ECOLOGICAL SURVEY AND MANAGEMENT PLAN FOR CROWN VANTAGE LANDS WITHIN THE LAKE UMBAGOG NATIONAL WILDLIFE REFUGE

Appalachian Mountain Club

Crown Vantage Paper Company

U.S. Fish and Wildlife Service

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July 1997

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EXECUTIVE SUMMARY

This project was a cooperative effort among the U.S. Fish and Wildlife Service, Crown Vantage Paper Company, and the Appalachian Mountain Club to gather information on the ecological resources of the New Hampshire portion of the Lake Umbagog National Wildlife Refuge and incorporate it into a long-term management plan for Crown Vantage's lands within the refuge boundaries. The project area encompassed 11,865 acres, of which about 6,100 are owned and managed by Crown Vantage and about 4,400 are owned by federal or state government agencies.

The focus of the project was to inventory and map the natural communities and significant ecological resources of the study area, and to develop a long-term resource management plan for Crown Vantage lands that integrates silvicultural goals and needs with the conservation of wildlife habitat and other important ecological resources. No management plans were developed for public lands, but the composition and condition of these lands was considered in the development of the plan, with the intent that the entire area be considered an integrated management unit.

Field work was conducted during the summer of 1996 by AMC Research Department staff. Natural communities were delineated and mapped using existing New Hampshire Natural Heritage Inventory designations as much as possible. Surveys were conducted to identify significant ecological features such as rare plant locations and special wildlife habitat features. Eight upland and seven wetland communities were delineated. About 78% of the study area was in upland communities and 22% in wetland communities. Three upland communities (Northern Hardwood-Spruce-Fir, Beech-Birch-Maple, and Lowland Spruce-Fir) encompassed nearly two-thirds of the study area. The most common wetland community was Cedar Swamp Forests, covering about 6% of the study area.

Populations of four species of state-threatened rare plants (meagre sedge [*Carex exilis*], small yellow lady's slipper [*Cypripedium parviflorum*], heart-leaved twayblade [*Listera cordata*] and lily-leaved twayblade [*L. convallarioides*]) not previously known from the refuge were identified during the survey. Though comprehensive wildlife surveys were not undertaken, eleven bird species that are of concern to the refuge were seen. Several areas of forest with late-successional characteristics were identified, as well as one area apparently being used as a deeryard.

Based on community designations, about one-third of the study area (about 4000 acres) is of particular ecological significance due to community rarity or value as habitat for wildlife or rare plants. Of this, over 1600 acres is potentially commercial timber land, with lowland spruce-fir forests being the most significant. Of particular interest is the area adjacent to Mountain Pond Stream between Sweat Meadow and Thurston Cove, a complex of cedar swamp and other wetland and upland forests with a high concentration of rare plants and significant wildlife habitat features.

Timber stand maps were used to assess the current distribution of wildlife habitats within the study area. Nearly two-thirds of the forested portion of the study area is in mature or semi-mature closed forest habitat (>30 feet tall and >60% crown closure), and about 14% is in young or regenerating stands (<30 feet tall) with or without a scattered residual overstory of larger trees.

About 13% of the study area is in non-forested habitats, the great majority being the extensive wet meadows around the confluence of the Magalloway and Androscoggin Rivers.

The primary goals of the management plan are to: 1) create and maintain balanced size-class distributions within each natural community to provide both a sustainable flow of timber products and a diversity of forest habitats, and 2) provide a high level of protection to aquatic and wetland habitats, uncommon natural communities, rare plants, and critical habitat features. At least 10% of each forested community (across public and private lands combined) should remain unharvested to allow the development of old-growth conditions. While it is appropriate that the majority of this area be located on public lands, the specific distribution remains to be determined.

Crown Vantage's land was allocated to five management classes: general management, riparian management (both harvestable and no-harvest) and reserve areas (operable and inoperable). Reserve areas were designated based on operability, ecological significance, and sensitivity to disruption by harvesting. Of Crown Vantage's forested acreage, about 82% was designated general management, 6% riparian management, and 12% reserve area. The great majority of the reserve area is inoperable. About 54 acres (1% of operable forested acreage) are excluded from harvest as riparian no-harvest zones or reserve areas. The primary communities suitable for timber management are Northern Hardwood-Spruce-Fir (2002 acres), Beech-Birch-Maple (1798 acres), Lowland Spruce-Fir (648 acres) and Mountain Spruce-Fir (287 acres). The relatively low allocation to riparian management and reserve areas reflects the fact that most river and lake shorelines are under public ownership.

Both general and community-specific management guidelines have been specified. Detailed specification of desired future stand composition and structure have not been made, though guidelines for the general desired condition of each community have been made as appropriate. The most significant management issue is the need to regenerate spruce-fir stands before significant loss of mature balsam fir timber occurs, while still retaining sufficient mature habitat in this community.

An estimate was made of the long-term sustainable harvest level for these lands. Estimated growth for all of Crown Vantage's operable forest land is 1881 cords per year. Reductions to this harvest due to riparian management considerations, operable reserved areas, and wildlife tree retention come to about 101 cords/year, or 5.4% of the total. Additional reductions to harvest were not calculated but may include the presence of unmapped inoperable areas, the need to include some lands to meet the 10% old-growth retention goal, and fluctuations in harvest level as stands are brought into the desired balanced condition. The actual sustainable harvest level for Crown Vantage lands was estimated to be 1600 to 1700 cords per year, or 85 to 90% of net growth.

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ACKNOWLEDGMENTS

Funding for this project was provided through grants to the Appalachian Mountain Club from the Surdna Foundation, the Richard King Mellon Foundation, the Moriah Fund, and James and Elizabeth Nichols. In-kind contributions, including materials and staff time, were provided by the AMC, Crown Vantage, and the U.S. Fish & Wildlife Service.

Brad Wyman, Wood Operations Manager for Crown Vantage, was instrumental in the development of this project and provided advice and encouragement throughout. Without his commitment to the future of the Lake Umbagog region neither the refuge nor this project would have been possible.

Doug Johnson and Kevin Lemire of Crown Vantage and Tamara Tisdale and Paul Casey of USFWS made significant contributions of information, advice, and support (both logistical and conceptual).

The following individuals provided information or advice at various stages in the project: Dan Sperduto and Cory Craig of the New Hampshire Natural Heritage Inventory, Will Staats and John Kantor of New Hampshire Fish & Game, Chris Martin and Carol Foss of the New Hampshire Audubon Society, Tom Burke of the Natural Resources Conservation Service, and New Hampshire State Geologist Eugene Beaudette. Rick Vollick, Janith Taylor and Allen Carter of the U.S. Fish and Wildlife Service provided useful reviews of the draft plan.

This project is dedicated to the memory of Steve Breeser, the first manager of the Lake Umbagog National Wildlife Refuge, who provided valuable encouragement during the early stages of this project, but whose untimely death prevented him from seeing it completed.

I. INTRODUCTION

The Lake Umbagog National Wildlife Refuge (LUNWR) was created in 1992 and encompasses some of the most valuable wildlife habitat in northern New England. The refuge was established for the purpose of "the conservation of the wetlands of the Nation in order to maintain the public benefits they provide and to help fulfill international obligations contained in various migratory bird treaties and conventions". Most famous as the site of New Hampshire's only breeding pair of bald eagles, the refuge's forests and wetlands provide habitat for many other species of animals and plants as well. The protection of the Lake Umbagog area is an ongoing cooperative protection and management effort to preserve wildlife, wildlife habitat, wetlands and timber resources along the northern Maine/New Hampshire border. The effort involves a complex mix of federal, state and private agencies, conservation organizations, land trusts, and paper companies.

This project was a cooperative effort among the U.S. Fish and Wildlife Service (USFWS), Crown Vantage Paper Company, and the Appalachian Mountain Club (AMC) to gather information on the ecological resources of the New Hampshire portion of the LUNWR and incorporate it into a long-term management plan for Crown Vantage's lands within the refuge boundaries. The primary objectives of the project were:

1. To inventory, map and report on important ecological resources on Crown Vantage's lands and adjacent public lands within the Lake Umbagog National Wildlife Refuge.
2. To develop a long-term integrated resource management plan for these lands that incorporates both silvicultural goals and needs and conservation of important non-timber resources.
3. To develop educational materials that describe the project and demonstrate the benefits and challenges of integrating timber management with conservation of other ecological resources.

The parties anticipate the project will have the following benefits:

- It will provide more complete information on the nature and distribution of wildlife habitat, natural communities, and other ecological resources and allow better integration of timber management and resource conservation within the refuge.
- It will lead to specific actions designed to maintain and enhance wildlife habitat and other non-timber resources in the context of a working forest.
- It will increase the level of understanding and cooperation by building relationships between the forest products industry, conservation groups, and resource management professionals.
- It will provide opportunities for public education in which the benefits and challenges of integrating timber management with conservation of wildlife habitat and other ecological values may be demonstrated.
- It will allow an assessment of the direct and indirect costs associated with conducting this type of assessment and conserving significant non-timber resources within a timber management program.

II. ECOLOGICAL SURVEY

A. STUDY AREA

The Lake Umbagog National Wildlife Refuge encompasses about 16,000 acres astride the northern Maine/New Hampshire border (Figure 1). Considerable background information on the history and ecology of the refuge area can be found in the Environmental Assessment developed for the refuge (USFWS 1991).

This project focused on the portion of the refuge in New Hampshire and the adjacent Umbagog State Park, an area of 11,865 acres (Figure 2). Nearly 3,000 acres of the study area are owned and managed by the U.S. Fish and Wildlife Service, with an additional 1,400 acres owned by the state of New Hampshire. Public purchases have focused on the most valuable wetland and riparian habitats. Public lands encompass nearly all of the Lake Umbagog shoreline in New Hampshire, significant lengths of shoreline along the Androscoggin and Magalloway Rivers, and extensive marshes and bogs around the confluence of these rivers. Crown Vantage owns about 6,100 acres of primarily forested land within the refuge boundary, of which about 2,500 acres are protected by conservation easements with the State of New Hampshire that prohibit development but allow timber harvesting. About 1,400 acres are owned by other private landowners.

1. Ecoregional Classification

The study area has been mapped to the Landtype Association Level according to the U.S. Forest Service's ecoregional classification system (Bailey 1995, NHDRED 1995). The mapping units are hierarchical and based on climate, geology, landform, soils, and potential vegetation. From highest to lowest levels of the hierarchy the study area falls into the following classifications:

Domain: Humid Temperate
Division: Warm Continental
Province: Adirondack-New England Mixed Forest
Section: White Mountain
Subsection: Mahoosuc-Rangeley Lakes

Within the study area two Landtype Associations have been tentatively mapped (NHDRED 1995):

Valleys with Silty Substrate - encompassing the floodplain of the Magalloway and upper Androscoggin Rivers, including the lowlands along Mountain Pond Stream. This LTA is characterized by silty sediments deposited in association with glacial lake processes. Soils are finer-textured and potentially more productive than the more common sand and gravel alluvial soils of surrounding areas. Forest cover is primarily spruce-fir.

Hills and Slopes of Low Mountains - encompassing all uplands above the floodplain areas as well as the low flat area between Lake Umbagog and Mountain Pond Stream. Soils

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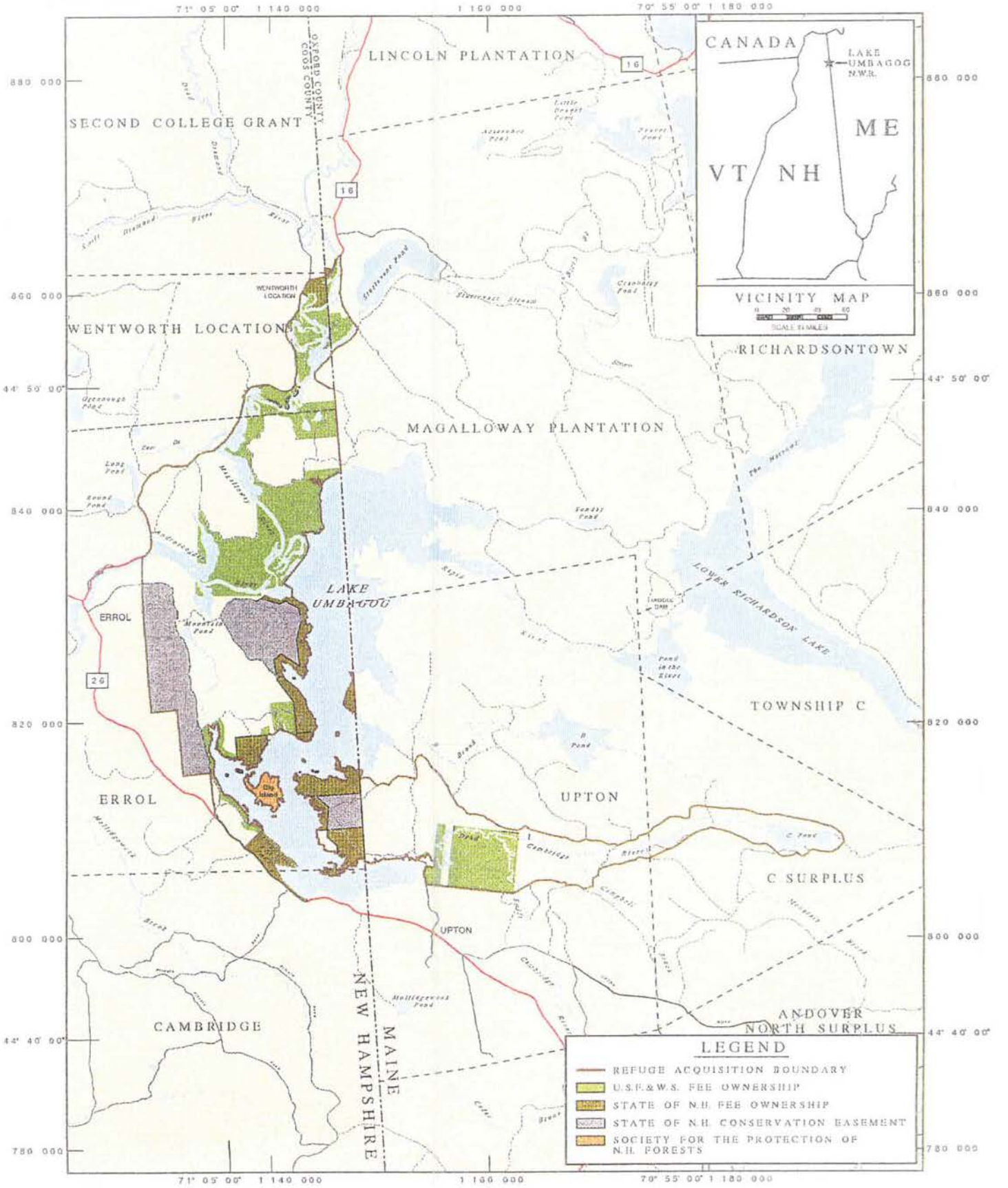

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1983 NORTH AMERICAN DATUM

HADLEY, MASSACHUSETTS APRIL 1992
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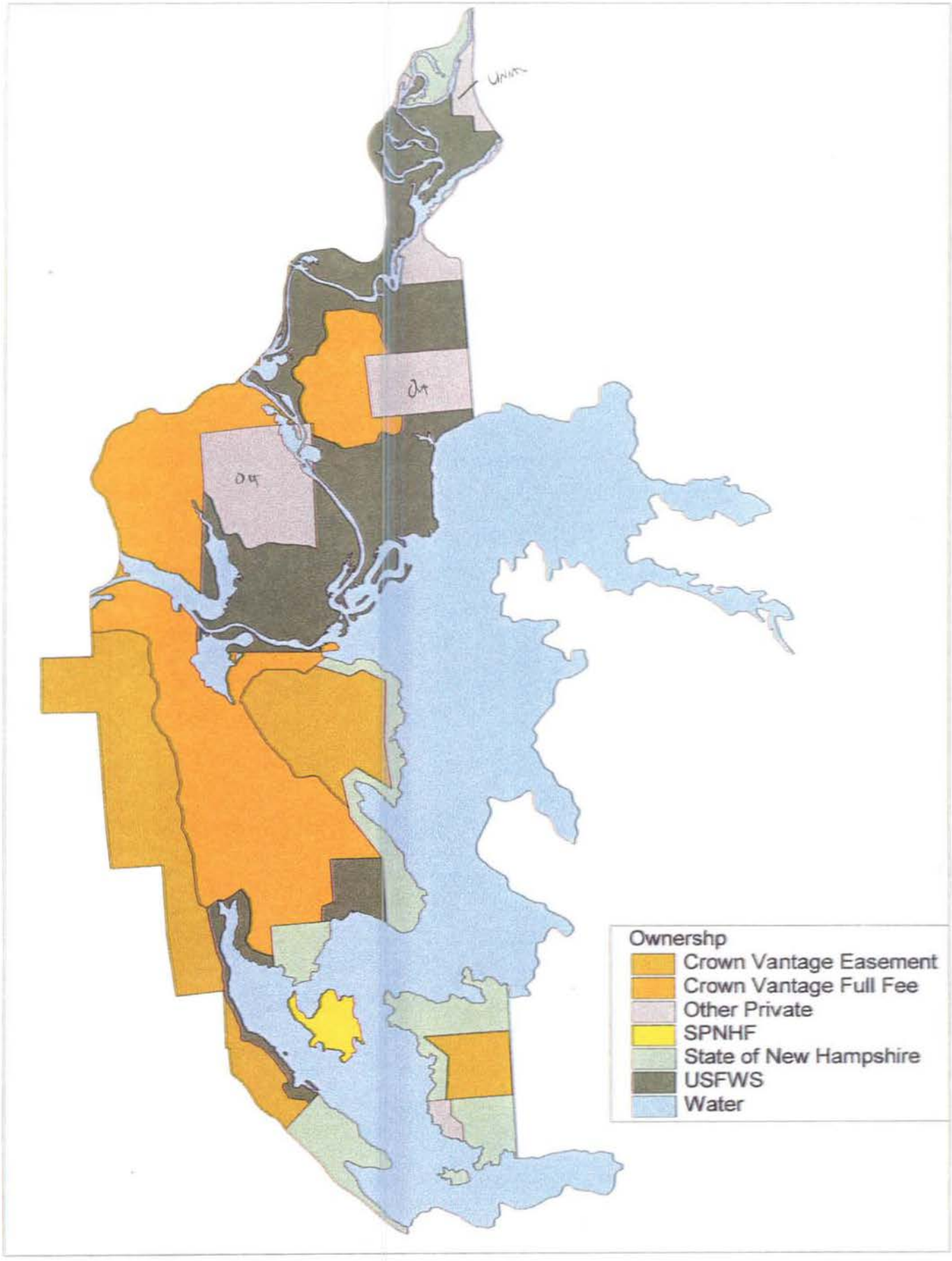

Figure 2. Land ownership within the study area.

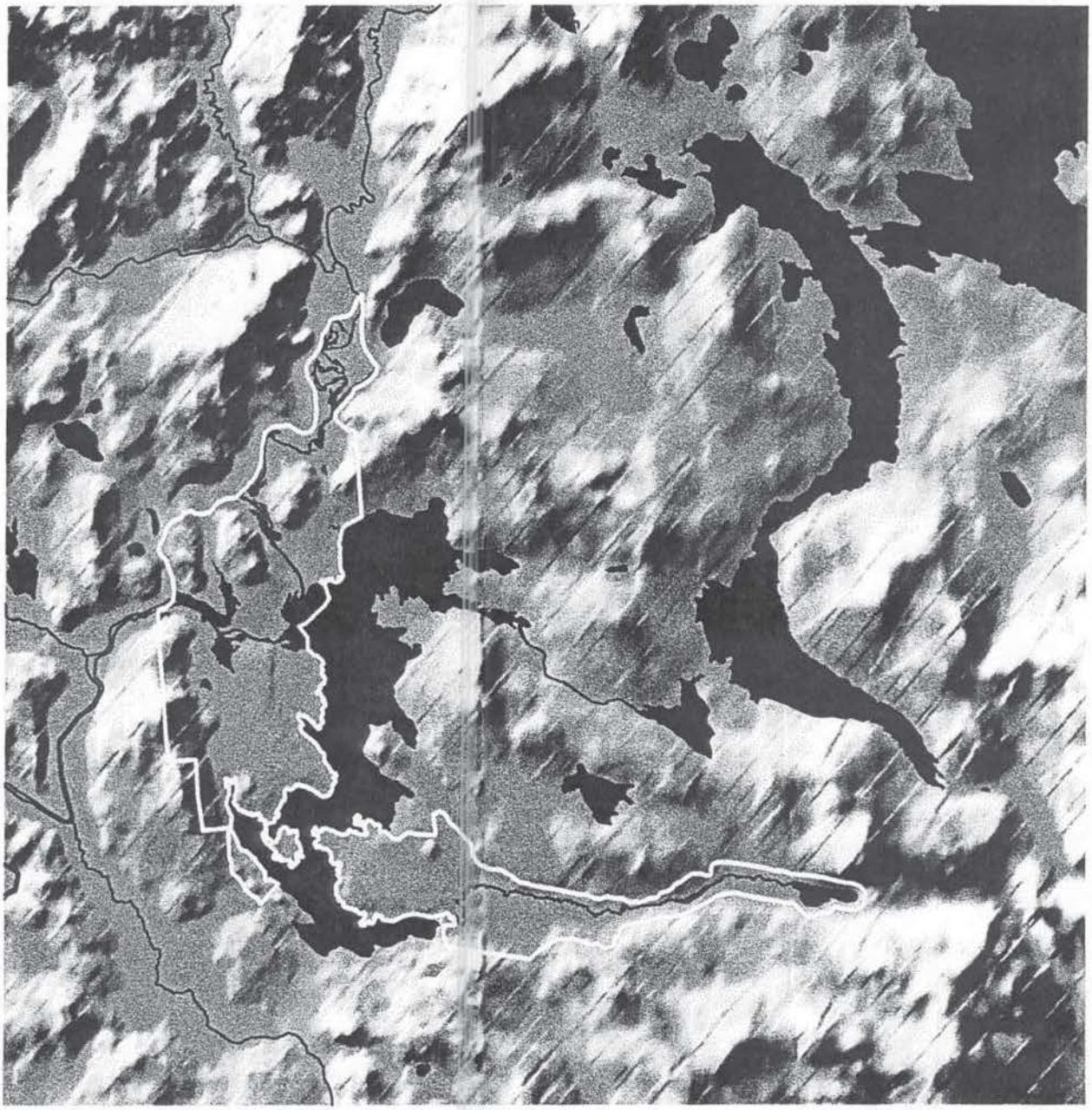

Figure 3. Topographic relief map of study area and vicinity. Refuge boundary is shown in white.

are derived primarily from tills; forest cover is a mixture of hardwoods on sloping uplands and softwoods on both hilltops and level and depressional areas at lower elevations.

2. Bedrock and Glacial Geology

The area's bedrock is comprised of three geologic formations. Errol Hill, Mill Mountain and the low hills to the north of Lake Umbagog are relatively resistant metamorphic rocks of the Ordovician period Dead River formation (greenschist and slate mixed with quartzite) which were formed from ocean bottom sediments half a billion years ago. The two other formations are igneous intrusions that were interjected into the slate and schist a quarter billion years ago. They are less resistant to erosion and now underlie the low-elevation regions of the Magalloway River and Lake Umbagog. The northern tip of the study area consists primarily of infertile granitic rocks. The other formation, which underlies Lake Umbagog and its adjacent lowlands, is a combination of slightly more enriched minerals including hornblende, biotite, and granodiorite.

Most of this bedrock lies under glacially deposited sediments that originated from all three bedrock types. Hilltops have shallow till soils because of ice scouring. Hillslopes have deeper till deposits that were smeared under the ice as it moved downslope. Most of this till has a lens of coarse sand, gravel, and pebbles between 2 and 3 feet below the soil surface. The most enriched sites are lower slopes and saddles where glacial action and subsequent downslope movement have left deeper deposits of fine-textured materials.

Glacial meltwater left a swath of well-sorted sands from the east side of the Magalloway River, through a depression near the Whaleback Ponds, to South Island and Tidswell Point near the southeastern reach of the study area. Fine-textured silts were deposited along the Magalloway and upper Androscoggin Rivers in relatively calm glacial lakewaters as well as by subsequent flooding of the rivers. The Mountain Pond area is kettle and kame topography with deep organic soils in the swamps that now fill the former kettle holes.

3. Climate

The climate in northern New Hampshire is primarily continental with occasional influence from the Atlantic Ocean. The Lake Umbagog area receives nearly 40 inches of precipitation annually, ranging from 2.4 inches in February to about 4 inches in July. Average temperatures range from about 12° F in January to about 65° F in July and August, with between 100 and 130 frost free days.

4. Topography

The study area includes both low mountains to the north and west of the lake and low-lying flatter areas around the lake and along the large rivers (Figure 3). At 2,283 feet, Errol Hill is the highest point in the study area, with other summits ranging from 1,600 to 2,160 feet. As a result of the bedrock orientation and bedding, the eastern slopes of all the hills are steeper (10-35 degrees) than the western slopes (5-15 degrees). There are 5- to 15-foot high cliffs on Errol Hill

and Mill Mountain and 30- to 50-foot high cliffs on the unnamed hill just west of the Whaleback Ponds. Erosion from these cliffs has deposited talus piles on the middle slopes of these hills. The lake level fluctuates a few meters with the seasons but averages around 1,245 feet at the surface. The lowlands around Mountain Pond and Tidswell Point are between lake level and 1,450 feet. The overall relief across the study area is about 1,000'.

5. Wildlife and Botanical Resources

The refuge provides breeding and migration habitat for many aquatic and wetland-dependent waterfowl species, as well as diverse wetland and upland habitats for migratory songbirds and resident mammals. The following species were either specifically listed as significant wildlife resources in the Lake Umbagog Environmental Assessment (USFWS 1991), were listed as species of concern to the region in the New Hampshire Forest Resources Plan (NHDRED 1995), or were suggested by knowledgeable professionals. Only species that are potential breeders in the refuge area are included. Many other species, such as other songbirds, small mammals and amphibians, are also present on the refuge but are not listed here.

Endangered and threatened species: bald eagle, peregrine falcon.

Other species of management concern: common loon, northern harrier, American bittern, red-shouldered and sharp-shinned hawks, merlin, osprey, great blue heron, gray jay, spruce grouse, black-backed and northern three-toed woodpeckers, Cape may and palm warblers, rusty blackbird and northern goshawk.

Waterfowl: black, ring-necked and wood duck; common goldeneye, common and hooded mergansers, blue-winged and green-winged teal, and mallard.

Mammals: white-tailed deer, moose, black bear, coyote, red fox, bobcat, beaver, raccoon, snowshoe hare, river otter, mink, fisher, marten, muskrat, long-tailed shrew and rock vole.

Some of these species are associated primarily with non-forested or aquatic habitats. However, many of these species depend on specific forest habitats or habitat features that may be affected (either positively or negatively) by forest management (Table 1). This table lists only those habitats or habitat features that are considered preferred or critical; these species (and others not listed) may utilize a wide range of other habitats throughout the year.

The USFWS is also responsible for the management of federally- or state-listed rare plant species. The refuge includes a diversity of vegetative types acknowledged as unique in the region, mainly due to the interaction of topography and geology with the meandering Magalloway and Androscoggin Rivers (USFWS 1991). The area contains a wide variety of wetland and boreal communities, including floating bogs, river and lakeshore marshes, spruce bogs, northern white-cedar and alder swamps, and upland coniferous and hardwood forests. At least three state-listed threatened plant species [jack pine (*Pinus banksiana*), satin willow (*Salix pellita*) and wapato (*Sagittaria cuneata*)] have previously been recorded within the refuge.

Table 1. (a) Preferred habitats and (b) special habitat requirements of significant wildlife species of the refuge. Information from DeGraaf et al. (1992), NHDRED (1995), and FSSWT (1997).

(a)

SPECIES	NHNHI rank[1]	Open water[2]	Mature coniferous forest	Mature hardwood forest	Young coniferous forest	Young hardwood forest	Swamp forest	Shallow emergent marsh	Shrub swamp	Bog
Common loon	S3	X								
American bittern	S3							X		
Great blue heron	S4						X	X		
Wood duck	S5						X			
Black Duck	S4							X		
Mallard	S5						X			
Green-winged teal	S3						X			
Blue-winged teal	S3						X			
Ring-necked duck	S3	X								
Common goldeneye	S3	X								
Common merganser	S4	X								
Hooded merganser	S5	X								
Osprey	S2	X								
Bald eagle	S1	X								
Northern harrier	S2						X			
Sharp-shinned hawk	S4		X	X						
Northern goshawk	S4			X						
Red-shouldered hawk	S4						X			
Merlin	SP		X							
Spruce grouse	S4		X							
Three-toed woodpecker	S1		X							
Black-backed woodpecker	S3		X							
Gray jay	S3		X							
Palm warbler	S1				X					X
Cape May warbler	S3		X							
Rusty blackbird	S3		X		X					X
Snowshoe hare	S5				X				X	X
Beaver	S5	X				X				
Muskrat	S5							X		
Red fox	S5				X	X				
Black bear	S5			X		X	X			
Raccoon	S5						X	X	X	X
Pine marten	S2		X							
Fisher	S5			X						
Mink	S5	X					X	X		
River Otter	S5	X								
Bobcat	S4				X	X				
White-tailed deer	S5		X			X				
Moose	S5	X					X	X		

Table 1. (continued)

(b)

SPECIES	Large nest or perch trees	Large cavity trees	Coarse woody debris[3]	Riparian forest	Hard or soft mast[4]	Cliffs or ledges	Stable banks
Great blue heron	X						
Wood duck		X		X	X		
Black Duck					X		
Mallard					X		
Ring-necked duck			X	X			
Common goldeneye		X		X			
Common merganser		X		X			
Hooded merganser		X		X			
Osprey	X						
Bald eagle	X						
Sharp-shinned hawk	X						
Northern goshawk	X						
Red-shouldered hawk	X			X			
Merlin		X					
Peregrine falcon						X	
Three-toed woodpecker			X				
Black-backed woodpecker			X				
Long-tailed shrew			X				
Beaver				X			X
Muskrat							X
Rock vole						X	
Coyote					X		X
Red fox					X		X
Black bear		X	X		X		
Raccoon		X			X		
Pine marten		X	X				
Fisher		X	X				
Mink			X	X			X
River Otter			X	X			
Bobcat			X			X	
White-tailed deer					X		

[1] The Heritage Program ranks species as to their rarity in the state; rankings include S1 (critically imperilled), S2 (imperiled), S3 (rare or vulnerable), S4 (apparently secure), S5 (demonstrably secure), and SP (potentially occurs).

[2] Includes lakes, ponds, rivers, and streams.

[3] Includes large standing dead trees (snags) and downed or hollow logs.

[4] Primarily beech, pin cherry, mountain ash, blackberry and raspberry.

B. METHODS

This survey focused on the terrestrial communities of the New Hampshire portion of the refuge, including the Tidswell Point area. All public and private lands were included in the mapping of natural communities. More detailed examinations for rare plants and other special ecological features, as well as mapping of timber stands, was limited to public and Crown Vantage lands. No detailed examination was done of aquatic communities or of the extensive wetlands and marshes around the confluence of the Magalloway and Androscoggin Rivers (Harpers and Sweat Meadows), as these have been the subject of previous surveys.

1. Background Information

Existing information was collected to provide a starting point for the survey and to provide background for the delineation and mapping of natural communities. Information obtained for this project included:

-U.S. Geological Survey bedrock geology map of New Hampshire (unpublished).
-U.S. Natural Resource Conservation Service soil descriptions.
-U.S. Forest Service Land Type Association map.
-Crown Vantage stand map and timber inventory data.
-New Hampshire Natural Heritage Inventory element occurrences map.
-New Hampshire Natural Heritage Inventory species lists and natural community descriptions.
-1:15,840 infrared aerial photographs.
-U.S. Geological Survey 7.5 minute topographic maps.

2. Natural Community Delineation and Mapping

Natural communities were delineated and mapped according to existing New Hampshire Natural Heritage Inventory descriptions (Sperduto 1994) as much as possible. These community descriptions primarily reflect the potential natural vegetation of a site, and thus allow an assessment of the long-term capability of the land. The advantage of using the Natural Heritage system, in addition to providing consistent community descriptions across the state, is that each natural community has a conservation ranking that reflects its rarity and protection status. However, detailed classification of forest communities is still under development by NHNHI, and an exact correspondence was not always possible.

Assessing natural communities involved investigating landform, parent material and existing overstory and understory vegetation. An initial reconnaissance was conducted to evaluate the range of potential community designations, as well as to develop a search image for each of the potential communities based on comparison of infrared aerial photographs with on-the-ground conditions. At the end of this reconnaissance the communities that would be delineated in the mapping had been identified.

Homogenous areas on the infrared photographs were identified as potential community mapping units. These boundaries were then ground-truthed in the field. Boundaries reflecting past logging activity rather than underlying site characteristics were eliminated; other boundaries

reflecting underlying changes in site characteristics not evident on the aerial photos were added. Where final community boundaries were approximately coincident with existing boundaries shown on Crown Vantage stand maps, the latter were used as the community boundary when producing the final map.

Community boundaries designated on the photos were transferred to a mylar overlay using the Crown Vantage stand map as a base. For northern and southern portions of the study area not covered by this base map, USGS 7.5' quads were enlarged to the same scale as the stand map and appended to the stand map. This introduced some error in the boundary locations due to the differing projections of the maps; this error was corrected at a later stage. Boundary lines were digitized and imported to PC Arc/Info for final editing.

To quantitatively describe each natural community, landform, soil, and plant data were collected from 10-meter radius plots. Between 1 and 4 plots were located in representative sections of each community. In each plot soil pits were excavated to the C horizon; parent material, depth to mottles or water table, and the thickness and texture of each horizon were recorded. Vegetation was divided into 3 strata: canopy (>10 cm DBH), subcanopy (2-10 cm DBH), and shrub/herb (< 2 cm DBH). Species, DBH, and live/dead status of each canopy tree was recorded. Species and live/dead status of each subcanopy tree was recorded. Abundance of each species in the shrub/herb layer was rated on a scale from 1 to 4.

3. Stand Mapping

Stand maps show existing vegetation based on general species categories, canopy height, and crown closure. These maps are the primary tool for planning timber management. Stand maps, like natural community maps, reflect underlying site characteristics. However, because they put greater emphasis on existing overstory vegetation, they are more likely to change over time in response to timber harvesting or natural disturbance.

Existing Crown Vantage stand maps cover about 70% of the study area (their retained lands and some lands sold to the USFWS). The remainder of the public and private conservation lands within the study area were mapped according to the criteria used in their stand designations. Stand type (species composition), canopy height and crown closure were estimated from stereoscopic interpretation of infrared aerial photographs and by comparison with already mapped stands of similar appearance on the photos and in the field.

Categories used in the stand mapping were as follows:

<u>Stand type</u>

S	Softwood
C	Cedar
H	Hardwood (species undesignated)
I	Intolerant hardwoods (white birch, aspen)
M	Moderately tolerant hardwoods (red maple, yellow birch)
T	Tolerant hardwoods (sugar maple, beech)
Alder	
Swamp	

Canopy Height		Crown Closure	
1	0 - 15 feet	A	80 - 100%
2	16 - 30 feet	B	60 - 79%
3	31 - 50 feet	C	30 -59 %
4	> 50 feet	D	< 30%

Each stand is designated by a combination of these characteristics, thus "S3A" refers to a softwood stand between 31-50 feet high with at least 80% crown closure. Two-storied stands may have more complex designations (for example, M4D/H2A).

4. Special Ecological Features Survey

Special areas include such things as wetlands, rare plant locations, exemplary examples of all natural communities, and special habitat areas such as deeryards or heron rookeries. Occurrences of any area with special ecological values were noted during all phases of the project. Targeted searches were made of areas with a high potential for harboring rare plants (such as wetlands and enriched coves and benches) identified from aerial photographs, topographic maps, or Natural Heritage Inventory maps.

5. Habitat Analysis

Forested habitats were analyzed by using stand types as a proxy for various habitat structural types. To simplify the analysis of habitat structure, the 86 separate stand type categories present on the stand map were grouped into 23 broader types. These include 18 upland forest types and 5 other types as follows:

Upland forest types:

Species composition: Hardwood, Mixedwood, Softwood

Height/Density:
- Mature closed (>50 feet and >60% crown closure; 4A, 4B)
- Mature open (>50 feet and 30-59% crown closure; 4C)
- Semi-mature closed (31-50 feet and >60% crown closure; 3A, 3B)
- Semi-mature open (31-50 feet and 30-59% crown closure; 3C)
- Residual overstory (>31 feet and <30% crown closure; 3D, 4D)
- Young and Regeneration (<30 feet; 1A-D, 2A-D)

Other: Forested Wetland, Non-forested Wetland, Open, Road, Water

Specific information on trees classified as "wildlife trees" was obtained from the Crown Vantage timber cruise of their lands within the study area.

6. Timber Inventory

A timber cruise of forested Crown Vantage lands within the study area (excluding Tidswell Point) was conducted by company foresters. The species, diameter and product classification of all live trees greater than 1" DBH were recorded on 286 randomly located points. This cruise was designed to meet Crown Vantage's information needs, and was stratified

by categories that are approximately equivalent to the habitat classes described above. Combination of cruise data into overall totals, or recombination of cruise points into new categories (such a natural communities) as was done for this plan, introduces a certain degree of error, but should be accurate enough to indicate general patterns.

C. RESULTS

1. Natural Communities

a. Community Designation and Mapping

Fifteen natural communities were identified and mapped (Figure 4, Table 2). Detailed descriptions of these communities are given in Appendix A.

In some cases communities were easily identified and boundaries were quite distinct. In other cases community boundaries are less precise, either because past harvesting has altered the natural composition of these communities (making community identification problematic in some areas), or because communities naturally blend into each other across a landscape gradient. This was particularly true between the Northern Hardwood-Spruce-Fir and Lowland Spruce-Fir communities. Most large community units contain unmapped pockets of other communities.

About 78% of the study area was mapped as upland communities and about 22% as wetland communities or water (not including Lake Umbagog or the Magalloway and Androscoggin Rivers). It must be noted that the delineation of wetland communities in this project was somewhat narrower than wetlands as legally defined under New Hampshire law. Most if not all upland communities (but especially the Lowland Spruce-Fir, Northern Hardwood-Spruce-Fir, and High Terrace communities) contain wetter areas that may meet the legal definition of wetlands.

<u>Upland Communities</u>

- Northern Hardwood-Spruce-Fir: dominated by red maple, yellow birch, red spruce and balsam fir; found on tills on northern and western hillslopes and better-drained ridges in the Mountain Pond Basin.
- Beech-Birch-Maple: dominated by sugar maple, yellow birch and beech; found on deep well-drained tills on east- and southeast-facing slopes of large hills.
- Lowland Spruce-Fir: dominated by red spruce, balsam fir and cedar; found on hydric mineral soil in level, lower elevation areas.
- Red Spruce-Hemlock-White Pine: dominated by a variety of softwoods; found on deep well-drained gravely and sandy soils.
- High Terrace: similar in overstory composition to the Northern Hardwood-Spruce-Fir community; found on well-drained silty alluvial terraces along the Magalloway River. This community includes narrow strands along the river margins that may more appropriately be described as wetland communities.
- Mountain Spruce-Fir: dominated by red spruce; found on shallow rocky soils on the summits of larger hills. The inclusion of a significant hardwood component in this

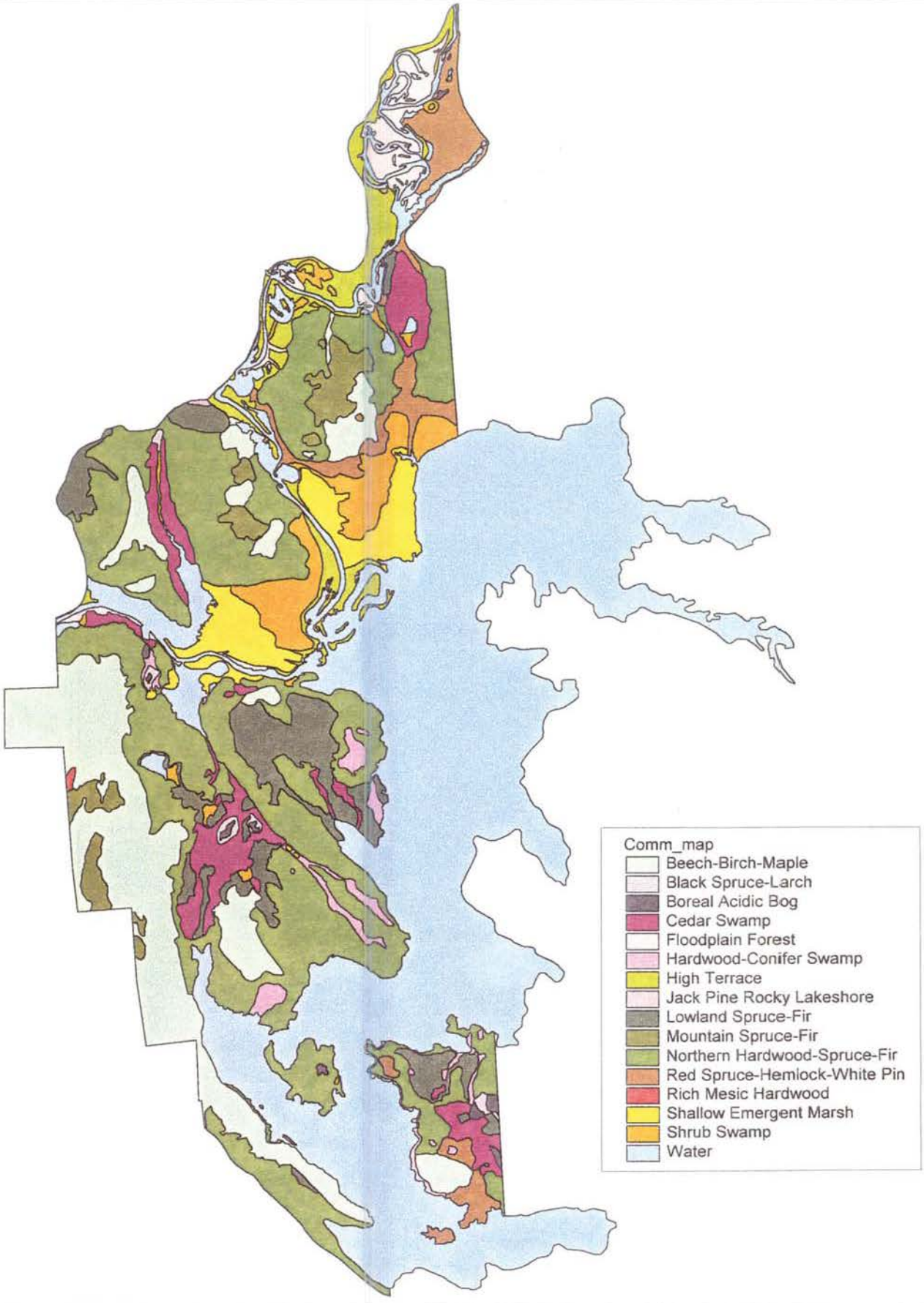

Figure 4. Natural communities of the study area.

community (Table 3) indicates that it may be mapped incorrectly or that it intergrades with the Beech-Birch-Maple community.

- Jack Pine Rocky Lakeshore: Similar to the Red Spruce-Hemlock- White Pine community, though with the inclusion of jack pine; found on thin rocky soils in a narrow band along the shoreline of Tidswell Point.
- Rich Mesic Forest: an enriched variant of the Beech-Birch-Maple community; found as small inclusions in coves and benches on the east slope of Errol Hill and Mill Mountain.

Wetland and Aquatic Communities

- Northern White-cedar Swamp: dominated by white-cedar, balsam fir, and red and black spruce; found in large poorly-drained areas with deep hummocky peat deposits.
- Shrub Swamp: dominated by speckled alder; found in poorly drained areas adjacent to open water. This community also includes areas on the upland margin of Harpers Meadow that are dominated by low stature open white-cedar and larch stands.
- Emergent Marsh: dominated by grasses, sedges and rushes; includes the large Harpers and Sweat Meadow complexes as well as smaller areas in abandoned beaver flowages. No attempt was made to delineate this broad community according to more detailed NHNHI designations.
- Floodplain Forest: dominated by silver and red maple; found on frequently flooded low terraces along the Magalloway River.
- Hardwood-Conifer Swamp: dominated by balsam fir, white-cedar, red spruce, red maple and white birch; found on shallow-to-deep peat deposits in poorly drained but somewhat enriched basins.
- Black Spruce-Larch: dominated by black spruce and larch; found on deep peat deposits around the margins of Boreal Acidic Bog communities.
- Boreal Acidic Bog: dominated by sphagnum moss, sedge, heath plants and scattered shrubby black spruce and larch; found on deep peat deposits in small basins.
- Water: Mountain and the Whaleback Ponds and oxbow ponds along the Magalloway River.

Data on overstory composition for six forested communities with substantial acreage on Crown Vantage lands was obtained by re-stratifying the company's timber cruise points (Table 3). These figures highlight the distinct characteristics of the different communities. For example, red spruce comprises 50% of the basal area of the Mountain Spruce-Fir community (versus 6% for balsam fir) but only 22% of the Lowland Spruce-Fir community (versus 31% for balsam fir). Some species (such as red spruce, balsam fir, red maple, and yellow birch) are common in a wide variety of communities, while other species (such as black spruce, beech, and white ash) are found primarily in one community.

Table 2. Acreage of natural communities within the study area (see map, Figure 4).

Community Type	Acreage	% of Total
Upland Communities		
Northern Hardwood-Spruce-Fir	4408	37.2
Beech-Birch-Maple	2220	18.7
Lowland Spruce-Fir	974	8.2
Spruce-Hemlock-White Pine	622	5.2
High Terrace	594	5.0
Mountain Spruce-Fir	376	3.2
Jack Pine Rocky Lakeshore	32	0.3
Rich Mesic Hardwood	8	0.1
Total Upland	9234	77.8
Wetland and Aquatic Communities		
Cedar Swamp	716	6.0
Shallow Emergent Marsh	606	5.1
Shrub Swamp	602	5.1
Floodplain Forest	309	2.6
Hardwood-Conifer Swamp	216	1.8
Black Spruce-Larch	51	0.4
Boreal Acidic Bog	47	0.4
Water[1]	84	0.7
Total Wetland and Aquatic	2631	22.2
TOTAL	11865	100.0

[1]does not include Lake Umbagog or the Magalloway and Androscoggin Rivers.

Table 3. Overstory composition by species for major natural communities (percent of total community basal area of trees >1" DBH).

	Natural Community					
SPECIES	Northern Hardwood-Spruce-Fir	Beech-Birch-Maple	Lowland Spruce-fir	Mountain Spruce-Fir	Cedar Swamp	Hardwood-Conifer Swamp
Balsam fir	23	3	31	6	18	24
Red Spruce	16	10	22	50	16	17
White spruce	<1		2		3	1
Black Spruce			3		19	
Hemlock	<1	2	<1		<1	1
White pine	2	<1	5		<1	1
Northern white-cedar	6	<1	14		28	19
Larch	<1		<1		1	
Beech	3	18		2		
White birch	7	3	5	9	<1	12
Yellow birch	13	16	6	12	5	9
Red maple	22	6	8	2	7	13
Sugar maple	<1	33	<1	13		
Aspen	4	1	1		<1	1
White ash		2				
Other hardwoods[1]	3	5	3	6	1	1
Total	100	100	100	100	100	100

[1]pin cherry, striped maple, black ash

b. Correlation with stand types

Understanding the relationship between natural community and stand type classifications can provide valuable information about both the range of variation within a community and the potential responses to forest management activities. By considering the natural community classification underlying a particular stand, managers can better understand the successional pathways the stand is likely to follow. Applying a single prescription to similar stand types can lead to distinctly different responses in different natural communities.

The relationship was assessed by overlaying the community and stand maps for the portion of the study area for which stands had been previously typed by Crown Vantage. Overall the correlation between the two classifications is fair (Table 4). Most communities contain a variety of stand types, reflecting both the inherent variability within the community and the response to past harvesting.

In some cases there is a fairly strong relationship. Seventy percent of the Beech-Birch-Maple community is typed as Tolerant Hardwoods, 61% of the Lowland Spruce-Fir community is typed as Softwoods, and 70% of the Northern Hardwood-Spruce-Fir community is typed as Moderately Tolerant Hardwoods, either alone or mixed with Softwoods (stand types M, MS, and SM). In other cases the relationship was weaker than was expected. For example, only about 19% of the Cedar Swamp community was typed as Cedar stands, and only 37% of the Mountain Spruce-Fir community was typed as Softwoods.

c. Correlation with soil types

Underlying site characteristics (slope, parent material, drainage, etc.) form the underlying basis of both natural community and soil classifications, and a strong relationship between the two should be present. Because soil series is a useful indicator of site potential (both productivity and expected species composition), understanding this relationship would provide valuable insight into the accuracy of the community map, the inherent variability within each community, and the potential productivity of each community for different timber species. However, because the Natural Resource Conservation Service (NRCS) has not completed the soils map for the study area, a direct correlation between community types and soil series could not be performed. Investigation of soil characteristics during the community mapping was not detailed enough to allow a precise assignment of communities to soil series, and attempts to approximate the relationships based on landform, parent material, and general soil characteristics proved inconclusive.

Table 4. Percentage of each natural community in different stand types.

COMMUNITY	Acres	STAND TYPE[1]									
		I	M	T	IS, SI	MS,SM	S	C, CS	NFW	Other	Total
Upland Forest											
No. Hdwood-Spruce-Fir	2631	2	30	18	1	40	8	0	<1	1	100
Beech-Birch-Maple	1914	2	14	70	3	10	0	0	0	1	100
Lowland Spruce-Fir	763	0	24	4	1	8	61	0	1	<1	100
Mountain Spruce-Fir	292	0	1	29	0	34	36	0	0	0	100
High Terrace	253	0	26	1	0	52	20	0	1	0	100
Spruce-Hemlock-Pine	115	5	0	28	0	44	19	2	0	2	100
Rich Mesic Hardwood	8	0	0	100	0	0	0	0	0	0	100
Wetland											
Cedar Swamp	588	<1	<1	0	0	3	70	19	7	<1	100
Shrub Swamp	375	0	0	0	0	<1	29	50	20	0	100
Shallow Emerg. Marsh	325	0	0	0	0	0	1	0	98	<1	100
Hdwd-Conifer Swamp	102	1	10	0	0	10	78	0	1	<1	100
Floodplain Forest	40	0	24	0	0	66	0	0	10	0	100
Black Spruce-Larch	51	0	0	0	0	0	100	0	0	0	100
Boreal Acidic Bog	32	0	0	0	0	0	68	0	32	0	100

[1] I = Intolerant Hardwoods, M = Moderately Tolerant Hardwoods, T = Tolerant Hardwoods, S = Softwoods, C = Cedar, NFW = Nonforest Wetland (Alder and Swamp stand types), Other = Open, Road, Yard, or Water.

2. Rare Element Occurrences

The New Hampshire Natural Heritage Inventory database, which contains information on known occurrences of rare species, contained records for eleven species (six birds and five plants) within the study area (Table 5). Of these species, six (great blue heron, northern harrier, common loon, bald eagle, osprey, and jack pine) were observed during the course of this project. Heron, loon, eagle and osprey were observed nesting. An additional ten species (six birds and four plants) that are either listed on NHNHI tracking lists or of special concern to the refuge were observed during the course of this project. None of the birds were observed nesting. Detailed measurement of the extent or populations of the plants were not made.

Seven active osprey nests were present in the study area in 1996 (Figure 5) (information provided by Chris Martin, ASNH). Six of these were located on Crown Vantage land and one on USFWS land. Six were located within the wetland complexes described above (primarily in Cedar Swamp communities) and one in a large area of Lowland Spruce-Fir community.

The state of New Hampshire also lists certain plants as Special Concern Plant Species. These species, though not endangered and not tracked by NHNHI, are listed because they may be subject to commercial exploitation or overcollecting. Of the eleven species with this status, five were observed during this survey: pink lady's-slipper (*Cyperidium acaule*), Dutchman's breeches (*Dicentra cucullaria*)[1], white-fringed orchis (*Habenaria [Platanthera] blephariglottis*), rose pogonia (*Pogonia ophioglossoides*), and pitcher plant (*Sarracenia purpurea*).

[1] These plants could not positively be identified to species. If not *D. cucullaria*, they are the rarer *D. canadensis* (squirrel-corn), which is a state threatened species.

Table 5: Species of conservation concern at the Lake Umbagog National Wildlife Refuge that are either listed in the New Hampshire Natural Heritage Inventory database or which were observed during this study. Natural Heritage state ranking[2] and legal status are indicated in parentheses.

Previously known from study area (recorded in NHNHI database)	
Birds	Plants
*Ardea herodias** Great Blue Heron (S4)	*Pinus banksiana** Jack Pine (S2, state threatened)
Aythya collaris Ring-necked Duck (S3)	*Potomageton nodosus* Knotty Pondweed (S2)
*Circus cyaneus** Northern Harrier (S2, state threatened)	*Salix pellita* Satiny Willow (S2, state threatened)
*Gavia immer** Common Loon (S3, state threatened)	*Sagittaria cuneata* Wapato (S2, state threatened)
*Haliaetus leucocephalus** Bald Eagle (S1, federally endangered)	*Senecio pauperculus* Dwarf Ragwort (S2, state threatened)
*Pandion haliaetus** Osprey (S2, state threatened)	
*also observed during this study	
Observed during this study	
Birds	Plants
Accipiter gentilis Northern Goshawk (S4)	*Carex exilis* Meagre Sedge (S1, state threatened)
Botaurus lentiginosus American Bittern (S3)	*Cypripedium parviflorum* Small Yellow Lady's Slipper (S1, state endangered)
Dendragapus canadensis Spruce Grouse (S4)	*Listera cordata* Heart-leaved Twayblade (S2, state threatened)
Falco columbarius Merlin (SP)	*Listera convallarioides* Lily-leaved Twayblade (S2, state threatened)
Perisoreus canadensis Gray Jay (S3)	
Anas rubripes Black duck (S5)	

3. Ecologically Significant Areas

Ecologically significant features within the study area include specific communities, late successional stands, rare plant and animal locations, and unusual habitats. Several areas described as "wetland complexes" were specifically designated because they contain a diverse mix of wetland communities within a contiguous area (as well as small inclusions of upland communities).

Communities and wetland complexes having particular ecological significance total about 3994 acres (Figure 5, Table 6), or one-third of all lands within the study area. Of this, about

[2] The Heritage Program ranks species as to their rarity in the state from S1 (critically imperilled) to S5 (demonstrably secure).

1656 acres consists of upland communities (primarily Lowland Spruce-Fir and High Terrace communities) that are potentially commercial timber land, though some of this area (especially within the wetland complexes) may be inoperable.

a. Natural Communities

- Boreal Acidic Bogs: Five of the seven bogs in the study area contain the state-listed meagre sedge (*Carex exilis*). These bogs contain a diverse flora including several orchid species and pitcher plant (*Sarracenia purpurea*). These bogs are rare in New Hampshire (Heritage rank S2)
- Cedar Swamps: Cedar swamps have the highest plant species richness of any natural community in the study area. Six orchid species, three of which are state listed, were found in this community. The Cedar Seepage Swamp community as designated by NHNHI is ranked S1S2, though not all Cedar Swamps as mapped by this project may meet the criteria for this community.
- Floodplain Forest and High Terrace: Floodplain forests are rare in New Hampshire (Heritage rank S1S2) because most rivers have been dammed or developed, leading to a significant decrease in the extent of this community. The forest along the Magalloway River is one of the few good examples in New Hampshire, though the flow of the river is regulated by an upstream dam and thus the community may not be completely natural. Both of these communities provide important riparian habitat along the Magalloway and Androscoggin Rivers.
- Jack Pine Rocky Lakeshore: Jack pine communities are extremely rare in New Hampshire (Heritage rank S1); the stands around Lake Umbagog are the only low-elevation occurrences in New Hampshire.
- Lowland Spruce-Fir: This community is of concern because mature spruce-fir is important habitat for wildlife including pine marten and spruce grouse and provides important winter cover for deer (NHDRED 1995). Though the type is relatively widespread, there are very few late successional examples in the state, and the community has a Heritage rank of S1S2.
- Rich Mesic Hardwoods: This uncommon community (Heritage rank S3) has high potential to contain rare upland forest plants.
- Non-forested wetlands: Both Shrub Swamp and Emergent Marsh communities (including the extensive areas around Harpers and Sweat Meadows and smaller areas resulting from beaver activity) provide important habitat diversity within this largely forested area.

b. Wetland Complexes

- Mountain Pond Wetland Complex: The large wetland area running from Mountain Pond and Sweat Meadow south to Thurston Cove contains a complex of Cedar Swamps, Boreal Acidic Bog, Black Spruce-Larch, Shrub Swamp, Lowland Spruce-Fir and Northern Hardwood-Spruce-Fir communities with a variety of ecological values. Six species of orchids, including three state-listed threatened or endangered

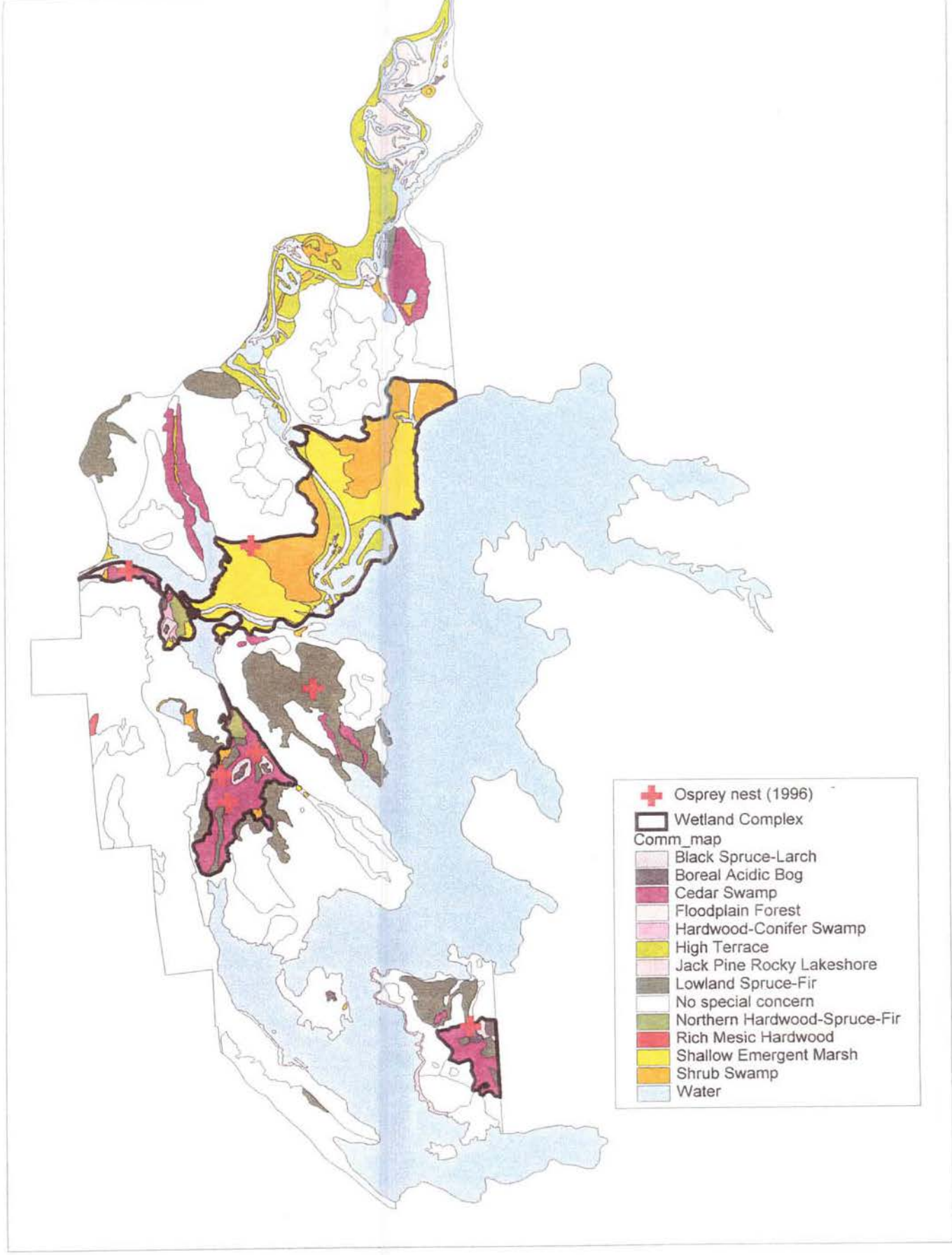

Figure 5. Ecologically significant communities within the study area.

species (*Cypripedium parviflorum, Listera convallarioides,* and *Listera cordata*) were found in this area as well as two occurrences of *Carex exilis*. Several isolated pockets of Lowland Spruce-Fir on hummocks in the interior of the complex exhibit late-successional characteristics. The supercanopy white pine provided nesting sites for three breeding pairs of ospreys and at least one pair of great blue herons in 1996.

- Androscoggin Wetland Complex: This area along the western side of Sweat Meadow and the south bank of the Androscoggin contains a diverse mix of Boreal Acidic Bog, Black Spruce-Larch, Hardwood-Conifer Swamp, Cedar Swamp, Floodplain Forest, Shrub Swamp, Shallow Emergent Marsh and Northern Hardwood-Spruce-Fir communities. The area contained at least one rare plant (*Carex exilis*) and one osprey nest. A black spruce in the southern portion of this area was cored and estimated to be about 300 years old.
- Tidswell Point Wetland Complex: This area adjacent to the New Hampshire-Maine border contains Cedar Swamp, Boreal Acidic Bog, Black Spruce-Larch and Lowland Spruce-Fir communities. Two occurrences of *Carex exilis* were found in this area. The small isolated Lowland Spruce-Fir communities exhibit late-successional characteristics. One osprey nest is located in this area.
- Harpers Meadow Complex: This large area around the confluence of the Magalloway and Androscoggin Rivers (including the eastern side of Sweat Meadow) includes Emergent Marsh, Shrub Swamp, High Terrace, and Floodplain Forest communities. The values of this area are well-known (USFWS 1991) and include critical habitat for numerous species of raptors and waterfowl. No detailed investigation of this area was performed. A pair of merlins, an American bittern and a northern harrier were observed over Sweat Meadow.

c. Special Habitats

Several areas had particular habitat characteristics that are worth noting. These areas have not been fully delineated on maps and acreages have not been calculated. Some of these areas are included within the communities or wetland complexes listed above.

- Late successional stands: No areas that could be considered true old-growth were located. However, several softwood stands showed significant late successional characteristics, such as relatively large trees (especially white pine, red spruce, or hemlock) and large diameter snags and down rotten logs. Two of the wetland complexes (Mountain Pond and Tidswell Point) contain islands of late-successional Lowland Spruce-Fir community. Another area (mapped as High Terrace community and dominated by spruce, hemlock, and white pine) is located along the east bank of the Magalloway River just south of the oxbow pond across the river from refuge headquarters.
- Deeryard: The late-successional softwood stand along the east bank of the Magalloway River (discussed above) contained a high density of winter deer pellets and appeared to have been used as a yard. This area was adjacent to hardwood stands and shrub swamps that could provide a source of browse.

Table 6: Ecologically significant areas within the study area (see map, Figure 5). Shaded numbers represent acreage that is potential commercial timber land based on community classification, though some of these areas may be inoperable or inaccessible.

Type of Area	Acreage	Ecological Significance (S-Rank)
Natural Communities		
Boreal Acidic Bogs	47	Rare in NH (S2); rare plants
Cedar Swamps	716	Rare in NH (S1S2); rare plants
Floodplain Forest	309	Rare in NH (S1S2); riparian habitat
High Terrace	594	Riparian habitat
Jack Pine Rocky Lakeshore	32	Very rare in NH (S1)
Lowland Spruce-Fir	974	Late successional examples rare in NH (S1S2); wildlife habitat
Rich Mesic Hardwood	8	Uncommon in NH (S3); potentially contains rare plants
Shrub Swamp	602	Wildlife habitat
Shallow Emergent Marsh	606	Wildlife habitat
Wetland Complexes		
Mountain Pond Wetland Complex	381	Rare plants; nesting herons and osprey; late-successional stands; high community diversity
• Black Spruce-Larch[2]	(22)	
• Boreal Acidic Bog[1]	(9)	
• Cedar Swamp[1]	(259)	
• Lowland Spruce-Fir[1]	(55)	
• No. Hardwood-Spruce-Fir[2]	(21)	
• Shrub Swamp[1]	(15)	
Androscoggin Wetland Complex	130	Rare plants; nesting osprey; high community diversity
• Black Spruce-Larch[2]	(10)	
• Boreal Acidic Bog[1]	(6)	
• Cedar Swamp[1]	(32)	
• Floodplain Forest[1]	(24)	
• Hardwood-Conifer Swamp[2]	(14)	
• No. Hardwood-Spruce-Fir[2]	(27)	
• Shallow Emergent Marsh[1]	(14)	
• Shrub Swamp[1]	(3)	
Tidswell Point Wetland Complex	153	Rare plants; high community diversity; late-successional stands
• Black Spruce-Larch[2]	(12)	
• Boreal Acidic Bog[1]	(24)	
• Cedar Swamp[1]	(99)	
• Lowland Spruce-Fir[1]	(18)	
Harpers Meadow Complex	1256	Habitat for species of concern including eagle, osprey, northern harrier and ring-necked duck; rare plants; National Natural Landmark
• Floodplain Forest[1]	(10)	
• High Terrace[1]	(159)	
• Shallow Emergent Marsh[1]	(590)	
• Shrub Swamp[1]	(497)	
Total	3994	
Other lands within study area	7871	
Study Area Total	11865	

[1]acreage already included under "Natural Communities" at beginning of table; not included in Total.
[2]additional areas not included under "Natural Communities at beginning of table; acreage included in Total

- Riparian areas: All riparian areas, even those consisting of common upland forest communities, should also be considered ecologically significant. They provide important habitat for many species of concern (Table 1). In many cases these areas have been harvested less intensively than surrounding uplands and contain a higher density of large, cavity or supercanopy trees and snags.
- Upland openings: Several wet open areas (probably old landings) along the winter road east of the Mountain Pond Wetland Complex contain a tall herbaceous and shrub community that was not found elsewhere on the refuge, though they were not extensive or distinct enough to be separately mapped. In addition, several small grassy meadows (probably remnants of old fields) are located along the Magalloway River in the northern part of the study area. These openings provide local diversity and should be considered for maintenance as permanent openings.
- Cliffs: The low cliffs on the east slope of the hill west of the Whaleback Ponds provide a distinctive habitat not found elsewhere in the study area, though no particular elements of concern were located. These cliffs are too small to be used by peregrine falcons (C. Martin, ASNH, pers. comm.), but may provide denning or nesting sites for species such as bobcat.

4. Habitat analysis

Figure 6 and Table 7 show the distribution of habitat classes on Crown Vantage and public land across the study area (other private ownerships are not included). The area includes a wide array of existing stand conditions. Among the significant points regarding existing habitat condition are:

- About 29% of upland forests are in mature closed habitat, with the majority of this in hardwood stands along the east slope of Errol Hill. However, when mature and semi-mature stands are combined, about 65% of upland forest acreage is in closed stands, with significant acreage in each forested type.
- About 12% of the study area is in softwood stands, but only a small fraction of this is in mature stands. The vast majority (about 90%) is in semi-mature closed stands; these are generally even-aged stands resulting from clearcut harvests in the early part of the century.
- About 7% of upland forest is in young and regenerating stands, with most of this concentrated around the southern shore of the lake (especially Tidswell Point). However, an additional 7% is classed as residual overstory (two-storied stands with a dense early-successional understory and a scattered overstory). Most of these are hardwood or mixedwood stands that were harvested heavily (but not clearcut) in the 1960s.
- About 13% of the area is in open habitats (non-forested wetlands and upland openings). The great majority of this is the Harpers Meadow area. Of the portion of the area dominated by upland and wetland forests, about 2.5% is in scattered small open habitats such as bogs, alder swamps, landings and fields (data not shown).

Table 7. Distribution of habitat classes for Crown Vantage and public lands within the study area (see map, Figure 6). Bold numbers indicate acreage, non-bold number indicate percentages.

	Mature closed	Mature open	Semi-mature closed	Semi-mature open	Residual Overstory	Young & Regen-eration	TOTAL	% of Total
Upland forest								
Hardwood	**1677**	**950**	**105**	**173**	**446**	**193**	**3544**	33.9
% of total	47.3	26.8	3.0	4.9	12.6	5.4	100.0	
Mixedwood	**658**	**135**	**1654**	**313**	**98**	**327**	**3185**	30.4
% of total	20.7	4.2	51.9	9.8	3.1	10.3	100.0	
Softwood	**25**	**40**	**1095**	**63**	**31**	**35**	**1289**	12.3
% of total	1.9	3.1	90.0	4.9	2.4	2.7	100.0	
Total upland forest	**2360**	**1125**	**2854**	**549**	**575**	**555**	**8018**	76.6
% of total	29.4	14.0	35.6	6.9	7.2	6.9	100.0	
Other								
Forested wetland							**953**	9.1
Non-forested wetland							**1293**	12.4
Upland open							**56**	0.5
Roads							**60**	0.6
Water[1]							**87**	0.8
TOTAL							**10467**	100.0
Other Private Lands							1398	
Study Area Total							11865	

[1]Does not include Lake Umbagog or the Magalloway and Androscoggin Rivers.

Table 8 shows a comparison between the existing condition (cover type and size classes) in the study area and habitat composition goals presented by DeGraaf et al. (1992). These data include both upland and wetland forests on public and Crown Vantage land, but exclude the Tidswell Point area. This comparison is only approximate, as the stand types and size classes used by Crown Vantage are not fully equivalent to the classes used by DeGraaf.

The cover type comparison (Table 8a) indicates that the study area has an excess of hardwood type and a shortage of birch-aspen type compared to goals presented by DeGraaf et al. (1992). Softwood cover is at the low end of the desired range, due to both land capability (only about 16% of the study area was mapped as true softwood communities) and past harvesting (which may have converted some softwood or mixed stands to hardwoods). Total nonforest is within the desired range, though dominated by the large wetland meadows. The inherent capability of the land will set the ultimate limits on the potential mix of stand types. The greatest opportunity for manipulating stand types is in the Northern Hardwood-Spruce-Fir community.

The size class comparison (Table 8b) indicates an excess of timber in the sapling-pole classes and a shortage of both regeneration and large sawtimber stands. Some of the stands classified as Residual Overstory (which were included in the Sapling-pole or Sawtimber classes) could be considered Regeneration, thus the shortage of this size class may not be as great as indicated.

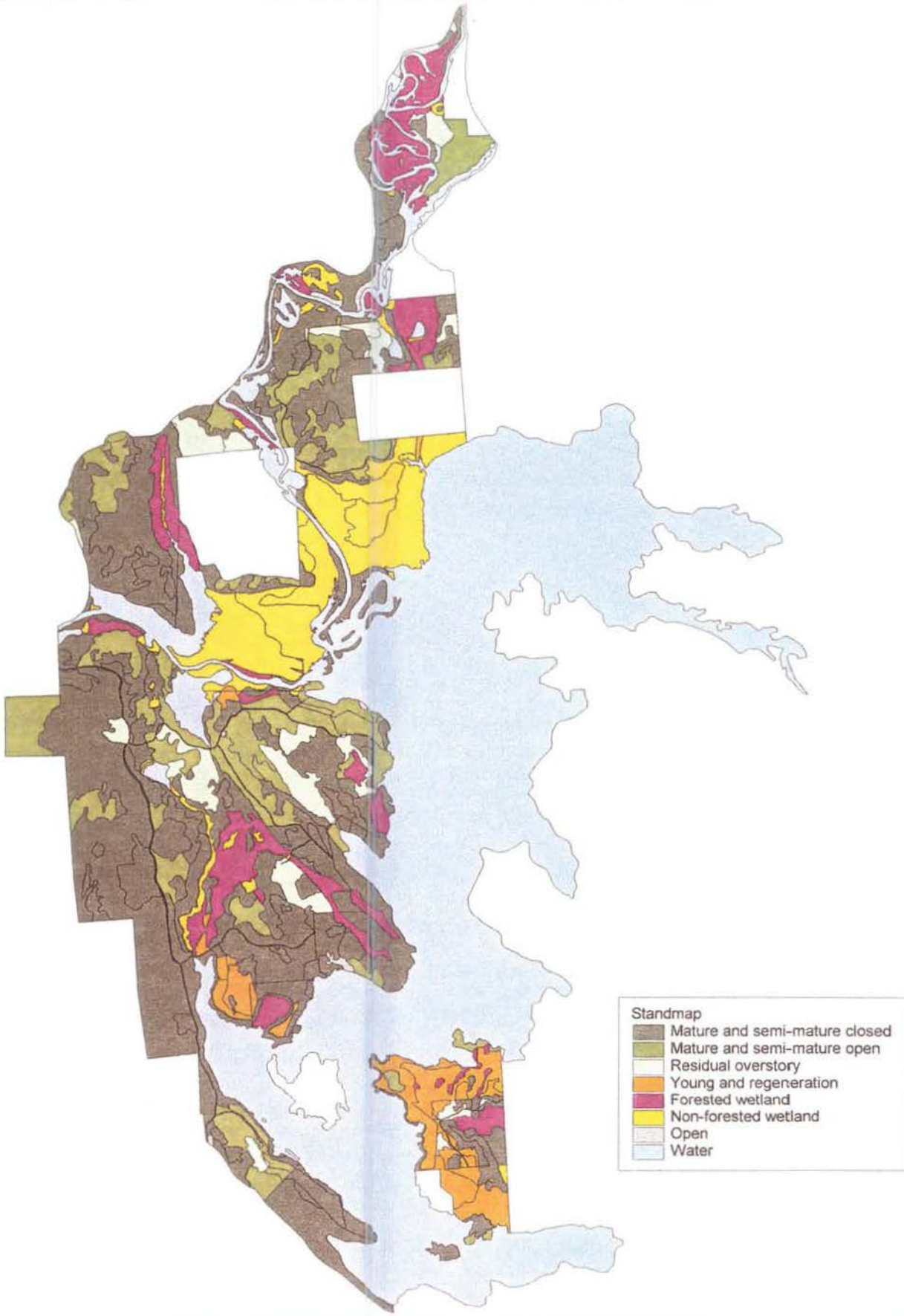

Figure 6. Map of habitat classes on Crown Vantage and public lands within the study area. (Note: distinctions between Softwood, Mixedwood and Hardwood not shown.)

Table 8. Comparison of existing (a) cover type and (b) size class distribution on public and private lands within the study area (excluding Tidswell Point) with habitat composition goals presented by DeGraaf et al. (1992). These data include both upland and wetland forests.

(a)

DeGraaf cover types	Crown Vantage stand types[1]	Composition goal[2] (% of area)	Existing condition (% of area)
Aspen-birch	I, IS	5-20	2
Hardwood	T, H, M, MS	10-35	58
Softwood	S, SM, SI, C, CS	25-50	26
Nonforest			
Upland openings	Open, Road, Yard	5-10	1
Wetlands	Swamp, Alder	3-5	13

(b)

DeGraaf size class	Crown Vantage height classes[1]	Composition goal[2] (% of area)	Existing condition (% of area)
Regeneration	1	5-15	3
Sapling-pole	2, 3	30-40	56
Sawtimber	4	40-50	41
Large sawtimber	5	<10	0

[1]see section II.B.3.
[2]from DeGraaf page 17, Table 1, habitat opportunity class IV.

Data on wildlife trees were collected by Crown Vantage foresters during the course of their timber inventory. These are live trees with cavities that could be used as nesting sites or shelter by wildlife. An average of 0.4 trees/acre were classed as wildlife trees (Table 9); these included hemlock, cedar, beech and yellow birch and ranged in size from 9" to greater than 23" DBH. This is less than the 6 cavity trees and snags per acre recommended in the draft *Recommended Voluntary Forest Management Practices for New Hampshire* (though no data on stocking of snags were collected). An additional 1.4 trees/acre are classed as "cull" (live trees with no merchantable volume due to rot or defect) and could be considered potential wildlife trees; the vast majority of these are cedar.

Table 9. Wildlife trees on Crown Vantage land within the study area.

Species	Trees/acre	Basal Area (ft^2/acre)
Hemlock	0.0	0.04
Cedar	0.2	0.13
Beech	0.1	0.10
Yellow Birch	0.1	0.22
Total	0.4	0.49

III. MANAGEMENT PLAN

This plan is designed to integrate management of timber and non-timber resources within the Lake Umbagog National Wildlife Refuge. Land allocation, forest composition and management guidelines have been developed for Crown Vantage lands within the study area. Guidelines for management of public lands are not included, but the composition and condition of these lands has been considered in developing this plan, with the intent that the entire area be considered an integrated management unit.

Harvesting on public lands in the future may be appropriate to meet specific wildlife or timber management objectives. Any future harvesting would require the development of comprehensive management plans by the appropriate agencies (the USFWS and the NH Division of Forests and Lands). An initial assessment of the potential for timber management on public lands is included within this plan. Any future harvesting on these lands would likely be limited in extent; for the near future the assumption that the majority of these lands will remain unharvested is safe (P. Casey, USFWS and R. MacGregor, NHDFL, personal communications).

The plan does not cover all details of forest management on Crown Vantage lands. The plan primarily focuses on issues of landscape-level management. Many additional guidelines for specific practices (especially at the stand level) are described in the handbook *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire* (NHDRED 1997). The RVFMP handbook should also be considered part of this plan for activities and practices not specifically discussed below.

The quantitative information in this section was developed for Crown Vantage and public lands along the western side of Lake Umbagog, a total of about 9712 acres, of which 5876 belong to Crown Vantage. Lands belonging to other private landowners were not included. Crown Vantage and public lands in the Tidswell Point area on the east side of Umbagog were also not included; these lands should most logically be analyzed in association with other Crown Vantage and public lands along the eastern shore.

A. MANAGEMENT GOALS

The following general management goals highlight the most important factors to be considered in management of this area and set forth general trends that should be promoted.

- Create and maintain balanced size-class distributions within each natural community to provide both a sustainable flow of timber products and a diversity of forest habitats.
- Provide a high level of protection to aquatic and wetland habitats, uncommon natural communities, rare plants, and critical habitat features.
- Maintain at least 50% of spruce-fir stands in semi-mature or mature closed stands (size/density class 3B or greater), as these forests are considered a habitat of particular concern in northern New Hampshire (NHDRED 1995).
- Increase the overall stocking in larger diameter trees and large sawtimber stands where site conditions allow to provide a source of future cavity trees and snags. The

long-term goal is to increase the stocking of wildlife trees to an average of 3-6 trees/acre (equivalent to a basal area stocking of about 4-8 ft^2/acre). Higher densities may be maintained on public lands and in reserve and riparian areas, and lower densities in general management areas.

- Maintain the overall component of regenerating and early-successional stands (especially stands dominated by aspen and pin cherry) to provide habitat for species dependent on this successional stage.
- Maintain at least 10% of each forested community (across public and Crown Vantage lands combined) in an unharvested condition to allow for the long-term development of old-growth habitat. Management direction of both the U.S. Fish and Wildlife Service and the New Hampshire Division of Forests and Lands recognize the restoration of old-growth as a management goal, and it is appropriate that most of this acreage should be located on public lands. However, the actual distribution of these areas should take into account the nature of the landscape as well as ownership, and should be worked out cooperatively between Crown Vantage, USFWS, and NHDFL.

Detailed overall composition and structural goals for the planning area have not been specified. Structural goals and silvicultural guidelines are specified where appropriate at the natural community level, which is the basic ecological unit around which management should be designed. These guidelines have been developed for the Northern Hardwood-Spruce-Fir, Beech-Birch-Maple, Lowland Spruce-Fir, and Mountain Spruce-Fir communities, which are the primary communities under Crown Vantage ownership that are suitable for timber management.

B. BACKGROUND INFORMATION

1. Community distribution by ownership

Understanding the distribution of natural communities between different owners gives an indication of those communities for which the various owners bear primary responsibility. Because public land purchases have focused on areas with the highest habitat value (primarily wetlands and riparian areas), communities are distributed unequally across ownerships (Table 10). Public lands, which constitute about 40% of the planning area, contain the large majority of the High Terrace, Red Spruce-Hemlock-White-Pine, Shallow Emergent Marsh, Shrub Swamp, and Floodplain Forest communities. Crown Vantage, which owns about 60% of the area, owns a disproportionate share of the Beech-Birch-Maple, Lowland and Mountain Spruce-fir, Rich Mesic Hardwood, Cedar Swamp, Black Spruce-larch and Boreal Acidic Bog communities.

2. Timber Stocking

Information on the stocking and distribution of timber volume was obtained from Crown Vantage's timber cruise. Timber stocking across the management plan area averages about 29 cords and 118 square feet of basal area per acre (Table 11). Over two-thirds of the stocking is in five species: red spruce, balsam fir, yellow birch, and red and sugar maple.

Table 10. Distribution of natural communities by ownership within the management plan area. (Note: totals do not sum exactly due to rounding.)

COMMUNITY	Total Acres	Community ownership (%) Crown Vantage	State of NH	USFWS	Total
Upland Communities					
Northern Hardwood-Spruce-Fir	3399	66	15	18	100
Beech-Birch-Maple	2007	92	5	4	100
Lowland Spruce-Fir	827	91	9	0	100
High Terrace	578	5	6	89	100
Mountain Spruce-Fir	292	98	0	2	100
Red Spruce-Hemlock-White Pine	250	11	0	89	100
Rich Mesic Hardwood	8	100	0	0	100
Wetland and Aquatic Communities					
Shallow Emergent Marsh	605	3	0	97	100
Cedar Swamp	561	76	1	23	100
Shrub Swamp	558	7	0	93	100
Floodplain Forest	302	8	24	67	100
Hardwood-Conifer Swamp	187	48	42	10	100
Black Spruce-Larch	39	100	0	0	100
Boreal Acidic Bog	16	93	7	1	100
Water[1]	83	24	2	73	100
Total for planning area	9712	60	9	30	100
Other Crown Vantage and public lands (Tidswell Point)	754				
Other private lands	1398				
Study area total	11865				

[1]does not include Lake Umbagog or the Magalloway and Androscoggin Rivers.

For large areas, a graph of trees/acre by diameter class should follow a reverse J-shaped curve if the distribution is balanced; such a distribution maintains both a sustainable flow of forest products and a range of habitat conditions (Bryce 1995). The diameter distribution for the planning area was compared with a theoretical balanced distribution with the same average basal area (120 ft^2/acre) and maximum tree size (23" DBH). A Q-factor of 1.4 gave the best match with the existing distribution.

The results (Figure 7) indicate that the existing stocking is relatively well balanced up to 18" DBH, with both sufficient reproduction and larger trees (23"+). However, there is a shortage of trees in the 18-22" range. The shortage of larger trees complements the results of the comparison with DeGraaf's composition goals (section II.C.4), which indicated a lack of large sawtimber stands. This is just one of many possible balanced distributions that could be used for comparison; changing the parameters of the distribution (basal area, maximum tree size, and Q-factor) would give different results. The actual desired stand structure will vary with forest type. More detailed information on the stocking and desired structure of specific natural communities is presented in sections III.F.1 through III.F.4.

Table 11. Volume and basal area stocking of live trees >1" DBH on Crown Vantage lands within the management planning area.

SPECIES	Total Vol./ Acre (cords)	Merch. Vol./ acre (cords)[1]	Basal Area (ft^2/acre)
Softwoods			
Red Spruce	4.9	3.9	20.1
Balsam fir	4.3	2.8	20.6
Cedar	2.3	2.0	8.7
White pine	0.4	0.4	2.1
Black spruce	0.3	0.3	1.5
Hemlock	0.3	0.2	0.9
White spruce	0.2	0.1	0.9
Larch	0.0	0.0	0.1
Total softwoods	**12.8**	**9.7**	**54.9**
Hardwoods			
Yellow birch	3.6	2.4	15.0
Red maple	3.4	2.5	15.6
Sugar maple	3.2	2.8	11.4
White birch	2.0	1.2	6.8
Beech	1.4	1.1	6.8
Aspen	0.8	0.6	2.7
White ash	0.2	0.2	0.7
Other hardwoods	1.4	0.3	4.7
Total hardwoods	**16.0**	**11.1**	**63.7**
Total	**28.8**	**20.8**	**118.5**

[1] excludes trees <4.5" DBH and trees classed as cull or wildlife, but includes tops and limbs of merchantable trees that may be merchantable as biomass.

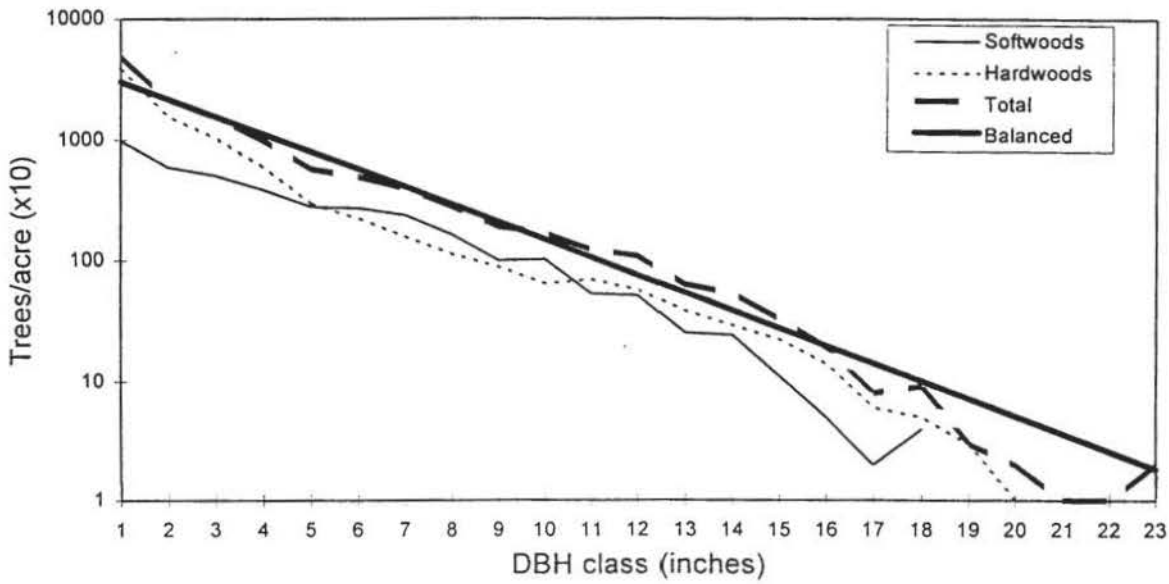

Figure 7. Distribution of trees/acre by diameter class on Crown Vantage lands within the planning area. Vertical axis is on a logarithmic scale; values have been multiplied by 10 to simplify presentation. Balanced distribution is based on a basal area of 120 ft^2/acre, a maximum tree size of 23", and a Q-factor of 1.4.

C. LAND ALLOCATION

Land within the planning area was allocated to five classes: general management, riparian management zones (harvest and no-harvest), and reserve areas (operable and inoperable) (Figure 8). General management lands have no restrictions other than the guidelines discussed below. Riparian management zones are designed to protect aquatic resources and associated habitats. Reserves are areas that should not be harvested due to operability constraints or special ecological values. The operability of various communities and specific areas was determined in consultation with Crown Vantage field staff. Additional unmapped inoperable areas (especially at higher elevations) may be present in the areas designated general management.

The location of osprey nests and their associated 1/4-mile buffer zones are also shown on Figure 8. Of the five nests within the planning area, one is located in the general management area and four are located in reserve areas (though their buffer zones extend into general management areas). These buffer zones have not been given a separate land allocation, since the location of active nests shifts from year to year and because they create no restrictions on harvesting other than its timing.

1. Reserve Areas

The following forested habitats should be reserved from future harvesting to protect significant wetland, rare plant, and wildlife habitat resources:

- Cedar and Hardwood-Conifer Swamp communities. These areas have severe operability constraints due to continually wet soils and deep peat deposits. The peat soils are easily disturbed and growth is very slow. Cedar Swamps contain a high potential for rare plants. Hardwood-Conifer Swamps provide the primary habitat in the area for red-shouldered hawks.
- Floodplain Forests. This community is uncommon in the state and has high value as riparian habitat.
- The Rich Mesic Hardwood community near the summit of Errol Hill is uncommon in the state and has a high potential for rare plants.
- The Mountain Pond and Androscoggin Wetland Complexes. These areas have severe operability constraints due to extensive peat soils and difficult access to interior upland communities. They have high value for rare plants and wildlife habitat, including nesting heron and osprey.

Areas of Crown Vantage land that may be included as part of the 10% old-growth retention goal for each community have not been included as these have yet to be determined.

2. Riparian Management Zones

Guidelines for designating riparian management zones are presented in *Recommended Voluntary Forest Management Activities for New Hampshire*:

- 100' along either side of 1st- or 2nd-order streams and ponds and non-forested wetlands <10 acres in size.
- 300' along 3rd-order streams and ponds and non-forested wetlands >10 acres in size.
- 600' along 4th-order and higher streams (the Androscoggin and Magalloway Rivers).

These zones have been adjusted within the management planning area as follows:

- Along Mountain Pond Stream between Mountain Pond and Thurston Cove the riparian management zone will be expanded to 300'
- The zone has been expanded or contracted in a few places so that roads or other features could serve as the boundary where this seemed logical.
- Though no buffers are required around forested wetlands, a no-harvest zone should be established on short steep slopes adjacent to Cedar Swamp communities to protect potential rare plant habitat, which tends to be located around the fringes of these swamps.

These designations are approximate; the actual layout of these zones in the field should take into account natural topographic breaks, unmapped areas of special value, or other relevant features

Management within these zones should utilize an uneven-aged system, with at least 70% crown closure or B-line stocking maintained in the residual stand. Within wider zones (300' and greater), a minimum of 25' adjacent to aquatic features should remain unharvested (NHDRED 1997). These guidelines have been adjusted within the project area as follows:

- The no-harvest zone will be expanded to 50' adjacent to Mountain Pond and the Magalloway River and to 100' along the Androscoggin River (including Sweat Meadow).
- Within the 300' zone along Mountain Pond and Mountain Pond Stream the following guidelines on opening size will be followed:

	Mountain Pond	Mountain Pond Stream
No harvest	0 - 50' from pond	0 - 25' from stream[1]
Openings < 1/2 acre	50 - 150'	25 - 150'
Openings < 1 acre	150 - 300'	150 - 300'

[1]Exceptions may be made for harvest of patches of timber at high risk to loss.

3. Summary

Of the 5780 acres of forested Crown Vantage land within the planning area, about 88% is operable and 12% is inoperable reserve (Table 12). Of the operable acreage, 93.5% is designated general management, 6.3% riparian management zones, and 0.2% reserve areas (Table 11). About 54 acres of operable land (1.0%) are excluded from harvest as either riparian no-harvest zone or reserved areas. The timber base of 5042 acres (about 87% of the forested area) consists of the general management areas and harvestable riparian zones.

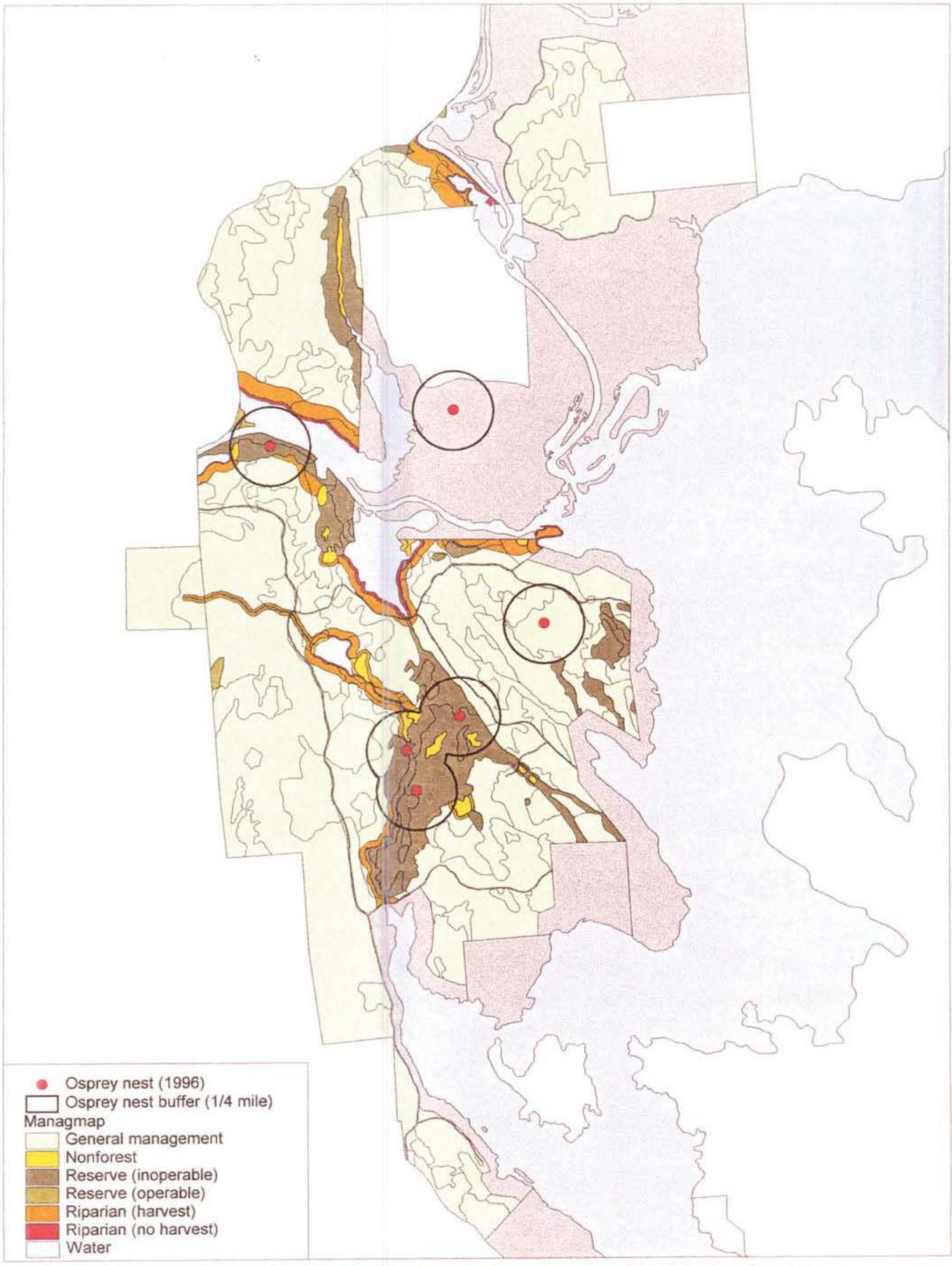

Figure 8. Land management allocation for Crown Vantage lands within the planning area. Public lands are shown in gray.

Table 12. Allocation of Crown Vantage land into different management areas (acres) (see map, Figure 8).

COMMUNITY	General Management	Riparian Zones[1]		Reserve Areas		Total
		Harvest	No Harvest	Operable	Inoperable	
Northern Hardwood-Spruce-Fir	2002	173	31	0	46	2252
Beech-Birch-Maple	1798	44	2	0	0	1844
Lowland Spruce-Fir	648	46	3	0	55	752
Mountain Spruce-Fir	287	0	0	0	0	287
Red Spruce-Hemlock-Wh. Pine	28	0	0	0	0	28
High Terrace	0	16	7	0	7	30
Rich Mesic Hardwood	0	0	0	8	0	8
Cedar Swamp	0	0	0	0	426	426
Hardwood-Conifer Swamp	0	0	0	0	89	89
Black Spruce-Larch	0	0	0	0	39	39
Floodplain Forest	0	0	0	3	22	25
Total forest	4763	279	43	11	684	5780
% of forested acres	82.4	4.8	0.8	0.2	11.8	
% of operable forested acres	93.5	5.5	0.8	0.2	-	
Nonforest						96
Total Crown Vantage land in planning area						5876
Public lands in planning area						3836
Total planning area						9712

[1]does not include acreage of communities already excluded from harvest as reserve areas.

D. GENERAL GUIDELINES

The following general guidelines should be applied to all timber management activities within the planning area:

- All management activities should follow guidelines specified in *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire* (NHDRED 1997) and *Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire* (Cullen 1996).
- Officials of the New Hampshire Department of Fish and Game and the U.S. Fish and Wildlife Service should be consulted during the planning stages for all harvest operations.
- Current policies for protection of nesting osprey should be continued in cooperation with USFWS and New Hampshire Audubon Society.
- White pine should not be harvested due to its importance as potential nest trees, with the exception of thinning of patches of younger pine to improve the health and growth of remaining trees.
- Hemlock should not be harvested due to its very limited stocking within the study area and value as both softwood cover and potentially long-lived wildlife trees.
- Poor quality larger diameter trees should be retained wherever possible to increase the future supply of cavity trees and snags.

- Clearcuts, where used, should be limited to 20 acres or less according to current company policy.
- No herbicides should be used.
- The transportation system should be designed and maintained to minimize impact to wildlife habitat and aquatic resources. The road east of Mountain Pond Stream should be used as a winter road only.

E NATURAL COMMUNITY MANAGEMENT GUIDELINES

1. Northern Hardwood-Spruce-Fir Community

Though no critical ecological values are associated with this community, it can make an important contribution to the maintenance of habitat diversity for a wide range of species, both because it is the most extensive community in the study area and because of its natural diversity of composition. Currently the community consists of about 40% hardwood stands, 50% mixedwood stands, 8% softwood stands, and 2% other types (Table 13). About 60% of the community is in mature or semi-mature closed stands. About two-thirds of this community is on Crown Vantage land and about one-third on public land (Table 10).

This community is well-suited for timber management. Current average stocking is about 113 ft^2/acre, with a reasonably well-balanced diameter distribution and adequate regeneration but a lack of trees larger than 18" DBH (Figure 9a), perhaps reflecting earlier diameter-limit harvesting. The most valuable timber species in this community are yellow birch, red spruce, and balsam fir. The biggest concern from a timber management standpoint is the potential for dominance by early-successional hardwoods (such as pin cherry and striped maple) with low commercial value (but high wildlife value).

Because of the wide variety of conditions in this community, it is difficult to prescribe any single management strategy, and any attempt to force this community into a particular configuration may be neither practical nor desirable. Management should follow generally accepted silvicultural principles according to the existing stand and site conditions in any particular area. However, the following specific guidelines should be incorporated:

- Management should encourage multi-aged and mixed-species stands across most of this community.
- The proportion of this community in softwood stands (currently 8%) should be maintained or increased. Harvesting in softwood or mixedwood stands should utilize group selection or small patch or strip cuts located in areas with established advanced softwood regeneration.
- Currently about 14% of the community is in young, regenerating or residual overstory stands. Future management should retain 10-15% of this community in this condition to provide early successional habitat and promote the growth of intolerant species. Small clearcuts (2-20 acres) should be located in areas of poor quality timber with a component of pin cherry or aspen to encourage the regeneration of these species.

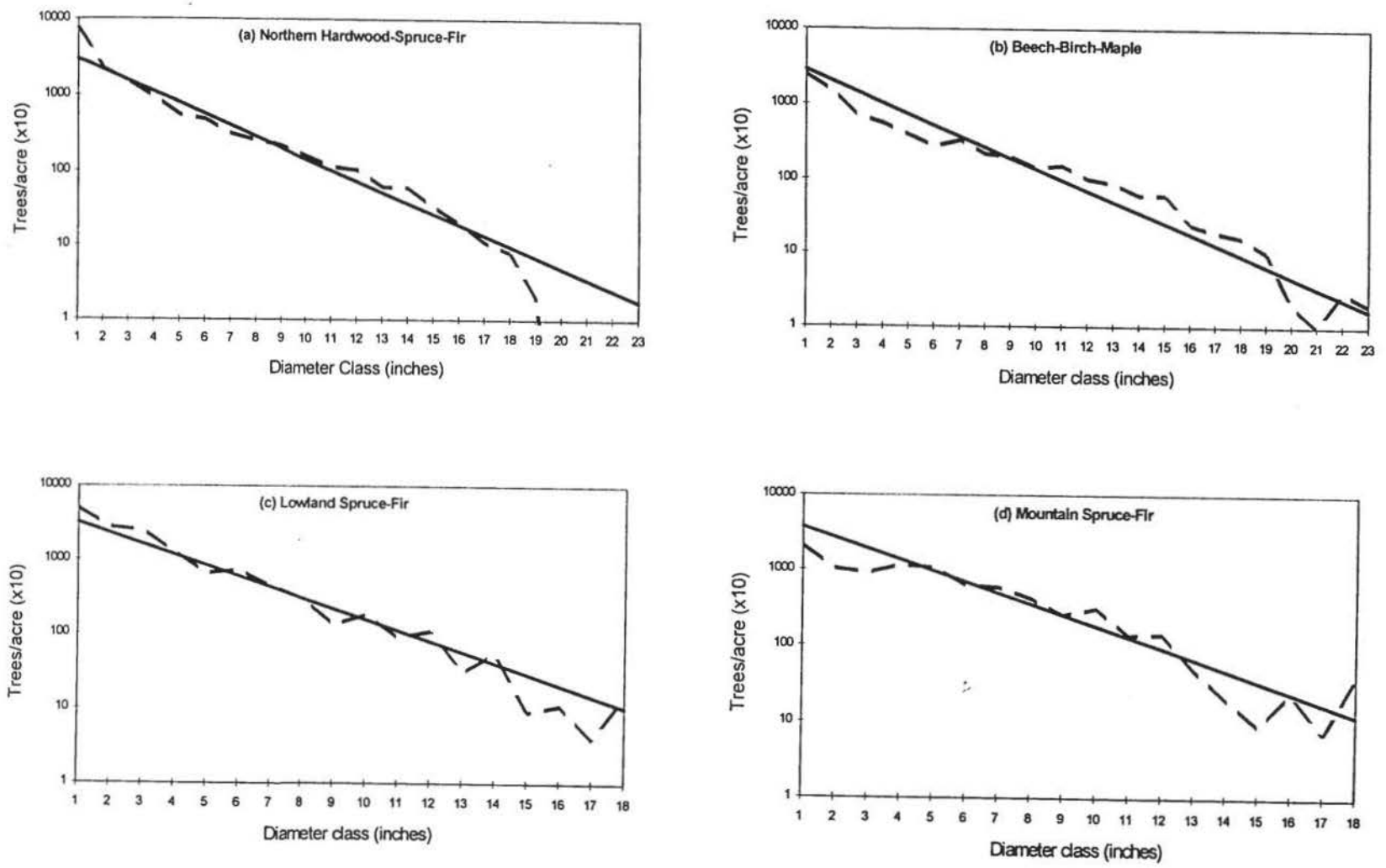

Figure 9. Comparison of existing (dashed line) and balanced (solid line) diameter distributions for the four major natural communities under timber management. Vertical axis is logarithmic; values have been multiplied by 10 to simplify presentation. Balanced distribution is based on a Q-factor of 1.4, a target basal area approximately equal to existing stocking, and a maximum tree size of 23" DBH for the Northern Hardwood-Spruce-Fir and Beech-Birch-Maple communities and 18" DBH for the two Spruce-Fir communities.

Table 13 Distribution of stand and habitat types within the management planning area for the Northern Hardwood-Spruce-Fir community. Designations in parentheses refer to height/crown closure categories used on Crown Vantage stand maps.

	Crown Vantage		Public		Total	
	acres	%	acres	%	acres	%
STAND TYPE						
Softwood	182	8.1	83	7.2	265	7.8
Mixedwood	936	41.6	804	70.1	1740	51.2
Hardwood	1087	48.2	218	19.0	1305	38.4
Other	47	2.1	42	3.7	89	2.6
HABITAT TYPE						
Mature closed (4A, 4B)	450	20.0	361	31.4	810	23.8
Mature open (4C)	575	25.5	78	6.8	653	19.2
Semi-mature closed (3A, 3B)	740	32.9	486	42.4	1225	36.0
Semi-mature open (3C)	90	4.0	73	6.4	162	4.8
Residual overstory (3D, 4D)	302	13.4	56	4.9	359	10.6
Young & Regeneration (1, 2)	48	2.1	52	4.5	100	2.9
Other	47	2.1	42	3.7	89	2.6
TOTAL	2252	100.0	1147	100.0	3399	100.0

2. Beech-Birch-Maple Community

Of all the upland forest communities, the Beech-Birch-Maple community probably retains the most natural structure and species composition, which is a multi-aged mature forest dominated by shade-tolerant hardwoods. This community is ideally suited for growing high-quality hardwoods (sugar maple, yellow birch, and white ash) as well as red spruce in certain areas. It provides habitat for a variety of migratory songbirds, raptors, and small mammals, and is the primary source of hard mast (beechnuts) in the planning area.

The community is dominated by mature closed-canopy hardwood stands (70% of total area), with only about 4% in regenerating, young, or residual overstory stands (Table 14). Stocking currently averages about 110 ft^2/acre; the diameter distribution (Figure 9b) shows an excess of small sawtimber, and deficiencies in poletimber and large sawtimber, though with adequate representation of trees 23" DBH and larger. About 92% of this community is on Crown Vantage land and about 8% on public land (Table 10).

The following guidelines should be applied to the management of this community:

- This community should be managed under an uneven-aged system (single-tree and small group selection) that retains the majority of the community in mature stands.
- 3-5% of this community should be maintained in regenerating stands using small clearcuts (2-10 acres) to create early successional habitat. These cuts should be placed so as to minimize their visibility from Lake Umbagog and the Androscoggin and Magalloway Rivers.
- Inclusions of softwood (primarily red spruce) should be harvested conservatively to maintain their presence in this community.
- Retain any beech showing bear claw marks.

- Unmapped pockets of the Rich Mesic Hardwood community should be reserved from harvesting or harvested lightly during dry or frozen ground conditions.

Table 14. Distribution of habitat types for the Beech-Birch-Maple community within the management planning area. Designations in parentheses refer to height/crown closure categories used on Crown Vantage stand maps.

HABITAT TYPE	Crown Vantage acres	%	Public acres	%	Total acres	%
Mature closed (4A, 4B)	1277	69.3	120	73.5	1397	69.6
Mature open (4C)	284	15.4	29	17.6	313	15.6
Semi-mature closed (3A, 3B)	112	6.1	10	5.8	122	6.0
Semi-mature open (3C)	69	3.7	0	0.0	69	3.4
Residual overstory (3D, 4D)	61	3.3	1	0.8	62	3.1
Young & Regeneration (1, 2)	16	0.9	4	2.3	20	1.0
Other	25	1.3	0	0.0	25	1.2
GRAND TOTAL	1844	100.0	163	100.0	2007	100.0

3. Lowland Spruce-Fir Community

This community is well-suited for growing spruce and fir timber. The dominant understory vegetation is advance regeneration of these species, and hardwood competition is less severe than in the Northern Hardwood-Spruce-Fir community. Creating a balanced stand structure while maintaining sufficient mature habitat and preventing losses of mature timber is the primary management challenge in this community. The long term goal for this community is to create a balanced age-class structure that provides both mature softwood cover and a sustainable periodic level of harvest. The short term goal is to regenerate stands that are currently in a high risk condition, primarily those dominated by balsam fir that is nearing its pathological rotation.

Currently about 63% of this community is in semi-mature closed stands (Table 15), with another 24% is in mature and semi-mature open stands. About 12% is in young, regeneration or residual overstory stands. Average stocking in this community is about 120 ft^2/acre; the diameter distribution is well balanced up to 14" DBH (Figure 9c), with a shortage in the 15-17" range and a good representation of trees 18" and larger. About 901% of this community is on Crown Vantage land and about 9% on public land (Table 10).

The following management guidelines should be applied to this community:

- These areas should be managed by a combination of even- and uneven-aged methods (group selection and small patch or strip clearcuts) aimed at regenerating spruce and fir.
- The long term goal is to reach a balanced age-class distribution with 60-70% of the community in adequately stocked pole and sawtimber stands (height/density class of 3B or greater) (NHDRED 1997). Currently about 60% of this community is in this condition, and many of these stands need to be harvested in the next 20 to 30 years to avoid excessive losses of mature balsam fir timber. The long-term goal will not be attainable until several decades in the future when newly regenerated stands mature.

- The near term goal (next 20-30 years) should be to regenerate mature stands as necessary while retaining at least 50% of this community in stands typed 3B or above. This goal follows guidelines for management of softwood deer yards (NHDRED 1997). This will allow approximately 100 acres of this community to be regenerated using even-aged techniques over the next 30 years. Beyond this point, even-aged harvests will need to be balanced by ingrowth of regenerated stands into a semi-mature closed condition.
- Even-aged harvests should be conducted in several entries at 5 to 10 year intervals over the next 30 years. Overstory removal of areas greater than 2 acres should only be done where advanced regeneration is established. If advanced regeneration is not established, harvest should be by multi-stage techniques (strip or group cuts or shelterwood) designed to establish regeneration before final overstory removal.
- The remainder of this community should be managed using uneven-aged techniques. Scattered group selection or small patch cuts (<2 acres but preferably 1/4-1/2 acre) should be concentrated in areas with adequate advance softwood regeneration. Harvesting should not drop stands below a 3B condition (approximately equivalent to a minimum recommended basal area stocking of 90-100 ft^2/acre). Current average stocking of stands classified by Crown Vantage as High Softwood (3B and above) is about 160 ft^2/acre, thus allowing about 40% of current volume to be removed in these areas during the next harvest cycle.

Table 15. Distribution of habitat types for the Lowland Spruce-Fir community within the management planning area. Designations in parentheses refer to height/crown closure categories used on Crown Vantage stand maps.

HABITAT TYPE	Crown Vantage acres	%	Public acres	%	Total acres	%
Mature open (4C)	12771212 46	6.1	1	1.2	47	5.6
Semi-mature closed (3A, 3B)	469	62.4	52	69.6	521	63.1
Semi-mature open (3C)	133	17.6	20	26.7	153	18.5
Residual overstory (3D, 4D)	79	10.4	0	0.0	79	9.5
Young & Regeneration (1, 2)	9	1.2	0	0.0	9	1.1
Other	17	2.3	2	2.6	19	2.2
GRAND TOTAL	752	100.0	75	100.0	827	100.0

4. Mountain Spruce-Fir Community

This community provides similar habitat values as Lowland Spruce-Fir, though with less value as deer wintering area. It is less well-suited for timber production than Lowland Spruce-Fir due to the thin rocky soils and more difficult access. Because it is drier (and perhaps because it has been harvested less intensively in the past), it is dominated by red spruce, with fir only a minor component.

Currently this entire community is in a semi-mature or mature condition (Table 16), with about three-quarters of the area in closed stands. Average stocking is about 140 ft^2/acre; the stand distribution is deficient in both sapling and middle sawtimber diameters (Figure 9d), with

good representation of larger trees. This community is found almost entirely on Crown Vantage land (Table 10).

This community should be managed according to guidelines specified in the Memorandum of Understanding for High Elevation Forest Management that Crown Vantage has signed with state resource agencies. Though this community is not covered by this agreement (which only deals with lands above 2700' in elevation), it shares many of the same characteristics and provides many of the same habitat values. The stand structure guidelines would apply to this community as follows:

- At least 70% of this community should be maintained in pole or sawtimber stands with at least 90 ft^2/acre of basal area (approximately equivalent to a height/density class of 3B). Since about 75% of this community is currently in this condition, only 5% (about 15 acres) may be regenerated using even-aged management without dropping below this threshold. However, this threshold may be exceeded if necessary to harvest high-risk stands during the transition to a balanced age-class condition.
- The majority of the area should be managed under an uneven-aged system, using group selection or small patch cuts focused on areas containing advance regeneration, especially those where balsam fir is dominant or there is a high risk of windthrow. Spruce should be favored over fir for retention.

Table 16. Distribution of habitat types for the Mountain Spruce-Fir community within the management planning area. Designations in parentheses refer to height/crown closure categories used on Crown Vantage stand maps.

	Crown Vantage		Public		Total	
	acres	%	acres	%	acres	%
Mature closed (4A, 4B)	52	18.0	0	0.0	52	17.7
Mature open (4C, 4D)	18	6.2	5	85.4	23	7.7
Semi-mature closed (3A, 3B)	166	57.8	1	14.0	167	57.0
Semi-mature open (3C, 3D)	51	18.0	0	0.0	51	17.6
TOTAL	287	100.0	6	100.0	293	100.0

F. SUSTAINABLE HARVEST LEVELS

The long-term sustainable harvest was estimated as the annual net growth for all operable forest communities, minus the harvest foregone due to the need to meet other management goals. This approach assumes that stands are in a balanced condition; it does not consider how harvest levels will fluctuate over time as currently unbalanced forests are brought into the desired future condition.

The potential total harvest was calculated by multiplying all potentially operable areas (including general management, riparian zones, and operable reserves) by estimated net growth figures for each natural community supplied by Crown Vantage (Table 17). Total potential harvest on all operable acres is 1881 cords per year.

Table 17. Potential total harvest on Crown Vantage lands within the planning area (cords/year).

COMMUNITY	Operable area[1] (acres)	Growth (cds/ac/yr)	Total growth (cords/year)
Northern Hardwood-Spruce-Fir	2206	.38	838
Beech-Birch-Maple	1844	.40	738
Lowland Spruce-Fir	697	.30	209
Mountain Spruce-Fir	287	.25	72
Red Spruce-Hemlock-White Pine	28	.38	11
High Terrace/Floodplain Forest	26	.38	10
Rich Mesic Hardwood	8	.40	3
Total	5096		1881

[1]Includes general management, riparian zones and operable reserves

Reductions to this harvest incurred to protect significant ecological values include:

- Harvest foregone by placing operable lands into reserve or riparian no-harvest areas.
- Timber losses in harvestable riparian zones. These losses were estimated to be 50% of potential harvest in the Lowland Spruce-Fir Community and 25% in the Northern Hardwood-Spruce-Fir community. These losses will be primarily in softwood stands where timely regeneration is foregone due to the need to retain mature forest cover in these areas. Some of this loss would occur even without the guidelines in this plan due to the requirements of the state's Basal Area Law. No losses are expected in the Beech-Birch-Maple or High Terrace communities, as management in these areas will not differ greatly between general management and riparian areas.
- Harvest foregone by the need to supply and retain wildlife trees. In general management areas, wildlife tree retention can be at the low end of the recommended range of 3-6 trees (4-8 ft^2 of basal area) per acre. Four square feet of basal area is about 3.3% of current average stocking of 120 ft^2/acre, thus retaining these trees will reduce potential harvest by about the same proportion.

Table 18. Reductions to total potential harvest on Crown Vantage lands due to ecological protection guidelines (cords/year).

COMMUNITY	Total Potential Harvest (crds/yr)	Harvest reduction due to (cords/year): Operable Reserves	Riparian no-harvest zones	Riparian harvest zones	Wildlife tree Retention	Total Reduction (cords/year)	%
Northern Hardwood-Spruce-Fir	838	0	12	16	25	53	6.3
Beech-Birch-Maple	738	0	1	0	23	24	3.1
Lowland Spruce-Fir	209	0	1	7	6	14	6.7
Mountain Spruce-Fir	72	0	0	0	2	2	2.8
Red Spruce-Hemlock-Wh. Pine	11	0	0	0	<1	<1	3.3
High Terrace/Floodplain Forest	10	1	3	0	0	4	38.3
Rich Mesic Hardwood	3	3	0	0	0	3	100.0
Total	1881	4	17	23	57	101	5.4
Potential harvest minus reductions	1780						

The total harvest reduction incurred in meeting these guidelines is 101 cords/year, or about 5.4% of total potential harvest (Table 18); over half of this was accounted for by the need to meet wildlife tree retention goals. The estimated sustainable harvest after reductions was 1780 cords/year. The reduction in harvest is relatively low because most of the major riparian areas lie within the public land portion of the study area.

This analysis does not include all factors that may reduce harvests below the maximum potential level. Actual harvest levels will probably be less than the amount calculated above due to the following additional factors:

- The presence of unmapped inoperable areas.
- The need to include some areas to meet the 10% old-growth reserve goal (though these may overlap with the unmapped inoperable areas).
- Limitations on harvesting white pine and hemlock. These species comprise 0-5% of the stocking of the four major forest communities and were included in the growth projections. Some this reduction will be included in the reserve area and wildlife tree reductions calculated above.
- The need to bring communities into a balanced condition, especially the need to "fill in" the larger diameter classes. Calculating this reduction would require growth and harvest modeling beyond the scope of this project. Currently the shortage in stocking of larger diameter classes compared to the theoretical balanced distribution is between 1 and 5 ft^2/acre for the major communities. This is in the same range as the reductions due to wildlife tree retention and white pine and hemlock retention, and there is much overlap among these three goals.

Given these unknowns, an estimate that the sustainable harvest level should be set at about 85-90% of the total potential harvest (or about 1600-1700 cords per year) appears reasonable.

G. MONITORING

The primary tool for monitoring progress toward the goals outlined in this plan will be future timber inventories conducted by Crown Vantage, including both timber cruise data and updating of stand maps. Crown Vantage updates this information at approximately 5 year intervals. Maps and other information developed for management planning by USFWS or NH Division of Forests and Lands will also be valuable.

Future assessments should be performed cooperatively by Crown Vantage, the USFWS, and the AMC Research Department. Updated timber cruise data and stand maps should be used as they are developed to monitor progress toward or adherence to the plan's goals. These assessments should focus on:

- changes in the overall distribution of forest habitat classes.
- changes in diameter-class distributions.
- retention of mature spruce-fir habitat.

- maintenance of early-successional habitat.
- stocking of wildlife trees.

The U.S. Fish and Wildlife Service bears primary responsibility for monitoring wildlife populations on the refuge. Permanent plots or transects for monitoring songbird and other wildlife populations should be established by refuge staff.

Monitoring of rare plant populations should be done by USFWS in cooperation with the New Hampshire Natural Heritage Inventory.

H. FUTURE RESEARCH NEEDS

The following additional steps are recommended as a follow-up to information gathered in this study:

- The appropriate distribution of old-growth retention areas needs to be determined cooperatively by Crown Vantage, U.S. Fish and Wildlife Service, and New Hampshire Division of Forests and Lands. The Appalachian Mountain Club should assist with this effort.
- Permanent wildlife monitoring plots should be established on both public and private lands within the refuge.
- All rare plant locations should be surveyed to Natural Heritage Inventory standards. This would provide more accurate information on location, habitat, and population size.
- The full boundaries of Cedar Swamp communities (especially the large area within the Mountain Pond Wetland Complex) should be surveyed for additional rare plant sites.
- The Rich Mesic Hardwood community on Errol Hill should be surveyed during the prime flowering season to determine whether rare plants associated with this community may be present.
- The area across the Magalloway River from the refuge headquarters identified as a potential deeryard should be surveyed by state or federal wildlife biologists to determine its value and level of use as a deeryard.
- A more detailed survey of the Whaleback Ponds area should be conducted. This area received only cursory attention during this survey.

I. POTENTIAL FOR TIMBER MANAGEMENT ON PUBLIC LANDS

The management planning area west of Lake Umbagog includes about 3836 acres of public land. Of this, about 40% is in upland forest types potentially suitable for timber management. Harvesting on these lands would take place only after the development of comprehensive management plans by the relevant public agencies (the U.S. Fish and Wildlife Service and the New Hampshire Division of Forests and Lands). The following is intended as a

preliminary assessment only, and is not intended to prejudice the choice of land allocation or management goals and policies by these agencies.

This assessment used the same guidelines for land allocation and calculation of harvest as was used for Crown Vantage lands. However, the following additional assumptions and guidelines were used:

- No distinction was made between USFWS and State of New Hampshire lands, though the management policies of these agencies may differ.
- No harvesting will take place within riparian management zones. This is likely to be the policy of the USFWS (P. Casey, personal communication), though their designation of these zones may differ from that used here.
- Floodplain Forest and High Terrace communities were assumed to be inoperable. These communities may contain relatively dry areas that could be considered operable, but the majority consists of wet strands or areas interspersed by sloughs and oxbows that make access difficult.
- Public lands will be used where available to meet the 10% goal for old-growth reserve in each community. Actual distribution of these areas between public and Crown Vantage land has not been determined, and needs to consider the most appropriate location of these areas across the landscape. The majority of this acreage is likely to be on public lands. However, this assumption is made only for the purposes of this analysis.
- Wildlife tree retention will be at the high end of the suggested range of 3-6 trees/acre (4-8 ft^2/acre). Eight ft^2/acre of basal area is about 6.7% of current average stocking, so potential harvest in general management areas will be reduced by this amount.

Of the 3836 acres of public land in the planning area, about 1165 acres (30%) are in nonforest communities, 1058 acres (28%) are inoperable forested wetland communities, and 1613 acres (42%) are operable upland forested communities (Table 19). Of the operable forest, about 45% is contained within designated riparian zones and another 7% is in operable reserves needed to meet the 10% old-growth reserve goal. This leaves about 771 acres as general management area (48% of the operable forested area). If these guidelines were followed, harvesting would be limited to the Northern Hardwood-Spruce-Fir and Red Spruce-Hemlock-White Pine communities.

Using the growth figures supplied by Crown Vantage, the total potential harvest on the 1613 acres of operable forest land is about 609 cords/year (Table 20), or about one-third the level on Crown Vantage Lands. If the environmental constraints assumed here were implemented, the harvest would be reduced by about 60%, to a sustainable level of 245 cords/year. About three-quarters of this reduction is due to the exclusion of harvesting from riparian zones. Given the focus of public land acquisition on areas with high ecological value, this high level of reduction in potential harvest due to ecological restrictions is not surprising, and it is consistent with harvest levels on other lands managed by the New Hampshire Division of Forests and Lands (Tom Minor, NHDFL, personal communication).

Table 19. Hypothetical allocation of public land within the planning area into different management areas.

COMMUNITY	General Management	Riparian Zones[1]	Reserve Areas Operable[2]	Reserve Areas Inoperable	Total
Northern Hardwood-Spruce-Fir	696	451	0	0	1147
Beech-Birch-Maple	0	87	76	0	163
Lowland Spruce-Fir	0	41	34	0	75
Mountain Spruce-Fir	0	0	6	0	6
Red Spruce-Hemlock-Wh. Pine	75	147	0	0	222
High Terrace	0	0	0	548	548
Cedar Swamp	0	0	0	135	135
Hardwood-Conifer Swamp	0	0	0	98	98
Floodplain Forest	0	0	0	277	277
Total forest	771	726	116	1058	2671
% of forested acres	29	27	4	40	
% of operable forested acres	48	45	7	-	
Nonforest					1165
Total public land in planning area					3836

[1]does not include acreage of communities already excluded from harvest as inoperable reserve areas.
[2]acreage outside of riparian zones required to meet 10% old-growth goal for these communities.

Table 20. Hypothetical assessment of potential sustainable harvest levels on public lands within the planning area.

COMMUNITY	Operable acreage	Growth (cd/ac/yr)	Potential Harvest (crds/yr)	Harvest foregone due to (cords/year): Operable Reserves	Riparian zones	Wildlife tree Retention	Total Reduction (cords/year)	%
Northern Hardwood-Spruce-Fir	1147	.38	436	0	171	46	217	49.8
Beech-Birch-Maple	163	.40	65	30	35	0	65	100.0
Lowland Spruce-Fir	75	.30	22	10	12	0	22	100.0
Mountain Spruce-Fir	6	.25	2	2	0	0	2	100.0
Red Spruce-Hemlock-Wh. Pine	222	.38	84	0	56	2	58	69.0
Total	1613		609	42	274	48	364	59.8
Total sustainable harvest			245					

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APPENDICES

APPENDIX A: DESCRIPTIONS OF NATURAL COMMUNITIES

Upland Communities
- Northern Hardwood-Spruce-Fir
- Beech-Birch-Maple
- Lowland-Spruce-Fir
- Mountain Spruce-Fir
- Red Spruce-Hemlock-White Pine
- High Terrace
- Rich Mesic Hardwood
- Jack Pine Rocky Lakeshore

Wetland Communities
- Cedar Swamp
- Hardwood-Conifer Swamp
- Floodplain Forest
- Black Spruce-Larch
- Boreal Acidic Bog
- Shrub Swamp
- Shallow Emergent Marsh

APPENDIX B: SPECIES LISTS FOR SHRUB/HERB LAYERS

Upland Communities
- Northern Hardwood-Spruce-Fir
- Beech-Birch-Maple
- Lowland-Spruce-Fir
- Mountain Spruce-Fir
- Red Spruce-Hemlock-White Pine
- High Terrace
- Rich Mesic Hardwood

Wetland Communities
- Cedar Swamp
- Hardwood-Conifer Swamp
- Floodplain Forest
- Black Spruce-Larch
- Boreal Acidic Bog

APPENDIX C: GOOD FORESTRY IN THE GRANITE STATE: RECOMMENDED VOLUNTARY FOREST MANAGEMENT PRACTICES FOR NEW HAMPSHIRE (TABLE OF CONTENTS)

APPENDIX A : DESCRIPTION OF NATURAL COMMUNITIES

To quantitatively describe each natural community, landform, soil, and plant data were collected from 10-meter radius plots. Between 1 and 4 plots were non-randomly located in representative sections of each community. No plots were located in the Jack Pine Rocky Lakeshore, Shrub Swamp or Shallow Emergent Marsh communities.

In each plot soil pits were excavated to the C horizon. Parent material, depth to mottles or water table, and the thickness and texture of each horizon were recorded.

Vegetation was divided into 3 strata: canopy (>10 cm DBH), subcanopy (2-10 cm DBH), and shrub/herb (<2 cm DBH). For each canopy tree species, DBH, and live/dead status were recorded. For each subcanopy tree we recorded the species and live/dead status. We rated each species in the shrub/herb layer on a scale from 1 to 4 as shown below.

Rating	Quantitative Description
1	<10 individuals
2	11-50 individuals
3	> 50 individuals and < 80% ground cover
4	> 80% ground cover

The quantitative measures were calculated as follows:

$$\text{Relative density of species } a = \frac{\text{trees/acre for species } a}{\text{trees/acre for all species}} \times 100$$

$$\text{Relative dominance of species } a = \frac{\text{basal area/acre for species } a}{\text{basal area/acre for all species}} \times 100$$

$$\text{Frequency of species } a = \frac{\text{no. of plots on which species } a \text{ occurs}}{\text{total no of plots in community}}$$

The quantitative measures of overstory composition shown in this appendix show some differences from the composition shown in Section C.1.a, Table 3. The measures in this appendix were based on a small number of non-randomly located plots, and are subject to the authors' bias regarding what was representative of each community. The figures shown in Table 3 are based on a larger number of randomly located plots and should be considered a more accurate representation of overstory composition for those communities.

Northern Hardwood-Spruce-Fir

Synopsis: This community is transitional between Beech-Birch-Maple and Lowland Spruce-Fir and is quite variable in species composition. Management history has had an effect on current species composition and it is difficult to predict the relative dominance of individual species in the future. Areas that were not clearly spruce-fir nor beech-birch-maple were lumped into the mixed type. It was generally separated from the Beech-Birch Maple Community by the absence of sugar maple and from Lowland Spruce-Fir by the greater dominance of red maple and yellow birch relative to white birch.

Landform and Soil: The mixed type occurs on northern and western hillslopes and on ridges in the Mountain Pond Basin. Parent material is till varying in texture from coarse sandy to sandy clay loam, with a 2-10 cm O horizon. Two of the three soil pits had A horizons, one of which may have been anthropogenic. The third pit had a classic spodosol with a 7 cm E horizon over Bhs and Bs horizons. All three pits were only moderately well drained with mottling beginning from 18 to 70 cm deep.

Vegetation: In early seral stages, trembling aspen and pin cherry dominate the canopy. In later seral stages, balsam fir, red maple, yellow birch, and red spruce dominate both overstory and understory, with American beech and striped maple also present. The mixed type has the second highest species richness herb layer (42 species), dominated by intermediate wood fern, wood-sorrel, blue-bead lily, Canada mayflower, starflower, sarsaparilla, and wild lettuce (see Appendix B). There were no herbs unique to the mixed community.

Species	Relative Density	Relative Dominance	Frequency (n=3)
Overstory			
Trembling Aspen	0.25	0.30	0.67
Pin Cherry	0.22	0.15	0.33
Red Maple	0.16	0.20	1.00
Red Spruce	0.09	0.10	1.00
White Birch	0.09	0.08	0.67
American Beech	0.04	0.08	0.33
Yellow Birch	0.06	0.04	0.67
Balsam Fir	0.04	0.04	0.67
Striped Maple	0.03	0.02	0.33
Dead Stems	0.02	0.00	-
Understory			
Red Maple	0.31	-	1.00
Balsam Fir	0.15	-	1.00
Striped Maple	0.14	-	1.00
Yellow Birch	0.10	-	1.00
Pin Cherry	0.05	-	0.67
Red Spruce	0.04	-	0.67
White Birch	0.03	-	1.00
Mountain Maple	0.02	-	0.33
American Beech	0.02	-	0.67
Sugar Maple	0.01	-	0.33
White Pine	0.01	-	0.33
Dead Stems	0.12	-	-

Beech-Birch-Maple Forest

Synopsis: This is the "classic" northern hardwood forest type (Sperduto 1994), with only an occasional red spruce or hemlock softwood component. At higher elevations near the hilltops, this community grades into Mountain Spruce-Fir; at the lower elevations and on north or west aspects, it is replaced by the Northern Hardwood-Spruce-Fir forest. The presence of sugar maple as the overstory dominant distinguishes this community types from all others on the refuge except the Rich Mesic Forest, which is identified by herb species indicating rich sites. This community may actually more closely resemble the Semi-rich Mesic Forest of Sperduto (1994) than his Beech-Birch-Maple community.

Landform and soil: On refuge lands, this type is found on the east and southeast-facing slopes of large hills, and on elevated areas of the Mountain Pond basin. The soils are typically well-drained and derived from till (or occasionally shallow till or colluvium over ledges), with A and E horizons of sandy or silty loam, and Bhs, Bs, and C horizons of sandy clay loam.

Vegetation: Sugar maple was the dominant overstory tree in all three plots, with yellow birch and beech also present; white ash and red spruce were each present in one plot. Sugar maple was the dominant understory species, with beech, red spruce, and striped maple also present.
The most abundant tree species in the herb layer were sugar maple and striped maple, with beech, hop-hornbeam, and white ash the next most common (see Appendix B). Intermediate wood-fern, wild sarsaparilla, lady-fern, wood-sorrel, hobblebush and trillium were the most abundant herbs and shrubs. New York fern, Jack-in-the-pulpit, spikenard, and hay-scented fern were indicative of this community type on the refuge.

Species	Relative Density	Relative Dominance	Frequency (n=3)
Overstory			
Sugar Maple	0.72	0.69	1.00
Yellow Birch	0.11	0.12	0.67
American Beech	0.09	0.09	0.67
White Ash	0.04	0.04	0.33
Red Spruce	0.04	0.04	0.33
Dead Stems	0.00	0.02	-
Understory			
Sugar Maple	0.68	-	0.33
American Beech	0.21	-	0.33
Striped Maple	0.05	-	0.33
Red Spruce	0.05	-	0.33
Dead Stems	0.01	-	-

Lowland Spruce-Fir Forest

Synopsis: This community occupies flat, poorly drained areas. As drainage improves it grades into the Northern Hardwood-Spruce-Fir community; in wetter areas it grades in the Cedar Swamp community. It is distinguished from Mountain Spruce-Fir by its landscape position, from Northern Hardwood-Spruce-Fir by the greater presence of white birch relative to yellow birch and red maple, and from cedar swamps by its parent material (mineral soil rather than peat). Tip-ups are common in lowland spruce-fir because tree roots are generally shallow due to the hydric, often bouldery soils.

Landform and Soil: On the tract, the lowland spruce-fir community occurs in two areas: in hydric mineral soil in the Mountain Pond area, near Route 16 and on Tidswell Point, and on islands of glacial drift within the Mountain Pond and Tidswell Point wetland complexes. The soils are mostly poorly drained and range in texture from silty loam to boulders. The only exceptions are the islands of glacial drift, which have well-drained spodosols developed in gravely loamy sand.

Vegetation: The Lowland Spruce-Fir community is more diverse than the Mountain Spruce-Fir community. While balsam fir and red spruce dominate the canopy, there were 6 overstory species on the plot. The understory composition is similar to that of the canopy. The shrub/herb layer contains 12 species of tree seedlings and 28 species of herbs, mostly common boreal species such as blue-bead lily, creeping snowberry, bunchberry, and mosses (see Appendix B). Rattlesnake orchid, shinleaf, dewdrop, Indian pipe, twinflower, and pink lady's slipper were found in the Lowland Spruce-Fir community but not the Mountain Spruce-Fir.

Species	Relative Density	Relative Dominance	Frequency (n=4)
Overstory			
Red Spruce	0.60	0.58	1.00
Balsam Fir	0.24	0.22	1.00
White Birch	0.09	0.12	0.75
White Cedar	0.04	0.05	0.25
White Pine	0.01	0.01	0.25
Red Maple	0.01	0.01	0.25
Dead Stems	0.01	0.01	-
Understory			
Balsam Fir	0.42	-	1.00
Red Spruce	0.26	-	1.00
White Birch	0.05	-	0.25
White Cedar	0.01	-	0.25
Dead Stems	0.25	-	-

Mountain Spruce-Fir Forest

Synopsis: Higher summits and ridgetops within the study area resemble typical high-elevation spruce-fir forests with white birch and mountain ash present but lacking northern hardwoods due to climatic influences. This community exists on the hilltops because of the shallow, rocky organic soil rather than climate. Blowdowns are common on the exposed ridgetops and fire is potentially a factor (a white pine on one of the hilltops had been struck by lightning).

Landform and Soil: This community type occurs on the rocky summits of Mill Mountain (2160 ft.) and Errol Hill (2283 ft.) and the unnamed hills (~1600 ft.) north of the Androscoggin River. The sites are rocky and the soils are well-drained and shallow, consisting of organic duff and discontinuous thin till. One pit on top of Errol Hill was a spodosol in 50 cm of sandy clay loam till.

Vegetation: Red spruce dominates the overstory and understory. Balsam fir and white birch are common and yellow birch is incidental. White pine did not occur in our plots but is present on the hilltops north of the Androscoggin River. Five percent of the basal area was spruce and fir snags. The herb and shrub layer was dominated by spruce, fir, and mountain ash seedlings, and a mixture of boreal and temperate herbs (intermediate wood fern, wood sorrel, Canada mayflower, moss and sarsaparilla) (see Appendix B). There were no herbs unique to this community and it had the lowest species richness of any community type.

Species	Relative Density	Relative Dominance	Frequency (n=2)
Overstory			
Red Spruce	0.47	0.46	1.00
Balsam Fir	0.31	0.35	1.00
White Birch	0.09	0.06	1.00
Yellow Birch	0.06	0.08	1.00
Dead Stems	0.07	0.05	-
Understory			
Red Spruce	0.67	-	1.00
White Birch	0.22	-	0.50
Balsam Fir	0.11	-	1.00

Red Spruce-Hemlock-White Pine Forest

Synopsis: This community type is recognized by its sandy outwash parent material and by the increase in white pine and hemlock in the canopy. It is distinguished from Beech-Birch-Maple by the lack of sugar maple and from Lowland Spruce-Fir by the well-drained, sandy soils and landform.

Landform and Soil: The type occurs on gravely and sandy outwash terraces and kames along the Magalloway River, near the Whaleback Ponds, and on Tidswell Point. The soils are well drained and deep.

Vegetation: The potential vegetation is difficult to ascertain due to management history. At present, balsam fir and red spruce are canopy codominants with pine, but historically white pine and hemlock may have been more prevalent. The most common herbs are Canada mayflower, goldthread, bunchberry, sarsaparilla, wood sorrel, mountain-holly, starflower, and blueberry (see Appendix 2). The type is intermediate in species richness and has no unique herbs.

Species	Relative Density	Relative Dominance	Frequency (n=2)
Overstory			
Red Spruce	0.35	0.32	1.00
Balsam Fir	0.16	0.16	0.50
White Pine	0.07	0.15	1.00
Hemlock	0.05	0.04	0.50
Larch	0.05	0.05	0.50
Yellow Birch	0.02	0.05	0.50
Dead Stems	0.30	0.23	-
Understory			
Balsam Fir	0.23	-	1.00
White Birch	0.19	-	0.50
Hemlock	0.12	-	0.50
Red Maple	0.08	-	0.50
Black Cherry	0.08	-	0.50
White Pine	0.04	-	0.50
Striped Maple	0.04	-	0.50
Dead Stems	0.22	-	-

High Terrace Forest

Synopsis: This forest occupies the higher portions of the riverine forest/swamp complex along the Magalloway River. It is distinguished from the Floodplain Forest community by the absence of silver maple and the presence of distinct soil horizons. Its overstory composition is similar to the Northern Hardwood-Spruce-Fir community and would probably be included with that community in a broader classification. It was separated in this study by its parent material and landscape position.

Landform and Soil: This type is found along alluvial terraces of the Magalloway River, one meter or more above the summer water level. There is no annual deposition of new sediments so soil horizonation is evident. Parent material is well-drained silt and very fine sand.

Vegetation: Red spruce, balsam fir, red maple, and white birch were the dominant overstory and understory species on the sample plots, though in other areas mapped as this community hardwoods are dominant. The herb layer contains more boreal species than the Northern Hardwood-Spruce-Fir community and was dominated by bunchberry, starflower, velvet-leaf blueberry, goldthread, intermediate wood fern, Canada mayflower, moss, wood-sorrel, and wiry ground-cedar (see Appendix B). Herb species richness was moderate and there were no herbs unique to this community.

Species	Relative Density	Relative Dominance	Frequency (n=2)
Overstory			
Red Spruce	0.55	0.54	1.00
Balsam Fir	0.23	0.22	1.00
Red Maple	0.10	0.10	1.00
Yellow Birch	0.03	0.07	1.00
Dead Stems	0.09	0.07	-
Understory			
Balsam Fir	0.64	-	1.00
Red Spruce	0.08	-	0.50
Yellow Birch	0.04	-	0.50
Dead Stems	0.24	-	-

Rich Mesic Forest

Synopsis: This is an enriched hardwood type that grades into the Beech-Birch-Maple community. The combination of a predominantly sugar maple canopy and herbs such as Dutchman's breeches, Braun's holly fern, and sweet cicely distinguish the Rich Mesic Forest from all other community types.

Landform and soil: This community is present in the refuge as inclusions within the Beech-Birch-Maple type, occupying concavities at the base of steep east-facing slopes or ledges on Errol Hill and Mill Mountain. The soil in the sample plot was well drained, had a well-developed A horizon of silty loam colluvium over a Bs and C horizon of sandy clay loam till, and was less cobbly than the surrounding slopes.

Vegetation: Sugar maple dominates the overstory and understory of this plot, with yellow birch in the overstory and striped maple in the understory. Sugar maple, mountain maple, and hop-hornbeam were the most common tree seedlings (see Appendix B). The most common herbs were lady fern, cinnamon fern, hobblebush, and wood fern.

Species	Relative Density	Relative Dominance	Frequency (n=2)
Overstory			
Sugar Maple	0.80	0.73	-
Yellow Birch	0.20	0.27	-
Understory			
Sugar Maple	0.90	-	-
Striped Maple	0.10	-	-

Jack Pine Rocky Lakeshore

Synopsis: This community has jack pine, red pine, and some hemlock, white pine, red spruce, balsam fir, and red oak. It is very similar to the Red Spruce-Hemlock-White Pine type and is distinguished by its landscape position and soils. It is distinguished from all other types by the occasional presence of jack and red pines.

Landform and Soil: The jack pine community is found only on a 15 to 20m strip along Tidswell Point on the eastern shore of Lake Umbagog. Its exposure to prevailing winds desiccates the site. The soils are organic duff or shallow till over rock.

Vegetation: No sample point was taken in this community. The dominant tree species were hemlock, white pine, red pine, red spruce, and jack pine. Because it is along the lake, this type has not been heavily logged. The dominant herbs were common boreal species such as bunchberry, blue-bead lily, and velvet-leaf blueberry.

Northern Whitecedar Swamp Forest

Synopsis: This community occurs in peatland basins that are more extensive and less hydrologically isolated than Boreal Bogs and Black Spruce-Larch communities. Cedar Swamps are distinguished from the Black Spruce-Larch community by the increase in cedar in the canopy. The canopy is often taller and more dense than in the Black Spruce-Larch type. The community grades into Lowland Spruce-Fir or Northern Hardwood-Spruce-Fir as drainage improves. Cedar Swamps are distinguished from Mixed Hardwood-Conifer Swamps by presence of black spruce and much lower hardwood component (especially white birch).

Landform and Soil: Cedar Swamps are found in the Mountain Pond basin, around the Whaleback Ponds, in the interior of Tidswell Point, and in two backwater areas along the Androscoggin River. They always have deep, hydric peat accumulations and usually have hummock and hollow microtopography.

Vegetation: With 46 herb species and 11 tree species, Cedar Swamps have the highest plant diversity of any community type (see Appendix B). The dominant overstory and understory species are northern whitecedar, balsam fir, and red and black spruce. The dominant herbs are sphagnum moss, three-seeded sedge, goldthread, wood-sorrel, sarsaparilla, blue-bead lily, bunchberry, creeping snowberry, cinnamon fern, mountain-holly, and dwarf raspberry. One site (designated "Orchid Hill") contains six orchid species, three of which -- heart-leaved twayblade, lily-leaved twayblade, and small yellow lady's slipper -- are state-listed threatened species. Eleven herbs were found only in this community.

Species	Relative Density	Relative Dominance	Frequency (n=2)
Overstory			
Northern Whitecedar	0.47	0.55	1.00
Balsam Fir	0.28	0.21	1.00
Red and Black Spruce	0.17	0.17	1.00
Black Ash	0.02	0.02	0.50
Dead Stems	0.06	0.05	-
Understory			
Balsam Fir	0.55	-	1.00
Red Spruce	0.13	-	1.00
White Cedar	0.05	-	1.00
Black Ash	0.05	-	0.50
Yellow Birch	0.02	-	0.50
Dead Stems	0.20	-	-

Hardwood-Conifer Swamp Forest

Synopsis: This type is a forested peatland that is very similar in landform and soil to the Cedar Swamp. The major distinction is canopy composition, which contains more red maple, black ash, birches and alder than the Cedar Swamp. It is distinguished from upland types by its peat parent material.

Landform: Most Hardwood-Conifer swamps on the tract are relatively close to Lake Umbagog and may receive nutrient enrichment from the lake waters. Their organic soils are not as deep as those in Cedar Swamps so they may also be enriched by the underlying mineral soil. Like Cedar Swamps, the hardwood-conifer seepage swamps have hummock and hollow microtopography.

Vegetation: The overstory composition of this type is very variable from swamp to swamp. Red maple and black ash are commonly present, and cedar, hemlock, red spruce, and balsam fir may also be present. Speckled alder is the most common understory species. Common herbs and shrubs are sphagnum moss, three-seeded sedge, bunchberry, cinnamon fern, bog sedge, goldthread, round-leaved sundew, swamp candle, Canada mayflower, wood-sorrel, dwarf raspberry, three-leaved Solomon's seal, and wild raisin (see Appendix B). Two herbs -- alpine enchanter's nightshade and crested wood fern -- were found only in this community.

Species	Relative Density	Relative Dominance	Frequency (n=2)
Overstory			
Balsam Fir	0.29	0.24	1.00
White Cedar	0.13	0.22	0.50
White Birch	0.11	0.09	1.00
Black Ash	0.08	0.05	0.50
Red Maple	0.05	0.06	1.00
Red Spruce	0.05	0.05	0.50
Hemlock	0.03	0.03	0.50
Dead Stems	0.26	0.26	-
Understory			
Speckled Alder	0.57	-	0.50
Black Ash	0.09	-	0.50
Balsam Fir	0.08	-	1.00
Red Spruce	0.07	-	1.00
Red Maple	0.01	-	0.50
Mountain Maple	0.01	-	0.50
Yellow Birch	0.01	-	0.50
Larch	0.01	-	0.50
Mountain Holly	0.01	-	0.50
Dead Stems	0.14	-	-

Floodplain Forest

Synopsis: This community includes a complex of riverside red maple and alder swamps and silver maple groves. It is distinguished from the High Terrace in that it receives nearly annual sediment deposits and has only incipient soil horizons and swales with standing water. It also contains far fewer softwoods in the canopy.

Landform and soil: The floodplain forest is on alluvial terraces less than one meter above summer water levels on the Magalloway River. The parent material is silt and fine sand. One plot had mottles throughout the pit and the water level was 30 cm below the surface. The other plot had no mottles, a 4 cm A horizon, and the water table was 58 cm below the surface. Both plots had earthworms but very little litter.

Vegetation: This is the only type with silver maple and elm in the canopy. Common herbs and shrubs were various grasses and sedges, sensitive fern, ostrich fern, dwarf raspberry, meadow rue, wild raisin, lady fern, shining clubmoss, Canada mayflower and hairy Solomon's seal (see Appendix B). Red-osier dogwood was unique to this type.

Species	Relative Density	Relative Dominance	Frequency (n=2)
Overstory			
Silver Maple	0.54	0.60	0.50
Red Maple	0.27	0.24	0.50
American Elm	0.07	0.05	0.50
White Pine	0.05	0.07	0.50
Balsam Fir	0.05	0.03	1.00
Dead Stems	0.02	0.01	-
Understory			
American Elm	0.56	-	1.00
Balsam Fir	0.22	-	0.50
Red Maple	0.11	-	0.50
Dead Stems	0.11	-	-

Black Spruce-Larch Basin Swamp Forest

Synopsis: This community type occurs in deep peatland basins between Cedar Swamps and Boreal Acidic Bogs. It is distinguished from Cedar Swamps by its predominantly black spruce and larch overstory and from Boreal Acidic Bogs by its canopy cover.

Landform and Soil: The Black Spruce-Larch community exists as a fringe around Boreal Acidic Bogs in deep basins. It is a later successional stage of the bogs and the community can be seen gradually progressing toward the center of the bog. The soils are deep, hydric peat, but unlike Cedar Swamps the peat is usually continuous and level rather than hummocky.

Vegetation: The overstory is black spruce and larch with greater than 20 percent canopy closure. The trees are small diameter; of the trees in our plot, most were under 20 cm DBH, and the largest was 27 cm. The understory was also dominated by black spruce and larch. This community had the second lowest species richness in the shrub/herb layer with only 21. The most common herbs and shrubs were sphagnum, few-flowered sedge, three-seeded sedge, leatherleaf, goldthread, bunchberry, creeping snowberry, Labrador tea, cinnamon fern, three-leaved Solomon's seal and high-bush blueberry (see Appendix 2).

Species	Relative Density	Relative Dominance	Frequency (n=1)
Overstory			
Black Spruce	0.97	0.98	-
Larch	0.03	0.02	-
Understory			
Black Spruce	0.47	-	-
Larch	0.42	-	-
Balsam Fir	0.02	-	-
Mountain Holly	0.02	-	-
Speckled Alder	0.01	-	-
Dead Stems	0.06	-	-

Boreal Acidic Bog (Boreal/Transitional Dwarf Shrub Bog)

Synopsis: The bogs in the study area are classic boreal acidic peatlands. They are distinguished from the Black Spruce-Larch community by the lack of canopy trees and from Shrub Swamps by the presence of acidic indicator species such as pitcher plant, sundew, bog laurel, cranberry, and cotton grass.

Landform and Soil: The bogs are in deep basins, some of which are probably kettleholes, and are usually surrounded by other peatland communities such as Black-Spruce Larch or Cedar Swamps. The soil is deep, hydric peat.

Vegetation: The only overstory species are scattered black spruce and larch. The common herbs were sphagnum moss, three-leaved Solomon's seal, meagre sedge, sheep laurel, small cranberry, bog rosemary, few-flowered sedge, Labrador tea, pitcher plant, black chokeberry, leatherleaf, tawny cottongrass, and bog laurel (see Appendix B). Meagre sedge (*Carex exilis)*, an state-listed threatened plant ranked S1 by the Natural Heritage Inventory, was abundant in the four bogs surveyed. Ten herb and shrub species were restricted to this community.

Shrub Swamp

Synopsis: Shrub Swamps are found adjacent to open water and are successional between marshes and Hardwood-Conifer Swamps. Shrub Swamps are distinguished from marshes by the abundance of woody stems and from hardwood-conifer swamps by the lack of trees over 10 cm diameter. (Note: the natural community map also includes areas adjacent to Harper's Meadow that are dominated by low-stature, open softwood stands of cedar and larch. These areas did not fit into other community designations and were lumped with primarily hardwood shrub swamps. These areas were not surveyed and are not included in the following descriptions.)

Landform and Soil: Shrub swamps are found in former oxbows on the Magalloway River, in abandoned beaver ponds, along the shores of Lake Umbagog, and on the Mountain Pond outlet stream. They are hydrologically connected to open water. Their soils are mostly fibrous peat, but there are often hollows of standing water.

Vegetation: No plots were taken in this community. The most common shrubs are speckled alder, sweet gale, and meadowsweet. Common understory species are grasses, sedges, sensitive fern, jewelweed, marsh St. John's-wort and bugleweed.

Shallow Emergent Marsh

Synopsis: Marshes are dominated by grasses, sedges, and rushes. They are usually successional predecessors to shrub swamps and are distinguished by the lack of woody stems.

Landform and Soil: Marshes on the tract are on the shores of Lake Umbagog and in recently abandoned beaver meadows. The soils are hydric fibrous peat, often in standing water.

Vegetation: No plots were taken in this community. The U.S. Fish and Wildlife Service has information about the two largest marshes on the tract -- Harper's Meadow and Sweat Meadow.

Northern Hardwood-Spruce-Fir

Tree Seedlings	mean rank	freq.
Abies balsamea	1.33	0.67
Acer pensylvanicum	1.00	0.67
Acer rubrum	1.00	0.67
Acer spicatum	1.00	0.67
Betula alleghaniensis	1.00	0.67
Fagus grandifolia	0.33	0.33
Populus tremuloides	0.33	0.33
Sorbus americana	0.33	0.33
Herbs		
Dryopteris intermedia	2.67	1.00
Oxalis montana	2.00	0.67
Clintonia borealis	1.67	0.67
Maianthemum canadense	1.67	0.67
Trientalis borealis	1.67	1.00
Aralia nudicaulis	1.33	0.67
Prenanthes sp.	1.33	0.67
Aster sp.	1.00	0.33
Cornus canadensis	1.00	0.33
Dennstaedia punctiloba	1.00	0.33
Lycopodium lucidulum	1.00	0.33
Thelypteris noveboracensis	1.00	0.67
Thelypteris phegopteris	1.00	0.67
Trillium acutiloba	1.00	0.67
Athryrium felix-femina	0.67	0.33
Carex plantago	0.67	0.33
Coptus groenlandicum	0.67	0.33
Epipactus helleborine	0.67	0.33
Gymnocarpium dryopteris	0.67	0.67
Impatiens capensis	0.67	0.33
Onoclea sensibilis	0.67	0.33
Osmunda cinnamomea	0.67	0.33
Rubus pubescens	0.67	0.33
Rubus strigosus	0.67	0.33
Sambucus pubescens	0.67	0.33
Viburnum alnifolium	0.67	0.33
Viola sp.	0.67	0.33
Arisaema trilobum	0.33	0.33
Carex sp.	0.33	0.33
Gallium triflorum	0.33	0.33
Lonicera canadensis	0.33	0.33
Monotropa uniflora	0.33	0.33
Moss sp.	0.33	0.33
Streptopus roseus	0.33	0.33
Species Richness	42	

Beech-Birch-Maple

Tree Seedlings	mean rank	freq.
Acer saccharum	2.67	1.00
Acer pensylvanicum	2.33	1.00
Fagus grandifolia	1.33	1.00
Fraxinus americana	1.33	0.67
Ostrya virginiana	1.33	0.67
Acer spicatum	0.67	0.67
Picea rubens	0.67	0.67
Abies balsamea	0.33	0.33
Acer rubrum	0.33	0.33
Betula alleghaniensis	0.33	0.33
Prunus pennsylvanica	0.33	0.33
Herbs		
Dryopteris intermedia	2.67	1.00
Aralia nudicaulis	2.00	0.67
Athryrium felix-femina	1.67	0.67
Oxalis montana	1.67	0.67
Viburnum alnifolium	1.67	1.00
Trillium acutiloba	1.33	1.00
Sambucus pubescens	1.00	0.67
Streptopus roseus	1.00	0.67
Thelypteris noveboracensis	1.00	0.67
Arisaema trilobum	0.67	0.67
Carex sp.	0.67	0.67
Clintonia borealis	0.67	0.33
Dennstaedia punctiloba	0.67	0.33
Dryopteris spinulosa	0.67	0.33
Graminoid sp.	0.67	0.67
Lonicera canadensis	0.67	0.67
Medeola virginiana	0.67	0.33
Thelypteris phegopteris	0.67	0.67
Aralia racemosa	0.33	0.33
Aster sp.	0.33	0.33
Circaea alpina	0.33	0.33
Epipactus helleborine	0.33	0.33
Lycopodium lucidulum	0.33	0.33
Polystichum acrostichoides	0.33	0.33
Prunus virginiana	0.33	0.33
Ribes sp.	0.33	0.33
Polypodium virginianum	0.33	0.33
Rubus strigosus	0.33	0.33
Smilacina racemosa	0.33	0.33
Trientalis borealis	0.33	0.33
Species Richness	41	

Lowland Spruce-Fir

Tree Seedlings	mean rank	freq.
Abies balsamea	3.00	1.00
Picea rubens	2.25	1.00
Acer rubrum	1.75	1.00
Acer pensylvanicum	1.25	0.75
Betula alleghaniensis	1.00	0.75
Betula papyrifera	0.75	0.50
Thuja occidentalis	0.75	0.50
Sorbus americana	0.50	0.25
Fagus grandifolia	0.25	0.25
Fraxinus americana	0.25	0.25
Pinus strobus	0.25	0.25
Tsuga canadensis	0.25	0.25
Herbs		
Clintonia borealis	2.00	0.75
Gaultheria hispidula	1.75	0.75
Moss sp.	1.75	0.50
Sphagnum sp.	1.50	0.50
Cornus canadensis	1.25	0.50
Maianthemum canadense	1.00	0.75
Oxalis montana	1.00	0.50
Trillium acutiloba	1.00	0.75
Carex trisperma	0.75	0.25
Coptus groenlandicum	0.75	0.25
Dalibarda repens	0.75	0.25
Gaultheria procumbens	0.75	0.25
Linnea borealis	0.75	0.25
Nemopanthus mucronata	0.75	0.25
Viburnum cassinoides	0.75	0.25
Goodyera repens	0.50	0.50
Monotropa uniflora	0.50	0.50
Pyrola elliptica	0.50	0.25
Trientalis borealis	0.50	0.50
Vaccinium angustifolium	0.50	0.25
Vaccinium corymbosum	0.50	0.25
Vaccinium myrtilloides	0.50	0.25
Cyperipedium acaule	0.25	0.25
Dryopteris spinulosa	0.25	0.25
Equisetum sylvaticum	0.25	0.25
Kalmia angustifolia	0.25	0.25
Osmunda cinnamomea	0.25	0.25
Salix sp.	0.25	0.25
Species Richness	40	

Mountain Spruce-Fir

Tree Seedlings	mean rank	freq.
Abies balsamea	2.00	1.00
Picea rubens	1.50	1.00
Sorbus americana	1.00	1.00
Acer pensylvanicum	0.50	0.50
Betula alleghaniensis	0.50	0.50
Betula papyrifera	0.50	0.50
Herbs		
Dryopteris intermedia	3.50	1.00
Oxalis montana	3.50	1.00
Cornus canadensis	3.00	1.00
Maianthemum canadense	2.50	1.00
Moss sp.	2.00	0.50
Aralia nudicaulis	1.50	1.00
Aster sp.	1.00	0.50
Clintonia borealis	1.00	0.50
Ribes sp.	1.00	0.50
Rubus strigosus	1.00	0.50
Thelypteris noveboracensis	1.00	0.50
Trientalis borealis	1.00	1.00
Carex trisperma	0.50	0.50
Streptopus roseus	0.50	0.50
Species Richness	20	

Spruce-Hemlock-Pine

Tree Seedlings	mean rank	freq.
Abies balsamea	3.50	1.00
Acer rubrum	2.50	1.00
Betula alleghaniensis	1.50	1.00
Sorbus americana	1.50	1.00
Acer spicatum	1.00	0.50
Betula papyrifera	1.00	0.50
Tsuga canadensis	1.00	0.50
Acer pensylvanicum	0.50	0.50
Fraxinus americana	0.50	0.50
Prunus serotina	0.50	0.50
Quercus rubra	0.50	0.50
Herbs		
Cornus canadensis	3.00	1.00
Coptus groenlandicum	2.50	1.00
Maianthemum canadense	2.50	1.00
Aralia nudicaulis	2.00	1.00
Nemopanthus mucronata	2.00	1.00
Oxalis montana	1.50	0.50
Trientalis borealis	1.50	1.00
Carex intumescens	1.00	0.50
Carex pensylvanicum	1.00	0.50
Clintonia borealis	1.00	0.50
Dryopteris intermedia	1.00	0.50
Dryopteris spinulosa	1.00	0.50
Lonicera canadensis	1.00	0.50
Lycopodium tristachyum	1.00	0.50
Medeola virginiana	1.00	0.50
Moss sp.	1.00	0.50
Rubus pubescens	1.00	0.50
Rubus strigosus	1.00	0.50
Vaccinium myrtilloides	1.00	0.50
Viburnum cassinoides	1.00	0.50
Carex plantago	0.50	0.50
Linnea borealis	0.50	0.50
Osmunda cinnamomea	0.50	0.50
Osmunda regalis	0.50	0.50
Streptopus roseus	0.50	0.50
Viburnum alnifolium	0.50	0.50
Species Richness	37	

High Terrace

Tree Seedlings	mean rank	freq.
Abies balsamea	3.00	1.00
Acer rubrum	1.50	1.00
Picea rubens	1.00	0.50
Acer pensylvanicum	0.50	0.50
Betula alleghaniensis	0.50	0.50
Betula papyrifera	0.50	0.50
Fagus grandifolia	0.50	0.50
Herbs		
Cornus canadensis	2.50	1.00
Trientalis borealis	2.50	1.00
Vaccinium myrtilloides	2.50	1.00
Coptus groenlandicum	2.00	1.00
Dryopteris intermedia	2.00	1.00
Maianthemum canadense	2.00	1.00
Moss sp.	2.00	0.50
Lycopodium tristachyum	1.50	0.50
Oxalis montana	1.50	0.50
Clintonia borealis	1.00	0.50
Gaultheria hispidula	1.00	0.50
Linnea borealis	1.00	0.50
Nemopanthus mucronata	1.00	1.00
Dennstaedia punctiloba	0.50	0.50
Goodyera repens	0.50	0.50
Monotropa uniflora	0.50	0.50
Osmunda cinnamomea	0.50	0.50
Trillium acutiloba	0.50	0.50
Viburnum cassinoides	0.50	0.50
Species Richness	26	

Rich Mesic Hardwood		Cedar Swamp			Hardwood-Conifer Swamp		
Tree Seedlings	rank	*Tree Seedlings*	mean rank	freq.	*Tree Seedlings*	mean rank	freq.
Acer saccharum	3	Thuja occidentalis	2.50	1.00	Acer rubrum	2.00	1.00
Acer spicatum	2	Abies balsamea	2.00	1.00	Thuja occidentalis	2.00	1.00
Ostrya virginiana	2	Acer rubrum	2.00	1.00	Abies balsamea	1.00	0.50
		Acer pensylvanicum	1.50	1.00	Acer spicatum	1.00	0.50
		Acer spicatum	1.50	1.00	Betula alleghaniensis	1.00	0.50
Herbs		Betula alleghaniensis	1.50	1.00	Fraxinus nigra	1.00	0.50
Athyrium felix-femina	3	Fraxinus nigra	1.00	0.50	Acer pensylvanicum	0.50	0.50
Osmunda cinnamomea	3	Picea rubens	1.00	0.50			
Viburnum alnifolium	3	Fagus grandifolia	0.50	0.50			
Aster sp.	2	Picea mariana	0.50	0.50	*Herbs*		
Dryopteris spinulosa	2	Sorbus americana	0.50	0.50	Sphagnum sp.	3.50	1.00
Epipactus helleborine	2				Carex trisperma	3.00	1.00
Gymnocarpium dryopteris	2	*Herbs*			Cornus canadensis	3.00	1.00
Mattheucia struthiopteris	2	Sphagnum sp.	4.00	1.00	Osmunda cinnamomea	3.00	1.00
Polypodium braunii	2	Carex trisperma	3.00	1.00	Alnus rugosa	2.50	1.00
Rubus pubescens	2	Coptus groenlandicum	3.00	1.00	Carex paupercula	1.50	0.50
Sambucus pubescens	2	Oxalis montana	3.00	1.00	Coptus groenlandicum	1.50	0.50
Thelypteris phegopteris	2	Aralia nudicaulis	2.50	1.00	Drosera rotundifolia	1.50	0.50
Trillium acutiloba	2	Clintonia borealis	2.50	1.00	Lysimachia terrestris	1.50	0.50
Viola pubescens	2	Cornus canadensis	2.50	1.00	Maianthemum canadense	1.50	0.50
Arisaema trilobum	1	Gaultheria hispidula	2.50	1.00	Oxalis montana	1.50	0.50
Botrychium sp.	1	Osmunda cinnamomea	2.50	1.00	Rubus pubescens	1.50	0.50
Dryopteris camplyoptera	1	Nemopanthus mucronata	2.00	1.00	Smilacina trifolia	1.50	0.50
Dryopteris intermedia	1	Rubus pubescens	2.00	1.00	Viburnum cassinoides	1.50	0.50
Graminoid sp.	1	Alnus rugosa	1.50	0.50	Aralia nudicaulis	1.00	0.50
Osmorhiza claytonii	1	Mitella nuda	1.50	0.50	Carex intumescens	1.00	0.50
Ribes sp.	1	Trientalis borealis	1.50	1.00	Chaemadaphne caliculata	1.00	0.50
Smilacina racemosa	1	Carex disperma	1.00	0.50	Circaea alpina	1.00	0.50
		Carex sp.	1.00	0.50	Clintonia borealis	1.00	0.50
		Dalibarda repens	1.00	0.50	Dryopteris cristata	1.00	1.00
		Fragaria vesca	1.00	0.50	Dryopteris spinulosa	1.00	0.50
		Gaultheria procumbens	1.00	0.50	Gaultheria hispidula	1.00	0.50
		Habenaria obtusata	1.00	0.50	Ilex verticilata	1.00	0.50
		Habenaria hyperborea	1.00	0.50	Impatiens capensis	1.00	0.50
		Linnea borealis	1.00	0.50	Linnea borealis	1.00	0.50
		Listera convollariodes	1.00	0.50	Lonicera canadensis	1.00	0.50
		Listera cordata	1.00	0.50	Lycopus sp.	1.00	0.50
		Lonicera canadensis	1.00	1.00	Nemopanthus mucronata	1.00	0.50
		Pyrola secunda	1.00	0.50	Trientalis borealis	1.00	0.50
		Ranunculus sp.	1.00	0.50	Viola sp.	1.00	0.50
		Ribes sp.	1.00	0.50	Dryopteris intermedia	0.50	0.50
		Thelypteris noveboracensis	1.00	0.50	Iris versicolor	0.50	0.50
		Vaccinium angustifolium	1.00	0.50	Onoclea sensibilis	0.50	0.50
		Vaccinium corymbosum	1.00	0.50	Vaccinium myrtilloides	0.50	0.50
		Viola sp.	1.00	0.50			
		Aster sp.	0.50	0.50			
		Botrychium virginianum	0.50	0.50			
		Corylus cornuta	0.50	0.50			
		Cyperipedium calciolis var.	0.50	0.50			
		Gallium triflorum	0.50	0.50			
		Goodyera pubescens	0.50	0.50			
		Gymnocarpium dryopteris	0.50	0.50			
		Ilex verticilata	0.50	0.50			
		Kalmia angustifolia	0.50	0.50			
		Lycopus sp.	0.50	0.50			
		Maianthemum canadense	0.50	0.50			
		Onoclea sensibilis	0.50	0.50			
		Pyrola uniflora	0.50	0.50			
		Rhamnus alnifolia	0.50	0.50			
		Pyrola uniflora	0.50	0.50			
Species Richness	25	Species Richness	58		Species Richness	41	

Floodplain Forest

Tree Seedlings	mean rank	freq.
Abies balsamea	1.50	1.00
Acer rubrum	1.00	0.50
Acer saccharum	1.00	0.50
Ulmus americana	1.00	0.50
Fraxinus americana	0.50	0.50
Herbs		
Graminoid sp.	3.00	1.00
Onoclea sensibilis	3.00	1.00
Carex sp.	2.50	1.00
Mattheucia struthiopteris	2.50	1.00
Rubus pubescens	2.50	1.00
Thalictrum sp.	2.00	1.00
Viburnum cassinoides	2.00	1.00
Athyrium felix-femina	1.50	0.50
Lycopodium lucidulum	1.50	0.50
Maianthemum canadense	1.50	0.50
Polygonatum pubescens	1.50	0.50
Aralia nudicaulis	1.00	0.50
Arisaema trilobum	1.00	0.50
Aster sp.	1.00	0.50
Carex intumescens	1.00	0.50
Cornus stolonifera	1.00	0.50
Gallium sp.	1.00	0.50
Spirea tomentosa	1.00	0.50
Carex disperma	0.50	0.50
Corylus cornuta	0.50	0.50
Dryopteris spinulosa	0.50	0.50
Epipactus helleborine	0.50	0.50
Ilex verticilata	0.50	0.50
Impatiens capensis	0.50	0.50
Lycopus sp.	0.50	0.50
Lysimachia terrestris	0.50	0.50
Prunus virginiana	0.50	0.50
Solidago sp.	0.50	0.50
Spirea alba	0.50	0.50
Viburnum trilobum	0.50	0.50
Species Richness	35	

Black Spruce-Larch

Tree Seedlings	rank
Picea mariana	3
Acer rubrum	2
Herbs	
Sphagnum sp.	4
Carex pauciflora	3
Carex trisperma	3
Chaemadaphne caliculata	3
Coptus groenlandicum	3
Cornus canadensis	3
Gaultheria hispidula	3
Ledum groenlandicum	3
Osmunda cinnamomea	3
Smilacina trifolia	3
Vaccinium corymbosum	3
Alnus rugosa	2
Andromeda glaucophylla	2
Aronia melanocarpa	2
Drosera rotundifolia	2
Eriophorum virginicum	2
Kalmia angustifolia	2
Vaccinium myrtilloides	2
Vaccinium oxycoccus	2
Aster sp.	1
Dalibarda repens	1
Species Richness	23

Boreal Acidic Bog

Tree Seedlings	mean rank	freq.
Picea mariana	3.00	1.00
Larix laricina	2.50	1.00
Acer rubrum	1.00	0.50
Herbs		
Sphagnum sp.	4.00	1.00
Smilacina trifolia	3.50	1.00
Carex exilis	3.00	1.00
Kalmia angustifolia	3.00	1.00
Vaccinium oxycoccus	3.00	1.00
Andromeda glaucophylla	2.50	1.00
Carex pauciflora	2.50	1.00
Ledum groenlandicum	2.50	1.00
Serracinia purpurea	2.50	1.00
Aronia melanocarpa	2.00	1.00
Chaemadaphne caliculata	2.00	1.00
Eriophorum virginicum	2.00	1.00
Kalmia polifolia	2.00	1.00
Carex trisperma	1.50	0.50
Vaccinium macrocarpon	1.50	0.50
Aster sp.	1.00	0.50
Cicuta bulbifera	1.00	0.50
Cornus canadensis	1.00	0.50
Drosera rotundifolia	1.00	0.50
Drosera spatulifolia	1.00	0.50
Epilobium leptophyllum	1.00	0.50
Eriophorum sp.	1.00	0.50
Habenaria blephariglottis	1.00	0.50
Lycopus sp.	1.00	0.50
Nemopanthus mucronata	1.00	0.50
Rhyncosphora alba	1.00	0.50
Triadenum fraseri	1.00	0.50
Vaccinium corymbosum	1.00	0.50
Viburnum cassinoides	1.00	0.50
Species Richness	32	

Good Forestry in the Granite State:

Recommended Voluntary* Forest Management Practices for New Hampshire

Presented by: The New Hampshire Forest Sustainability Standards Work Team

*Not all practices recommended in this manual are strictly voluntary; some are required by state law.

Published by:

The Society for the Protection of New Hampshire Forests
54 Portsmouth Street
Concord, New Hampshire 03301
(603) 224-9945

Printed at the Sant Bani Press, Tilton, New Hampshire

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