Appendix H

USFWS

Herods Cove shoreline looking north

Forest Health Assessment

Forest Health Assessment
Great Bay National Wildlife Refuge

US Forest Service
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Introduction

An assessment of the health of forested land at Great Bay National Wildlife Refuge was requested by the U.S. Fish and Wildlife Service in 2006. This assessment is being conducted by the USDA Forest Service, Durham Field Office, Forest Health Protection staff. The survey design was implemented during the summer/fall of 2006 and is summarized in this report.

Forest health assessments provide a general overview of the conditions of forested areas and can be used to guide forest management decisions and/or inform natural resource managers about potential health concerns in forests under their stewardship. Assessments consider the "health" of overstory trees (e.g., crown condition, growth form etc.), regeneration in stands, presence/absence of native insects at damaging levels, and presence of exotic or invasive species that could threaten the integrity of native ecosystems. Forest health assessments also provide a means for comparing the condition of targeted forest stands to regional growth patterns found in other forest stands.

The Great Bay National Wildlife Refuge, established in 1992, is a 1,100+ acre refuge located on the former Pease Air Force Base in Newington, NH. The refuge was established to encourage the natural diversity of plant, fish and wildlife species within the refuge and to provide for their conservation and management; to protect species listed as endangered, threatened or candidate species; to preserve and enhance water quality of aquatic habitat within the refuge; and to fulfill international treaty obligations of the United States relating to fish and wildlife. The refuge contains a diverse set of ecosystem types including tidal, wetlands, and forests. Forests make up approximately 70% (763 acres) of the land area and have been classified into ten separate natural community types. These forested areas are the focus of this forest health assessment.

Methods

Inventory Design

Plot Design: Temporary variable radius plots (BAF 10) were placed on transects throughout the forested areas of GBNWR during the summer and fall 2006. Within each plot, tree measurements (species, diameter at breast height, crown class, stocking level), estimates of tree health, and snag density were recorded. Snags were placed into one of three decay classes. Visual inspections for native and invasive insect species were conducted. Signs or symptoms of bark beetles (Coleoptera: Scolytinae), woodborers (Coleoptera: Cerambycidae, Buprestidae; Hymenoptera: Siricidae), and late season defoliators on trees were recorded. Visual surveys for invasive species including hemlock woolly adelgid (*Adelges tsugae* Annand), Asian longhorned beetle (*Anoplophora glabripennis* Motschulsky), emerald ash borer (*Agrilus planipennis* Fairmaire), and *Sirex noctilio* F. were conducted. Inspections for native and invasive tree pathogens were also completed.

Inventory Stratification: A Natural Communities map created by the New Hampshire Natural Heritage Bureau (Sperduto 2000) was used to stratify the inventory. These natural communities are recurring assemblages of plants found in particular physical environments (Sperduto et al. 2004). Each natural community is distinguished by three characteristics: 1) a definite plant species composition; 2) a consistent physical structure (such as forest, shrubland, or grassland); and 3) a specific set of physical conditions (such as different combinations of nutrients, drainage, and climate conditions). The New Hampshire Natural Heritage inventory identified 763 acres of forest, divided into 10 natural communities (Figure 1). The 10 natural communities identified were:

1) Black gum-red maple basin swamp (not sampled)
2) Dry Appalachian oak-hickory forest
3) Dry-mesic Appalachian oak-hickory forest
4) Forest on fill
5) Low red maple-elm/musclewood/ladyfern silt forest
6) Mesic Appalachian oak-hickory forest
7) Plantation
8) Red maple/sensitive fern-tussock sedge basin/seepage (not sampled)
9) Red pine forest/woodland
10) Seasonally saturated red maple swamp

The assessment consisted of a stratified random sample, utilizing variable radius plots as detailed above. This portion of the assessment was implemented to characterize the forested vegetation, including species and size class distribution, stocking, and volume estimates in the natural communities and to familiarize the authors with Refuge lands. While not all stands were inventoried, we attempted to stratify the sample so that examples of each of the natural communities were represented. The black gum-red maple basin swamp and the red maple/sensitive fern/tussock sedge basin/seepage natural communities were not inventoried due to excessive water levels.

Variables collected on the inventory points:

Species

Diameter at breast height

Timber Product Quality Assessment: Common forest health and general forestry metrics. They are used to gauge the overall quality of the site and growth potential. The amount and quality of the wood products are measures of productivity of the site. They also give insights to the current composition, as well as vertical structure potential.

- Timber quality - A determination if the tallied tree will produce a sawtimber product. AGS means Acceptable Growing Stock for timber - capable of producing sawtimber when it reaches appropriate size, and expected to live at least 15 years; UGS = Unacceptable Growing Stock for timber - not capable of producing sawtimber at any time in future and/or not expected to survive for 15 years.
- Product - An estimate of the highest value product or grade obtained in the tree.
- Sawlog height - The total height of sawtimber products in the tree in feet.

- Pulp height - The portion of the tree above sawtimber height, or if the tree does not contain any sawtimber, the merchantable pulpwood height.

Cavity - Cavity present in main stem or large branches.
- Live/Dead - condition of tree where cavity was found.
- Tree species - tree species if identifiable. Grouped as conifer or hardwood for analysis.

Crown class - The position of the tree crown using these classifications:
- Open grown - a tree that is free of competition and receives light on top and on all sides of the crown as a result of a very heavy thinning or being in an isolated, open-grown position.
- Dominant - a tree with the crown extending above the general level of the main crown canopy and receiving full light from above and partly from the sides.
- Codominant - a tree with a crown forming the general level of the main canopy, receiving full light from above but little from the sides.
- Intermediate - a tree with a crown extending into the lower portions of the main crown canopy, but shorter than the codominants and receiving little direct light from above and none from the sides.
- Suppressed - a tree whose crown is entirely below the general level of the canopy and receives no direct light from either above or the sides.

Crown condition - An estimate of the tree crown's condition based upon the percent of the normal crown relative to total height; often called live crown ratio. Trees with live crowns less than 25% are considered poor condition; between 25% and 50% in fair condition; and in good condition if they have more than 50% live crown.

Snags: An estimate of forest structure and potential wildlife habitat. Snags were classified based on the following groups slightly modified from Bull et al. 1997:
- Class I – recently dead tree, fine branches often present, bark tight on tree, with little decay present.
- Class II – Bark loose or falling off of bole and branches, fine branches absent, larger limbs decaying or falling, decay in bole present.
- Class III – Small and large branches absent, most bark gone, in advanced stages of decay.

The inventory data was collected electronically using NEDLite (Knopp and Twery, 2006). Data was processed, and stand reports generated using NED-1 software (Simpson et al, 1995).

Results

A total of 61 stands were mapped on the original natural community map that consisted of ten forest community types (Figure 1). Of the 61 forest stands, 18 were inventoried (29.5%) for a total of 399.7 acres of the 763 acres of forested covertype (52.4%).

Figure 1. Natural Communities of Great Bay National Wildlife Refuge based on Sperduto (2000).

Great Bay National Wildlife Refuge has a diverse forested habitat given its relatively small area. Twenty four overstory species were inventoried. The overstory species are dominated by northern red oak (17.6% of trees per acre), eastern white pine (16.5%), red maple (16.4%), shagbark hickory (12.8%), and black cherry (16.8%). Nineteen tree species account for the remaining 20% of stems per acre.

Most of the stands inventoried are overstocked, larger diameter stands (Table 1). This forest condition is common for stands that have had no active management for a long period of time. The distribution of size classes is not balanced, meaning that some size classes are under or over-represented.

An overstocked condition in a forest has several complicating factors. Stands that are overstocked tend to be less vigorous with too many trees competing for the limited resources present at a site. Less vigorous trees are more susceptible to primary and secondary pests, which further weaken and may kill trees. Overstocked stands often lack adequate regeneration in the understory. For species that are moderate to intolerant to shade, including paper birch, quaking aspen, and sweet birch that are present on GBNWR, the lack of sunlight in overstocked stands

creates an unbalanced age class distribution that could ultimately lead to the loss of these species in future stands.

Table 1. Characteristics of forest stands surveyed on Great Bay National Wildlife Refuge.

Natural Community	Stand Area	Forest Type	Size Class	Medial DBH	Canopy Closure (%)	Relative Density	Basal Area
Black gum-red maple basin swamp	14.4	**Not Sampled**					
Dry Appalachian oak-hickory forest	80.5	Other Hardwood	Small Sawtimber	12.36	93	116.7	140.0
Dry-mesic Appalachian oak-hickory forest	146.8	Other Hardwood	Small Sawtimber	16.34	97	109.9	153.3
Forest on Fill	12.5	Allegheny Hardwood	Small Sawtimber	16.04	63	62.9	115.0
Low red maple-elm/musclewood/ladyfern silt forest	69.2	Pine Hardwoods	Small Sawtimber	13.80	75	78.2	125.0
Mesic Appalachian oak-hickory forest	357.6	Other Mixedwood	Small Sawtimber	15.90	93	109.8	165.6
Plantation	25.4	Pine	Pole	8.78	80	90.1	156.0
Red maple/sensitive fern-tussock sedge basin/seepage	10.7	**Not Sampled**					
Red pine forest/woodland	7.7	Red Pine	Large Sawtimber	16.84	84	86.0	190.0
Seasonally saturated red maple swamp	38.2	Oak	Large Sawtimber	17.22	89	88.6	115.0

A measure of size class distribution is the *q* factor. The *q* factor is the ratio of numbers of trees between successive diameter classes. A *q* of 1.3 means that there are 1.3 times as many 10 inch trees as 11 inch trees, and that there are similar ratios between the other diameter classes. The range of *q* factors at the refuge were 1.14-1.26, with most below 1.2. In northeastern forest types, *q* factors between 1.3 and 1.8 (for 2 inch diameter classes) are frequently recommended for timber management. Values below 1.3 could be useful for wildlife and visual goals and are common on the refuge. At a low *q*, large trees occupy a relatively large proportion of the growing space. Consequently, regeneration is often limited in these stands as available resources are used by the dominant trees. Attempts to maintain a very low *q* may not be sustainable and future stands of similar types may be jeopardized. If current forest and stand conditions are considered the desired future condition, active management with long-term goals geared towards maintaining given forest types should be considered.

Cavity trees are vitally important to many types of wildlife; they provide nesting, roosting, and denning sites for approximately 25% of the wildlife species in the Northeast, including birds, mammals, reptiles, and amphibians (DeGraaf and Shigo 1985). Presence of cavities were tallied for live and dead trees, and are summarized in Table 2. Except for the red pine forest/woodland natural community, most of the cavities were in hardwood species, with a mixture of live and dead cavities. No cavities were recorded in the forest on fill, low red maple-elm/musclewood/ladyfern silt forest, or the plantation natural communities.

Snags were a common occurrence on GBNWR and occurred in all natural community types surveyed (Table 3). Class II snags were the most common and accounted for 61.6% of all snags. Class I (26.8%) and Class III (11.6%) were less frequently encountered. Snags are an important component of a healthy forest ecosystem and are used by a variety of invertebrates, vertebrates, and other organisms as habitat.

A summary of data collected for each natural community surveyed, including a description of the natural community, overstory narrative, and a timber narrative are included on pages 12 to 30.

Table 2. Description of tree cavities for the natural communities found on Great Bay National Wildlife Refuge.

Stand	Total # Cavities per Acre	Cavities in Live Trees	Cavities in Dead Trees	Cavities in Conifer Trees	Cavities in Hardwood Trees
Black gum-red maple basin swamp	**Not Sampled**				
Dry Appalachian oak-hickory forest	16.3	1.1	15.2	6.1	10.2
Dry-mesic Appalachian oak-hickory forest	5.1	0.3	4.8	0	5.1
Forest on Fill	0	0	0	0	0
Low red maple-elm/musclewood/ladyfern silt forest	0	0	0	0	0
Mesic Appalachian oak-hickory forest	3.1	2.7	0.4	0.3	2.8
Plantation	0	0	0	0	0
Red maple/sensitive fern-tussock sedge basin/seepage	**Not Sampled**				
Red pine forest/woodland	18.3	13.4	4.9	17.7	0.6
Seasonally saturated red maple swamp	23.5	23.5	0	0	23.5

Table 3 Snags by decay class for the natural communities found on Great Bay National Wildlife Refuge. See text for description of decay classes.

Stand Number	Snags per acre			
	Class I	Class II	Class III	Total
Black gum-red maple basin swamp	**Not Sampled**			
Dry Appalachian oak-hickory forest	0	12	19	31
Dry-mesic Appalachian oak-hickory forest	0	25	10	35
Forest on Fill	0	5	0	5
Low red maple-elm/musclewood/ladyfern silt forest	60	57	1	118
Mesic Appalachian oak-hickory forest	10	13	10	33
Plantation	34	127	0	161
Red maple/sensitive fern-tussock sedge basin/seepage	**Not Sampled**			
Red pine forest/woodland	0	0	2	2
Seasonally saturated red maple swamp	0	0	3	3

Insect & Disease Surveys

Visual surveys for non-native insects were conducted on the inventory plots as well as on transects through the stands. Introduced insects of concern are the hemlock woolly adelgid, Asian longhorned beetle, emerald ash borer, and *Sirex noctilio*. These invasive species have been found in North America and several have caused serious economic and ecological impacts. While no evidence was found for these species during our initial survey period, in July 2007, two red pine were located in NHI point 67 that showed characteristics similar to trees attacked by *S. noctilio*. With permission from GBNWR, we removed one of these suspect trees, dissected the bole, and found no sign of *S. noctilio* larvae or adults in the wood. Because *S. noctilio* often attacks trees but does not oviposit, we have placed four semiochemical-baited traps within the stand to survey for presence of adult woodwasps. Results from this survey will be complete by December, 2007.

Native insects, including bark beetles and fall webworm were found on GBNWR. *Ips* spp. are bark beetles usually considered secondary species, but occasionally kill living trees when populations are epidemic. On GBNWR, *Ips* were found attacking severely suppressed red pine in one stand (NHI point 67). Codominant trees showed no sign of attack and likely will not be impacted by this beetle unless epidemic populations build in the surrounding area. However, given the small amount of pine in poor condition on the Refuge, it is unlikely *Ips* will become a primary tree killer. Another bark beetle, the Columbian timber beetle (*Corthylus columbianus* Hopkins), was found attacking mature red maple on GBNWR (NHI point 137). This ambrosia beetle attacks apparently healthy trees, but has little direct effect on tree health. Attacked trees are capable of tolerating the insect damage, but adult entrance holes often become inoculation points for other wood decay fungi. Wood products may be affected, but because high-value timber production is not the goal of GBNWR there should be no concern for the presence of this insect. Fall webworm, *Hyphantria cunea* (Drury), was noted on hardwoods, but populations of this insect rarely cause tree mortality.

Visual surveys for forest diseases were conducted as well. While lab confirmation was not possible, white pine showing symptoms of Caliciopsis pine canker, *Caliciopsis pinea* (Peck) infection were found in one stand (NHI point 157). This canker is thought to be a weak perennial fungus which attacks thin barked areas of the branch and bole, and while tree mortality is usually low, increased crown transparency and reduced crown density suggests tree vigor is being reduced by heavy infections of this disease. The canker was found in an overstocked pine stand, which is also a candidate for another pine pathogen, white pine blister rust, *Cronartium ribicola* (Fisch).

While not currently found on GBNWR, a pathogen threat to continue to monitor for is ash yellows. Ash yellows is caused by mycoplasmalike organisms that invade the vascular system of infected trees. Reported in New Hampshire and northeastern Massachusetts, this pathogen is a major threat to the ash resource. Symptoms include poor growth, reduced vigor, and premature mortality of infected trees. In severe cases, complete loss of the ash component of a stand can occur.

Management Recommendations

There are several conifer plantations (red and white pine, white fir) that are overstocked. These plantations would benefit from a thinning to reduce the density and increase the vigor of the stands. They are currently stagnating, with evidence of decline agents present (Caliciopsis pine canker, *Ips* beetles). With no intervention, these stands will continue to decline and break up, with competing hardwoods eventually overtaking the site. This would eliminate the pure conifer component from the landscape. There are several silvicultural prescription options available, dependent upon the habitat goals of the refuge.

Many of the stands at GBNWR are mature, with low *q* factor values, or an uneven distribution of tree sizes. One simple management regime to address this would be to create wildlife openings in some of these stands. This technique will increase the range of vertical structure, as well as create conditions that favor more shade intolerant species. Small openings in several of these stands would create more habitat heterogeneity and diversify the habitat for species that favor early successional habitats. One factor to consider in opening up canopies is increased browse availability for deer. Deer browsing can influence future forest conditions by altering tree species composition, understory plant species richness, and abundance/distribution of invasive plant species (Augustine and Frelich 1998, Horsley et al. 2003, Rossell et al. 2007).

Mature stands create challenges to any recreation opportunities. With active recreation (i.e., hiking trails) traversing these types of stands, hazard tree management becomes an important issue. Older, unmanaged stands tend to have higher rates of failure on tree limbs with latent defects. If not previously undertaken, we recommend a hazard tree survey be completed in the high activity areas (e.g., parking areas and trail corridors). This survey may help prevent an incident, as well as lay the foundation for management of risk to the public.

Natural Community Summary Overview

The following natural community summaries include basic metrics of the stand, a description of the natural community (taken from Sperduto 2004), and an overstory summary narrative. Many of the metrics and terminology in the overstory narrative are timber management oriented. They are presented here for use in comparison with other forested stands in northeastern forests. They can be used to forecast future conditions in these stands, and model ecological development. The types of habitats and vertical structure required for species of importance to the Refuge can be planned for and developed using these metrics.

The effective age of the natural community is computed using species specific growth factors related to size (diameter) of the tree at the time of inventory. An adjusted median age is calculated.

Acceptable growing stock are trees capable of producing sawtimber when it reaches appropriate size, whereas unacceptable growing stock is considered incapable of producing sawtimber at any time in future because of species, growth form, or current vigor.

Black gum-red maple basin swamp

Identification and Location
Stand ID: 1
Compartment: Black gum-red maple basin swamp
Date of inventory: **Not sampled**

Measures
Area: 14.4 ac

Natural Community Description

Black gum - red maple basin swamps are very similar in vegetation, soils, and hydrology to red maple - *Sphagnum* basin swamps. A principal distinction between these communities is the codominance of black gum with red maple in the canopy of black gum - red maple basin swamps. These swamps typically occur in perched upland till basins with watersheds smaller than one square mile. Species typical of acidic, relatively stagnant conditions are prevalent, but these swamps are highly variable in structure and composition ranging from forest (greater than 65% tree cover) to sparse woodland (10-25% tree cover). The shrub layer density increases in woodland and sparse woodland examples. Historical logging activities may also have influenced the structure and composition of some examples, and additional research on stand history is needed to clarify the relationships between land use history and current vegetation. Soils are typically acidic, nutrient-poor, very poorly drained Histosols (deep peat or muck) or poorly to very poorly drained mineral soils with histic epipedons. Peat is well decomposed near the surface, and pHs average approximately 4.4 (range: 3.7–5.3). Hummocks are well developed and average approximately 0.4 m high. There is little evidence of seepage or surface water flow in black gum swamps. Examples in lakeside settings may be influenced somewhat by surface flow, but water sources are generally restricted to precipitation, seasonal runoff or subsurface flow from surrounding uplands. Many of these swamps have stagnant outlet streams but no perennial inlets or streams running through them; others have neither inlets nor outlets.

Dry Appalachian oak-hickory forest

Identification and Location
Stand ID: 2
Compartment: Dry Appalachian oak-hickory forest
Date of inventory: 8/16/2006

Measures
Area: 80.5 ac
Plot count: 5
Number of plot size classes: 2
Trees per acre: 736.36 #/ac
Basal area: 140.0 sq ft/ac
Relative density: 116.7 pct.
Canopy closure: 93%

Stand Characteristics
Forest type: other hardwoods
Forest type for prescription: other

Natural Community Description

These oak - hickory and oak forests occur in southern and south-central New Hampshire and are characterized by southern species that reach the northern extent of their ranges in this region. It is distinguished from dry red oak - white pine forests, which tend to lack significant representation of southern or Appalachian species. The ability of many oak species to root or stump sprout contributes to their perpetuation under regular fire regimes or harvests. Oak forests appear to be fire-dependant over long periods in other regions of the country. Some of these forests may succeed to other overstory species in time due to lack of adequate red oak regeneration, and from increases in beech on drier sites and sugar maple and beech on more mesic sites. Repeated fire would tend to knock back fire-sensitive species like beech and sugar maple. As such, any natural, semi-natural, and/or controlled fire regimes may be necessary for the long-term maintenance of oak and hickory on some sites. These forests are typically found on middle and upper slopes of low hills with acidic, well to excessively drained soils of low available nutrient status (oligotrophic). They are also common on slopes with south or west aspects. Known or potential soil series include Hollis, Shapleigh, Brimfield, Charlton, Canton, and perhaps Paxton soils.

Overstory Summary Narrative

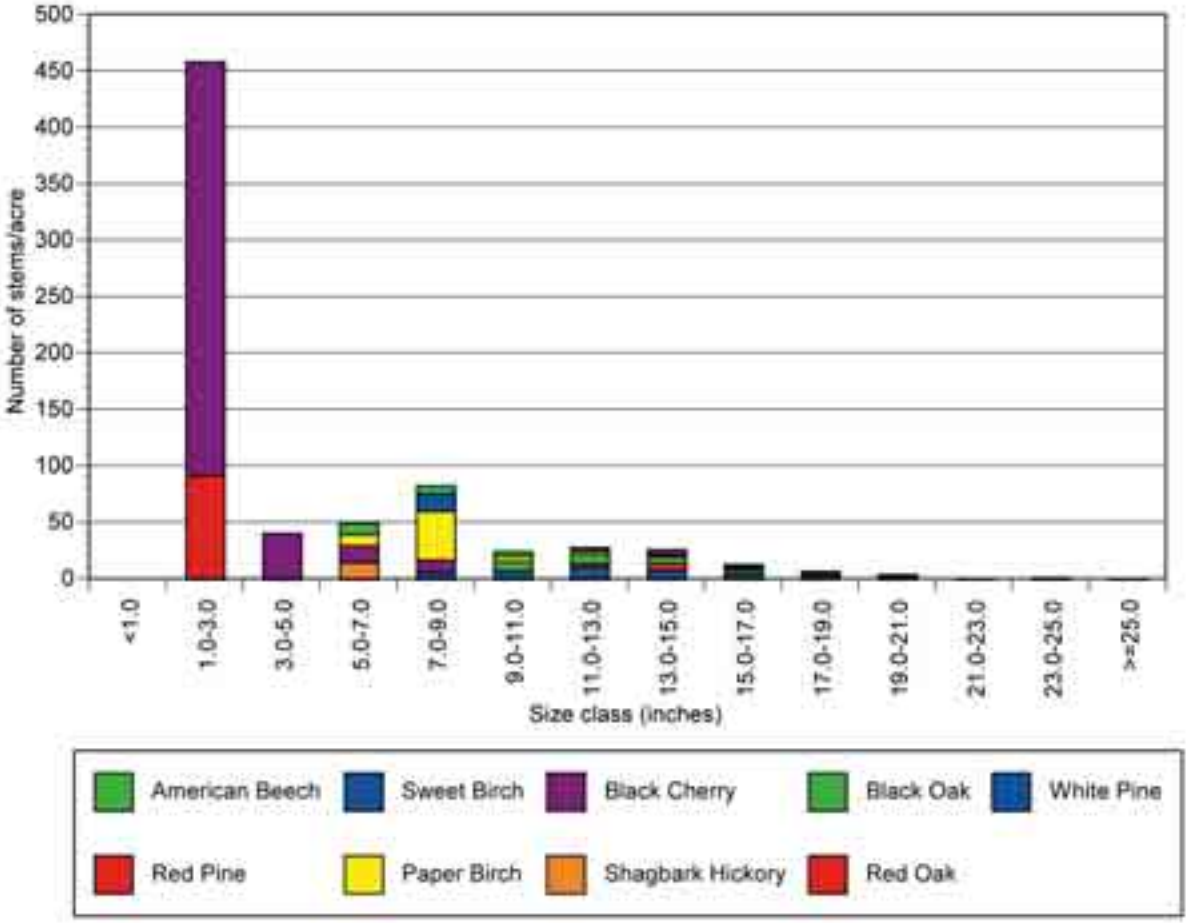
This dry Appalachian oak – hickory forest is currently considered mature and has a diverse group of tree species present. Effective stand age was estimated at 101 years. Species distribution by basal area was: eastern white pine (30%), northern red oak (14%), paper birch (14%), black oak (14%), black cherry (10%), American beech (6%), shagbark hickory (6%), sweet birch (4%), and red pine (1%).

In a timber management setting, this natural community would be considered small sawtimber having a medial stand diameter of 12.36 in. Relative stand density was 116.7 percent of the average maximum stocking expected in undisturbed stands of similar size and species. This

density is well above the optimum for best individual tree growth. At this relative density, growth rate of the biggest trees is probably moderate, while growth of medium and smaller-sized trees is probably fair, and mortality due to crowding moderate. Mortality due to crowding will add important structure to the stand.

The growing stock amounted to 114.0 sq ft/ac. Gross total volume in all trees to a 4 inch top was 2898.2 cu.ft/ac. There were 736 trees/ac in this stand. The basal area of acceptable growing stock was 114.0, while unacceptable growing stock represented 26.0 sq ft/ac of basal area. Acceptable growing stock represented 80.1 of the relative density, while unacceptable growing stock represented 36.7 of the relative density. The *q* factor for this stand was 1.25.

The mean diameter of this dry Appalachian oak-hickory forest was 3.94. The quadratic mean diameter was 5.90. The net board foot volume of this stand was 10,209 bd.ft/ac and 24% of the basal area were considered of high value. Trees of acceptable quality for future growing stock provide a fully stocked stand by themselves.



Dry-mesic Appalachian oak-hickory forest

Identification and Location
Stand ID: 3
Compartment: Dry-mesic Appalachian oak-hickory forest
Date of inventory: 9/21/2006

Measures
Area: 146.8 ac
Plot count: 6
Number of plot size classes: 2
Trees per acre: 344.94 #/ac
Basal area: 153.3 sq ft/ac
Relative density: 109.9 pct.
Canopy closure: 97%

Stand Characteristics
Forest type: other hardwoods
Size class: small sawtimber

Natural Community Description

This community occurs on dry-mesic sites in coastal and southern New Hampshire and is characterized by a broad diversity of trees, including Appalachian (central hardwood) oaks, hickories, white pine, and transitional hardwood trees. The shrub and herb layers are sparse to moderately well developed. Heaths and other dry site understory plants are absent or in low abundance, as are species characteristic of more northern forests, such as sugar maple, yellow birch, and wood ferns (*Dryopteris* spp.). Soils range from well drained sandy to very fine sandy loams (such as Eldridge, Chatfield-Hollis, and Pennichuck series) on gentle to moderate slopes.

Overstory Summary Narrative

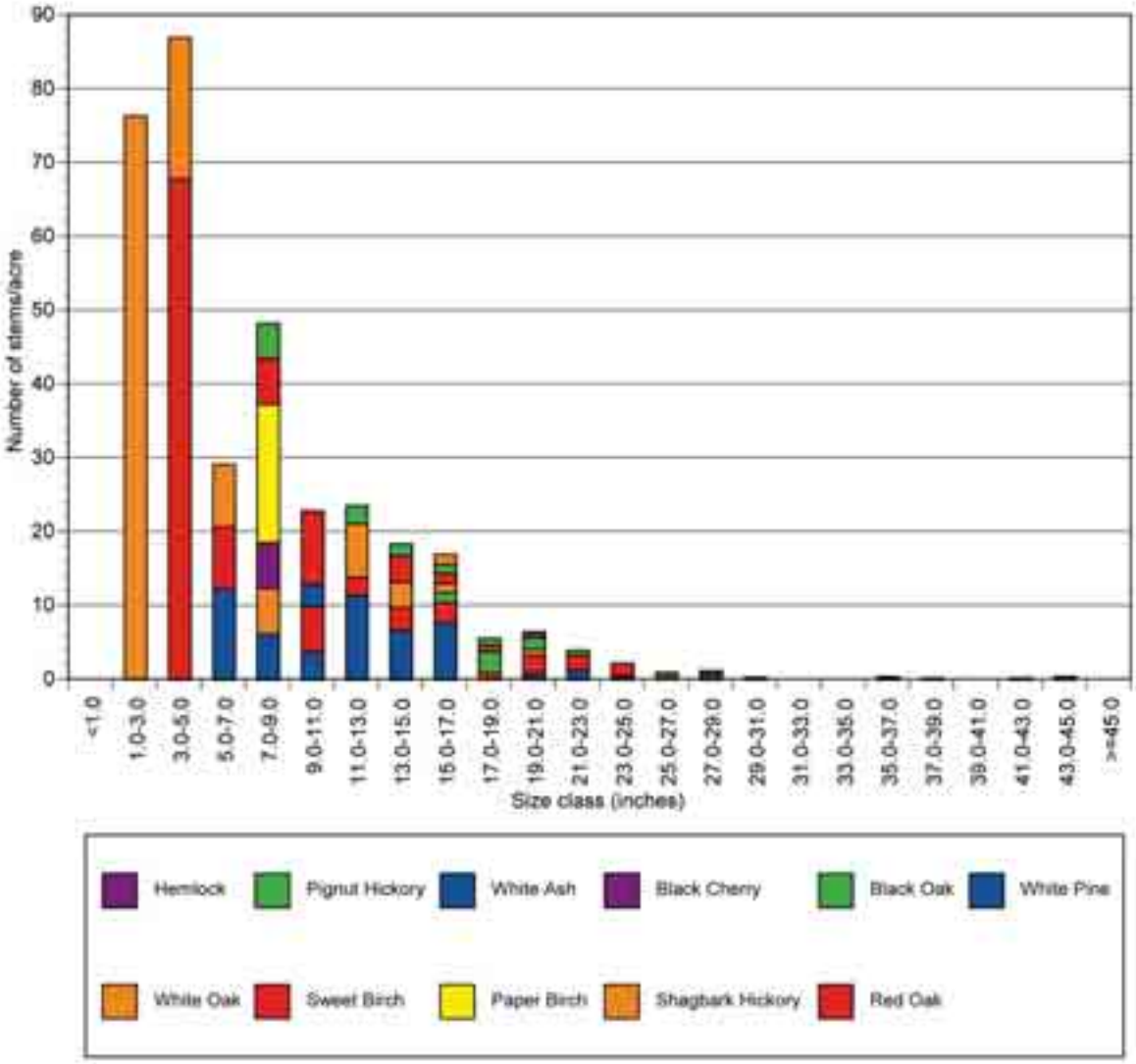
This dry-mesic Appalachian oak – hickory is currently considered mature. Effective stand age was estimated to be 158 years. There were eleven tree species present in the stand, with the following species distribution by basal area: eastern white pine (29%), northern red oak (25%), shagbark hickory (13%), pignut hickory (10%), sweet birch (9%), black oak (5%), paper birch (3%), white ash (2%), black cherry (1%), white oak (1%), and eastern hemlock (1%).

In a timber management setting, this natural community would be considered small sawtimber, having a medial stand diameter of 16.34 in. Relative stand density was 109.9 percent of the average maximum stocking expected in undisturbed stands of similar size and species. This density is well above the optimum for best individual tree growth. At this relative density, growth rate of the biggest trees is probably moderate, while growth of medium and smaller-sized trees is probably fair, and mortality due to crowding moderate. If this natural community is managed under an even-age silvicultural system, the several species groups will mature at about the same time.

The growing stock amounted to 138.3 sq ft/ac. Gross total volume in all trees to a 4 inch top was 3049.6 cu.ft/ac. There were 345 trees/ac in this stand. The basal area of acceptable growing

stock was 138.3, while unacceptable growing stock represented 15.0 sq ft/ac of basal area. Acceptable growing stock represented 101.7 of the relative density, while unacceptable growing stock represented 8.2 of the relative density. The *q* factor for this stand was 1.15.

The mean diameter of this dry-mesic Appalachian oak-hickory forest was 7.01. The quadratic mean diameter was 9.03. The net board foot volume of this stand was 10,245 bd.ft/ac and 27% of the basal area in this stand were considered of high value. Trees of acceptable quality for future growing stock provide a fully stocked stand by themselves.



Forest on Fill

Identification and Location
Stand ID: 4
Compartment: Forest on fill
Date of inventory: 9/22/2006

Measures
Area: 12.5 ac
Plot count: 2
Number of plot size classes: 1
Trees per acre: 139.36 #/ac
Basal area: 115.0 sq ft/ac
Relative density: 62.9 pct.
Canopy closure: 63%

Stand Characteristics
Forest type: Allegheny hardwoods
Size class: small sawtimber

Natural Community Description

This community is highly variable, existing on extremely disturbed sites. Species typically are planted varieties, recruited from neighboring stands, or introduced invasive and pioneer. Physical characteristics of nutrient cycles and drainage may have been altered during the disturbance, rendering the community different from its original as well as neighboring communities.

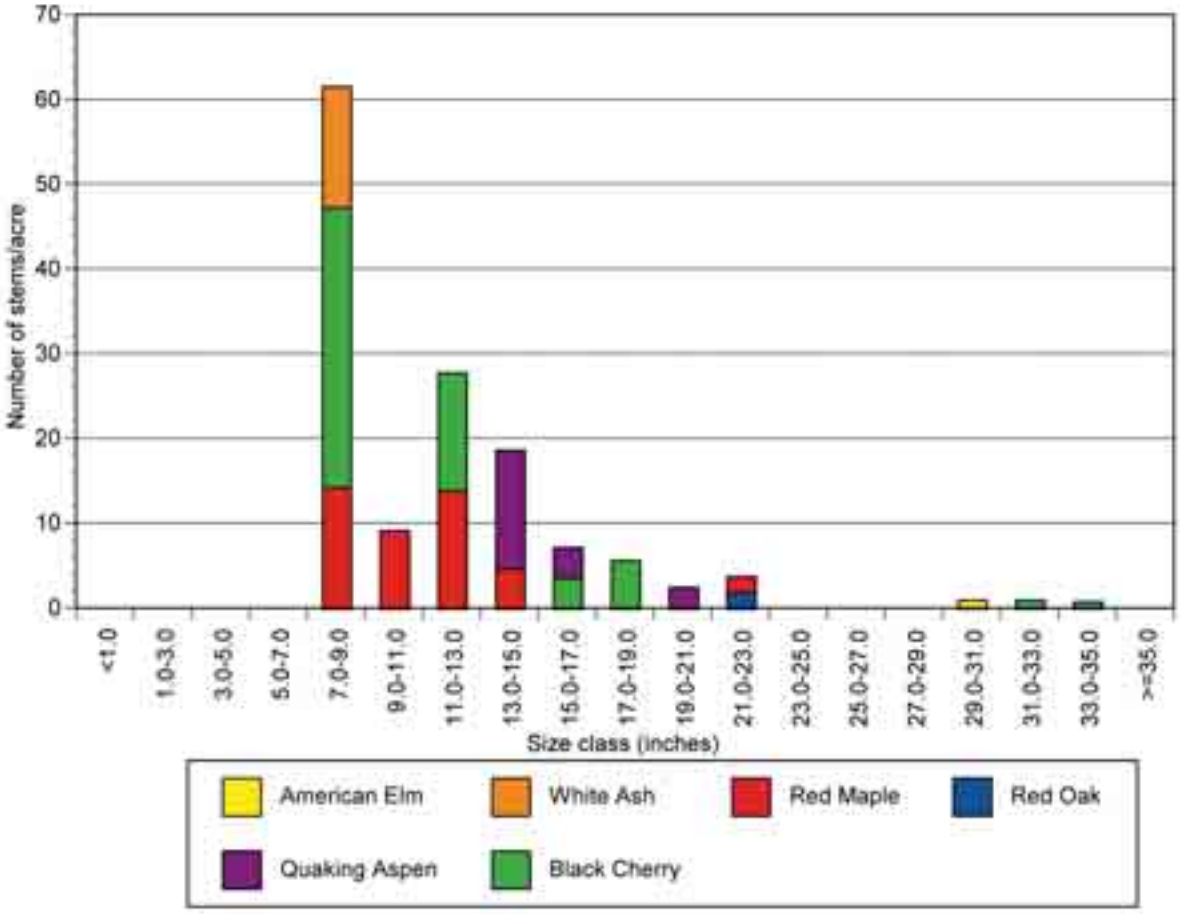
Overstory Summary Narrative

This Allegheny hardwoods stand is currently considered mature. Effective stand age was estimated to be 125 years. There were six tree species present in the stand with the following species distribution by basal area: black cherry (39%), red maple (26%), quaking aspen (22%), northern red oak (4%), white ash (4%), and American elm (4%).

In a timber management setting, this natural community would be considered small sawtimber having a medial stand diameter of 16.04 in. Relative stand density was 62.9 percent of the average maximum stocking expected in undisturbed stands of similar size and species. This density is in the optimum range for optimal individual tree growth. At this relative density, growth rate of the biggest trees is probably excellent, while growth rate of medium and smaller-sized trees is probably good and mortality due to crowding low.

The growing stock amounted to 95.0 sq ft/ac. Gross total volume in all trees to a 4 inch top was 2535.0 cu.ft/ac. There were 139 trees/ac in this stand. The basal area of acceptable growing stock was 95.0, while unacceptable growing stock represented 20.0 sq ft/ac of basal area. Acceptable growing stock represented 50.2 of the relative density, while unacceptable growing stock represented 12.7 of the relative density. The overall stand relative density was 62.9. The *q* factor for this stand was 1.14.

The mean diameter of this forest on fill forest was 11.36. The quadratic mean diameter was 12.30. The net board foot volume of this stand was 6882 bd.ft/ac and 43% of the basal area in this stand were considered of high value. Trees of acceptable quality for future growing stock are inadequate to provide a fully stocked stand in themselves.



Low red maple-elm/musclewood/ladyfern silt forest

Identification and Location
Stand ID: 5
Compartment: Low red maple-elm/musclewood/ladyfern silt forest
Date of inventory: 05/23/2007

Measures
Area: 69.2 ac
Plot count: 4
Number of plot size classes: 3
Trees per acre: 422.81 #/ac
Basal area: 125.0 sq ft/ac
Relative density: 78.2 pct.
Canopy closure: 75%

Stand Characteristics
Forest type: pine hardwoods
Size class: small sawtimber

Natural Community Description

This forest type is intermediate between upland and wetland communities. It has a seasonally high water table and silt soils with a high water holding capacity and intermediate nutrient status. The vegetation consists of a moderately diverse combination of upland, moist-site forest species and facultative wetland species. The woody and herbaceous understories are sparse to moderately well developed. Unlike most swamps, there is very little or no organic soil horizon or hummock-hollow microtopography development. Soils are somewhat poorly drained silt loams with a seasonally high water table, high moisture holding capacity due to the silt content, and moderate base-cation status judging from species composition and silty soils. Soil types include some Buxton and Scitico silt loams (of marine origin), among other soils. There is typically no or a very shallow O horizon (<2 cm), very dark gray-black silt loam A horizon, and olive gray silt loam B horizon with redoxymorphic features (mottles) found near the transition to the B horizon. One example has a distinct plow layer, although others have a more distinct horizon development and have not been plowed. This community is similar in some respects to somewhat poorly drained floodplains forests and seepage forests, but are not flooded and do not have mucky organic horizons. It is also similar to hemlock – cinnamon fern and red maple - red oak - cinnamon fern forests in terms of drainage class.

Overstory Summary Narrative

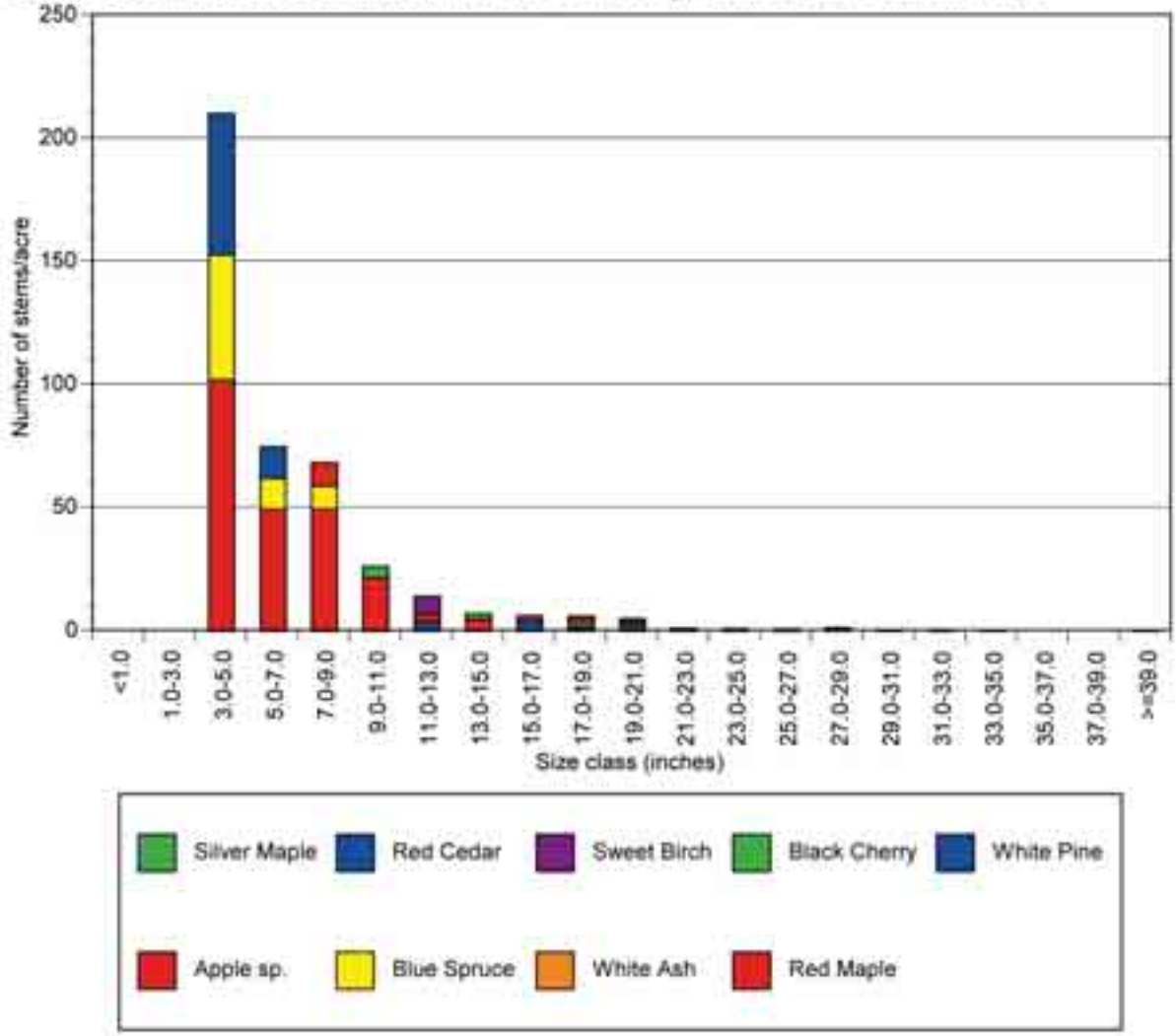
This pine hardwoods stand is currently considered mature. Effective stand age was estimated at 156 years. Nine tree species were present in the stand with the following species distribution by basal area: red maple (40%), eastern white pine (28%), black cherry (6%), blue spruce (6%), redcedar (6%), apple sp. (6%), sweet birch (4%), white ash (2%), and silver maple (2%).

In a timber management setting, this natural community would be considered small sawtimber stand, having a medial stand diameter of 13.80 in. Relative stand density was 78.2 percent of the average maximum stocking expected in undisturbed stands of similar size and species. This

density is in the optimum range for best individual tree growth. At this relative density, growth rate of the biggest trees is probably excellent, while growth rate of medium and smaller-sized trees is probably good and mortality due to crowding low.

The growing stock amounted to 87.5 sq ft/ac. Gross total volume in all trees to a 4 inch top was 2133.9 cu.ft/ac. There were 423 trees/ac in this stand. The basal area of acceptable growing stock was 87.5, while unacceptable growing stock represented 37.5 sq ft/ac of basal area. Acceptable growing stock represented 56.2 of the relative density, while unacceptable growing stock represented 22.1 of the relative density. The *q* factor for this stand was 1.19.

The mean diameter of this low red maple-elm/musclewood/ladyfern silt forest was 6.01. The quadratic mean diameter was 7.36. The net board foot volume of this stand was 5760 bd.ft/ac and 6% of the basal area in this stand were considered of high value. Trees of acceptable quality for future growing stock are inadequate to provide a fully stocked stand in themselves.



Mesic Appalachian oak-hickory forest

Identification and Location
Stand ID: 6
Compartment: Mesic Appalachian oak-hickory forest
Date of inventory: 8/17/2006

Measures
Area: 357.6 ac
Plot count: 9
Number of plot size classes: 2
Trees per acre: 234.98 #/ac
Basal area: 165.6 sq ft/ac
Relative density: 109.8 pct.
Canopy closure: 93%

Stand Characteristics
Forest type: other mixedwoods
Size class: small sawtimber

Natural Community Description

This community occurs on mesic sites in coastal and southern New Hampshire and is characterized by a broad diversity of trees, including Appalachian (central hardwood) oaks, hickories, white pine, and transitional hardwood trees. The shrub and herb layers are sparse to moderately well developed. Heaths and other dry site understory plants are absent or in low abundance, as are species characteristic of more northern forests, such as sugar maple, yellow birch, and wood ferns (*Dryopteris* spp.). Soils range from well drained sandy to very fine sandy loams (such as Eldridge, Chatfield-Hollis, and Pennichuck series) and moderately well drained silt loams (such as Scitico and Boxford silt loams) on gentle to moderate slopes. The moisture regime of sandy loams tends to be dry-mesic and the silt loams tend to be mesic.

Overstory Summary Narrative

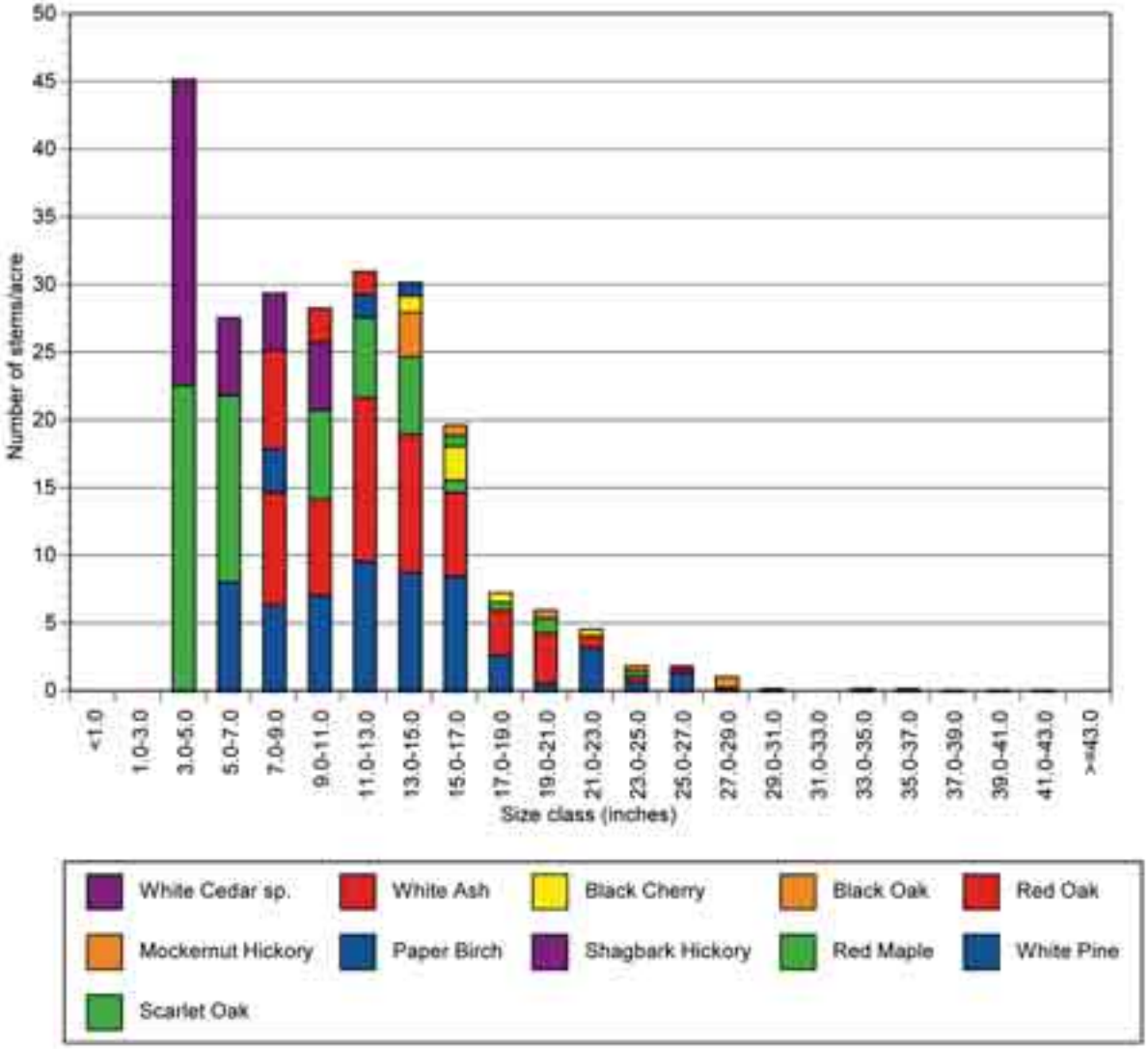
This mesic Appalachian oak-hickory forest is currently considered mature. Effective stand age was estimated at 131 years. There were 11 tree species present in the stand with the following species distribution by basal area: eastern white pine (34%), northern red oak (32%), red maple (14%), black oak (6%), black cherry (4%), shagbark hickory (3%), white ash (3%), paper birch (2%), scarlet oak (1%), mockernut hickory (1%), and white-cedar sp. (1%).

In a timber management setting this natural community would be considered a sawtimber stand, with a medial stand diameter of 15.90 in. Relative stand density was 109.8 percent of the average maximum stocking expected in undisturbed stands of similar size and species. This density is well above the optimum for best individual tree growth. At this relative density, growth rate of the biggest trees is probably moderate, while growth of medium and smaller-sized trees is probably fair, and mortality due to crowding moderate.

The growing stock amounted to 137.8 sq ft/ac. Gross total volume in all trees to a 4 inch top was 3606.4 cu.ft/ac. There were 235 trees/ac in this stand. The basal area of acceptable growing

stock was 137.8, while unacceptable growing stock represented 27.8 sq ft/ac of basal area. Acceptable growing stock represented 93.0 of the relative density, while unacceptable growing stock represented 16.7 of the relative density. The *q* factor for this stand was 1.18.

The mean diameter of this mesic Appalachian oak-hickory forest was 9.90. The quadratic mean diameter was 11.37. The net board foot volume of this stand was 13,882 bd.ft/ac and 36% of the basal area in this stand were considered of high value. Trees of acceptable quality for future growing stock provide a fully stocked stand by themselves.



Plantation

Identification and Location
Stand ID: 7
Compartment: Plantation
Date of inventory: 9/19/2006

Measures
Area: 25.4 ac
Plot count: 5
Number of plot size classes: 2
Trees per acre: 467.51 #/ac
Basal area: 156.0 sq ft/ac
Relative density: 90.1 pct.
Canopy closure: 80%

Stand Characteristics
Forest type: pine
Size class: pole

Natural Community Description

This forest type is an artificial community, planted typically in a monoculture and mainly of conifer species. They are often planted in rows, adding to the artificial appearance. Plantations are typically used in production forests, where maximum wood fiber is the objective, or in watershed protection.

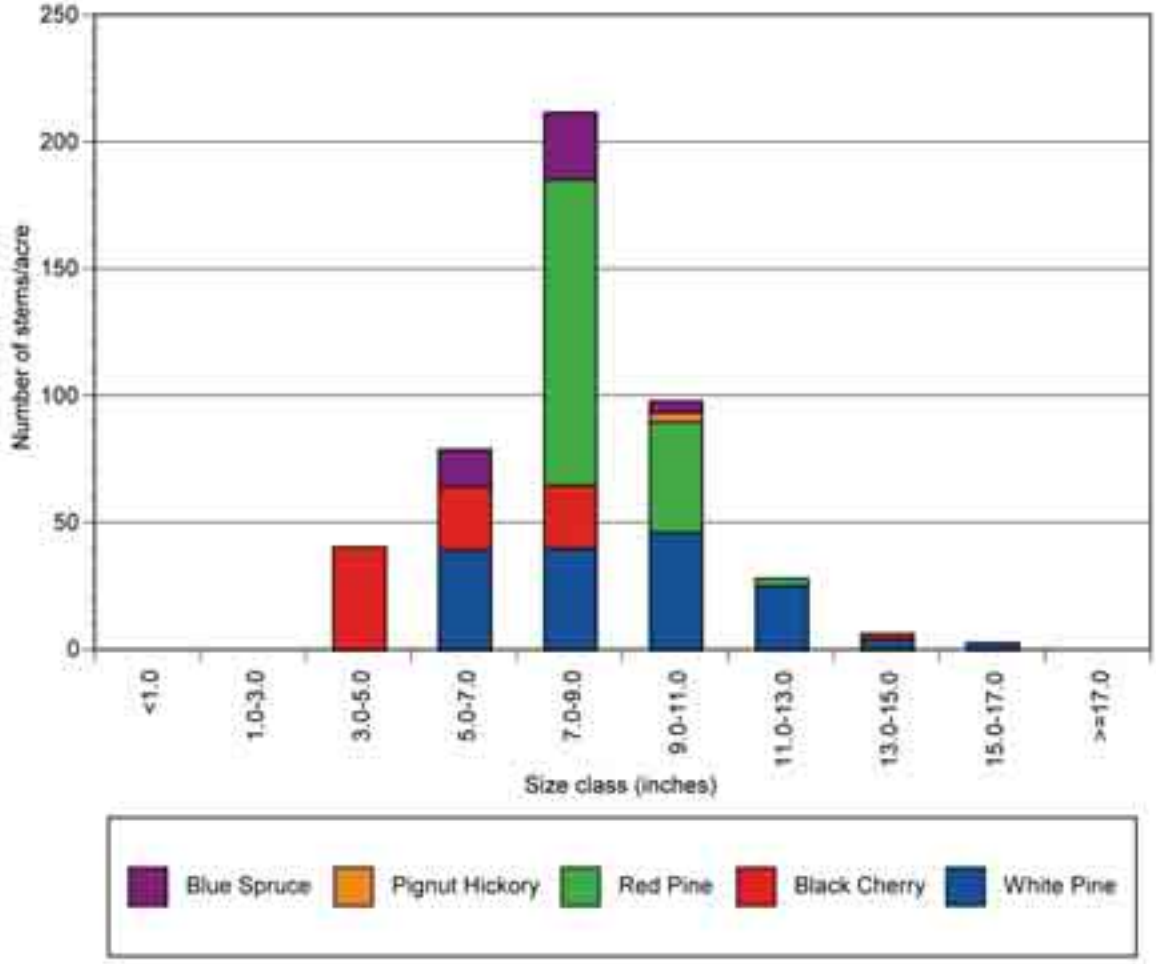
Overstory Summary Narrative

This pine plantation is currently considered mature. Effective stand age was estimated at 66 years. There were five tree species present in the stand with the following species distribution by basal area: eastern white pine (44%), red pine (37%), black cherry (10%), blue spruce (8%), and pignut hickory (1%).

In a timber management setting this natural community would be considered a pole stand, with a medial stand diameter of 8.78 in. Relative stand density was 90.1 percent of the average maximum stocking expected in undisturbed stands of similar size and species. This density is higher than optimum for best individual tree growth. At this relative density, growth rate of the biggest trees is probably moderate, while growth of medium and smaller-sized trees is probably fair, and mortality due to crowding moderate.

The growing stock amounted to 128.0 sq ft/ac. Gross total volume in all trees to a 4 inch top is 2338.0 cu.ft/ac. There were 468 trees/ac in this stand. The basal area of acceptable growing stock was 128.0, while unacceptable growing stock represented 28.0 sq ft/ac of basal area. Acceptable growing stock represented 71.4 of the relative density, while unacceptable growing stock represented 18.6 of the relative density. The overall stand relative density was 90.1. The *q* factor for this stand was 1.26.

The mean diameter of this pine plantation was 7.48. The quadratic mean diameter was 7.82. The net board foot volume of this stand was 2086 bd.ft/ac and 10% of the basal area in this stand were considered of high value. Trees of acceptable quality for future growing stock are inadequate to provide a fully stocked stand in themselves.



Red maple/sensitive fern-tussock sedge basin/seepage

Identification and Location
Stand ID: 8
Compartment: Red maple/sensitive fern-tussock sedge basin/seepage
Date of inventory: **Not sampled**

Measures
Area: 10.7 ac
Plot count: 0
Number of plot size classes: 0

Natural Community Description

This is a common type of red maple swamp characterized by a diverse assemblage of herbaceous species, relatively little *Sphagnum* moss, and saturated or seasonally saturated to seasonally flooded soils. The swamps may be small or very large (10-100 acres) and typically occupy headwater basins that give rise to drainages or along drainages where seepage or non-channelized upland runoff contributes to the water budget. It lacks seasonal flooding from over-bank flooding (typical of seasonally flooded red maple swamps) and is more minerotrophic than red maple - Sphagnum basin swamps. *Onoclea sensibilis* (sensitive fern) is a good indicator of minerotrophic conditions in this type. Subsurface groundwater discharge is likely in at least some of these swamps. These swamps are often found with other swamp communities in a larger mosaic.

Red pine forest/woodland

Identification and Location
Stand ID: 9
Compartment: Red pine forest/woodland
Date of inventory: 8/16/2006

Measures
Area: 7.7 ac
Plot count: 3
Number of plot size classes: 1
Trees per acre: 139.51 #/ac
Basal area: 190.0 sq ft/ac
Relative density: 86.0 pct.
Canopy closure: 84%

Stand Characteristics
Forest type: red pine
Size class: large sawtimber

Natural Community Description

Red pine dominated forests and woodlands are most prominent on dry, montane rocky ridges, outcrops, and summits where acidic, nutrient-poor conditions prevail. Red pine stands are often evenaged and have park-like understories with a low heath shrub layer. Even-aged cohorts typically develop following an intense fire. This community is most common on southerly aspects, ranging from west to south to east, between 750-2700 ft. elevation. Typical examples consist of mosaics of open or partially vegetated rock outcrops interspersed with a scattered or patchy tree canopy. Rock exposures generally cover 25-50% of the ground surface. In some areas, particularly those with deeper soils or ones that have only a distant fire-history, red pine may form an essentially closed canopy. Red pine trees may exceed 60-70 ft (18-21 m) in height, but are, on average, shorter in woodland settings and at higher elevations. A closed forest canopy may form in the absence of fire for long periods or where soils are more well developed. Shade-intolerant species tend to be less abundant or absent in forested examples [e.g., *Corydalis sempervirens* (pale corydalis), *Potentilla tridentata* (three-toothed cinquefoil), *Deschampsia flexuosa* (common hair-grass), and *Danthonia spicata* (poverty oat-grass)]. Fire plays an important role in the formation and maintenance of this community, and controlled burns or wildfire may be required for substantial regeneration of red pine, whether or not harvesting is performed. Red pine can exceed 200 years of age, and its thick, platy bark affords mature trees some protection from fire when trees reach about 70 years of age. Younger trees have thinner bark and may not survive an intense fire. Several native red pine forests occur in central New Hampshire on deep sandy kame terraces with very little bedrock exposure. These are classified as red pine - white pine - balsam fir forests. Red pine is less frequent in sand plain settings relative to montane outcrops. Although individual red pine trees may be found in southern New Hampshire, native stands are rare or absent. Some outcrops in other landscape positions, such as along rocky lake shores, exhibit similar vegetation and are included in this type. Soils are thin, dry, and acidic with turfy (fibric) organic surface horizons and gravelly and/or coarse sand mineral layers over acidic to intermediate bedrock (oligotrophic). This is a distinct, narrowly defined community that intergrades with other northern rocky ridge communities. It is

considered distinct from the red oak and jack pine types due to differences in dominant tree species and probable differences in ecological histories or circumstances.

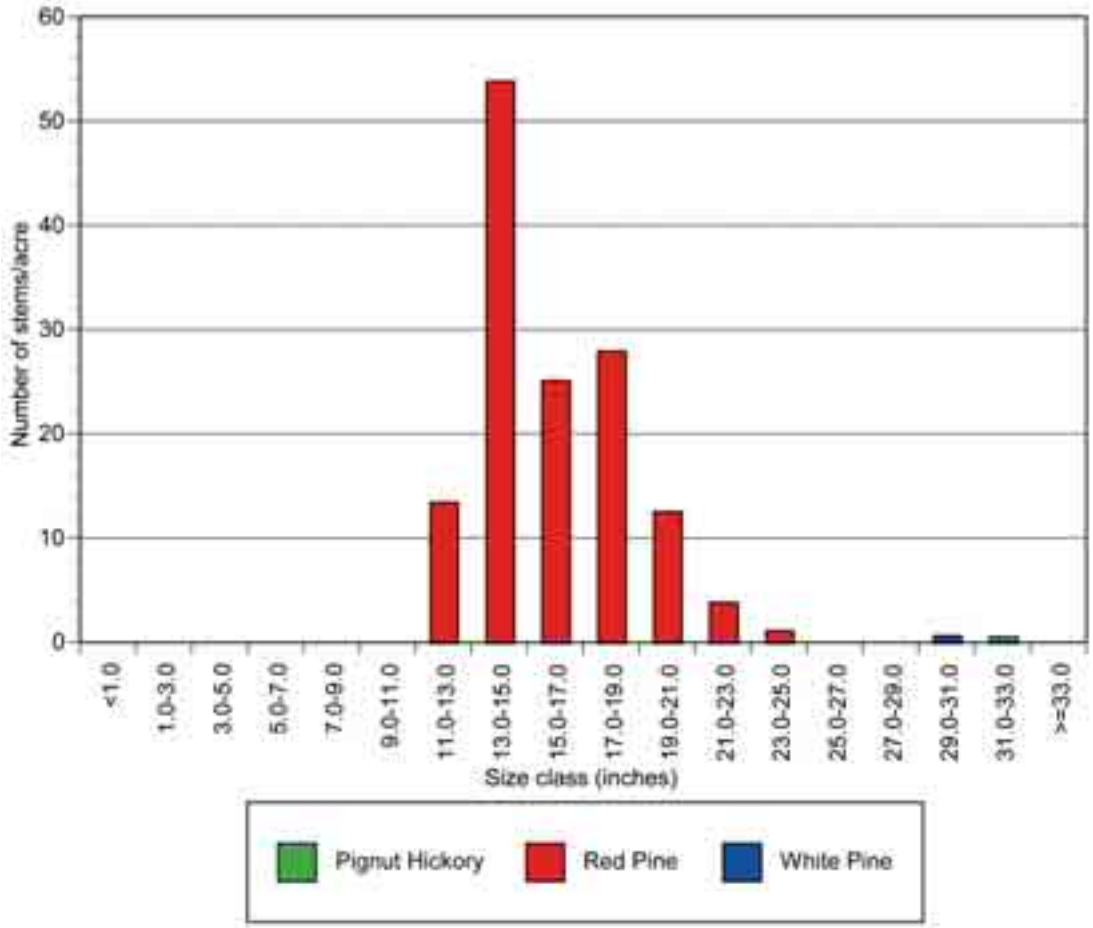
Overstory Summary Narrative

This red pine forest/woodland is currently considered mature. Effective stand age was estimated at 126 years. There were three tree species present in the stand with the following species distribution by basal area: red pine (96%), eastern white pine (2%), and pignut hickory (2%).

In a timber management setting this natural community would be considered a large sawtimber stand, with a medial stand diameter of 16.84 in. Relative stand density was 86.0 percent of the average maximum stocking expected in undisturbed stands of similar size and species. This density is higher than optimum for best individual tree growth. At this relative density, growth rate of the biggest trees is probably moderate, while growth of medium and smaller-sized trees is probably fair, and mortality due to crowding moderate.

The growing stock amounted to 183.3 sq ft/ac. Gross total volume in all trees to a 4 inch top was 4723.1 cu.ft/ac. There were 140 trees/ac in this stand. The basal area of acceptable growing stock was 183 sq ft/ac, while unacceptable growing stock represented 6.7 sq ft/ac of basal area. Acceptable growing stock represented 82.8 of the relative density, while unacceptable growing stock represented 3.2 of the relative density. The overall stand relative density was 86.0. The *q* factor for this stand was 1.19.

The mean diameter of this red pine forest/woodland was 15.50. The quadratic mean diameter was 15.80. The net board foot volume of this stand was 24,659 bd.ft/ac and none of the basal area of the trees in this stand were considered of high value. Trees of acceptable quality for future growing stock provide a fully stocked stand by themselves.


60
50
40
30
20
10
0
Number of stems/acre
<1.0
1.0-3.0
3.0-5.0
5.0-7.0
7.0-9.0
9.0-11.0
11.0-13.0
13.0-15.0
15.0-17.0
17.0-19.0
19.0-21.0
21.0-23.0
23.0-25.0
25.0-27.0
27.0-29.0
29.0-31.0
31.0-33.0
>=33.0
Size class (inches)
Pignut Hickory
Red Pine
White Pine

28

Seasonally saturated red maple swamp

Identification and Location
Stand ID: 10
Compartment: Seasonally saturated red maple swamp
Date of inventory: 8/17/2006

Measures
Area: 38.2 ac
Plot count: 2
Number of plot size classes: 1
Trees per acre: 231.60 #/ac
Basal area: 115.0 sq ft/ac
Relative density: 88.6 pct.
Canopy closure: 89%
Size class: large sawtimber

Natural Community Description

This community occurs in somewhat poorly drained mineral soil settings in transition zones between wetland and upland communities. It is dominated by hardwood trees, particularly red maple, oaks, and birches, with a relatively minor component of pine and hemlock. *Osmunda cinnamomea* (cinnamon fern) and tall wetland shrubs such as *Vaccinium corymbosum* (highbush blueberry) are present in moderate abundance (~1-15%). Other wetland plants are sparse. More coastal or southern examples contain Appalachian oaks, hickories, and possibly black huckleberry, which are absent from central NH examples. Soils consist of sand, sandy loams and silt loams, typically with a dark brown or black A horizon over B horizon materials with mottling within ~30 cm of the surface. This community is typically somewhat poorly drained, and therefore intermediate and transitional to more well drained upland forests and poorly or very poorly drained swamps. Soils series include Pipestone sand, Boxford silt loam, and possibly Raynham silt loam and Eldridge fine sandy loam.

Overstory Summary Narrative

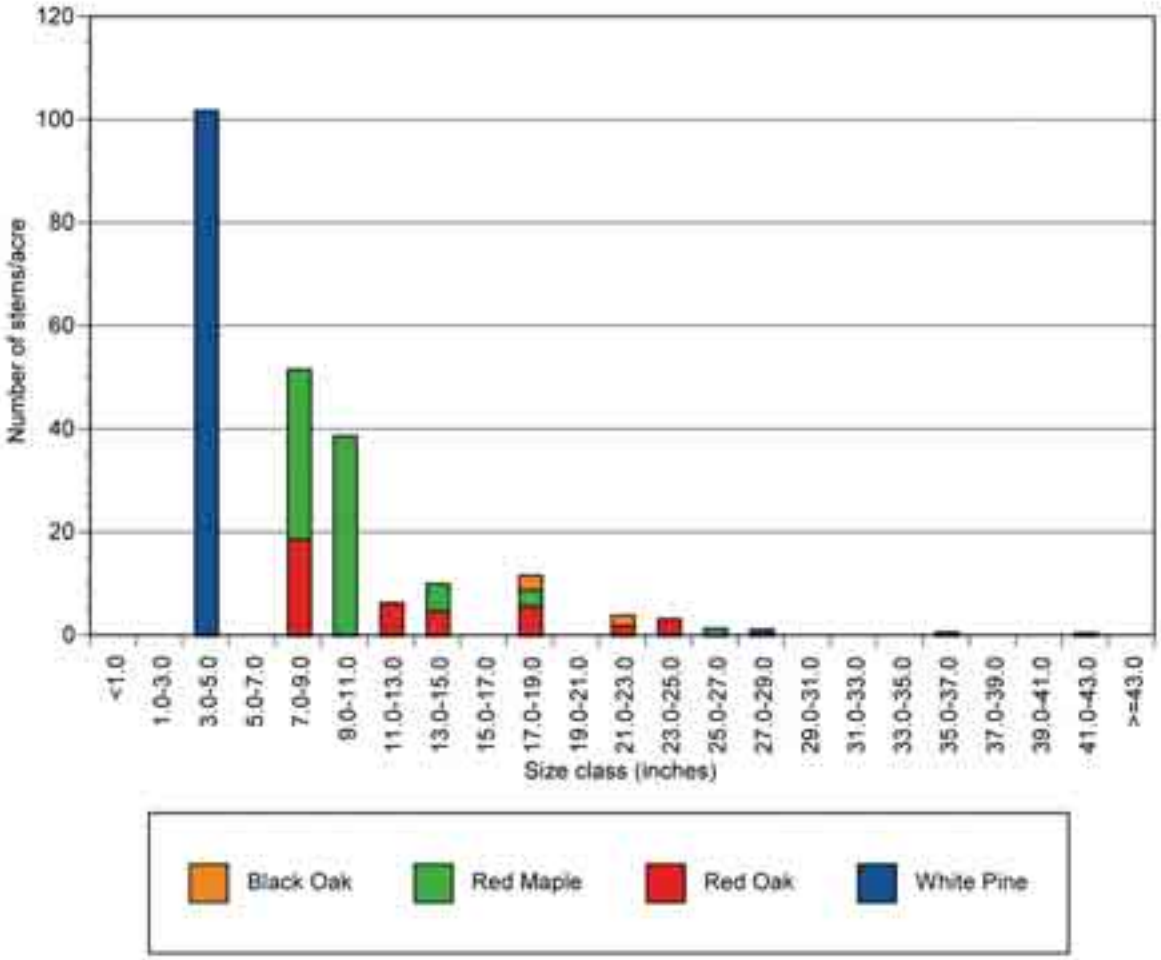
This seasonally saturated red maple swamp is currently considered mature. Effective stand age was estimated at 156 years. There were four tree species present in the stand with the following species distribution by basal area: northern red oak (39%), red maple (39%), black oak (13%), and eastern white pine (9%).

In a timber management setting this natural community would be considered a large sawtimber stand, with a medial stand diameter of 17.22 in. Relative stand density was 88.6 percent of the average maximum stocking expected in undisturbed stands of similar size and species. This density is higher than optimum for best individual tree growth. At this relative density, growth rate of the biggest trees is probably moderate, while growth of medium and smaller-sized trees is probably fair, and mortality due to crowding moderate.

The growing stock amounted to 100.0 sq ft/ac. Gross total volume in all trees to a 4 inch top was 2617.7 cu.ft/ac. There were 232 trees/ac in this stand. The basal area of acceptable growing stock was 100.0, while unacceptable growing stock represented 15.0 sq ft/ac of basal area.

Acceptable growing stock represented 77.6 of the relative density, while unacceptable growing stock represented 11.0 of the relative density. The overall stand relative density was 88.6. The *q* factor for this stand was 1.14.

The mean diameter of this seasonally saturated red maple swamp was 7.59. The quadratic mean diameter was 9.54. The net board foot volume of this stand was 9419 bd.ft/ac, and 39% of the basal area in this stand were considered of high value. Trees of acceptable quality for future growing stock are inadequate to provide a fully stocked stand in themselves.



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