	36.4	46.7	86.4	72.7	51.7	46.2	77.3	65.5	58.8		53.3	61.2
Maianthemum racemosum	9.1	1.8			1.9			0.9	11.8			1.6
Medeola virginiana	63.6	31.1	9.1	18.2	29.9	7.7	22.7	44.2	23.5			31.9
Melampyrum lineare		3.0	27.3	18.2	6.2	7.7	13.6	0.9	17.6	12.5	26.7	6.9
Mentha sp.		0.6			0.5							
Mitella nuda		0.6			0.5							
Moneses uniflora								0.9	5.9			1.1
Monotropa hypopithys			4.5	9.1	0.9			1.8			6.7	1.6
Monotropa uniflora	9.1	11.4	4.5	0.0	10.0	23.1	9.1	13.3			6.7	11.2
Oclemena acuminata	9.1	3.0		9.1	3.3			0.9	5.9			1.1
Oxalis montana		1.2			0.9							

Continued.

Table 18.—Continued.

	Northern unit					Southern unit						
	N1 (11)	N2 (167)	N3 (22)	N4 (11)	Total (211)	S1 (13)	S2 (22)	S3 (113)	S4 (17)	S5 (8)	S6 (15)	Total (188)
Oxalis stricta									5.9			0.5
Oxalis cf. *stricta*							4.5					0.5
Panax trifolius				9.1	0.5							
Persicaria arifolia							9.1					1.1
Persicaria sp.							4.5					0.5
Platanthera clavellata							9.1					1.1
Polygala paucifolia		10.8	18.2	45.5	12.8		13.6	4.4				4.3
Polygonatum pubescens		2.4		18.2	2.8							
Polygonatum sp.		0.6			0.5							
Polygonum sp.		0.6			0.5							
Potentilla canadensis								0.9				0.5
Potentilla norvegica							4.5					0.5
Potentilla simplex	9.1				0.5		9.1	0.9				1.6
Potentilla cf. *simplex*							4.5					0.5
Prenanthes altissima		1.8			1.4							
Prenanthes sp.	18.2	6.0	4.5	18.2	7.1		9.1					1.1
Pyrola americana		2.4	4.5	9.1	2.8		4.5	3.5				2.7
Pyrola elliptica		0.6	4.5		0.9							
Pyrola sp.		0.6			0.5			0.9				0.5
Rorippa sp.		0.6			0.5							
Rubus dalibarda	18.2	4.8			4.7			8.8				5.3
Rumex acetosella							4.5					0.5
Scutellaria galericulata		0.6			0.5		9.1					1.1
Scutellaria sp.		0.6			0.5							
Solidago cf. *puberula*		0.6			0.5							
Solidago cf. *rugosa*							4.5					0.5
Solidago sp.	18.2	3.6	22.7	9.1	6.6		22.7		5.9		6.7	3.7
Streptopus sp.		0.6			0.5							
Symphyotrichum lateriflorum	9.1				0.5							
Symphyotrichum sp.		0.6			0.5							
Symplocarpus foetidus		3.0			2.4							
Thalictrum pubescens								0.9				0.5
Thalictrum sp.		1.8			1.4							
Triadenum virginicum		0.6			0.5		9.1					1.1
Trientalis borealis	63.6	58.1	72.7	72.7	60.7	38.5	90.9	68.1	70.6	25.0	40.0	64.9

	Northern unit					Southern unit						
	N1 (11)	N2 (167)	N3 (22)	N4 (11)	Total (211)	S1 (13)	S2 (22)	S3 (113)	S4 (17)	S5 (8)	S6 (15)	Total (188)
Trillium sp.								0.9				0.5
Trillium undulatum	18.2	4.8		18.2	5.7			5.3				3.2
Uvularia sessilifolia	72.7	46.7	22.7	9.1	43.6	15.4	27.3	38.9	29.4	50.0	33.3	35.1
Veratrum viride		0.6			0.5							
Verbena hastata							9.1					1.1
Viola hastata		0.6			0.5							
Viola cf. *adunca*			4.5		0.5							
Viola sp.	9.1	5.4	13.6	9.1	6.6		13.6	0.9	5.9			2.7
Unknown herb							4.5	0.0				0.5
Ferns and allies												
Athyrium filix-femina		2.4			1.9		4.5					0.5
Botrychium virginianum		0.6			0.5							
Dennstaedtia punctilobula	18.2	2.4			2.8		9.1	9.7				6.9
Diphasiastrum complanatum	9.1	0.6	4.5		1.4							
Diphasiastrum cf. *complanatum*							4.5					0.5
Diphasiastrum digitatum		1.2	4.5		1.4	7.7		9.7				6.4
Diphasiastrum sp.								0.9				0.5
Dryopteris campyloptera		0.6			0.5							
Dryopteris carthusiana		0.6			0.5		4.5	4.4				3.2
Dryopteris cf. *carthusiana*							4.5					0.5
Dryopteris cristata		1.2			0.9		9.1					1.1
Dryopteris intermedia		7.2	9.1		6.6			7.1	5.9			4.8
Dryopteris marginalis							4.5					0.5
Dryopteris sp.	9.1	1.2	4.5		1.9		4.5	0.9				1.1
Equisetum sylvaticum		0.6			0.5							
Equisetum sp.		0.6			0.5		4.5	0.9				1.1
Gymnocarpium dryopteris								0.9				0.5
Huperzia lucidula		2.4			1.9			0.9				0.5
Lycopodium annotinum		0.6	4.5		0.9							
Lycopodium clavatum		3.6	13.6	27.3	5.7			1.8				1.1
Lycopodium cf. *dendroideum*							9.1					1.1
Lycopodium obscurum	9.1	17.4	22.7	36.4	18.5	30.8	9.1	35.4	52.9	62.5	13.3	33.0
Onoclea sensibilis	9.1	3.0		9.1	3.3	0.0	18.2	3.5	5.9			4.8
Osmunda cinnamomea	27.3	9.0	9.1	18.2	10.4	23.1	27.3	24.8	5.9			20.2
Osmunda claytoniana	9.1	7.2			6.2	7.7	0.0	7.1				4.8

Continued.

Table 18.—Continued.

	Northern unit					Southern unit						
	N1 (11)	N2 (167)	N3 (22)	N4 (11)	Total (211)	S1 (13)	S2 (22)	S3 (113)	S4 (17)	S5 (8)	S6 (15)	Total (188)
Osmunda regalis	18.2	2.4	4.5		3.3	7.7	13.6	2.7				3.7
Polypodium appalachiana X *P. virginianum*								4.5				0.5
Polystichum acrostichoides		0.6			0.5							
Pteridium aquilinum	54.5	44.9	81.8	18.2	47.9	23.1	63.6	38.9	76.5	50.0	73.3	47.3
Thelypteris novaboracensis		3.0		18.2	3.3			9.7	5.9			6.4
Thelypteris palustris		0.6			0.5			4.4	5.9			3.2
Thelypteris sp.		0.6			0.5							
Unknown fern		2.4			1.9			1.8				1.1
Grasses												
Agrostis gigantea								0.9				0.5
Agrostis perennans							4.5	1.8				1.6
Agrostis scabra								0.9				0.5
Agrostis cf. *capillaris*		0.6			0.5							
Agrostis sp.	9.1				0.5							
Anthoxanthum odoratum									5.9			0.5
Brachyelytrum septentrionale	18.2	4.8	4.5	9.1	5.7			1.8				1.1
Calamagrostis canadensis		0.6			0.5		4.5					0.5
Cinna latifolia		0.6			0.5							
Danthonia compressa								0.9				0.5
Danthonia spicata	9.1	2.4	4.5		2.8		13.6	1.8				2.7
Danthonia cf. *spicata*			4.5		0.5							
Danthonia sp.			4.5		0.5							
Glyceria canadensis							4.5					0.5
Glyceria striata		1.8			1.4		4.5					0.5
Glyceria cf. *striata*		0.6			0.5							
Glyceria sp.							4.5					0.5
Oryzopsis asperifolia	54.5	47.9	68.2	18.2	48.8	7.7	45.5	29.2	29.4	25.0	26.7	29.3
Panicum cf. *oligosanthes* var. *scribnerianum*			0.6			0.5						
Panicum sp.	9.1	1.2			1.4			0.9				0.5
Unknown grass		1.2	4.5	9.1	1.9		13.6	1.8	5.9			3.2
Sedges												
Carex albicans			9.1		0.9							
Carex arctata		0.6			0.5		4.5					0.5
Carex brachyglossa								0.9				0.5

	Northern unit					Southern unit						
	N1 (11)	N2 (167)	N3 (22)	N4 (11)	Total (211)	S1 (13)	S2 (22)	S3 (113)	S4 (17)	S5 (8)	S6 (15)	Total (188)
Carex brunnescens		0.6			0.5		9.1					1.1
Carex canescens							9.1					1.1
Carex communis			4.5		0.5		4.5					0.5
Carex cf. *communis*	9.1				0.5							
Carex crawfordii		0.6			0.5		4.5					0.5
Carex debilis	9.1	1.2	13.6	9.1	3.3		4.5	1.8	5.9			2.1
Carex cf. *echinata*							9.1					1.1
Carex foenea								0.9				0.5
Carex folliculata		0.6			0.5		4.5		5.9			1.1
Carex gynandra		0.6			0.5		4.5					0.5
Carex cf. *gynandra*		0.6			0.5							
Carex intumescens		1.8			1.4				5.9			0.5
Carex leptalea							4.5					0.5
Carex cf. *lucorum*	45.5	25.7	31.8	18.2	48.2	23.1	77.3	35.4	76.5	37.5	80.0	46.8
Carex cf. *stricta*		0.6			0.5	7.7						0.5
Carex tenera								0.9				0.5
Carex tonsa			4.5		0.5							
Carex cf. *tonsa*			4.5		0.5							
Carex trisperma								0.9				0.5
Carex umbellata			4.5		0.5							
Carex cf. *utriculata*							4.5					0.5
Carex sp.	9.1	3.0	4.5	9.1	3.8		4.5	1.8	5.9			2.1
Juncus brevicaudatus								0.9				0.5
Juncus sp.	9.1	0.6	4.5		1.4							
Vines												
Amphicarpa bracteata		2.4			1.9			0.9				0.5
Parthenocissus quinquefolia		1.2			0.9			0.9				0.5
Smilax herbacea		0.6			0.5							
Smilax sp.	9.1				0.5							
Toxicodendron radicans		2.4		18.2	2.8		4.5	3.5	5.9			3.2
Other												
Unknown seedling	9.1	0.6			0.9		4.5		5.9			1.1

sp. means there are potentially numerous species that could not be conclusively determined.
cf. means "compare to."

borealis), low sweet blueberry, and Canada mayflower. Across both units, common herbs are starflower in 63 percent of plots, Canada mayflower in 56 percent, bracken fern in 48 percent, wild sarsaparilla in 45 percent, wintergreen in 43 percent, wild oats (*Uvularia sessifolia*) in 40 percent, and mountain rice in 40 percent. In the northern unit, 18 understory species are found in more than 10 percent of the 211 plots and eight of these were in at least 40 percent (Fig. 19). In the southern unit, 29 understory species are found in at least 10 percent of the 188 plots, and six were in at least 40 percent (Fig. 20).

Possible reasons for the frequent occurrence of species that are found in more than 10 percent of plots per unit include: broad ecological niche; successful reproductive strategy; long history in the area; pollinators and dispersers are common; vigorous response to disturbance; or some combination of these. None of the common species are exclusive to one or the other unit. There are, however, two common species in the northern unit that are not among the most common in the southern unit: maple-leaved viburnum and bird on the wing (*Polygala paucifolia*). Nine of the most common species in the southern unit are not among the most common in the northern unit: sheep laurel, witch-hazel, highbush blueberry, mountain holly, pink lady's slipper, goldthread (*Coptis trifolia* ssp. *groenlandica*), bunchberry (*Cornus canadensis*), black huckleberry, Indian pipe (*Monotropa uniflora*), and whorled loosestrife (*Lysimachia quadrifolia*). These differences between the northern and southern units, and between parcels within units, could be due to: historic distribution of plant species; response to disturbance, which is patchy and heterogeneous, and includes agriculture, fire, harvest, and windthrow in an array of intensities; varying soil moisture and topography; dispersal capability; or some combination of these.

As expected, patchiness of herb species within the parcels varies. Our sampling effort was similar across parcels of differing sizes, yet some parcels, such as N4 and S6, have individual herb species that occur in at least 50 percent of plots, while in most of the other parcels these same herb species occur in few plots (Table 18). The two largest parcels, N2 and S3, have no species that occur in more than 10 percent of all plots. Patchiness among the herb communities in these parcels could have to do with the heterogeneous distribution of a wide range of soil types, or the abundance of small wetland inclusions interspersed among uplands, or various disturbances and land use histories, or some combination.

In addition to the common occurrence of pink lady's slipper, other orchids occur in the MEF in some unexpected habitats. For example, we were surprised to find that orchids in the genus *Goodyera,* the rattlesnake plantains, are much more abundant in pine plantations than in natural stands. We found two species (*G. pubescens* and *G. tesselata*) and a possible hybrid. Neither is considered particularly rare in Maine. These herbs produce numerous dust-like, wind-dispersed seeds. The association between *Goodyera* and plantations suggests that these species are capable of persisting in or colonizing after intense disturbance. They appear to benefit from a relatively open understory that lacks dense vegetation. A population of about 90 individuals of an orchid that grows in sphagnum bogs, swamp pink (*Arethusa bulbosa*), was found in a red maple swamp in the southern unit.

Rare plants

We found numerous uncommon and rare plants, some of which are listed by the state or federal governments for protection (Table 19). There are two small populations of a federally threatened and state-endangered orchid, small whorled pogonia (*Isotria medeoloides*). One population is in mature pine-oak and the other in mixed woods on a former agricultural field; both are on gradual slopes. The species appears to be associated with braided streams; i.e., an interlacing network of channels where leaf litter is shifted during heavy rains. Other rare plants in the MEF are state recognized but not federally listed (Maine Department of Conservation 1999). A single individual of the state-endangered spotted wintergreen (*Chimaphila maculata*) was discovered in 1999 by a local botanist. It was found under hemlock, an uncharacteristic habitat for the species, and its flowers did not open the year it was found. The MEF also has two small populations of a state-endangered plant, upright bindweed (*Calystegia spithamaea*). One occurs in a pine plantation, and a much larger population of at least 100 stems is in an area of rocky woods. No flowers or fruits were seen. A local botanist found swamp saxifrage (*Saxifraga pensylvanica*), a state-threatened plant. Atlantic white-cedar is listed as "Special Concern" in Maine and is near the northern limit of its range. The Maine Natural Areas Program classifies the Atlantic white-cedar swamp-community as state "Imperiled" and globally "Vulnerable" (Gawler and Cutko in press). We found four additional species designated as state "Special Concern" in the inventory: Wiegand's sedge (*Carex wiegandii*), a tall sedge of wetlands; Bailey's sedge (*Carex baileyi*), a sedge of forested wetlands and swamps; long-beaked sedge (*Carex sprengelii*), found at a cellar hole in mixed woods; and smooth winterberry holly (*Ilex laevigata*), a shrub in the Atlantic white-cedar swamp.

Table 19.—State- and federal-listed rare plants found in the Massabesic Experimental Forest.

Species	Common name	State rank[a]	Global rank	State status	Federal status
Agrostis hiemalis	ticklegrass			(rare*)	
Calystegia spithamaea	Upright bindweed	S1	G4G5	Threatened	
Carex baileyi	Bailey's sedge	S1?	G4	Special Concern	
Carex sprengelii	Long-beaked sedge	S2	G5?	Special Concern	
Carex wiegandii	Weigand's sedge	S2	G3	Special Concern	
Chamaecyparis thyoides	Atlantic white-cedar	S2	G4	Special Concern	
Chimaphila maculata	Spotted wintergreen	S1	G5	Endangered	
Ilex laevigata	Smooth winterberry holly	S2	G5	Special Concern	
Isotria medeoloides	Small whorled pogonia	S2	G2G3	Endangered	Threatened
Saxifraga pennsylvania	Swamp saxifrage	S2	G5	Threatened	

[a]Explanation of codes:
S1 = critically imperiled in Maine because of extreme rarity (< 5 occurrences or very few remaining individuals or acres) or because some aspect of its biology makes it especially vulnerable to extirpation from the State of Maine
S1? = assumed S1 but more information needed
S2 = imperiled in Maine because of rarity (6-20 occurrences or few remaining individuals or acres) or because of other factors making it vulnerable to further decline
G2= imperiled (typically 6-20 occurrences or 1000-3000 individuals)
G3 = vulnerable (rare; typically 21—100 occurrences or 3000-10,000 individuals)
G4 = apparently secure (uncommon but not rare; some cause for long-term concern; usually > 100 occurrences and 10,000 individuals)
G5 = secure (common, widespread and abundant)
G5? = thought to be secure but in need of verification
* = rare and proposed for official state status (Arthur D. Haines, 2002, personal communication.)

Plants found only on meander transects

Because our focus was on uplands, plants associated with wetter soils were not as well represented in the inventory. However, meander transects led observers through many small wetlands and larger swamps and greatly enhanced preparation of a more complete flora. Among plants tallied on transects but not on plots, 94 are obligate wetland species (Appendix II). Plants found only on transects include three deciduous tree species, four conifers, 20 shrubs, five subshrubs, 11 ferns or fern allies, 11 grasses, 37 sedges (28 in the genus *Carex*), and 77 other herbs, including seven orchid species (Appendix I).

Applying GIS

Variable-radius plot, fixed plot, and transect data can be related to landscape features such as soils, wetlands, and topography. There are many potential applications for GIS in research and management in the MEF. Maps can be produced that show clusters of plots with particular characteristics; e.g., high regeneration rate of selected tree species, percentage sawtimber, inoperable areas, and distance from a road, wetland, or stream. For example, the distribution of plots with trees 18 inches dbh or greater (Fig. 21) shows that in the northern unit larger trees are in stands south of Cooks Brook and west of CC Road, and also on the hill near the Thirteen Cellar Holes. In the southern unit, large trees are mostly west of Ida Jim Road. Examining the association of forest cover types with soil types is another example. In Figure 22 the area of the MEF covered by pine and pine-oak types where more than 50 percent of the trees are classified as sawtimber-size (shown in orange) was selected in the GIS. The proportion of soil types underlying this area is shown on the pie chart (Fig. 22). Soils supporting pine and pine-oak types with a high proportion of sawtimber-size trees in the MEF are mostly very stony, fine sandy loams.

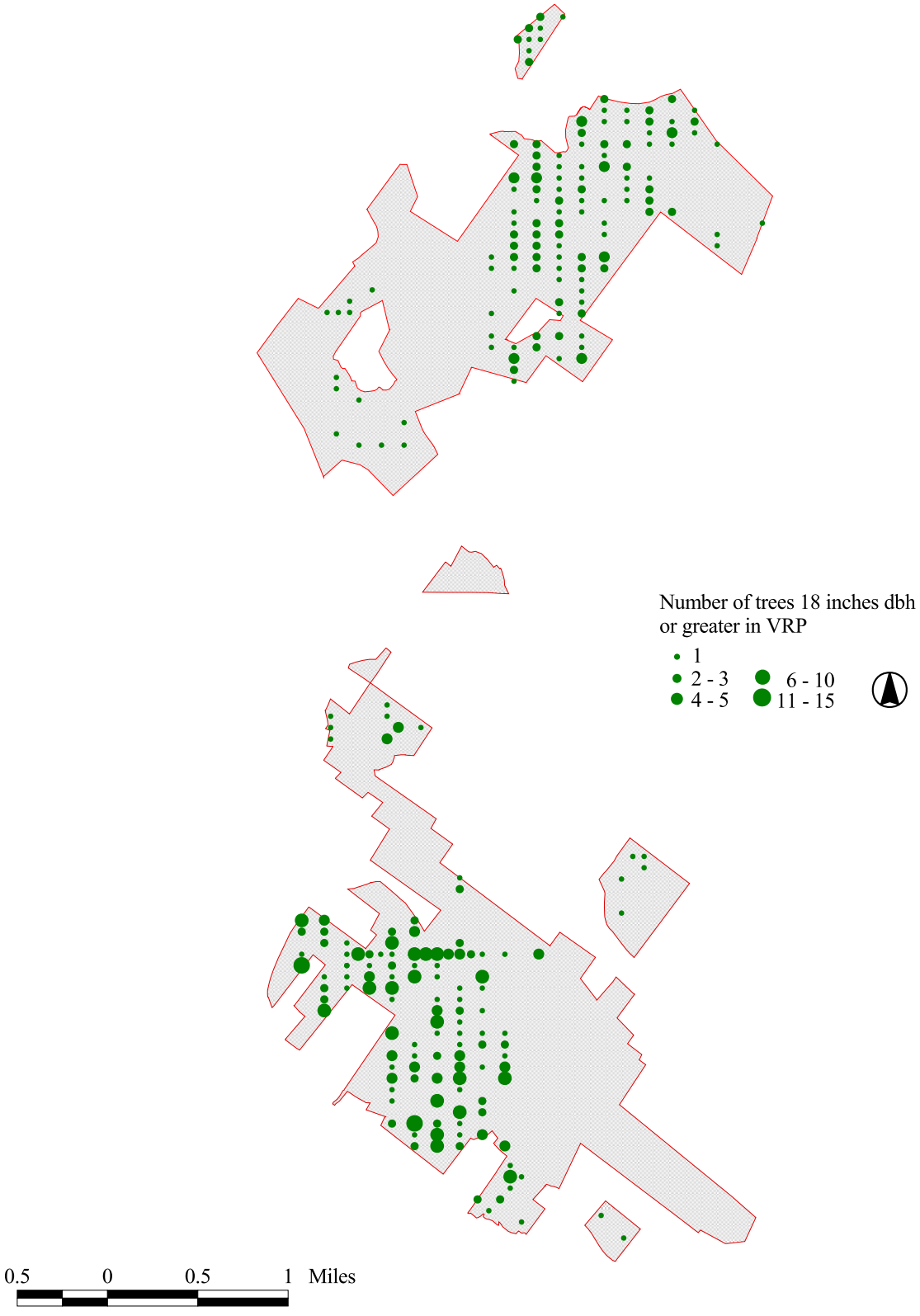

Figure 21.—Distribution of large trees (diameter breast height ≥ 18 inches) by permanent sample points, Massabesic Experimental Forest.

Figure 22.—Locations of stands in the Massabesic Experimental Forest with > 50 percent pine or pine—oak sawtimber, are shown in orange. The proportion of soil types underlying these areas are depicted in the pie chart.

Summary and Conclusions

We inventoried the flora on approximately one-half of the 3,700-acre MEF using a combination of VRP and fixed-area plot sampling, and meander transects. We concentrated on upland portions of the forest preparatory to establishing manipulative experiments in those areas. Half of the forest was not sampled and is made up of wetlands and a 52-acre administrative site. We established and sampled a grid of 399 permanent sample points. The points determined where VRP sampling was conducted and also defined centers of 0.01-acre circular plots. We inventoried trees 4.5 inches dbh or greater with VRP sampling, and quantified smaller trees and all other vegetation in the fixed-area plots. Because of the emphasis on uplands, and because a grid is not always the most efficient way to sample plant populations that may be clumped, meander transects between plots were used to ensure a more complete listing of plants.

We found six forest-cover types in the uplands, representing more than 2,500 acres. The most common of these is the white pine type with more than 900 acres, followed by pine-oak with more than 800 acres, and pine-hemlock with slightly more than 700 acres. A type that is rare in Maine, Atlantic white-cedar swamp, is relatively abundant in the southern unit with a total of 160 acres.

We found an unexpected high density of trees 18 inches dbh or greater in some parcels - up to 19.8 trees/acre for white pine, perhaps due to minimal harvest and low intensity or no fire in the recent past. Tree mortality suggests that without natural disturbances or management intervention, there will be a decrease in white pine and red oak, and an increase in hemlock over time. Hemlock is the most abundant tree seedling (taller than 1 ft and less than 0.5 inches dbh), followed by maples (especially red maple), oaks (northern red and white), and white pine. Parcel S3 has the highest seedling density, followed by Parcels S4 and N1. Density of shrub stems taller than 1 ft is greatest for beaked hazelnut, followed by viburnums, highbush blueberry, and winterberry. Shrub stems/acre is highest in N3, followed by S1 and N2. The most common understory plant is starflower, found in more than 60 percent of plots in each unit. Other common herbs and shrubs include low sweet blueberry, Canada mayflower, bracken fern, witherod, shadbush, pink lady's slipper, and partridgeberry. Listed rare plants include a federally threatened orchid, small whorled pogonia, and eight additional state-listed species.

The MEF ecosystems appear to be intact, given recent disturbances, and are mostly of high ecological integrity as evidenced by a noteworthy absence of invasive, exotic plants. Mature and over-mature stands provide important wildlife habitat in a matrix of successional post-fire regeneration. Together the database of flora and stand attributes, and the GIS with physical descriptions and data summaries, provide the information needed to devise, plan, and establish forest management experiments in the MEF. The data also provide a baseline against which to compare changes in forest structure and composition resulting from those experiments or from natural or anthropogenic disturbances.

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Appendix I. Checklist of vascular plants found during the inventory by parcel and by sampling technique.

"Other" includes parcel S7 and reconnaissance surveys.

Latin Name	Common Name	N1			N2			N3			N4			Total				S1			S2			S3			S4			S5			S6			Total			
		plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other
Abies balsamea (L.) P. Mill.	balsam fir	X	X	X	X	X	X	X	X	X	X		X	X	X	X			X	X				X	X	X	X		X	X		X				X	X	X	
Acer negundo L.	box elder																									X												X	
Acer pensylvanicum L.	striped maple	X		X	X	X	X					X	X	X	X	X					X		X	X		X										X		X	
Acer rubrum L.	red maple	X		X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X		X	X	X	X	X		X	X		X	X	X	X	X	X	X	
Acer saccharum Marsh.	sugar maple	X		X	X	X	X						X	X	X	X	X	X						X	X	X										X	X	X	
Achillea millefolium L.*	common yarrow	X					X		X					X	X	X									X												X		
Actaea pachypoda Ell.	white baneberry				X	X	X							X	X	X																							
Actaea sp.	baneberry species						X									X							X															X	
Agrostis canina L.	velvet bentgrass																									X												X	
Agrostis capillaris L.*	Rhode Island bentgrass									X						X	X							X	X	X										X	X	X	X
Agrostis gigantea Roth*	redtop																							X	X											X	X		X
Agrostis hyemalis (Walt.) B.S.P.	ticklegrass																									X												X	
Agrostis perennans (Walt.) Tuckerman	autumn bentgrass					X									X		X				X			X	X	X										X	X	X	X
Agrostis scabra Willd.	ticklegrass																							X												X			X
Agrostis sp.	bentgrass species	X			X	X	X							X	X	X									X	X											X	X	
Alnus incana (L.) Moench ssp. *rugosa* (DuRoi) Clause	speckled alder				X		X			X				X		X				X	X		X	X	X	X	X	X	X							X	X	X	
Alnus serrulata (Ait.) Willd.	smooth alder																												X									X	
Alnus sp.	alder species	X												X			X				X		X													X		X	
Ambrosia artemisiifolia L.*	common ragweed																X									X												X	X
Ambrosia sp.*	ragweed species						X									X																							
Amelanchier cf. *obovalis*	shadbush									X						X	X																						X
Amelanchier cf. *stolonifera* Wieg.	thicket shadbush																												X									X	
Amelanchier sp.	shadbush species	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	
Amphicarpaea bracteata (L.) Fern.	hog-peanut				X	X	X							X	X	X								X		X										X		X	
Anaphalis margaritacea (L.) Benth. & Hook. f.*	pearly everlasting				X		X							X		X	X				X					X										X		X	
Andromeda polifolia L. var. *glaucophylla* (Link) DC.	bog rosemary																									X												X	
Andropogon cf. *gerardii* Vitman	big bluestem						X									X																							
Anemone canadensis L.	Canada anemone						X									X																							
Anemone quinquefolia L.	wood anemone				X	X	X	X						X	X	X									X	X	X		X			X				X	X	X		
Antennaria howellii ssp. *neodioica* Greene	pussytoes																																							X
Anthoxanthum odoratum L.*	sweet vernal grass																										X		X							X		X	
Apios americana Medik.	common groundnut						X									X	X																						
Apocynum androsaemifolium L.	spreading dogbane				X	X	X	X	X	X				X	X	X					X		X		X	X		X				X	X			X	X	X	X	X
Apocynum sp.	dogbane species				X		X	X	X	X				X	X	X												X									X	X	

Latin Name	Common Name	N1			N2			N3			N4			Total				S1			S2			S3			S4			S5			S6			Total			
		plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other
Aralia nudicaulis L.	wild sarsaparilla	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	
Arethusa bulbosa L.	dragon's mouth																						X																X
Arisaema triphyllum (L.) Schott	jack-in-the-pulpit				X	X	X			X		X	X	X	X	X			X		X		X	X	X	X	X	X	X							X	X	X	
Asclepias exaltata L.	tall milkweed																																						X
Asclepias incarnata L.	swamp milkweed					X									X																								
Asclepias sp.	milkweed species						X									X									X	X											X	X	
Aster macrophyllus L.	big-leaved aster				X	X	X				X		X	X	X	X	X									X												X	
Aster sp.	aster species	X			X	X	X	X	X	X	X	X	X	X	X	X	X				X		X	X	X	X		X	X							X	X	X	
Asteraceae sp.	aster family			X	X	X	X	X	X	X		X	X	X	X	X							X	X	X	X	X					X		X		X	X	X	X
Athyrium filix-femina (L.) Roth *ex* Mertens var. *angustifolium* (Willd.) Lawson	lady fern				X	X	X			X				X	X	X	X				X		X		X	X										X	X	X	X
Berberis thunbergii DC.*	Japanese barberry					X	X								X	X									X												X		
Betula alleghaniensis Britt.	yellow birch	X	X	X	X	X	X				X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X	X				X	X	X		
Betula lenta L.	sweet birch	X		X	X	X	X							X	X	X					X	X	X	X	X	X			X	X					X	X	X	X	
Betula papyrifera Marsh.	paper birch	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X	X	X		
Betula populifolia Marsh.	gray birch	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		
Betula sp.	birch species	X			X		X			X				X		X					X			X	X	X										X	X	X	
Bidens connata Muhl. *ex* Willd.	purple stem beggar ticks																									X												X	
Bidens frondosa L.	devil's beggar ticks						X									X										X												X	
Bidens vulgata Greene	tall beggar ticks																								X												X		
Bidens sp.	beggar ticks species						X									X										X												X	
Botrychium virginianum (L.) Sw.	rattlesnake fern				X									X											X												X		
Botrychium matricariifolium (Doll) A. Braun *ex* Koch	Mingan moonwort						X									X	X																						
Brachyelytrum septentrionale (Babel) G. Tucker	grass	X		X	X	X	X	X	X	X	X		X	X	X	X						X	X	X	X	X			X			X				X	X	X	
Brassica sp.	mustard species																				X															X			
Bromus erectus Huds.*	bromegrass																X																						
Bromus sp.	bromegrass						X									X																							
Bulbostylis capillaris (L.) Kunthe *ex* C. B. Clarke	sedge																																						X
Calamagrostis canadensis (Michx.) Beauv.	bluejoint grass				X	X	X					X	X	X	X	X	X		X	X	X	X	X		X	X			X							X	X	X	X
Calopogon tuberosus (L.) B. S. P.	grass-pink																																						X
Calystegia spithamaea (L.) Pursh	upright bindweed					X									X																								
Cardamine pensylvanica Muhl. *ex* Willd.	Pennsylvania bitter-cress					X									X		X					X															X		
Cardamine sp.	bitter cress, toothwort						X									X																							
Carex albicans Willd. *ex* Spreng.	white-tinged sedge							X	X	X				X	X	X																							X

Continued.

Appendix I.—continued.

Latin Name	Common Name	N1			N2			N3			N4			Total				S1			S2			S3			S4			S5			S6			Total			
		plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other
Carex albicans var. *emmonsii* (Dewey ex Torr.) J. Rettig	white-tinged sedge									X						X																						
Carex aquatilis Whalenb.	water sedge																																						X
Carex arctata Boott	northern clustered sedge				X	X	X		X	X				X	X	X					X		X		X	X							X	X	X	X		
Carex argyrantha Tuckerman	sedge																X								X											X		
Carex atlantica Bailey	eastern sedge									X						X									X	X										X	X	
Carex atlantica ssp. *capillacea* Bailey	eastern sedge																																						X
Carex baileyi Britt.	Bailey's sedge																																						X
Carex blanda Dewey	woodland sedge																X																						
Carex brachyglossa Mackenzie	yellow-fruited sedge					X	X								X	X	X							X		X									X		X	X
Carex brunnescens (Pers.) Poir.	brownish sedge		X		X	X	X			X			X	X	X	X			X	X	X		X		X	X									X	X	X	
Carex bullata Schkuhr *ex* Willd.	button sedge																X																						
Carex canescens L.	silvery sedge						X		X				X		X	X	X				X				X	X										X	X	X	X
Carex communis Bailey	fibrous-rooted sedge						X	X	X	X				X	X	X					X															X			
Carex cf. *communis* Bailey	fibrous-rooted sedge	X												X																									
Carex comosa Boott	bristly sedge																						X															X	
Carex crawfordii Fern.	sedge				X	X	X							X	X	X					X		X			X		X	X							X	X	X	
Carex crinita Lam.	drooping sedge																																						X
Carex cumulata (Bailey) Fern.	sedge																									X												X	X
Carex debilis Michx.	white-edged sedge	X			X	X	X	X	X	X	X	X		X	X	X	X				X		X	X	X	X	X		X							X	X	X	X
Carex deflexa Horem.	northern sedge																									X												X	
Carex cf. *disperma* Dewey	two-seeded sedge																									X												X	
Carex echinata Murr.	star sedge								X	X					X	X																							X
Carex foenea Willd.	sedge																							X												X			
Carex folliculata L.	long sedge				X	X	X		X	X		X	X	X	X	X			X			X			X	X	X		X							X	X	X	
Carex gracillima Schwein.	graceful sedge																								X												X		X
Carex gynandra Schwein.	nodding sedge				X		X							X		X	X				X		X		X	X									X	X	X	X
Carex houghtoniana Torr. *ex* Dewey	Houghton's sedge																																						X
Carex intumescens Rudge	sedge				X	X	X			X			X	X	X	X									X	X	X		X							X	X	X	
Carex lacustris Willd.	lake bank sedge						X									X	X									X												X	X
Carex laxiflora Lam.	loose-flowered sedge																X																						
Carex leptalea Wahlenb.	bristly-stalked sedge					X									X		X					X			X											X		X	X
Carex leptonervia (Fern.) Fern.	two-edged sedge						X									X									X												X		
Carex lucorum Willd. *ex* Link	sedge					X									X		X																						X
Carex cf. *lucorum* Willd. *ex* Link	sedge	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	
Carex lurida Wahlenb.	sallow sedge									X						X										X												X	X
Carex magellanica ssp. *irrigua* (Wahlenb.) Hulten	bog sedge						X									X									X	X											X	X	
Carex merritt-fernaldii Mackenzie	Fernald's sedge																																						X

Latin Name	Common Name	N1			N2			N3			N4			Total				S1			S2			S3			S4			S5			S6			Total			
		plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other
Carex novae-angliae Schwein.	New England sedge																																					X
Carex ormostachya Wieg.	sedge									X						X	X																					
Carex pallescens L.	sedge																					X			X	X		X	X							X	X	
Carex pensylvanica Lam.	Pennsylvania sedge					X									X																							X
Carex projecta Mackenzie	necklace sedge					X	X								X	X	X											X								X		
Carex pseudocyperus L.	cyperus-like sedge																X								X											X		
Carex scabrata Schwein.	rough sedge					X									X																							
Carex scoparia Schkuhr *ex* Willd.	pointed broom sedge					X	X								X	X	X								X	X									X	X	X
Carex cf. *scoparia* Schkuhr *ex* Willd.	pointed broom sedge									X						X																						
Carex sprengelii Dewey *ex* Spreng.	long-beaked sedge																																					X
Carex stipata Muhl. *ex* Willd.	awl-fruited sedge					X									X		X								X	X									X	X	X
Carex stricta Lam.	tussock sedge																																					X
Carex cf. *stricta* Lam.	tussock sedge				X	X	X			X				X	X	X		X					X			X	X									X	X	X	
Carex swanii (Fern.) Mackenzie	sedge					X	X								X	X																						
Carex tenera Dewey	sedge																						X	X	X	X		X							X	X	X	X
Carex tonsa (Fern.) Bickn.	deep green sedge						X	X						X		X	X																					X
Carex tonsa var. cf. *rugosperma* (Mackenzie) W.J. Crins	deep green sedge						X									X																						X
Carex trisperma Dewey	three-seeded sedge					X									X								X	X	X	X									X	X	X	X
Carex trisperma (Dewey) var. *trisperma*	sedge																									X											X	
Carex trisperma var. *billingsii* Knight	three-seeded sedge																									X											X	
Carex umbellata Schkuhr *ex* Willd.	umbel-like sedge							X						X																								
Carex utriculata Boot	beaked sedge																									X											X	X
Carex vesicaria L.	inflated sedge						X									X	X																					X
Carex virescens Muhl. *ex* Willd.	ribbed sedge																X									X											X	
Carex wiegandii Mackenzie	Wiegand's sedge							X						X																								
Carex sp. (includes many possible species)	sedge species	X			X	X	X	X	X	X	X		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X			X		X	X	X	X
Carpinus caroliniana Walt. ssp. *virginiana* (Marsh.) Furlow	American hornbeam						X										X							X		X					X				X		X	
Carya ovata (P. Mill.) K. Koch	shagbark hickory					X	X								X	X																						X
Cephalanthus occidentalis L.	button bush					X	X								X	X						X				X									X	X	X	X
Celastrus orbiculata Thunb.*	Asian bittersweet																																					X
Chamaecyparis thyoides (L.) B. S. P.	Atlantic white-cedar																									X											X	
Chamaedaphne calyculata (L.) Moench	leatherleaf						X		X						X	X	X									X											X	
Chelone glabra L.	white turtlehead					X	X								X	X										X											X	
Chimaphila maculata (L.) Pursh	spotted wintergreen																																					X
Chimaphila umbellata (L.) W. Bart. ssp. *cisatlantica* (Blake) Hulten	pipsissewa					X	X		X						X	X									X	X										X	X	
Chrysosplenium americanum Schwein. *ex* Hook.	water carpet					X	X								X	X	X								X	X										X	X	

Continued.

Appendix I.—continued.

Latin Name	Common Name	N1			N2			N3			N4			Total				S1			S2			S3			S4			S5			S6			Total			
		plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other
Cicuta maculata L.	water hemlock						X									X									X												X	
Cinna cf. *arundinacea* L.	common woodreed						X									X																						
Cinna latifolia (Trev. ex Goepp.) Griseb.	drooping woodreed					X	X								X	X									X											X	
Circaea alpina L.	alpine enchanter's-nightshade				X	X	X							X	X	X					X			X	X	X									X	X	X	
Circaea lutetiana L. ssp. *canadensis* (L.) Aschers. & Magnus	common enchanter's-nightshade																X																					
Circaea sp.	enchanter's-nightshade				X	X	X							X	X	X						X			X	X											X	X	
Clematis virginiana L.	virgin's bower						X									X	X																					
Clematis sp.	clematis species						X									X																						
Clintonia borealis (Ait.) Raf.	blue-bead lily	X			X	X	X		X		X		X	X	X	X		X		X				X	X	X			X							X	X	X	
Comandra umbellata (L.) Nutt.	bastard toadflax																																						
Comptonia peregrina (L.) Coult.	sweetfern				X	X	X	X	X	X		X	X	X	X	X	X		X		X	X	X	X	X	X		X					X			X	X	X	
Coptis trifolia (L.) Salisb.	goldthread	X	X	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X		X	X	X	X	X	X	X			X				X	X	X	
Cornus alternifolia L. f.	alternate-leaved dogwood				X		X							X		X	X								X	X											X	X	
Cornus amomum P. Mill. ssp. *amomum*	silky dogwood						X									X	X																					
Cornus canadensis L.	bunchberry	X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X			X				X	X	X	
Cornus racemosa Lam.																	X																						
Cornus cf. *racemosa* Lam.	northern swamp dogwood					X									X						X		X													X		X	
Cornus sp.	dogwood species				X	X	X							X	X	X									X							X			X	X			
Corylus cornuta Marsh.	beaked hazlenut	X	X	X	X	X	X	X		X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X	X	
Crategus macrosperma Ashe	hawthorn						X									X	X																						
Crategus cf. *macrosperma* Ashe	hawthorn	X												X			X																						
Cyperus lupulinus (Spreng.) Marcks ssp. *macilentus* (Fern.) Marcks	sedge																																						X
Cypripedium acaule Ait.	pink lady's slipper		X		X	X	X		X	X	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Danthonia compressa Austin *ex* Peck	wild oatgrass						X									X								X		X										X		X	X
Danthonia spicata (L.) Beauv. *ex* Roemer & J. A.	poverty oatgrass	X			X	X	X	X		X				X	X	X	X				X		X	X	X	X										X	X	X	X
Danthonia sp.	oatgrass species		X			X	X	X	X	X		X	X	X	X	X										X		X									X	X	
Daucus carota L.*	Queen Anne's lace																									X												X	
Decodon verticillatus (L.) Ell.	water-willow																X																						
Dennstaedtia punctilobula (Michx.) T. Moore	hay-scented fern	X	X	X	X	X	X			X			X	X	X	X			X	X	X	X	X	X	X	X	X			X						X	X	X	X
Deparia acrostichoides (Sw.) M. Kato	silvery spleenwort					X				X			X		X	X																							X
Desmodium glutinosum (Muhl. ex Willd.) Wood	cluster-leaf tick-trefoil																X																						
Desmodium sp.	tick-trefoil species				X	X	X							X	X	X																								
Diervilla lonicera P. Mill.	bush-honeysuckle			X	X	X	X	X		X				X	X	X			X		X		X	X	X	X										X	X	X	

Latin Name	Common Name	N1			N2			N3			N4			Total				S1			S2			S3			S4			S5			S6			Total			
		plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other
Digitaria ischaemum (Schreb.) Muhl.*	smooth crabgrass																X																					X
Digitaria sanguinalis (L.) Scop.*	northern crabgrass																																					X
Digitaria sp.*	crabgrass species						X									X																						
Diphasiastrum complanatum (L.) Holub	northern running-pine	X			X		X	X						X		X							X	X	X	X										X	X	X
Diphasiastrum digitatum (Dill. *ex* A. Braun) Holub	southern running-pine				X	X	X	X	X			X	X	X	X	X		X					X	X	X	X									X	X	X	X	X
Diphasiastrum tristachyum (Pursh) Holub	blue ground-cedar																								X												X		
Diphasiastrum sp.	running-pine species					X			X			X	X		X	X						X			X	X	X	X									X	X	X	
Dirca palustris L.	leatherwood						X									X																							
Doellingeria umbellata (P. Mill.) Nees	flat-topped white aster						X									X										X												X	X
Drosera intermedia Hayne	spatulate-leaved sundew																X																						
Drosera rotundifolia L.	round-leaved sundew																									X												X	X
Dryopteris campyloptera (Kunze) Clarkson	mountain wood fern				X		X							X		X																						
Dryopteris carthusiana (Vill.) H. P. Fuchs	spinulose wood fern				X	X	X			X			X	X	X	X	X					X			X	X	X									X	X	X	X
Dryopteris cristata (L.) Gray	crested wood fern				X	X	X			X		X	X	X	X	X				X	X	X	X		X	X			X	X						X	X	X	X
Dryopteris intermedia (Muhl. ex Willd.) Gray	evergreen wood fern				X	X	X	X	X	X			X	X	X	X							X	X	X	X	X									X	X	X	X
Dryopteris marginalis (L.) Gray	marginal wood fern					X	X								X	X	X				X		X			X	X									X	X	X	X
Dryopteris sp.	wood fern	X			X	X	X	X		X		X	X	X	X	X			X	X	X	X	X	X	X	X	X						X			X	X	X	
Dulichium arundinaceum (L.) Britt.	three-way sedge					X	X								X	X						X	X			X	X										X	X	X
Echinochloa muricata (Beauv.) Fern.	barnyard grass																																						X
Elaeagnus angustifolia L.*	Russian-olive																																						X
Elymus repens (L.) Gould*	witch grass																									X												X	
Elymus cf. *trachycaulus* (Link) Gould *ex* Shinners	slender wheatgrass																									X												X	
Epifagus virginiana (L.) W. Bart.	beechdrops						X									X	X								X	X											X	X	
Epigaea repens L.	mayflower	X	X	X	X	X	X		X		X	X	X	X	X	X			X	X	X		X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	
Epilobium ciliatum Raf.	American willow-herb						X									X										X												X	
Epilobium cf. *coloratum* Biehler	eastern willow-herb						X									X										X												X	
Epilobium leptophyllum Raf.	American marsh willow-herb																																						X
Epilobium sp.	willow-herb						X									X									X	X											X	X	
Equisetum fluviatile L.	river horsetail																X																						
Equisetum pratense Ehrh.	meadow horsetail						X									X																							
Equisetum sylvaticum L.	woodland horsetail				X	X	X					X	X	X	X	X			X						X	X										X	X	X	X
Equisetum sp.	horsetail species				X		X							X		X					X	X	X	X		X										X	X	X	X

Continued.

Appendix I.—continued.

Latin Name	Common Name	N1			N2			N3			N4			Total				S1			S2			S3			S4			S5			S6			Total			
		plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other
Erechtites hieraciifolia (L.) Raf. *ex* D.C.	fireweed																X																					
Erigeron strigosus Muhl. *ex* Willd.	rough fleabane																																					X
Erigeron sp.	fleabane species																																					X
Eriophorum virginicum L.	tawny cotton-grass																							X												X	X
Eriophorum sp.	cotton-grass species																							X												X	
Eupatorium maculatum L.	spotted joe-pye weed						X									X	X				X														X			
Eupatorium sp.	joe-pye weed species						X									X																						
Euthamia graminifolia (L.) Nutt.	common flat-topped goldenrod																X									X										X	X	
Euthamia sp.	goldenrod species									X						X																						
Fagus grandifolia Ehrh.	American beech	X		X	X	X	X		X	X	X	X	X	X	X	X		X	X	X		X	X	X	X	X					X	X				X	X	X	
Fallopia cilinodis (Michx.) Holub	fringed bindweed																				X		X												X		X	
Fallopia japonica (Houtt.) Decraene*	Japanese bindweed																							X	X											X	X	
Festuca rubra L.*	red fescue																										X									X		X
Festuca sp.	sheep fescue species						X									X																						
Fragaria vesca L.	woodland strawberry						X									X																						
Fragaria virginiana Duchesne	wild strawberry				X		X							X		X					X				X	X									X	X	X	
Fragaria sp.	strawberry species					X		X						X	X											X											X	
Frangula alnus P. Mill.*	alder-leaved buckthorn						X																															
Fraxinus americana L.	white ash	X			X	X	X			X		X		X	X	X							X	X	X	X	X	X							X	X	X	X
Fraxinus nigra Marsh.	black ash				X	X	X						X	X	X	X				X		X	X		X	X											X	X	
Galium aparine L.	spring cleavers																																					X
Galium asprellum Michx.	rough bedstraw				X	X	X							X	X	X										X										X	X	
Galium lanceolatum Torr.	wild-licorice																X																					
Galium palustre L.	marsh bedstraw																									X										X		
Galium tinctorium (L.) Scop.	southern three-lobed bedstraw						X									X																						X
Galium trifidum L.	northern three-lobed bedstraw						X									X	X									X										X		
Galium triflorum Michx.	sweet-scented bedstraw					X	X								X	X									X	X										X	X	X
Galium sp.	bedstraw/cleavers species				X	X	X							X	X	X					X	X	X		X	X										X	X	X	
Gaultheria hispidula (L.) Muhl. *ex* Bigelow	creeping snowberry					X									X											X										X	X	
Gaultheria procumbens L.	wintergreen	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	
Gaylussacia baccata (Wangenh.) L. Koch	black huckleberry		X	X	X	X	X	X	X	X		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X
Gaylussacia dumosa (Andr.) TorFern.	dwarf huckleberry																									X										X		
Gentiana linearis Froel.	closed gentian																X																					
Glyceria borealis (Nash) Batchelder	northern mannagrass																X							X	X											X	X	X
Glyceria canadensis (Michx.) Trin	rattlesnake mannagrass																				X					X									X		X	X

Latin Name	Common Name	N1			N2			N3			N4			Total				S1			S2			S3			S4			S5			S6			Total			
		plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other
Glyceria grandis S. Wats.	American mannagrass																						X													X	
Glyceria melicaria (Michx.) F. T. Hubbard	northeastern mannagrass																X																					
Glyceria obtusa (Muhl.) Trin.	coastal mannagrass																X								X											X	X
Glyceria striata (Lam.) A. S. Hitchc.	fowl mannagrass				X	X	X							X	X	X	X				X		X		X	X									X	X	X	X
Glyceria sp.	mannagrass species				X	X	X			X				X	X	X					X				X	X									X	X	X	
Gnaphalium sp.	cudweed species																									X											X	
Goodyera pubescens (Willd.) R. Br. . *ex* Ait. f	downy rattlesnake plantain					X	X		X	X					X	X									X	X										X	X	X
Goodyera cf. *repens* (L.) R. Br. ex Ait. f.	dwarf rattlesnake plantain					X									X																							
Goodyera tesselata Lodd.	checkered rattlesnake plantain				X	X	X	X	X	X		X	X	X	X	X								X	X	X									X	X	X	
Goodyera tesselata x *repens* var. *ophioides*	rattlesnake plantain					X									X																							
Goodyera sp.	rattlesnake plantain species					X									X																								
Gymnocarpium dryopteris (L.) Newman	oak fern									X						X								X											X			X
Hamamelis virginiana L.	witch-hazel	X	X	X	X	X	X			X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X			X				X	X	X	
Hemerocallis sp.*	day lily species																									X											X	
Hieracium caespitosum Dumort.*	yellow king devil																								X											X		
Hieracium cf. *piloselloides* Vill.*	glaucous king devil									X						X																						
Hieracium sp.	hawkweed species				X	X	X			X				X	X	X										X											X	
Houstonia caerulea L.	bluets				X	X	X		X	X				X	X	X					X				X	X									X	X	X	
Huperzia lucidula (Michx.) Trevisan	shining clubmoss				X	X	X							X	X	X								X	X	X									X	X	X	
Huperzia/Lycopodium sp.	clubmoss species			X			X			X						X										X											X	
Hydrocotyle americana L.	marsh pennyroyal				X	X	X							X	X	X					X	X	X		X	X									X	X	X	
Hypericum boreale (Britt.) Bickn.	St. Johnswort																								X											X		
Hypericum cf. *boreale* (Britt.) Bickn.	St. Johnswort												X			X																						
Hypericum canadense L.	Canada St. Johnswort																X																					X
Hypericum ellipticum Hook.	St. Johnswort																X																					
Hypericum gentianoides (L.) B. S. P.	orange-grass																X																					
Hypericum perforatum L.*	common St. Johnswort																									X											X	X
Hypericum punctatum Lam.	spotted St. Johnswort																								X	X										X	X	
Hypericum sp.	St. Johnswort species						X			X			X			X						X			X	X										X	X	X	
Ilex laevigata (Pursh) Gray	smooth winterberry																									X											X	
Ilex verticillata (L.) Gray	winterberry	X		X	X	X	X	X	X	X			X	X	X	X		X	X	X	X		X	X	X	X	X	X	X		X	X	X		X	X	X	
Impatiens capensis Meerb.	orange touch-me-not					X	X								X	X					X	X	X		X	X										X	X	X	
Ionactis linariifolius (L.) Greene	still aster						X		X	X					X	X																							X
Iris versicolor L.	northern blue flag	X			X	X	X		X	X			X	X	X	X			X		X	X	X		X	X		X	X			X			X	X	X	
Isotria medeoloides (Pursh) Raf.	small whorled-pogonia					X	X								X	X																					
Juncus brevicaudatus (Engelm.) Fern.	short-tailed rush																							X		X										X	X	X

Continued.

Appendix I.—continued.

Latin Name	Common Name	N1			N2			N3			N4			Total				S1			S2			S3			S4			S5			S6			Total			
		plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other
Juncus effusus L.	soft rush																						X		X	X										X	X	X
Juncus filiformis L.	thread rush																X								X											X		
Juncus greenei Oakes & Tuckerman	Green's rush							X						X																								X
Juncus tenuis Willd.	path rush						X									X									X											X		X
Juncus sp.	rush species	X			X	X	X	X						X	X	X										X											X		
Juniperus communis L. var. *depressa* Pursh	common juniper		X		X		X		X	X		X		X	X	X	X					X		X	X	X	X									X	X	X	
Kalmia angustifolia L.	sheep laurel	X	X	X	X	X	X	X	X	X		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Kalmia polifolia Wangenh.	bog laurel																									X												X	
Lactuca biennis (Moench) Fern.	tall blue lettuce																																						X
Lactuca canadensis L.	tall lettuce																																						X
Lactuca sp.	lettuce species				X	X	X		X					X	X	X										X											X	X	
Lamiaceae sp.	mint family					X									X																								
Larix laricina (Du Roi) K. Koch	larch						X	X		X				X		X										X											X		
Lechea tenuifolia Michx.	slender pinweed									X						X																							X
Lechea sp.	pinweed species						X			X						X										X											X		
Leersia oryzoides (L.) Sw.	rice cutgrass																									X											X		
Lilium philadelphicum L.	wood lily					X	X						X		X	X					X		X			X									X		X		
Linnaea borealis L. ssp. *longifolia* (Torr.) Hulten	twinflower						X									X										X											X		
Lobelia cardinalis L.	cardinal flower																X																						
Lobelia inflata L.	Indian-tobacco						X									X	X								X	X										X	X	X	
Lobelia kalmii L.	Kalm's lobelia																																						X
Lonicera canadensis Bartr. *ex* Marsh.	fly honeysuckle			X	X	X	X	X	X					X	X	X						X	X			X						X				X	X		
Lonicera morrowii Gray*	Morrow's honeysuckle																																						X
Lonicera sp.*	honeysuckle species						X									X								X												X			X
Ludwigia sp.	water purslane						X									X																							
Luzula multiflora (Ehrh.) Lej.	common woodrush									X						X	X																						
Luzula pallidula Kirsch.*	woodrush																																						X
Luzula sp.	common woodrush		X				X			X						X	X								X	X	X	X								X	X	X	
Lycopodium annotinum L.	stuff clubmoss				X			X	X	X			X	X	X	X	X								X	X											X	X	
Lycopodium clavatum L.	wolfclaw clubmoss				X	X	X	X	X	X	X	X	X	X	X	X	X			X			X	X	X	X	X			X					X		X	X	X	
Lycopodium dendroideum Michx.	prickly tree clubmoss																					X			X											X		X	
Lycopodium obscurum L.	princess-pine	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		X	X	X	X	
Lycopodium sp.	clubmoss species						X			X						X	X																					X	
Lycopus americanus Muhl. *ex* W. Bart.	American water-horehound						X									X	X									X											X		
Lycopus uniflorus Michx.	northern water-horehound	X			X	X	X			X			X	X	X	X	X		X	X	X			X	X	X	X		X	X						X	X	X	X
Lycopus virginicus L.	Virginia water-horehound						X									X										X											X		

Latin Name	Common Name	N1			N2			N3			N4			Total				S1			S2			S3			S4			S5			S6			Total			
		plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other
Lycopus sp.	water-horehound species						X									X						X				X									X		X	
Lyonia ligustrina (L.) DC.	maleberry		X		X	X	X		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X	X
Lysimachia ciliata L.	fringed loosestrife																X																					X
Lysimachia quadrifolia L.	whorled loosestrife		X		X	X	X	X	X	X			X	X	X	X					X	X	X	X	X	X	X		X			X	X		X	X	X	X	X
Lysimachia terrestris (L.) B.S.P.	swamp candles				X	X	X			X		X	X	X	X	X	X				X		X	X	X	X										X	X	X	X
Lysimachia sp.	loosestrife species						X			X						X									X			X									X		
Maianthemum canadense Desf.	Canada mayflower	X	X	X	X	X	X	X		X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	
Maianthemum racemosum (L.) Link	false spikenard	X	X	X	X	X	X						X	X	X	X								X	X	X	X									X	X	X	
Maianthemum trifolium (L.) Sloboda	three-leaved false Solomon's seal																X									X											X	
Malus sylvestris P. Mill.*	apple							X						X												X											X	
Medeola virginiana L.	indian cucumber root	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X			X		X		X	X	X	
Melampyrum lineare Desr.	cow wheat		X		X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	
Menyanthes trifoliata L.	buckbean																									X											X	X
Mimulus ringens L.	Allegheny monkeyflower																X																					
Mitchella repens L.	partridgeberry	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	X	X	
Mitella nuda L.	naked miterwort				X		X							X		X																							
Moehringia lateriflora (L.) Fenzl	grove sandwort																								X	X											X	X	X
Moneses uniflora (L.) Gray	one-flowered shinleaf																							X		X	X									X		X	
Monotropa hypopithys L.	pinesap					X	X	X	X	X	X		X	X	X	X			X	X		X	X	X	X	X					X	X	X	X	X	X	X	
Monotropa uniflora L.	Indian pipe	X	X	X	X	X	X	X				X	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X		X		X	X	X	X	X	X	
Muhlenbergia racemosa (Michx.) B. S. P.*	muhly																X																					
Nemopanthus mucronatus (L.) Loes.	mountain holly				X	X	X	X	X	X	X		X	X	X	X		X	X	X	X		X	X	X	X	X	X	X			X	X	X	X	X	X	X	
Nuphar variegata Dur.	yellow water lilly																									X											X	
Nymphoides cordata (Ell.) Fern.	little floating heart																X																					
Nyssa sylvatica Marsh.	black tupelo				X		X	X		X				X		X					X		X		X	X					X			X	X	X	X	X
Oclemena acuminata (Michx.) Nesom	whorled aster	X	X		X	X	X				X		X	X	X	X			X	X			X	X	X	X	X	X			X			X	X	X		
Oenothera parviflora L.	small-flowered evening-primrose																																					X
Oenothera perennis L.	little sundrops																																					X
Onoclea sensibilis L.	sensitive fern	X		X	X	X	X			X	X		X	X	X	X			X	X	X		X	X	X	X	X	X	X			X			X	X	X	X
Oryzopsis asperifolia Michx.	rough-leaved ricegrass	X	X	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Oryzopsis pungens (Torr. ex Spreng.) A. S. Hitch	ricegrass																										X									X		
Osmunda cinnamomea L.	cinnamon fern	X		X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X		X	X	X	X	X	X	X			X			X	X	X	X
Osmunda claytoniana L.	interrupted fern	X	X	X	X	X	X		X	X		X	X	X	X	X		X	X	X		X	X	X	X	X			X						X	X	X	
Osmunda regalis L. var. *spectabilis* (Willd.) G	royal fern	X			X	X	X	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X			X			X	X	X	X
Osmunda sp.	fern species		X												X																							

Continued.

Appendix I.—continued.

Latin Name	Common Name	N1			N2			N3			N4			Total				S1			S2			S3			S4			S5			S6			Total			
		plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other
Ostrya virginiana (P. Mill.) K. Koch	eastern hophornbeam				X		X							X		X																							
Oxalis montana Raf.	common wood-sorrel				X	X	X							X	X	X																							
Oxalis stricta L.	common yellow wood-sorrel																X								X	X	X									X	X	X	X
Oxalis sp.	wood-sorrel						X									X					X			X												X	X		
Panax trifolius L.	dwarf ginseng		X	X		X	X			X	X		X	X	X	X	X							X			X	X									X	X	
Panicum acuminatum ssp. *fasciculatum* (Torr.) Freckmann & Lelong	woolly panic grass																								X													X	
Panicum acuminatum ssp. *implicatum* (Schribn.) Freckmann & Lelong	woolly panic grass					X									X		X																						
Panicum acuminatum ssp. *spretum* (J.A. Schultes) Freckmann & Lelong	wooly panic grass				X	X								X	X																								
Panicum clandestinum L.	deer tongue grass																																							X
Panicum depauperatum Muhl.	starved panic grass									X							X								X													X		
Panicum dichotomiflorum L.	fall panicum																																							X
Panicum sp.	panic grass species	X			X	X	X		X	X				X	X	X							X	X	X	X			X								X	X	X	X
Parthenocissus quinquefolia (L.) Planch	Virginia creeper				X	X	X							X	X	X	X						X	X	X	X												X	X	X	
Parthenocissus cf. *vitacea* (Knerr) A.S. Hitchc.	grape woodbine																									X													X	
Parthenocissus sp.	woodbine species						X									X																								
Peltandra virginica (L.) Schott	tuckahoe																X																							
Persicaria arifolia (L.) Haroldson	halberd-leaved tearthumb						X									X					X	X	X			X												X	X	X
Persicaria hydropiperoides (Michx.) Small	water pepper						X									X																								
Persicaria maculosa S. F. Gray*	lady's thumb																																							X
Persicaria cf. *punctata* (Ell.) Small	dotted smartweed																																							X
Persicaria sagittata (L.) H. Gross	arrow-leaved tearthumb					X	X								X	X									X	X											X	X	
Persicaria sp.	tearthumb species																				X		X														X		X	X
Phegopteris connectilis (Michx.) Watt	long beech fern						X									X																								X
Phleum pratense L.*	timothy																																							X
Photinia x *floribunda* (Lindl.) Robertson & Phipps	black chokeberry				X	X	X	X	X	X			X	X	X	X	X	X					X	X	X	X	X		X	X			X	X	X	X	X	X	X	X
Photinia sp.	chokeberry species		X												X																									
Picea glauca (Moench) Voss	white spruce						X									X																								
Picea mariana (P. Mill.) B. S. P.	black spruce								X	X					X	X										X													X	
Picea rubens Sarg.	red spruce				X	X	X	X	X	X	X		X	X	X	X	X						X	X	X	X							X			X	X	X		
Picea sp.	spruce species					X									X																									
Pinus monticola Dougl. ex D. Don	western white pine																									X													X	
Pinus resinosa Ait.	red pine				X	X	X	X	X	X	X	X	X	X	X	X			X		X	X	X	X	X	X	X		X			X	X	X	X	X	X	X	X	

Latin Name	Common Name	N1			N2			N3			N4			Total				S1			S2			S3			S4			S5			S6			Total		
		plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other
Pinus rigida P. Mill.	pitch pine				X	X	X							X	X	X									X	X	X	X	X				X	X	X	X	X	X	
Pinus strobus L.	white pine	X		X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X		X	X		X	X	X	X	
Pinus sylvestris L.*	Scotch pine				X		X							X		X										X											X		
Pinus sp.	pine species						X									X																							
Plantago major L.*	common plantain						X									X																							
Platanthera clavellata (Michx.) Luer	green woodland orchid						X						X			X			X		X	X	X			X		X	X						X	X	X		
Platanthera grandiflora (Bigelow) Lindl.	large purple-fringed orchid						X									X	X																						
Platanthera cf. *hyperborea* (Lindl. var. huronensis (Nutt.) Luer	leafy northern green orchid		X			X									X																							
Platanthera lacera (Michx.) G. Don	ragged orchid																									X											X		
Platanthera sp.	orchid species						X						X			X										X											X		
Poa compressa L.*	Canada bluegrass																									X											X	X	
Poa palustris L.	fowl meadowgrass																									X											X	X	
Poa pratensis L.*	Kentucky bluegrass								X						X		X									X		X									X		
Poa sp.	bluegrass species																												X								X		
Pogonia ophioglossoides (L.) Ker-Gawl.	rose pogonia																																						
Polygala paucifolia Willd.	bird on the wing			X	X	X	X	X	X	X	X	X	X	X	X	X					X	X	X	X	X	X			X							X	X	X	
Polygala sanguinea L.	bitter milkwort																X																						X
Polygonatum pubescens (Willd.) Pursh	hairy Solomon's seal				X	X	X				X	X	X	X	X	X										X											X		
Polygonatum sp.	Solomon's seal species				X	X	X							X	X	X																							
Polygonella articulata (L.) Meisn.	jointweed																X																						X
Polypodium appalachianum Haufler & Windham	Appalachian polypody						X									X								X												X		X
Polypodium appalachiana x *P. virginianum*	polypody hybrid																				X															X			
Polypodium virginianum L.	rock polypody					X	X								X	X	X					X	X		X	X											X	X	X
Polystichum acrostichoides (Michx.) Schott	Christmas fern				X	X	X							X	X	X										X											X		
Pontederia cordata L.	pickerelweed																									X											X	X	
Populus grandidentata Michx.	big-toothed aspen		X		X	X	X			X	X			X	X	X						X	X				X	X	X							X	X	X	
Populus tremuloides Michx.	quaking aspen			X	X	X	X	X	X	X	X	X	X	X	X	X			X		X	X	X	X	X	X	X		X							X	X	X	
Populus sp.	aspen species					X									X																								
Potentilla canadensis L.	running cinquefoil																							X		X											X		X	X
Potentilla norvegica L.	rough cinquefoil																				X																X			
Potentilla cf. *recta* L.*	rough-fruited cinquefoil																									X											X		
Potentilla simplex Michx.	old-field cinquefoil	X					X		X	X					X	X	X	X				X			X		X										X		X	X
Potentilla sp.	cinquefoil species						X			X							X					X				X	X										X	X	X	
Prenanthes alba L.	rattlesnake root												X				X																							
Prenanthes altissima L.	tall white-lettuce				X	X	X						X	X	X	X										X												X		
Prenanthes trifoliata (Cass.) Fern.	gall of the earth																																							X

Continued.

Appendix I.—continued.

Latin Name	Common Name	N1			N2			N3			N4			Total				S1			S2			S3			S4			S5			S6			Total			
		plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other
Prenanthes sp.	white-lettuce species	X	X	X	X	X	X	X	X	X	X		X	X	X	X					X		X		X	X			X						X	X	X	
Prunella vulgaris L.*	selfheal																																						X
Prunus pensylvanica L. f.	pin cherry					X	X			X					X	X										X													
Prunus serotina Ehrh.	black cherry		X		X	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Prunus virginiana L.	choke cherry					X	X	X		X				X	X	X					X	X		X		X		X								X	X	X	
Prunus sp.	cherry species				X		X	X		X				X		X																							
Pteridium aquilinum (L.) Kuhn *ex* Decken var. *latiusculum* (Desv.) Underwood ex Heller	bracken	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Pyrola americana Sweet	round-leaved pyrola				X		X	X		X	X			X		X					X	X		X	X	X										X	X	X	
Pyrola elliptica Nutt.	shinleaf		X	X	X	X	X	X	X					X	X	X	X							X		X	X										X	X	X
Pyrola sp.	pyrola species				X	X	X							X	X	X								X	X	X											X	X	X	
Quercus alba L.	white oak	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Quercus ilicifolia Wangenh.	bear oak				X	X	X							X	X	X	X						X															X	
Quercus rubra L.	northern red oak	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X		X	X	X	X	
Quercus velutina Lam.	black oak				X		X					X	X	X	X	X	X																						
Quercus sp.	oak species																X							X												X			X
Rhamnus sp.	buckthorn species						X									X																							
Rhododendron canadense (L.) Torr.	rhodora				X		X		X	X			X	X	X	X	X						X			X						X			X	X	X	X
Rhododendron groenlandicum (Oeder) Kron & Judd	Labrador-tea																									X										X			
Rhynchospora alba (L.) Vahl.	white beak-rush																			X																			
Rhynchospora capitellata (Michx.) Vahl	beak-rush																X																						X
Ribes hirtellum Michx.	bristly gooseberry					X									X																							
Ribes sp.	gooseberry/current species						X									X																							
Rorippa sp.*	water-cress species				X		X							X		X																							
Rosa carolina L.	pasture rose																																						X
Rosa multiflora Thunb. *ex* Murr.*	multiflora rose																									X												X	X
Rosa sp.	rose species					X									X										X	X											X	X	
Rubus allegheniensis Porter	common blackberry							X	X	X				X	X	X	X									X												X	X
Rubus cf. *canadensis* L.	Canada blackberry																				X				X											X	X		
Rubus dalibarda L.	dewdrop	X	X	X	X	X	X			X				X	X	X			X	X			X	X	X	X			X							X	X	X	X
Rubus cf. *flagellaris* Willd.	northern dewberry						X									X																							
Rubus hispidus L.	swamp dewberry	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X		X	X	X	X	X	X	X
Rubus idaeus L.	red raspberry				X	X	X		X					X	X	X						X	X		X	X											X	X	
Rubus idaeus ssp. *strigosus* (Michx.) Focke*	red raspberry																																						X
Rubus occidentalis L.	black raspberry							X		X				X		X								X	X	X											X	X	X	
Rubus pubescens Raf.	dwarf raspberry				X	X	X			X			X	X	X	X	X				X		X	X	X	X	X	X	X	X	X	X			X	X	X	X	
Rubus sp.	raspberry species				X	X	X	X	X	X			X	X	X	X							X	X	X	X							X			X	X	X	

Latin Name	Common Name	N1			N2			N3			N4			Total				S1			S2			S3			S4			S5			S6			Total			
		plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other
Rumex acetosella L.*	sheep sorrel						X		X	X					X	X					X					X									X		X	
Sagittaria latifolia Willd.	common arrowhead						X									X																						
Salix discolor Muhl.	pussy willow																X																						
Salix humilis var. *humilis* Marsh	prairie willow																X																						
Salix sp.	willow species					X	X								X	X																							
Sambucus canadensis L.	common elder						X									X								X												X		
Sambucus racemosa L. ssp. *pubens* (Michx.) House	red-berried elder					X									X								X														X	X
Sarracenia purpurea L.	pitcher plant																					X				X										X	X	X
Schizachyrium scoparium (Michx.) Nash	little bluestem					X									X		X							X		X										X	X	
Scirpus cyperinus (L.) Kunth	wool-grass																																						X
Scirpus microcarpus J. & K. Presl																										X											X	
Scirpus pedicellatus Fern.	bulrush																							X													X		
Scirpus sp.	bulrush species																									X											X		
Scutellaria galericulata L.	common skullcap				X	X	X							X	X	X	X				X	X	X			X									X	X	X		
Scutellaria lateriflora L.	mad-dog skullcap					X	X								X	X	X							X		X										X	X	X
Scutellaria sp.	skullcap species				X		X			X				X		X										X											X		
Senecio sp.	groundsel species						X									X																							
Sium suave Walt.	water parsnip						X									X	X																						
Smilax herbacea L.	carrion flower				X		X							X		X	X							X			X	X								X	X		
Smilax rotundifolia L.	common greenbrier						X									X																							
Smilax sp.	brier species	X				X	X			X				X	X	X																							
Solanum dulcamara L.*	bittersweet nightshade						X									X	X									X											X		
Solidago bicolor L.	silverrod					X									X																							X
Solidago juncea Ait.	early goldenrod																X					X														X		X
Solidago nemoralis Ait.	gray goldenrod						X									X																							
Solidago puberula Nutt.	downy goldenrod					X	X								X	X	X																						X
Solidago rugosa P. Mill.	rough-stemmed goldenrod						X			X			X			X										X											X	X	X
Solidago uliginosa Nutt.	northern bog goldenrod																X									X													X
Solidago sp.	goldenrod species	X			X	X	X	X	X	X	X			X	X	X	X		X	X	X	X	X		X	X	X		X			X			X	X	X	X	X
Sorbus americana Marsh.	American mountain-ash				X		X							X		X									X											X			
Sorbus sp.	mountain-ash species					X									X																								
Sparganium americanum Nutt.	lesser bur reed																									X											X		
Sparganium sp.	bur reed species					X	X								X	X									X	X										X	X		
Spiraea alba Du Roi var. *latifolia* (Ait) Dippel	meadowsweet	X			X	X	X	X	X	X		X	X	X	X	X					X		X	X	X	X		X	X							X	X	X	
Spiraea tomentosa L.	hardhack									X						X	X						X			X											X	X	
Streptopus amplexifolius (L.) DC.	twisted stalk						X									X																							
Streptopus lanceolatus (Ait.) Reveal	rose twisted stalk					X									X																							

Continued.

Appendix I.—continued.

Latin Name	Common Name	N1			N2			N3			N4			Total				S1			S2			S3			S4			S5			S6			Total			
		plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other
Streptopus sp.	twisted stalk species				X		X							X		X							X													X		
Symphotrichum cordifolium (L.) Nesom	common blue heart-leaved aster					X	X								X	X										X									X		
Symphyotrichum ericoides (L.) Nesom	squarrose white aster																																					X
Symphyotrichum lateriflorum (L.) A. & D. Love	calico aster	X					X							X		X								X	X										X	X	
Symphyotrichum novae-angliae (L.) Nesom	New England aster																								X											X	
Symphyotrichum cf. *racemosum* (Ell.) Nesom	bristly aster																X																				X
Symphyotrichum undulatum (L.) Nesom	clasping heart-leaved aster					X	X								X	X								X	X										X	X	
Symphyotrichum sp.	aster species				X									X																							X
Symplocarpus foetidus (L.) Salisb. ex Nutt.	skunk cabbage				X	X	X							X	X	X																					
Taxus canadensis Marsh.	American yew				X	X	X							X	X	X																					
Thalictrum pubescens Pursh	tall meadow-rue					X	X								X	X	X						X	X		X									X		X	X
Thalictrum sp.	meadow-rue				X	X	X			X				X	X	X						X						X								X	X	
Thelypteris noveboracensis (L.) Nieuwl.	New York fern				X	X	X			X	X		X	X	X	X	X							X	X	X	X		X			X				X	X	X	
Thelypteris palustris Schott var. *pubescens* (Lawson)	marsh ferns				X	X	X			X		X	X	X	X	X								X	X	X	X	X	X			X				X	X	X	X
Thelypteris simulata (Davenport) Nieuwl.	Massachusetts fern																						X														X	
Thelypteris sp.	fern				X	X	X							X	X	X								X												X		
Tiarella cordifolia L.	foam flower					X	X								X	X									X											X	
Tilia americana L.	basswood						X									X																					
Toxicodendron radicans (L.) Kuntze	poison-ivy			X	X	X	X			X	X		X	X	X	X					X	X	X	X	X	X	X		X			X			X	X	X	
Toxicodendron vernix (L.) Kuntze	poison-sumac																									X											X	X
Triadenum virginicum (L.) Raf.	marsh St. Johnswort				X		X							X		X					X					X			X						X		X	X
Triadenum sp.																																						X
Trichostema dichotomum L.	blue curls						X									X	X																					
Trientalis borealis Raf.	star flower	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Trifolium pratense L.*	red clover																									X											X	
Trifolium repens L.*	white clover									X						X																						
Trifolium sp.*	clover species																									X											X	
Trillium cernuum L.	nodding trillium																																					X
Trillium erectum L.	purple trillium																											X									X	
Trillium undulatum Willd.	painted trillium	X		X	X	X	X		X	X	X		X	X	X	X	X							X	X	X		X	X							X	X	X	
Trillium sp.	trillium species		X												X									X	X				X							X	X	X	
Tsuga canadensis (L.) Carr.	eastern hemlock	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X			X	X	X	X	X	X	X		X				X	X	X	
Ulmus americana L.	American elm				X	X	X							X	X	X					X		X		X	X										X	X	X	

Latin Name	Common Name	N1			N2			N3			N4			Total				S1			S2			S3			S4			S5			S6			Total			
		plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	plot	vicinity	meander	other
Uvularia sessilifolia L.	wild-oats	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	
Vaccinium angustifolium Ait.	low sweet blueberry	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	
Vaccinium corymbosum L.	highbush blueberry	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	
Vaccinium macrocarpon Ait.	large cranberry																X									X											X	X
Vaccinium myrtilloides Michx.	velvet-leaf blueberry				X		X	X	X	X				X	X	X	X									X											X	
Vaccinium oxycoccos L.	small cranberry																									X											X	X
Vaccinium sp.	blueberry/cranberry species						X									X																						X
Veratrum viride Ait.	false hellebore				X	X	X					X	X	X	X	X												X								X		
Verbena hastata L.	blue vervain					X	X								X	X					X		X												X		X	
Veronica scutellata L.	marsh speedwell																									X											X	X
Viburnum acerifolium L.	maple-leaved viburnum	X	X	X	X	X	X		X			X		X	X	X			X	X	X		X	X	X	X				X		X				X	X	X	
Viburnum dentatum L. var. *lucidum* Ait.	arrowwood	X		X	X	X	X		X	X			X	X	X	X				X	X		X	X	X	X	X	X	X			X				X	X	X	
Viburnum lantanoides Michx.	hobblebush	X	X	X	X	X	X							X	X	X							X		X	X											X	X	
Viburnum lentago L.	nannyberry				X									X			X																						
Viburnum nudum L. var. *cassinoides* (L.) Torr. & Gray	witherod	X	X	X	X	X	X	X	X	X		X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	
Viburnum opulus L. var. *americanum* Ait.	highbush cranberry																																						X
Viburnum sp.	viburnum species				X	X	X							X	X	X							X			X							X						
Vicia cracca L.*	cow vetch																									X											X		
Viola blanda Willd.	sweet white violet																X																						
Viola cf. *adunca* Sm.	hook-spurred violet							X						X																									
Viola cf. *affinis* Le Conte	violet																							X												X		X
Viola cucullata Ait.	blue marsh violet						X									X	X									X											X	
Viola hastata	halberd-leaved violet				X									X																								
Viola macloskeyi Lloyd ssp. pallens (Banks ex D.C.) M.S. Baker	wild white violet																X																						
Viola sagittata Ait.	arrowhead violet						X			X						X																							
Viola sagittata Ait. var. ovata (Nutt.) Torr. & Gray	arrowhead violet																																						X
Viola sp.	violet species	X	X		X	X	X	X		X	X		X	X	X	X			X	X	X	X	X	X	X	X	X		X			X				X	X	X	X
Vitis cf. labrusca	fox grape	X	X	X	X	X	X							X	X	X	X						X	X	X	X										X	X	X	X
Woodwardia virginica (L.) Sm.	Virginia chain fern					X	X								X	X								X	X	X										X	X	X
Unknown	unknown	X			X	X	X	X	X	X	X		X	X	X	X					X	X	X	X	X	X	X				X					X	X	X	X

Specimens for most of the less common taxa are stored in Bradley, ME or are deposited at the Maine Herbarium, University of Maine, Orono.

* indicates species not native to North America.

sp. means there are potentially numerous species that could not be conclusively determined.

cf. means "compare to."

Appendix II.—Wetland species found in the MEF and their status.

Latin Name	Common Name	Wetland Status[a]
Agrostis gigantea Roth	redtop	FACW-
Alnus serrulata (Ait.) Willd.	smooth alder	OBL
Andromeda polifolia L. var. *glaucophylla* (Link) DC.	bog rosemary	OBL
Anemone canadensis L.	Canada anemone	FACW
Apios americana Medik.	common groundnut	FACW
Arethusa bulbosa L.	dragon's mouth	OBL
Arisaema triphyllum (L.) Schott	jack-in-the-pulpit	FACW-
Asclepias incarnata L.	swamp milkweed	OBL
Bidens connata Muhl. *ex* Willd.	purple stem beggar ticks	FACW+
Bidens frondosa L.	devil's beggar ticks	FACW
Calamagrostis canadensis (Michx.) Beauv.	bluejoint grass	FACW+
Calopogon tuberosus (L.) B. S. P.	grass-pink	FACW+
Cardamine pensylvanica Muhl. *ex* Willd.	Pennsylvania bitter-cress	OBL
Carex aquatilis Whalenb.	water sedge	OBL
Carex atlantica Bailey	eastern sedge	FACW+
Carex atlantica ssp. *capillacea* Bailey	eastern sedge	OBL
Carex brunnescens (Pers.) Poir.	brownish sedge	FACW
Carex bullata Schkuhr *ex* Willd.	button sedge	OBL
Carex canescens L.	silvery sedge	OBL
Carex comosa Boott	bristly sedge	OBL
Carex crinita Lam.	drooping sedge	OBL
Carex echinata Murr.	star sedge	OBL
Carex folliculata L.	long sedge	OBL
Carex gynandra Schwein.	nodding sedge	OBL
Carex intumescens Rudge	sedge	FACW+
Carex lacustris Willd.	lake bank sedge	OBL
Carex leptalea Wahlenb.	bristly-stalked sedge	OBL
Carex leptonervia (Fern.) Fern.	two-edged sedge	FACW
Carex lurida Wahlenb.	sallow sedge	OBL
Carex magellanica ssp. *irrigua* (Wahlenb.) Hulten	bog sedge	OBL
Carex projecta Mackenzie	necklace sedge	FACW
Carex psuedocyperus L.	cyperus-like sedge	OBL
Carex scabrata Schwein.	rough sedge	OBL
Carex scoparia Schkuhr *ex* Willd.	pointed broom sedge	FACW
Carex stipata Muhl. *ex* Willd.	awl-fruited sedge	OBL
Carex stricta Lam.	tussock sedge	OBL
Carex trisperma Dewey	three-seeded sedge	OBL
Carex vesicaria L.	inflated sedge	OBL
Carex wiegandii Mackenzie	Wiegand's sedge	OBL
Cephalanthus occidentalis L.	button bush	OBL
Chamaecyparis thyoides (L.) B. S. P.	Atlantic white-cedar	OBL
Chamaedaphne calyculata (L.) Moench	leatherleaf	OBL
Chelone glabra L.	white turtlehead	OBL
Chrysosplenium americanum Schwein. ex Hook.	water carpet	OBL
Cicuta maculata L.	water hemlock	OBL
Cinna latifolia (Trev. *ex* Goepp.) Griseb.	drooping woodreed	FACW
Circaea alpina L.	alpine enchanter's-nightshade	FACW

Continued.

Appendix II.—continued.

Latin Name	Common Name	Wetland Status
Coptis trifolia (L.) Salisb.	goldthread	FACW
Cornus amomum P. Mill. ssp. *amomum*	silky dogwood	FACW
Decodon verticillatus (L.) Ell.	water-willow	OBL
Drosera intermedia Hayne	spatulate-leaved sundew	OBL
Drosera rotundifolia L.	round-leaved sundew	OBL
Dryopteris cristata (L.) Gray	crested wood fern	FACW+
Dulichium arundinaceum (L.) Britt.	three-way sedge	OBL
Eleocharis acicularis (L.) Roemer & J. A. Schultes	needle spikerush	OBL
Epilobium leptophyllum Raf.	American marsh willow-herb	OBL
Equisetum fluviatile L.	river horsetail	OBL
Equisetum pratense Ehrh.	meadow horsetail	FACW
Equisetum sylvaticum L.	woodland horsetail	FACW
Eriophorum virginicum L.	tawny cotton-grass	OBL
Eupatorium maculatum L.	spotted joe-pye weed	FACW
Fraxinus nigra Marsh.	black ash	FACW
Galium asprellum Michx.	rough bedstraw	OBL
Galium palustre L.	marsh bedstraw	OBL
Galium tinctorium (L.) Scop.	southern three-lobed bedstraw	OBL
Galium trifidum L.	northern three-lobed bedstraw	FACW+
Gaultheria hispidula (L.) Muhl. ex Bigelow	creeping snowberry	FACW
Glyceria borealis (Nash) Batchelder	northern mannagrass	OBL
Glyceria canadensis (Michx.) Trin	rattlesnake mannagrass	OBL
Glyceris melicaria (Michx.) F. T. Hubbard	northeastern mannagrass	OBL
Glyceria obtusa (Muhl.) Trin.	coastal mannagrass	OBL
Glyceria striata (Lam.) A. S. Hitchc.	fowl mannagrass	OBL
Huperzia lucidula (Michx.) Trevisan	shining clubmoss	FACW-
Hydrocotyle americana L.	marsh pennyroyal	OBL
Hypericum boreale (Britt.) Bickn.	St. Johnswort	OBL
Hypericum canadense L.	Canada St. Johnswort	FACW
Hypericum ellipticum Hook.	St. Johnswort	OBL
Ilex laevigata (Pursh) Gray	smooth winterberry	OBL
Ilex verticillata (L.) Gray	winterberry	FACW+
Impatiens capensis Meerb.	orange touch-me-not	FACW
Iris versicolor L.	northern blue flag	OBL
Juncus brevicaudatus (Engelm.) Fern.	short-tailed rush	OBL
Juncus effusus L.	soft rush	FACW+
Juncus filiformis L.	thread rush	FACW
Kalmia polifolia Wangenh.	bog laurel	OBL
Larix laricina (Du Roi) K. Koch	larch	FACW
Leersia oryzoides (L.) Sw.	rice cutgrass	OBL
Lobelia cardinalis L.	cardinal flower	FACW+
Lobelia kalmii L.	Kalm's lobelia	OBL
Lycopus americanus Muhl. *ex* W. Bart.	American water-horehound	OBL
Lycopus uniflorus Michx.	northern water-horehound	OBL
Lycopus virginicus L.	Virginia water-horehound	OBL
Lyonia ligustrina (L.) DC.	maleberry	FACW
Lysimachia ciliata L.	fringed loosestrife	FACW

Continued.

Appendix II.—continued.

Latin Name	Common Name	Wetland Status
Lysimachia terrestris (L.) B.S.P.	swamp candles	OBL
Maianthemum trifolium (L.) Sloboda	three-leaved false Solomon's seal	OBL
Menyanthes trifoliata L.	buckbean	OBL
Mimulus ringens L.	Allegheny monkeyflower	OBL
Mitella nuda L.	naked miterwort	FACW-
Nemopanthus mucronatus (L.) Loes.	mountain holly	OBL
Nuphar variegata Dur.	yellow water lilly	OBL
Nymphoides cordata (Ell.) Fern.	little floating heart	OBL
Onoclea sensibilis L.	sensitive fern	FACW
Osmunda cinnamomea L.	cinnamon fern	FACW
Osmunda regalis L. var. *spectabilis* (Willd.) G	royal fern	OBL
Panicum dichotomiflorum L.	fall panicum	FACW-
Peltandra virginica (L.) Schott	tuckahoe	OBL
Persicaria arifolia (L.) Haroldson	halberd-leaved tearthumb	OBL
Persicaria hydropiperiodes (Michx.) Small	water pepper	OBL
Persicaria sagittata (L.) H. Gross	arrow-leaved tearthumb	OBL
Picea mariana (P. Mill.) B. S. P.	black spruce	FACW-
Platanthera clavellata (Michx.) Luer	green woodland orchid	FACW+
Platanthera grandiflora (Bigelow) Lindl.	large purple-fringed orchid	FACW
Platanthera lacera (Michx.) G. Don	ragged orchid	FACW
Poa palustris L.	fowl meadowgrass	FACW
Pogonia ophioglossoides (L.) Ker-Gawl.	rose pogonia	OBL
Pontederia cordata L.	pickerelweed	OBL
Rhododendron canadense (L.) Torr.	rhodora	FACW
Rhododendron groenlandicum (Oeder) Kron & Judd	Labrador-tea	OBL
Rhynchospora alba (L.) Vahl.	white beak-rush	OBL
Rhynchospora capitellata (Michx.) Vahl	beak-rush	OBL
Rubus hispidus L.	swamp dewberry	FACW
Rubus pubescens Raf.	dwarf raspberry	FACW
Sagittaria latifolia Willd.	common arrowhead	OBL
Sambucus canadensis L.	common elder	FACW
Sarracenia purpurea L.	pitcher plant	OBL
Scirpus cyperinus (L.) Kunth	wool-grass	FACW+
Scirpus microcarpus J. & K. Presl	bulrush	OBL
Scirpus pedicellatus Fern.	bulrush	OBL
Scutellaria galericulata L.	common skullcap	OBL
Scutellaria lateriflora L.	mad-dog skullcap	FACW+
Sium suave Walt.	water parsnip	OBL
Solidago uliginosa Nutt.	northern bog goldenrod	OBL
Sparganium americanum Nutt.	lesser bur reed	OBL
Spiraea alba Du Roi var. *latifolia* (Ait) Dippel	meadowsweet	FACW+
Spiraea tomentosa L.	hardhack	FACW-
Symphyotrichum lateriflorum (L.) A. & D. Love	calico aster	FACW-
Symplocarpus foetidus (L.) Salisb. *ex* Nutt.	skunk cabbage	OBL
Thalictrum pubescens Pursh	tall meadow-rue	FACW+
Thelypteris palustris Schott var. *pubescens* (Lawson)	marsh ferns	FACW+
Thelypteris simulata (Davenport) Nieuwl.	Massachusetts fern	FACW

Continued.

Appendix II.—continued.

Latin Name	Common Name	Wetland Status
Toxicodendron vernix (L.) Kuntze	poison-sumac	OBL
Triadenum virginicum (L.) Raf.	marsh St. Johnswort	OBL
Ulmus americana L.	American elm	FACW-
Vaccinium corymbosum L.	highbush blueberry	FACW-
Vaccinium macrocarpon Ait.	large cranberry	OBL
Vaccinium oxycoccos L.	small cranberry	OBL
Veratrum viride Ait.	false hellebore	FACW+
Verbena hastata L.	blue vervain	FACW+
Veronica scutellata L.	marsh speedwell	OBL
Viburnum nudum L. var. *cassinoides* (L.) Torr. & Gray	witherod	FACW
Viburnum opulus L. var. *americanum* Ait.	highbush cranberry	FACW
Viola blanda Willd.	sweet white violet	FACW
Viola cucullata Ait.	blue marsh violet	FACW+
Viola macloskeyi Lloyd ssp. *pallens* (Banks ex D.C.) M.S. B	wild white violet	OBL
Viola sagittata Ait.	arrowhead violet	FACW
Viola sagittata Ait. var. *ovata* (Nutt.) Torr. & Gray	arrowhead violet	FACW
Woodwardia virginica (L.) Sm.	Virginia chain fern	OBL

[a]OBL = obligate wetland, FACW = facultative wetland.
FACW + = more frequently found in wetlands, - = less frequently found in wetlands.

Dibble, Alison C.; Rees, Catherine A.; Sendak, Paul E.; Brissette, John C. 2004. **Vegetation of forested uplands in the Massabesic Experimental Forest.** Gen. Tech. Rep. NE-320. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 71 p.

A summary of an inventory of vascular plants in the 3,700-acre Massabesic Experimental Forest in York County, Maine. We identified about 500 species and subspecies. The most common overstory trees were eastern white pine, eastern hemlock, northern red oak, and red maple. Hemlock was the most abundant tree seedling. Shrub density was greatest for beaked hazlenut, followed by several viburnum species, highbush blueberry, and winterberry. The most common herb was starflower. We found nine listed rare plants, including a federally threatened orchid, small whorled pogonia. A geographic information system was developed and includes inventory data, forest type, soils, fire history, topography, roads, and streams.

Keywords: Inventory, sampling, geographic information system, timber volume, shrubs and herbs, rare plants, regeneration, white pine, northern red oak, eastern hemlock, red maple, Atlantic white-cedar

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