

**PLANT COMMUNITY DEVELOPMENT
IN HISTORIC FOREST STANDS
AT HOPEWELL FURNACE
NATIONAL HISTORIC SITE**

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Summary

The species composition and structure of plant communities were described for two forested areas (Chestnut Hill and Mount Pleasure) at Hopewell Furnace National Historic Site (HOFU). Thirty 20- x 20-m plots, each with nested 10- x 10-m and 2- x 2-m subplots, were randomly located, and measurements of trees, shrubs, seedlings, and ground cover were made during 1991 and 1992. A 3- x 3-m fence was erected at the center of 15 plots in each stand to exclude deer from the central 2- x 2-m subplot.

The results of this survey provided a profile of current conditions and background data for future long-term monitoring to determine the effects of feeding by white-tailed deer on forest regeneration. Species of oak and hickory accounted for 39% of the overstory trees at the Chestnut Hill area and 59% of the overstory trees at the Mount Pleasure area. Black oak and red maple were dominant overstory species in both forest stands.

Black birch, yellow poplar, red maple, and black-gum made up 89% of the large saplings at Chestnut Hill, whereas red maple and black-gum were the most dominant large saplings at the Mount Pleasure stand. The density of small saplings was 468 stems per ha in the Chestnut Hill stand compared to only 18 stems per ha at the Mount Pleasure stand. The number of seedling species (14) and the number of seedlings per ha (29,750) at the Chestnut Hill area was higher compared to the number of seedling species (11) and number of seedlings per ha (12,417) at Mount Pleasure.

Aside from the differences in the number of saplings between the two stands, both areas appeared to be sufficiently stocked in the various size classes to maintain a diverse forest environment for at least the next 20 years. The composition and structure of woody species were similar in fenced and unfenced plots within each stand. Such similar conditions were expected and should provide the reference data needed for long-term monitoring.

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Introduction

The development and evaluation of comprehensive inventory and monitoring programs continue to be important functions of the National Park Service for managing renewable natural resources. Long-term monitoring programs are essential to (1) determine trends in ecosystem development, (2) provide reference data for understanding interactions among ecosystem components, and (3) describe and understand ecological relationships at the landscape level (Porter 1991, Silsbee and Peterson 1991, Underwood et al. 1991).

Monitoring of natural resources is essential to evaluate changes in forests due to factors such as aging and development of plants, weather events, insect defoliation, and feeding effects of large ungulates. The present survey at Hopewell Furnace National Historic Site (HOFU) was conducted because of concern over the effects of white-tailed deer (*Odocoileus virginianus*) on forest regeneration. Evidence of feeding by deer on woody plants has been reported by park managers to be quite noticeable throughout HOFU. A preliminary plant survey conducted in 1987 (Russell 1987) indicated that regeneration of oaks was less than expected.

The objectives of this study were to (1) describe the current status (species composition and structure) of forest communities in two areas of HOFU, (2) establish fenced and unfenced plots for monitoring changes in forest plant communities in areas where deer are excluded and in areas accessible to deer, and (3) describe the intensity of use by deer of woody stems in the forest communities.

This report describes the present conditions of two forest stands at HOFU with emphasis on woody vegetation. The description of plant communities in fenced (deer excluded) and unfenced plots constitutes a reference or baseline for long-term monitoring of the effects of deer on forest regeneration.

Study Area

Hopewell Furnace National Historic Site (HOFU), located in the Schuylkill River Valley in Berks County (Fig. 1), was established in 1938. HOFU consists of 257 hectares (635 acres) of mixed deciduous forest, 59 hectares (146 acres) of agricultural special use zones, and 27 hectares (66.7 acres) of developed or historic property. Elevation ranges from 140 meters (459 ft) to 280 meters (919 ft). Average annual precipitation is 117.4 centimeters (46.2 in). Average temperatures range from -4.3 degrees C (24.3 degrees F) in January to 22.5 degrees C (72.5 degrees F) in August.

During the 18th and 19th centuries, the area was an important iron-making community. The charcoal furnaces used to produce pig iron and castings relied on timber from the surrounding area for fuel. Repeated cuttings to supply charcoal, occasional fires, and the elimination of the American chestnut tree extensively changed the forest. The abandonment of the iron-making industry and some of the farmland associated with HOFU in the late 1800's resulted in a forest community primarily composed of secondary successional stages.

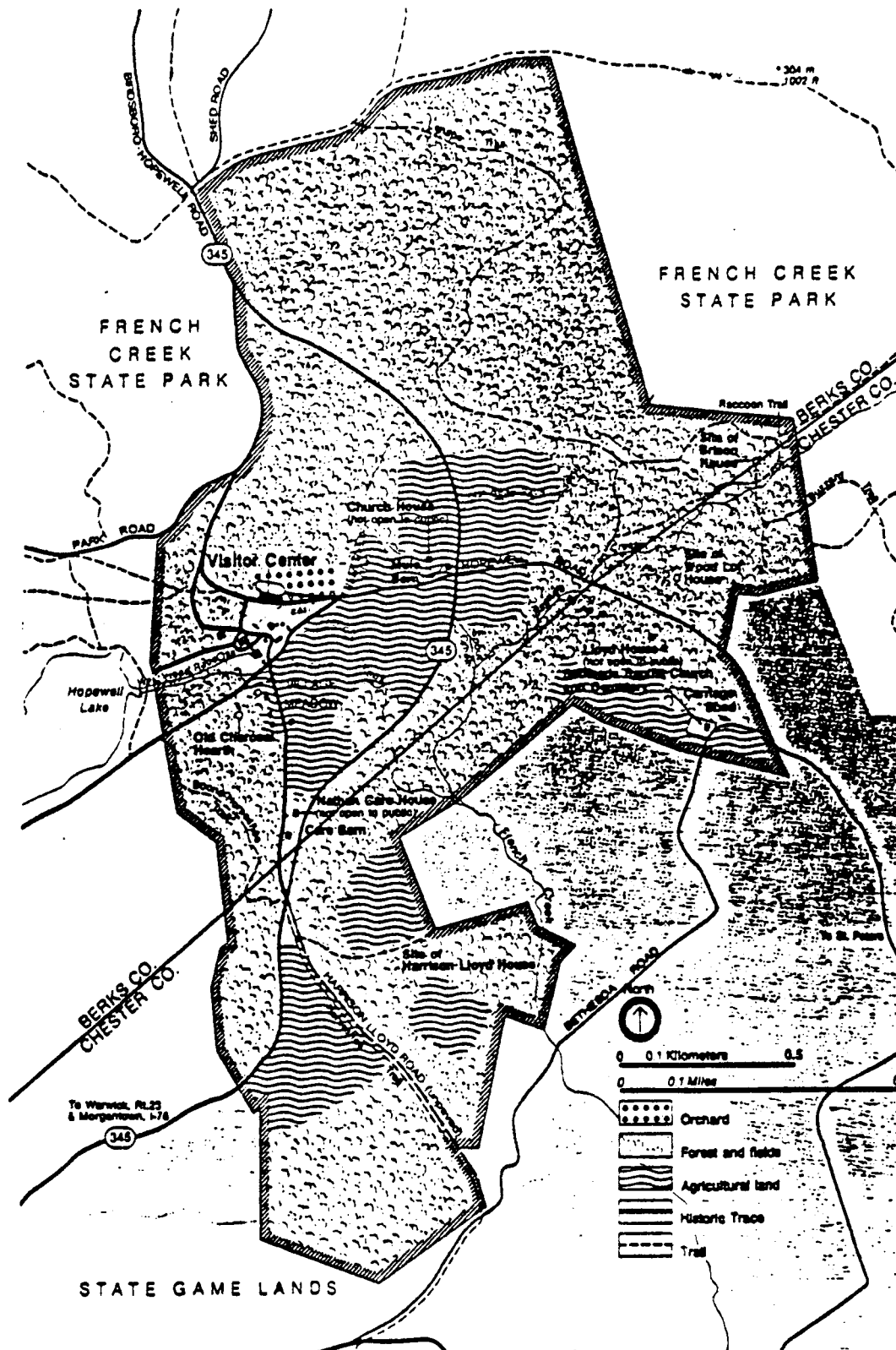


Figure 1. Location of Hopewell Furnace National Historic Site in Berks and Chester Counties, Pennsylvania.

Previous Studies

During the 1930's, a vegetation map and report was produced from the French Creek Project that included HOFU (Stearns 1939). The report identified a forest stand primarily composed of even-aged second growth oak. Scarlet oak, black oak, and chestnut oak were the major species identified in the report by Stearns (1939).

Russell (1987), using the point-centered-quarter method (Mueller-Dombois and Ellenberg 1974), identified 12 forest cover types and developed a species list for HOFU. Major categories reported were oak-dominated, yellow poplar-dominated, red maple-dominated, and old-field successional types. Russell (1987) suggested that future studies incorporate permanent, long-term monitoring plots and exclosures to study the effects of feeding by deer on forest regeneration.

Methods

Plot Design and Location

A fixed plot monitoring system (Storm and Ross 1992) was implemented to survey vegetation at HOFU. The study plot consisted of a 20- x 20-m area that was sub-divided into four quarters (10- x 10-m subplots denoted A, B, C, D). A 2- x 2-m subplot nested in the center of the plot was sub-divided into four 1- x 1-m sampling units (denoted a, b, c, d) (Fig. 2).

After consulting with park managers, two forest stands, one in the Chestnut Hill area and one in the Mount Pleasure area were selected as study sites (Fig. 3). The Chestnut Hill stand encompassed approximately 85 ha and was a mixed oak-sweet birch forest type. The Mount Pleasure stand encompassed approximately 45 ha and was a chestnut oak-scarlet oak-black oak forest type (Russell 1987). A list of common and scientific names of plants referenced in this report is presented in Appendix A.

Fifteen plots were established and inventoried in each of the two stands during July, 1991. Fifteen additional plots were established and inventoried in each of the two stands during July and August, 1992 (Table 1). All plots were randomly selected and were marked on a land cover map (Figs. 4 and 5). The distances and azimuths to conspicuous landmarks (i.e. boundary markers) were recorded for each plot. The study plot locations were referenced to the Universal Transverse Mercator (UTM) system.

The center of each plot was marked with a white 45 cm pvc pipe stake that was driven approximately 20 cm into the ground. Each stake was marked with a unique number (Chestnut Hill = 1, Mount Pleasure = 2) and a plot number. Two overstory trees closest to the plot center were selected as witness trees. The species, diameter at breast height [dbh; 1.37 m (4.5 ft) above ground], and any unique features (i.e. multiple stems) of each tree were recorded. The azimuth and distance from each witness tree to the plot center were recorded on forms described in a vegetation manual by Storm and Ross (1992). An aluminum tag containing the polygon number, plot number, and year the plot was established was attached to the base of each witness tree.

Stand Attributes

Trees

In each of the 10- x 10-m subplots, species and dbh (nearest cm) were recorded for all tree species stems > 1.5 m (4.9 ft.) in height. Trees $\leq$ 1.4 cm dbh were classified as small saplings. Trees > 1.4 cm dbh and $\leq$ 11.4 cm dbh were considered large saplings and those > 11.4 cm dbh were considered overstory. Height and health status were recorded for five randomly selected trees in each of the 10- x 10-m subplots. If there

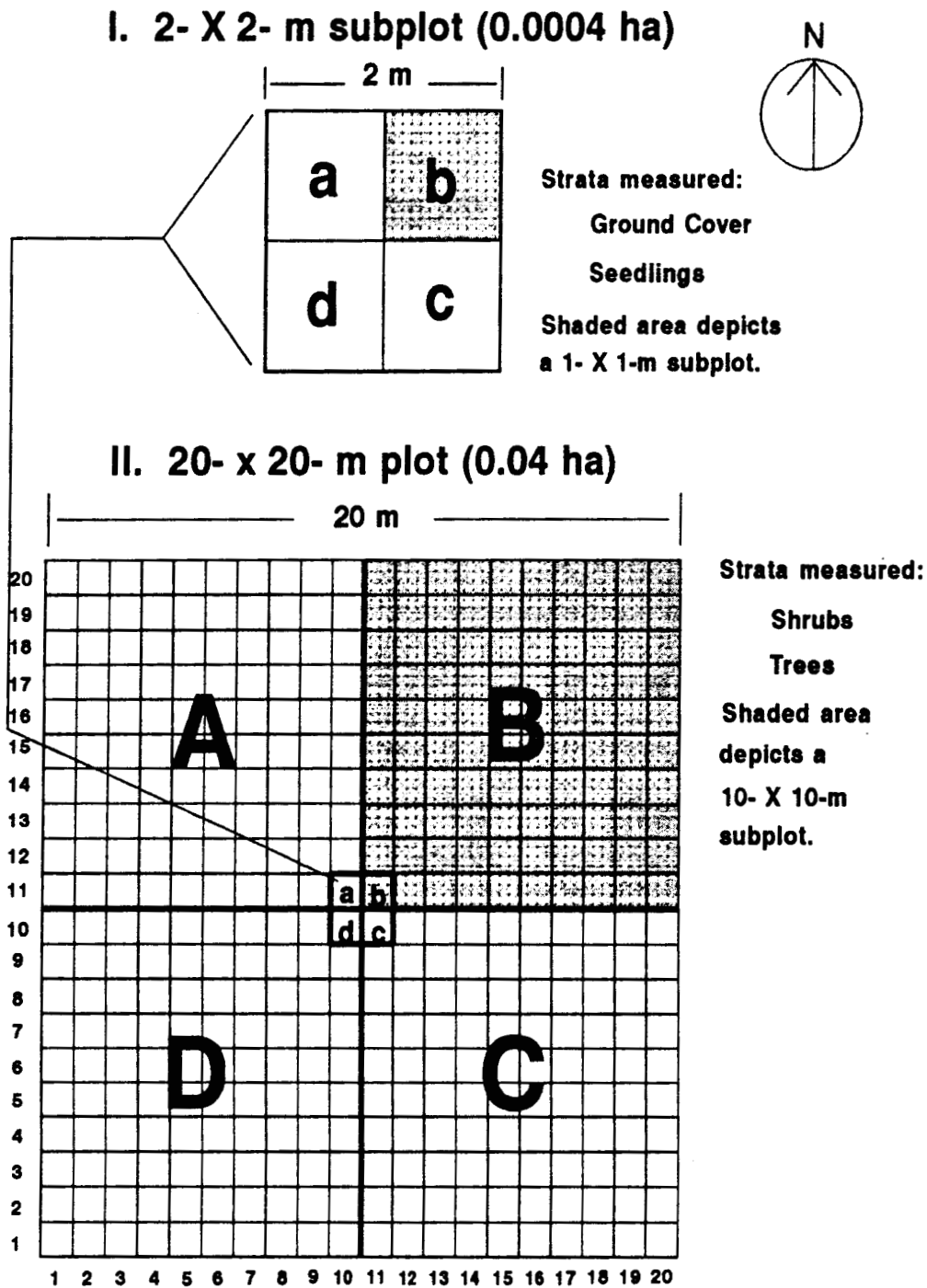


Figure 2. Layout and orientation of 20- x 20-m plots with nested 10- x 10-m and 2- x 2-m subplots to sample plant communities at HOFU. Shaded areas depict a 1- x 1-m and a 10- x 10-m subplot; note: two 1- x 1-m subplots are equivalent to a milacre sampling area.

Table 1. Number of fenced and unfenced study plots and browse plots established to describe plant communities and browse use by deer in two forest stands at Hopewell Furnace National Historic Site, 1991-92.

Forest Stand	Subplots ^a		Browse ^c
	Fenced ^b	Unfenced	
Chestnut Hill	15	15	10
Mount Pleasure	15	15	9
Total	30	30	19 ^d

^aEach subplot (2 x 2 m) was nested in the center of a 20- x 20-m plot.

^bEach fence, 3- x 3-m square and 1.8 m high, enclosed the 2- x 2-m subplot at the center of each plot.

^cEach browse plot was 9.3 m² (100 ft²) with a radius of 1.7 m (5.64 ft).

^dOnly 19 of the 60 subplots were associated with browse subplots because of time constraints.

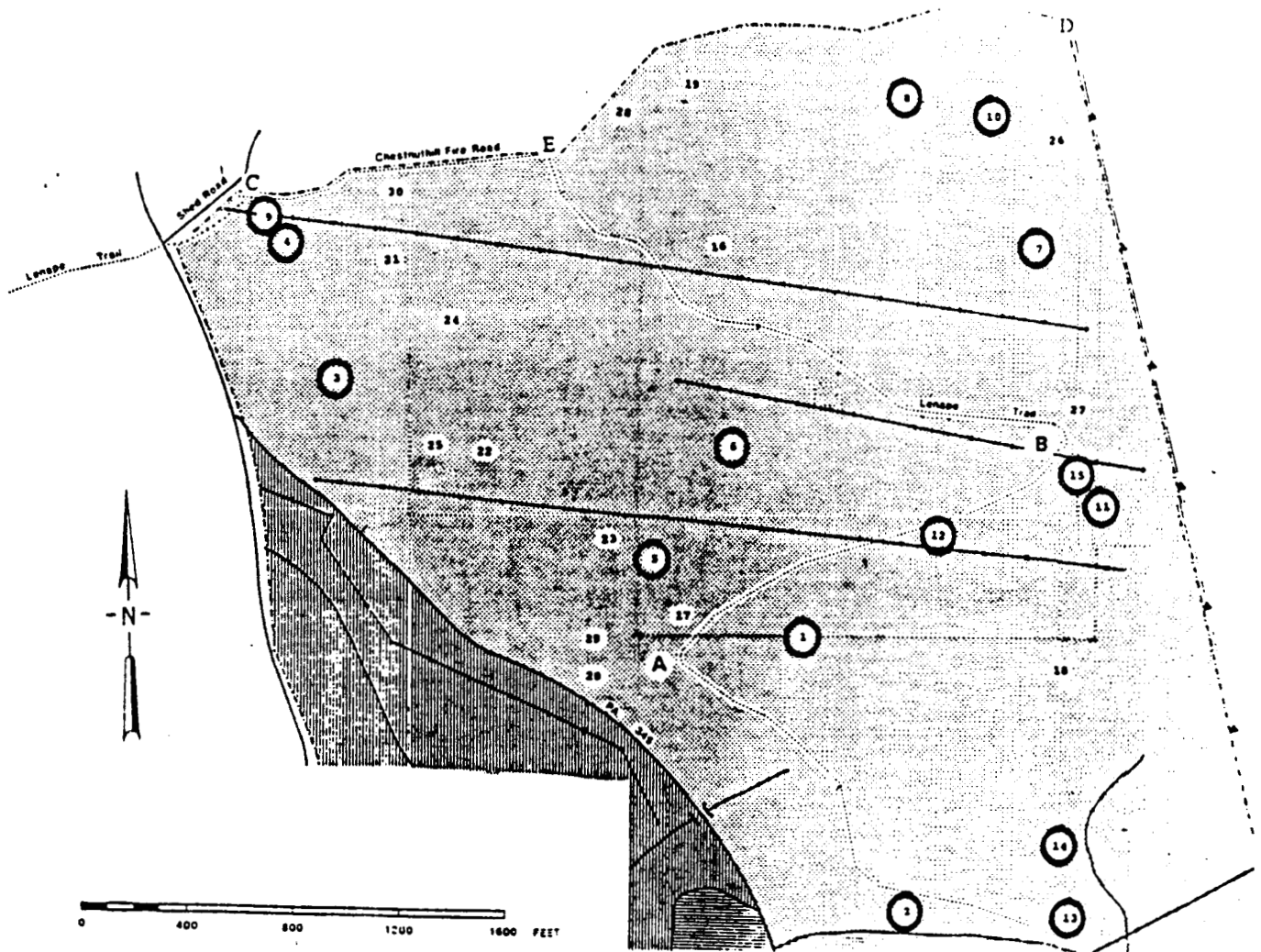


Figure 4. Location of 30 sampled plots (15 fenced and 15 unfenced) in the Chestnut Hill area; fenced 2- x 2-m subplots are depicted by the circles.

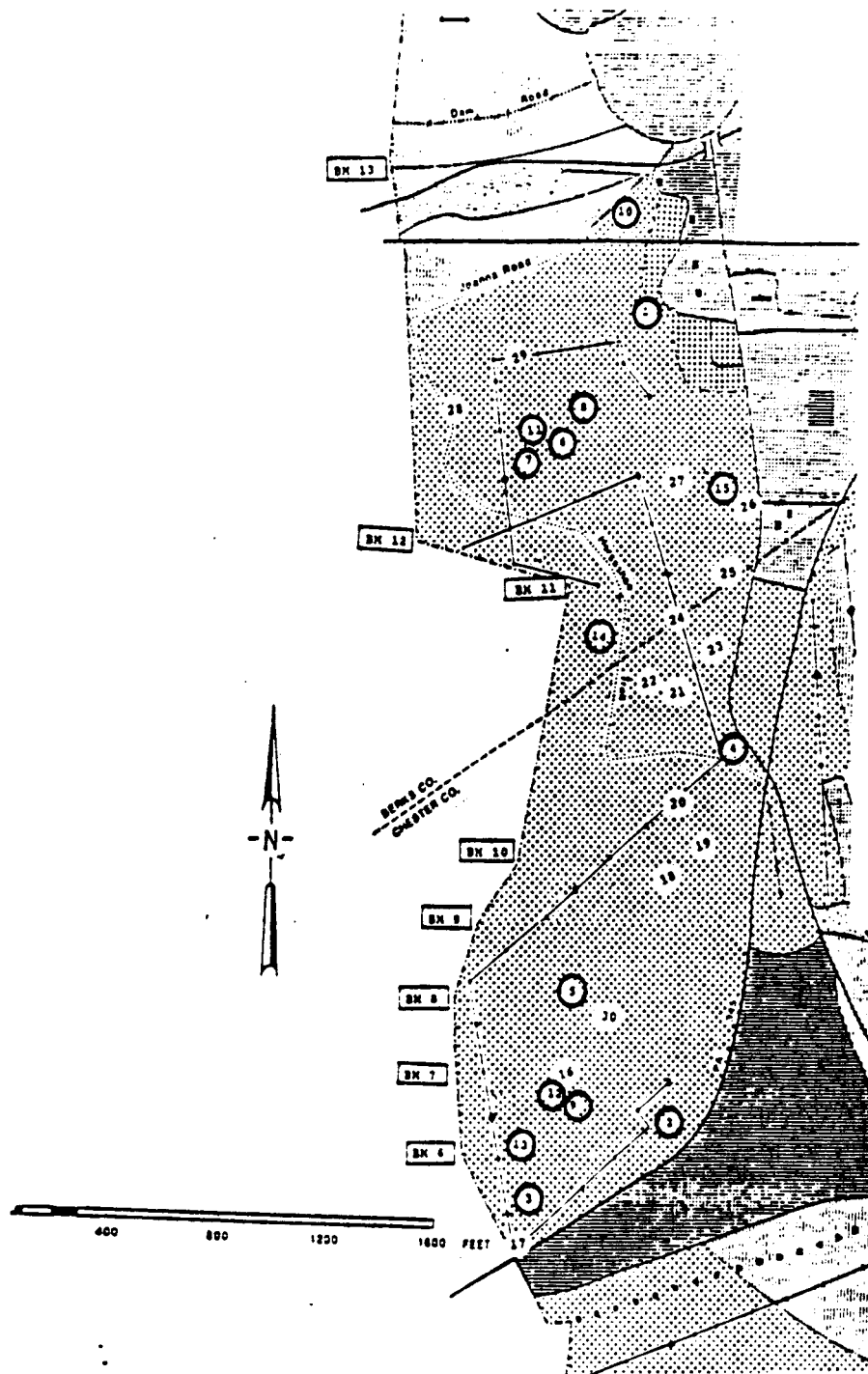


Figure 5. Location of 30 sampled plots (15 fenced and 15 unfenced) in the Mount Pleasure area; fenced 2- x 2-m subplots are depicted by the circles.

were ≤ 5 trees in the subplot, height and health status were collected from each tree present. A densiometer (Lemmon 1956) was used at the center of each 10- x 10-m subplot to estimate the amount of canopy closure.

Shrubs

A shrub was defined as having a persistent woody stem, relatively low growth form and usually with multiple basal stems. Shrub coverage was estimated in two of the 10- x 10-m subplots using the line-intercept method (Hays et al. 1981). A total of four lines (each 10-m in length, two in each subplot) was surveyed at each plot. Random distances were picked along the North-South line that divided the 10- x 10-m subplots, and the intercept lines were started at these points and placed perpendicular to the outside edge of the subplot. The amount of each shrub intersecting each 1,000 cm line was recorded to the nearest cm.

Seedlings--Tree and Shrub

Counts of tree and shrub seedlings (woody stems ≤ 1.5 m in height) were made in each 1-m² area of the 2- x 2-m subplot. Species and height (0-25, >25-50, >50-75, >75-100, >100-125, and >125-150 cm) were recorded for each tree and shrub seedling.

Ground Cover

Estimates of ground cover were made within two 1-m² areas located in the central 2- x 2-m subplot. Ocular estimates of percent cover (0, 1-4, 5-25, 26-50, 51-75, 76-95, or 96-100) were used to determine horizontal coverage of herbaceous material (grasses, sedges, forbs, and moss-lichens), rock/mineral soil, litter, woody material, and non-woody (inorganic) material. The maximum height (0-25, 26-50, 51-75, 76-100, 101-125, or 126-150 cm) reached by each attribute was recorded.

During 1991, woody material was recorded under the category 'other woody'. During 1992, woody material was separated into 'live woody' and 'dead woody' categories.

Vine Coverage

Vine coverage was ocularly estimated for the entire 2- x 2-m subplot in two zones; ≤ 2 m above ground and > 2 m above ground. Ocular estimates of percent cover were recorded in the same categories as ground cover.

Fenced and Unfenced Plots

A 3- x 3-m wire-fence enclosure was installed around the 2- x 2-m subplot in each of the 15 plots established in each stand during 1991. Enclosures were built larger than the subplot to provide a buffer area that would protect vegetation within the subplot from

feeding by deer. Each exclosure consisted of 14 gauge 7.5- x 10.0-cm mesh wire supported by 2.5-m steel t-posts driven approximately 0.5 m into the ground at each corner. Each exclosure was 1.8-m high. The remaining 15 subplots in each stand were left unfenced so fenced and unfenced plots could be compared to determine the effects of feeding by white-tailed deer on forest plant communities. Although the entire 20- x 20-m area was not fenced, plots with a fenced 2- x 2-m subplot were termed "fenced plots" and plots with an unfenced 2- x 2-m subplot were termed "unfenced plots" for this report.

Browse Availability and Use

To determine the relative use of woody stems of shrubs and trees by white-tailed deer, a total of 19 circular plots were established in the Chestnut Hill and Mount Pleasure stands. Plot centers were located by choosing a random azimuth and a random distance (1-25 m) from the center of 10 study plots in the Chestnut Hill stand and from the center of nine study plots in the Mount Pleasure stand. A circular plot of 9.3 m² (98.5 ft²) with a 1.72 m (5.6 ft) radius was delineated for estimating the availability of twigs and use of twigs by deer. The number of unbrowsed and browsed twigs of each species of trees and shrubs was recorded as the available twigs, and browsed twigs were recorded as twigs used by deer (Shafer 1963). A twig was defined as growth from the most recent year that was ≥ 2.5 cm long (Stiteler and Shaw 1966). Seedlings and root sprouts ≤ 15 cm tall with no twigs ≥ 2.5 cm long were counted as a single twig. Twigs were measured on stems, in a vertical stratum, extending from ground level to 1.83 m high. Use was defined as the % of total available twigs browsed.

Data Analysis

Objective One

The dbh (nearest cm) and number of each tree species (> 1.5 -m in height) within each of the 30 20- x 20-m plots were used to calculate average dbh, basal area (m² per ha), and number per hectare by diameter class for small and large saplings and overstory trees for each of the forest stands.

Shrub and tree seedlings were inventoried in a total of 30 2- x 2-m subplots (0.012 ha) in each of the Chestnut Hill and Mount Pleasure stands. Seedlings were counted in each 1- x 1-m subplot and summed for all 30 2- x 2-m subplots in each stand. For each stand the average number of seedlings per 1-m² and per hectare were calculated for each species.

Objective Two

The data collected on trees, shrubs, tree and shrub seedlings, and ground cover in the 30 20- x 20-m plots and associated 10- x 10-m and 2- x 2-m subplots in each stand were separated into fenced and unfenced categories for analysis.

Two-sample t-tests were used to determine differences between fenced and unfenced plots in each stand. Variables compared included tree dbh, tree density, canopy closure, coverage of shrubs, and total number of seedlings.

For trees, average dbh, basal area, density, frequency, and an importance value were calculated for each species for the 15 fenced and 15 unfenced plots. The importance value was based on measures of frequency, coverage, and density, which were defined as follows:

$$\text{Frequency} = \frac{\text{No. of subplots in which a species occurs}}{\text{Total no. of subplots examined}}$$

$$\text{Relative Frequency} = \frac{\text{Frequency of species A}}{\text{Sum of frequencies for all species}}$$

Relative frequency (RF) was defined as the frequency of a given species as a proportion of the sum of the frequencies of all species.

$$\text{Coverage} = \text{Basal area of species A per unit area [Basal area per tree (cm}^2\text{) = } 3.1416(\text{dbh}/2)^2\text{]}$$

$$\text{Relative Coverage} = \frac{\text{Coverage of species A}}{\text{Sum of coverage values for all species}}$$

Relative coverage (RC) was defined as the coverage of a species as a proportion of coverage for all species. Relative coverage as used in this report is equivalent to relative dominance as often used by plant ecologists (Mueller-Dombois and Ellenberg 1974).

$$\text{Density} = \frac{\text{Total number of individuals of species A}}{\text{Total area examined}}$$

$$\text{Relative Density} = \frac{\text{Density for species A}}{\text{Sum of densities for all species}}$$

Relative density (RD) was defined as the number of individuals of a given species as the proportion of the total number of individuals for all species.

RF, RC, and RD were summed for each species to obtain an importance value that could range from 0 to 3.00 (the higher the number, the more important the species).

Dividing the importance value by 3 and multiplying by 100% results in an importance percentage that could range from 0 to 100% (Brower and Zar 1977).

For shrubs, percent cover by species was calculated for the 15 fenced plots and 15 unfenced plots in each stand. Shrub coverage (cm) for each intercept line was summed for each species in each plot and separately across the 15 fenced and 15 unfenced plots in each woodlot. The total coverage of each species was divided by the total measured distance of the intercept lines to obtain a percent cover value.

Tree and shrub seedlings were counted by species in each 1- x 1-m sampling unit of the 15 fenced and 15 unfenced 2- x 2-m subplots in each stand. The number of seedlings was summed by species for each 2- x 2-m subplot and for each of the 15 fenced and the 15 unfenced subplots in each stand. The total number of seedlings recorded for the 15 fenced plots and 15 unfenced plots was then converted to number of seedlings per 1-m² and number of seedlings per hectare.

For ground cover, frequencies of occurrence were calculated by % cover class and maximum height class for each of the strata measured within the 15 fenced and 15 unfenced subplots in each stand.

Objective Three

Twigs counted for each species present in each circular plot were summed for all plots. The percentage of browsed twigs was calculated for the 10 plots in the Chestnut Hill stand and for the nine plots in the Mount Pleasure stand.

Results

Plot Design and Location

The locations and directions to each study plot, and the descriptive data acquired from vegetation measurements are stored in original hard copy format and in dBase III+ computer files. Copies of these files are available from the Pennsylvania Cooperative Fish and Wildlife Research Unit, The Pennsylvania State University, University Park, Pennsylvania and Hopewell Furnace National Historic Site, Elverson, Pennsylvania.

Stand Attributes - Trees and Seedlings

Chestnut Hill

Trees: Twenty-one percent of the trees at Chestnut Hill were overstory trees whereas the majority (79%) were in the large and small sapling categories (Fig. 6). Black oak, black birch, and red maple were the dominant species recorded in the overstory.

Overstory trees (> 11.4 cm dbh) averaged 387 per ha with a basal area of 30 m^2 per ha (Table 2). The oak and hickory species group accounted for 39% of the overstory trees based on the number of trees per ha (Fig. 7). The black birch and yellow poplar species group accounted for 28%, red maple accounted for 23%, and all other species accounted for 10% of the total. The number of overstory trees and basal area values would place the stand in the 108% stocking level, when compared to the standards developed for upland oaks (Dale and Lutz 1986).

Large saplings (> 1.4 and ≤ 11.4 cm, dbh) averaged 992 per hectare with a basal area of 2 m^2 per ha (Table 2). Black birch, yellow poplar, red maple, and black-gum were the most abundant species in the large sapling stage with 89% of the total. The composition of red maple was 18% in the large sapling stage compared to 23% in the overstory category. Oak and hickory combined had a much lower representation (2%) in the number of large saplings per ha than was present (39%) in the overstory. Large and small saplings combined averaged 1,414 stems per ha (Fig. 6).

Small saplings (≤ 1.4 cm dbh) comprised a relatively large component of the woody profile between seedlings and large saplings in the Chestnut Hill stand compared to the Mount Pleasure stand. Average density of small saplings was 468 per ha based on counts in the 30 plots. Black birch (45%), yellow poplar (28%), and red maple (15%) were the dominant small saplings counted. Small saplings were present in 28 of 30 plots sampled in the Chestnut Hill stand.

Seedlings - Tree: Fourteen species of tree seedlings were counted in the Chestnut Hill stand. The number of seedlings averaged 29,750 per ha (Table 3). Red maple comprised 40% of the total tree seedlings. Black birch and yellow poplar seedlings

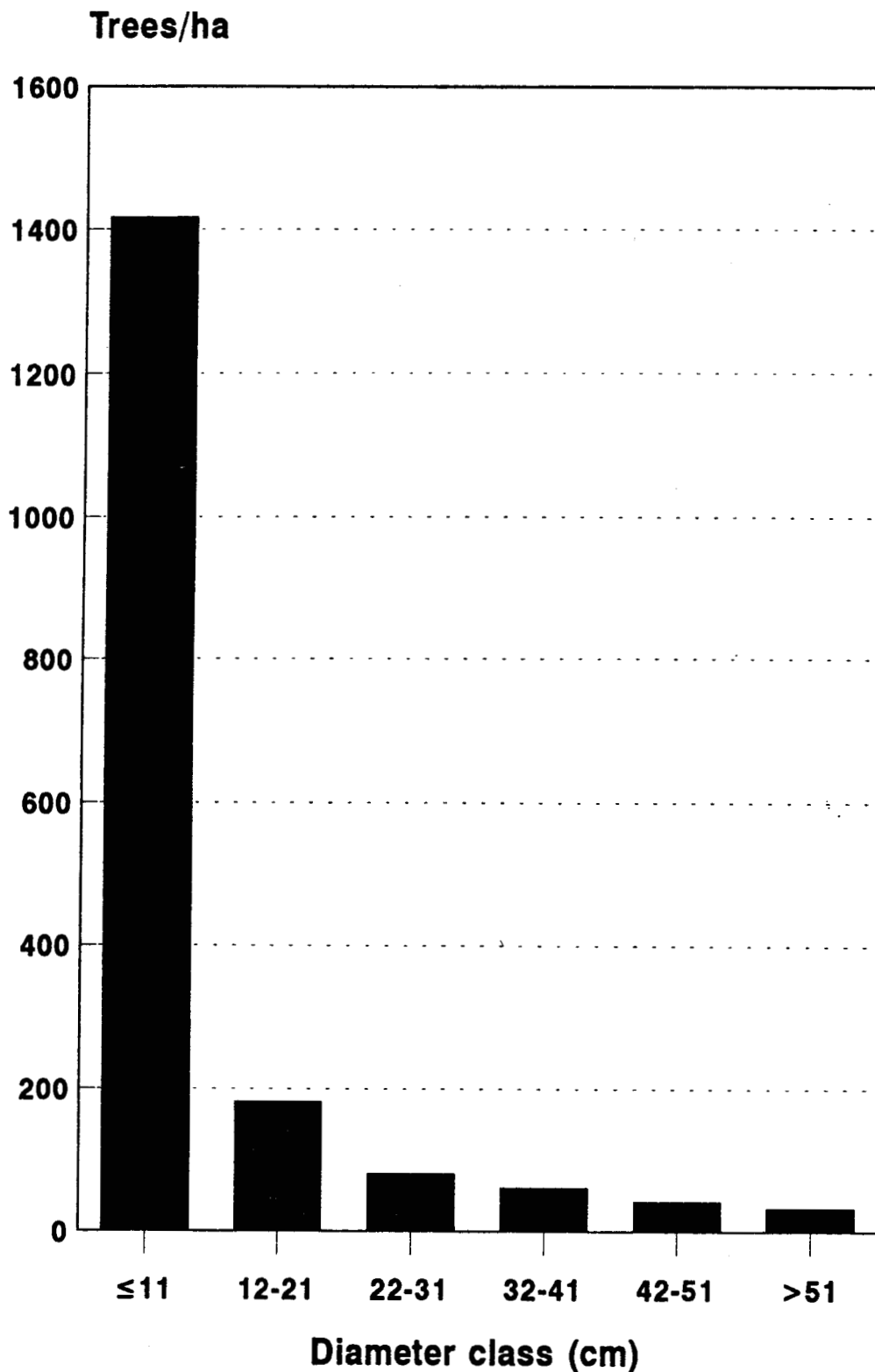


Figure 6. Abundance (trees per ha) by diameter class (cm) of small (≤ 1.4 cm dbh) and large (> 1.4 cm and ≤ 11.4 cm dbh) saplings and overstory (> 11.4 cm dbh) trees in the 30 plots measured in the Chestnut Hill stand, Hopewell Furnace National Historic Site, 1991-1992; in this figure saplings ≤ 11.4 cm dbh were included in the ≤ 11 cm diameter class, and those > 11.4 were included in a diameter class ≥ 12 cm dbh.

Table 2. Density, average diameter at breast height (dbh), and basal area for large saplings (> 1.4 cm and ≤ 11.4 cm dbh) and overstory (> 11.4 cm dbh) trees at the Chestnut Hill stand, Hopewell Furnace National Historic Site, 1991-92.

Unit	Large Saplings	Overstory
Density		
No./ha	992	387
(No./ac)	(402)	(157)
DBH		
cm	4	28
(in)	(2)	(11)
Basal Area		
m²/ha	2	30
(ft²/ac)	(9)	(131)

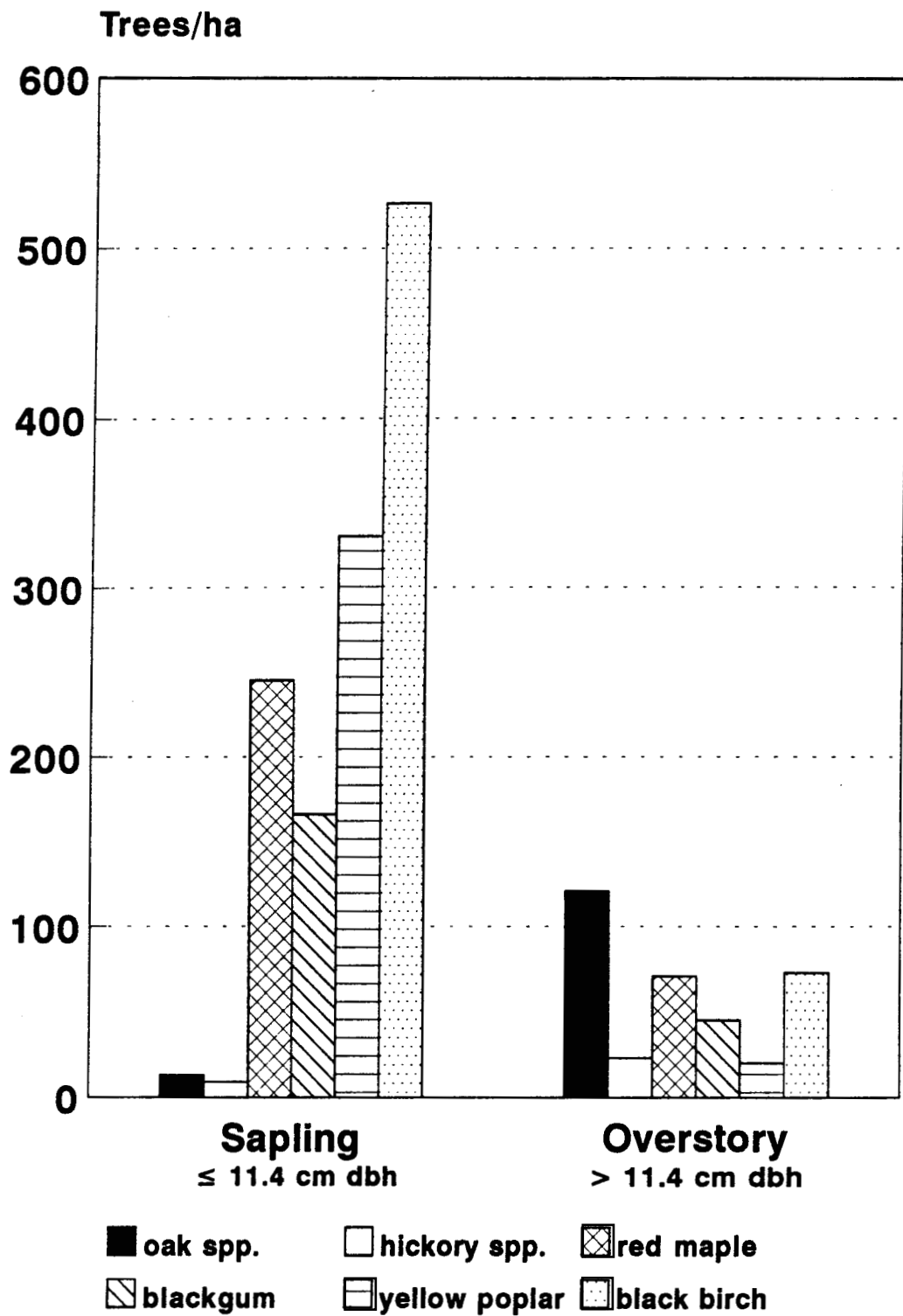


Figure 7. Number of sapling and overstory stems per hectare of selected tree species present in 30 plots measured in the Chestnut Hill stand, Hopewell Furnace National Historic Site, 1991-1992.

Table 3. Number of tree seedlings (≤ 1.5 m in height) per 0.012 hectare and per 1.0 hectare in the Chestnut Hill stand at Hopewell Furnace National Historic Site, 1991-92.

Species	Number per 0.012 ha^a	Number per 1.0 ha
Ash, white	1	83
Beech, American	2	167
Birch, black	74	6,167
Black-gum	8	667
Cherry, wild black	7	583
Hickory, mockernut	1	83
Maple, red	143	11,917
Oak, black	29	2,417
Oak, chestnut	1	83
Oak, pin	4	333
Oak, northern red	1	83
Oak, white	30	2,500
Poplar, yellow	9	750
Sassafras	47	3,917
Total	357	29,750

^aSeedlings were counted in each of 30 2- x 2-m subplots (each nested in the center of a 20- x 20-m plot) totaling 0.012 ha.

combined comprised 34% whereas oak and hickory seedlings combined comprised 10% of the total. The number of black oak and white oak each exceeded 2,400 per ha, whereas the density for each of northern red oak, chestnut oak, and mockernut hickory was less than 90 seedlings per ha (Table 3).

Seedlings - Shrub: Shrub seedlings represented 71% of all seedlings recorded at sampling plots in the Chestnut Hill stand (Table 4). Maple-leaved viburnum, *Vaccinium* spp., and azalea were the most dominant of the eight species of shrub seedlings present in the plots, each with densities greater than 14,000 stems per ha.

The current species composition, number, and size of trees and seedlings give the Chestnut Hill stand a high probability of self maintenance for the next 20 years. There were about 77 seedlings and four saplings present in the stand for every overstory tree. There appears to be adequate numbers of tree species and stems in the understory to replace any losses to the overstory trees. As some overstory trees die or are otherwise lost, there are sufficient numbers of trees to maintain a forested environment with a diversity of native hardwood species.

Table 4. Number of shrub seedlings (≤ 1.5 m in height) per 0.012 hectare and per 1.0 hectare in the Chestnut Hill stand at Hopewell Furnace National Historic Site, 1991-92.

Species	Number per 0.012 ha^a	Number per 1.0 ha
Azalea	173	14,417
Dogwood, flowering	3	250
Rubus spp.	89	7,417
Serviceberry	21	1,750
Spicebush	34	2,833
Vaccinium spp.	223	18,583
Viburnum, maple-leaved	332	27,667
Witch-hazel	2	167
Total	877	73,084

^aSeedlings were counted in each of 30 2- x 2-m subplots (each nested in the center of a 20- x 20-m plot) totaling 0.012 ha.

Mount Pleasure

Trees: Forty percent of the trees at Mount Pleasure were overstory trees whereas the majority (60%) were in the sapling stage (Fig. 8). Black oak, red maple, and chestnut oak were the dominant species in the overstory.

Overstory trees (> 11.4 cm dbh) averaged 420 per ha with a basal area of 25 m^2 per ha (Table 5). The oak and hickory species group accounted for 59% of the overstory trees based on the number of trees per ha (Fig. 9). Red maple accounted for 17%, large-toothed aspen accounted for 10%, and all other species accounted for 14% of the total. The number of overstory trees and basal area values would place the stand in the 93% stocking level, when compared to the standards developed for upland oaks (Dale and Lutz 1986).

Large saplings averaged 611 per ha with a basal area of 2 m^2 per ha (Table 5). Red maple and black-gum were the most abundant species present in the large sapling stage with each comprising 38% of the total. Sassafras represented 10%, and the oak and hickory species group was 8% of the large saplings. Large and small saplings combined averaged 629 per ha (Fig. 8).

The average density of small saplings (≤ 1.4 cm dbh) was 18 per ha based on counts in the 30 plots. Thus, this stratum was not as significant in the woody profile as compared to the Chestnut Hill stand. Wild black cherry (32%) and red maple (23%) were the dominant small saplings counted. Small saplings were present in 9 of 30 plots sampled in the Mount Pleasure stand.

Seedlings - Tree: Eleven species of tree seedlings were counted in the Mount Pleasure stand. Number of seedlings averaged 12,417 per ha (Table 6). Red maple was the most abundant tree seedling species with 34% of the total. Sassafras seedlings comprised 24% of the total and white ash seedlings represented 20%. Oak and hickory had a much lower representation (5%) per ha than was present in the overstory (59%).

Seedlings - Shrub: Shrub seedlings represented 88% of all seedlings recorded at plots in the Mount Pleasure stand (Table 7). *Vaccinium* spp., spicebush, and maple-leaved viburnum were the most dominant of the 13 species of shrub seedlings present in the plots, each with densities $> 13,500$ stems per ha.

The current species composition, number, and size of trees and seedlings indicate that the Mount Pleasure stand has a high probability of self maintenance for the next 20 years. There were about 30 tree seedlings and two saplings present in the stand for every overstory tree. There appears to be adequate numbers of tree species and stems in the understory to replace any losses to the overstory trees. As some overstory trees die or are otherwise lost, there is a sufficient number of trees to maintain a forested environment. The lower number of small saplings (≤ 1.4 cm dbh) in the Mount

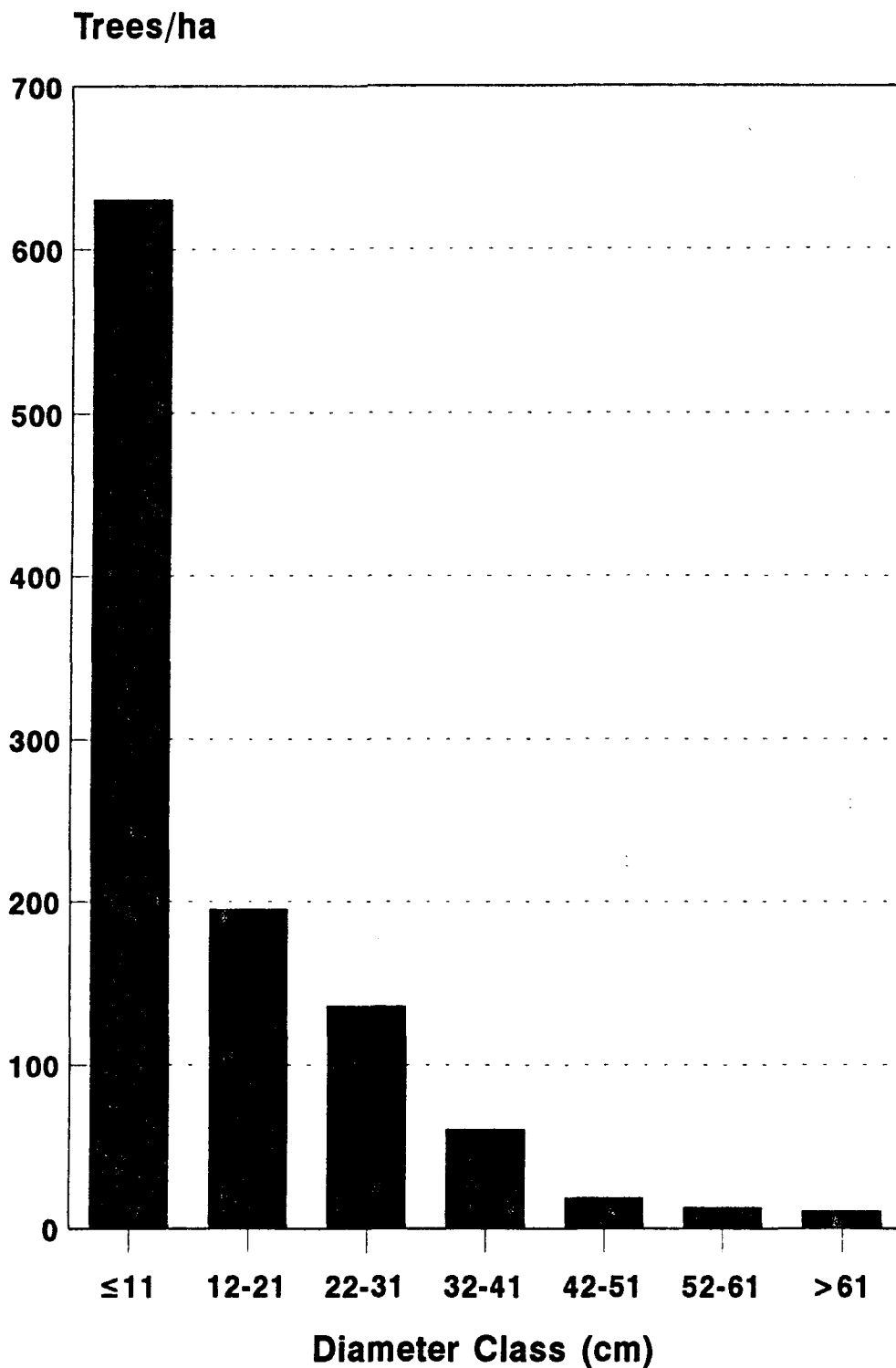


Figure 8. Abundance (trees per ha) by diameter class (cm) of small (≤ 1.4 cm dbh) and large (> 1.4 cm and ≤ 11.4 cm dbh) saplings and overstory (> 11.4 cm dbh) trees in the 30 plots measured in the Mount Pleasure stand, Hopewell Furnace National Historic Site, 1991-1992; in this figure saplings ≤ 11.4 cm dbh were included in the ≤ 11 cm diameter class, and those > 11.4 were included in a diameter class ≥ 12 cm dbh.

Table 5. Density, average diameter at breast height (dbh), and basal area for large saplings (> 1.4 cm and ≤ 11.4 cm dbh) and overstory (> 11.4 cm dbh) trees at the Mount Pleasure stand, Hopewell Furnace National Historic Site, 1991-92.

Unit	Large Saplings	Overstory
Density		
No./ha	611	420
(No./ac)	(247)	(170)
DBH		
cm	6	25
(in)	(2)	(10)
Basal Area		
m²/ha	2	25
(ft²/ac)	(9)	(109)

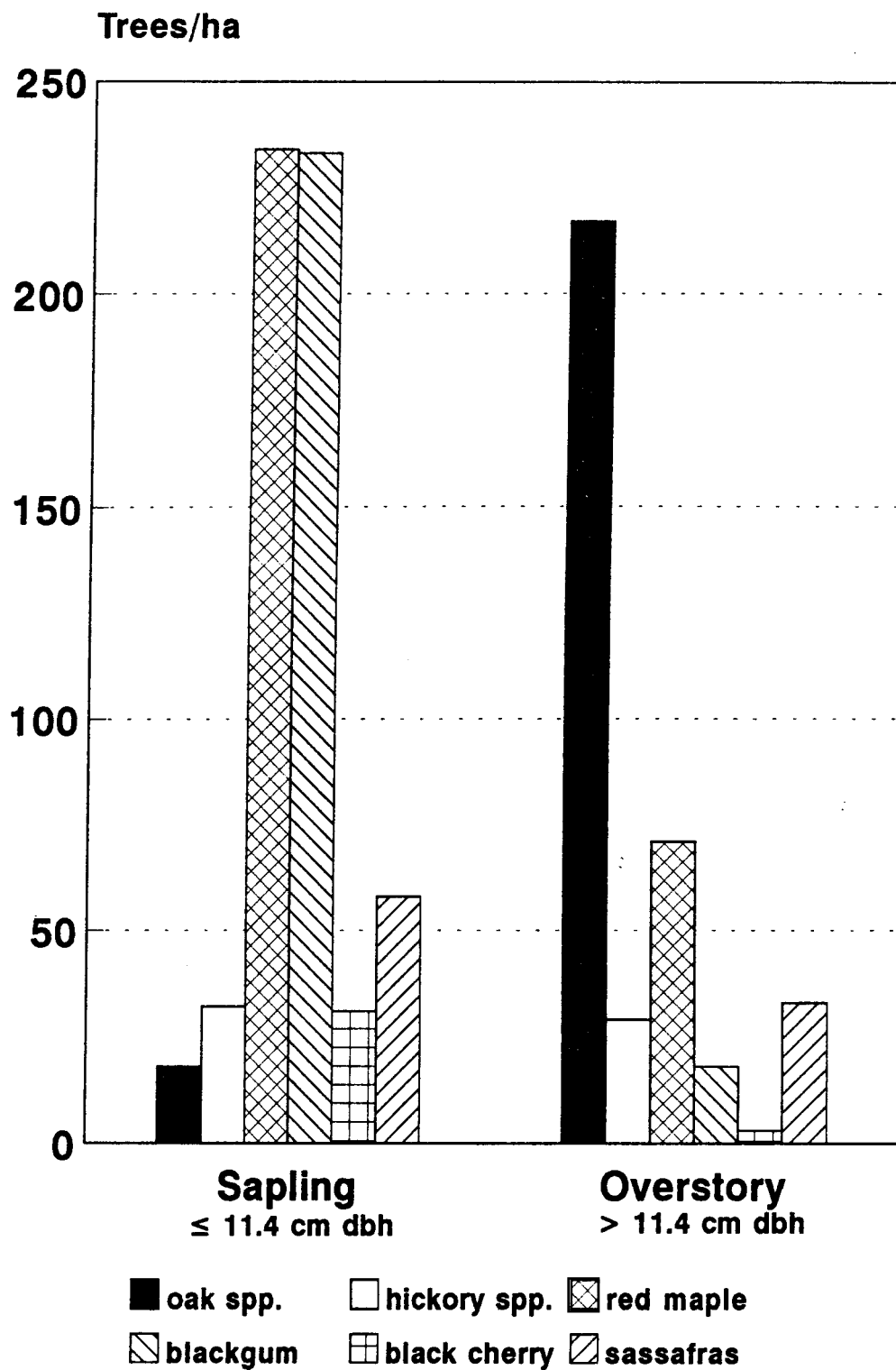


Figure 9. Number of sapling and overstory stems per hectare of selected tree species present in 30 plots measured in the Mount Pleasure stand, Hopewell Furnace National Historic Site, 1991-1992.

Table 6. Number of tree seedlings (≤ 1.5 m in height) per 0.012 hectare and per 1.0 hectare in the Mount Pleasure stand at Hopewell Furnace National Historic Site, 1991-92.

Species	Number per 0.012 ha^a	Number per 1.0 ha
Ash, white	30	2,500
Birch, black	1	83
Black-gum	4	333
Cherry, wild black	8	667
Hemlock, eastern	1	83
Hickory, shagbark	2	167
Maple, red	50	4,167
Oak, black	3	250
Oak, pin	2	167
Poplar, yellow	12	1,000
Sassafras	36	3,000
Total	149	12,417

^aSeedlings were counted in each of 30 2- x 2-m subplots (each nested in the center of a 20- x 20-m plot) totaling 0.012 ha.

Table 7. Number of shrub seedlings (≤ 1.5 m in height) per 0.012 hectare and per 1.0 hectare in the Mount Pleasure stand at Hopewell Furnace National Historic Site, 1991-92.

Species	Number per 0.012 ha^a	Number per 1.0 ha
Arrow-wood, southern	4	333
Barberry, Japanese	5	417
Black-haw	5	417
Dogwood, flowering	1	83
Hawthorn	8	666
Hop-hornbeam	23	1,916
Rhododendron	14	1,166
Rubus spp.	82	6,831
Serviceberry	2	167
Spicebush	271	22,574
Vaccinium spp.	530	44,149
Viburnum, maple-leaved	163	13,578
Witch-hazel	1	83
Total	1,109	92,380

^aSeedlings were counted in each of 30 2- x 2-m subplots (each nested in the center of a 20- x 20-m plot) totaling 0.012 ha.

Pleasure stand compared to the Chestnut Hill stand suggests an increased feeding rate on woody stems by wildlife at the Mount Pleasure stand. However, data are lacking to clarify the interaction between wildlife and the abundance of small woody stems.

Fenced and Unfenced Plots

Chestnut Hill

Trees: Black oak, black birch, black-gum, and red maple were dominant trees in the overstory (Table 8), and black birch, red maple, yellow poplar, and black-gum were dominant large saplings (Table 9) at fenced and unfenced plots in the Chestnut Hill stand. Other species that ranked high were chestnut oak and white oak in the overstory, and sassafras in the large sapling stage. White ash, shagbark hickory, and shellbark hickory and scarlet oak were present in the overstory of the fenced plots but absent in the unfenced plots. Calculated importance values for overstory and large sapling trees (Appendix B) compared favorably with importance values reported by Russell (1987), indicating that the general profile of the stand had not markedly changes between 1987 and 1991-92.

Average dbh and basal area for overstory and large sapling trees combined were not different ($P > 0.05$) between plots with and without fenced 2- x 2-m subplots (Figs. 10, 11). Average dbh was 10.9 cm for both fenced and unfenced plots. Average density of 51.1 trees per fenced plot (0.04 ha) was not different ($P > 0.05$) from an average density of 59.2 trees per unfenced plot. Mean canopy closure was 98% for both fenced and unfenced plots.

Table 8. Average dbh, basal area per hectare, and number of trees per hectare for overstory species (> 11.4 cm dbh) in 15 20- x 20-m plots with a fenced 2- x 2-m subplot^a and 15 20- x 20-m plots with an unfenced 2- x 2-m subplot in the Chestnut Hill stand at Hopewell Furnace National Historic Site, 1991-92.

Species	Fenced plots			Unfenced plots		
	Average dbh (cm)	Basal area (m ² /ha)	Number of trees/ha	Average dbh (cm)	Basal area (m ² /ha)	Number of trees/ha
Ash, white	20	0.1	2	0	0	0
Beech, American	26	0.9	15	20	0.4	12
Birch, black	26	3.3	55	23	4.2	90
Black-gum	20	1.7	48	17	1.1	42
Hickory, mockernut	23	0.3	8	19	0.5	17
Hickory, pignut	22	0.6	15	22	0.5	12
Hickory, shagbark	18	0.1	3	0	0	0
Hickory, shellbark	18	0.04	2	0	0	0
Maple, red	19	2.1	58	18	2.4	83
Oak, black	50	9.2	43	43	11.4	72
Oak, chestnut	31	2.0	25	31	1.7	20
Oak, northern red	44	1.1	7	32	1.0	12
Oak, scarlet	28	0.1	2	0	0	0
Oak, white	43	5.2	32	36	3.4	30

Table 8. (Continued)

Species	Fenced plots			Unfenced plots		
	Average dbh (cm)	Basal area (m ² /ha)	Number of trees/ha	Average dbh (cm)	Basal area (m ² /ha)	Number of trees/ha
Poplar, yellow	53	3.4	13	29	2.4	27
Sassafras	18	0.4	13	17	0.4	17

^aEach fence, 3- x 3-m square and 1.8-m high, enclosed the 2- x 2-m subplot at the center of each plot.

Table 9. Average dbh, basal area per hectare, and number of trees per hectare for large sapling species (> 1.4 and ≤ 11.4 cm dbh) in 15 20- x 20-m plots with a fenced 2- x 2-m subplot^a and 15 20- x 20-m plots with an unfenced 2- x 2-m subplot in the Chestnut Hill stand at Hopewell Furnace National Historic Site, 1991-92.

Species	Fenced plots			Unfenced plots		
	Average dbh (cm)	Basal area (m ² /ha)	Number of trees/ha	Average dbh (cm)	Basal area (m ² /ha)	Number of trees/ha
Ash, white	2	^b	7	0	0	0
Beech, American	6	0.03	8	4	0.02	12
Birch, black	4	0.4	240	4	0.7	403
Black-gum	6	0.3	85	6	0.7	228
Cherry, wild black	3	0.03	38	4	^b	2
Chestnut, American	0	0	0	3	^b	5
Hickory, mockernut	10	0.02	3	6	0.01	3
Hickory, pignut	4	^b	5	4	^b	7
Maple, red	5	0.4	200	6	0.4	148
Oak, black	2	^b	2	3	^b	2
Oak, chestnut	7	0.02	5	5	0.04	12
Oak, northern red	10	0.01	2	0	0	0
Oak, white	6	^b	2	0	0	0

Table 9. (Continued)

Species	Fenced plots			Unfenced plots		
	Average dbh (cm)	Basal area (m ² /ha)	Number of trees/ha	Average dbh (cm)	Basal area (m ² /ha)	Number of trees/ha
Poplar, yellow	3	0.2	265	4	0.2	165
Sassafras	5	0.2	73	4	0.1	62

^aEach fence, 3- x 3-m square and 1.8-m high, enclosed the 2- x 2-m subplot at the center of each plot.

^bValue < 0.01.

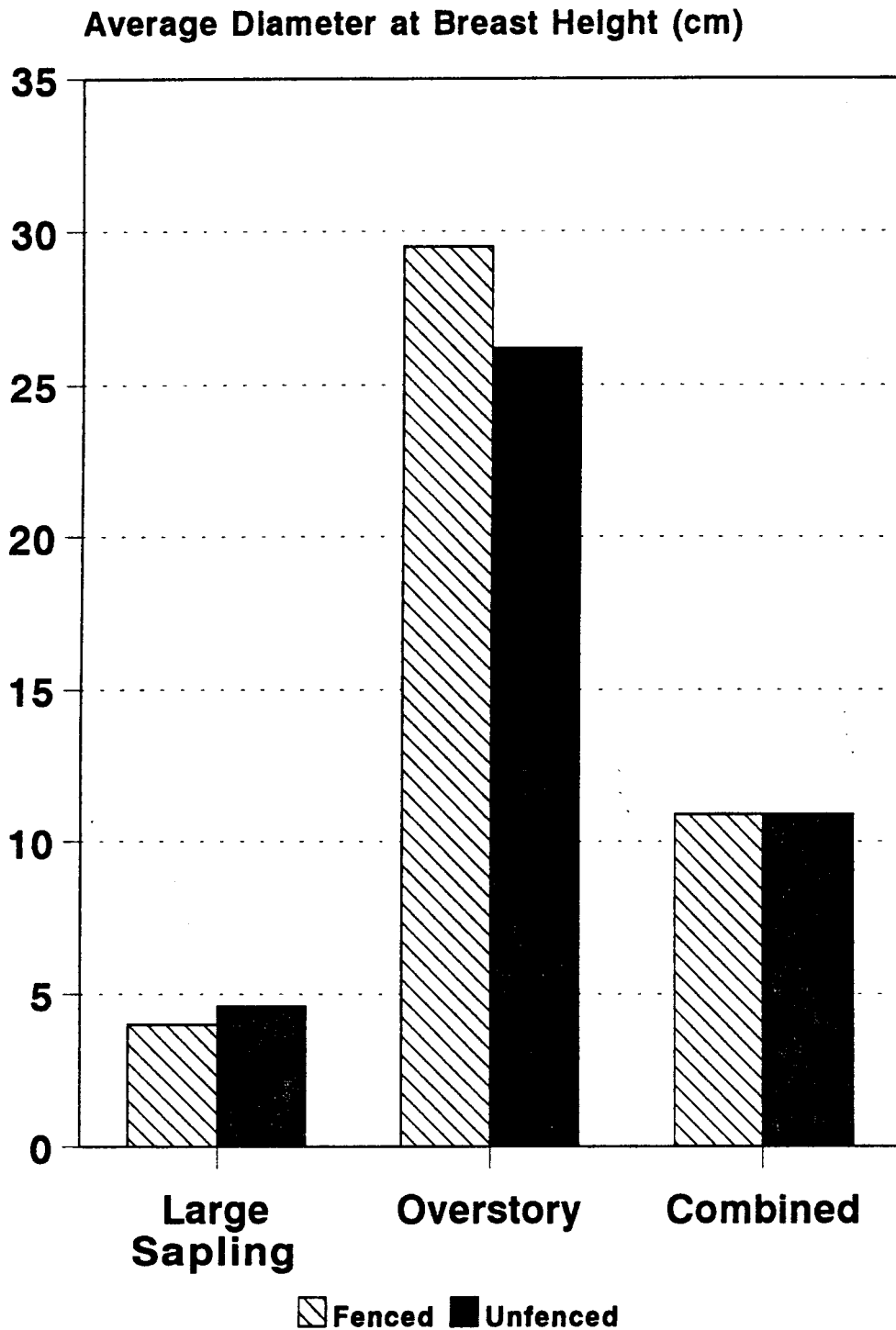


Figure 10. Average diameter at breast height (cm) of large saplings, overstory trees, and large sapling and overstory trees combined for 15 fenced and 15 unfenced plots in the Chestnut Hill stand, Hopewell Furnace National Historic Site, 1991-1992.

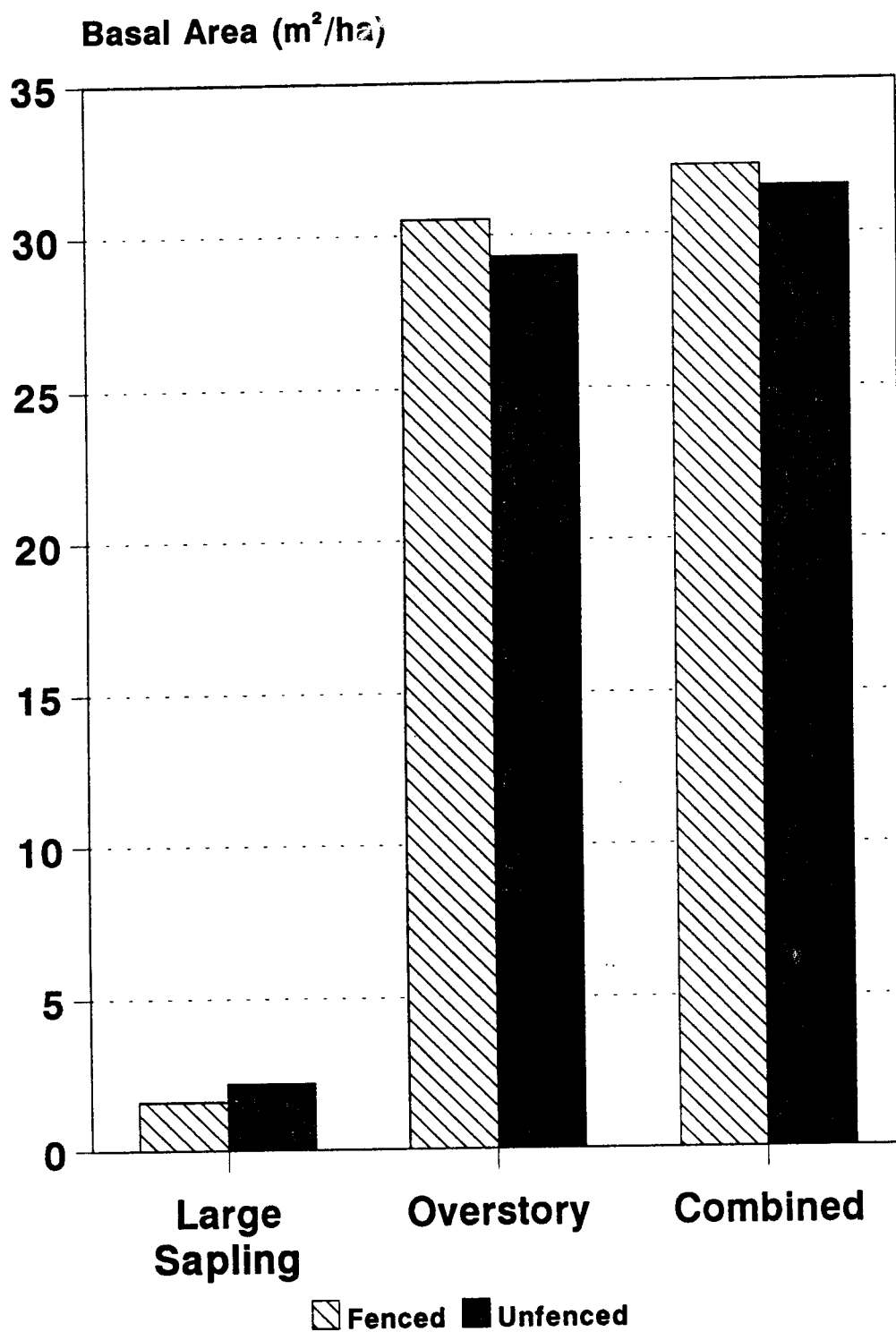


Figure 11. Basal area (m^2/ha) of large saplings, overstory trees, and large sapling and overstory trees combined for 15 fenced and 15 unfenced plots in the Chestnut Hill stand, Hopewell Furnace National Historic Site, 1991-1992.

Thirteen of 15 fenced plots and 15 of 15 unfenced plots in the Chestnut Hill stand contained small saplings. Black birch, yellow poplar, and red maple combined comprised 86% of the small saplings counted. Average density of 16.0 small saplings per fenced plot (0.04 ha) was not different ($P > 0.05$) from an average density of 17.8 small saplings per unfenced plot. Densities ranged from zero to 58 small saplings in the fenced plots and from one to 47 small saplings in the unfenced plots.

Shrubs: Thirteen shrub species were recorded at plots in the Chestnut Hill stand. Shrub coverage was estimated at 14% in each of fenced and unfenced plots. Dominant species included maple-leaved viburnum and *Vaccinium* spp. (Table 10).

Seedlings - Tree: Thirteen species of tree seedlings were recorded at the 15 fenced plots and 10 species were recorded at the 15 unfenced plots in the Chestnut Hill stand (Table 11). Red maple, black birch, sassafras, and white oak were the most abundant species in the fenced plots. Red maple, black oak, and sassafras were the most abundant species in the unfenced plots. The number of stems of black oak was similar in fenced and unfenced plots.

Seedlings - Shrub: Shrub seedlings represented 71% of all seedlings recorded in the fenced and unfenced plots in the Chestnut Hill stand. Maple-leaved viburnum, *Vaccinium* spp., and azalea were the most dominant of the 8 shrub species recorded (Table 12).

The combined number of shrub and tree seedlings did not differ ($P > 0.05$) between fenced and unfenced plots. Mean number of seedlings per plot in the 2- x 2-m fenced plots was 50.7. Mean number of seedlings per plot in the 2- x 2-m unfenced plots was 32.0.

Ground Cover: Litter occupied $> 50\%$ of the ground surface at the forest floor in 26 and 30 of the 30 1- x 1-m subplots sampled in each of the fenced and unfenced plots, respectively, in the Chestnut Hill stand (Tables 13, 14). Leaves were a major component of the litter layer in the 1-25 cm height category, whereas fallen branches and other unrooted woody material contributed to most of the upper height classes.

Fifty-one of 60 1- x 1-m subplots had less than 5% of the ground cover in herbaceous material. Seven of 60 1- x 1-m subplots had herbaceous material > 25 cm in height.

Vine Coverage: Vine coverage was $< 5\%$ in 14 of 15 fenced plots for vines > 2 m high and 15 of 15 fenced plots for vines ≤ 2 m high surveyed in the Chestnut Hill stand (Table 13). In all unfenced plots, vine coverage for both height classes was $< 5\%$ (Table 14).

Table 10. Percent cover for shrub species in 15 20- x 20-m plots, with a fenced 2- x 2-m subplot^a and 15 20- x 20-m plots with an unfenced 2- x 2-m subplot in the Chestnut Hill stand at Hopewell Furnace National Historic Site, 1991-92.^b

Species	Percent cover	
	Fenced plots	Unfenced plots
Arrow-wood, southern	^c	0.0
Azalea	0.0	1.3
Barberry, Japanese	^c	0.0
Black-haw	2.0	0.0
Dogwood, flowering	1.3	1.7
Ribes spp.	0.0	^c
Rhododendron spp.	^c	0.0
Rubus spp.	^c	^c
Serviceberry	^c	^c
Spicebush	3.0	^c
Vaccinium spp.	3.4	5.3
Viburnum, maple-leaved	2.5	5.4
Witch-hazel	2.0	^c

^aEach fence, 3- x 3-m square and 1.8 m high, enclosed the 2- x 2-m subplot at the center of each plot.

^bShrub cover was estimated within two 10- x 10-m subplots in each 20- x 20-m plot.

^cPresent but < 1% coverage.

Table 11. Frequency and total number for 14 species of tree seedlings (≤ 1.5 m in height) in 15 20- x 20-m plots with a fenced 2- x 2-m subplot^a and 15 20- x 20-m plots with an unfenced 2- x 2-m subplot in the Chestnut Hill stand at Hopewell Furnace National Historic Site, 1991-92.

Species	Fenced plots		Unfenced plots	
	Frequency ^b	Total number ^c	Frequency ^b	Total number ^c
Ash, white	1	1	0	0
Beech, American	1	1	1	1
Birch, black	9	65	5	9
Black-gum	4	7	1	1
Cherry, wild black	2	2	3	5
Hickory, mockernut	0	0	1	1
Maple, red	31	98	26	45
Oak, black	7	14	9	15
Oak, chestnut	1	1	0	0
Oak, pin	3	4	0	0
Oak, northern red	1	1	0	0
Oak, white	13	25	4	5
Poplar, yellow	6	7	2	2
Sassafras	17	34	9	13
Total		260		97

^aEach fence, 3- x 3-m square and 1.8-m high, enclosed the 2- x 2-m subplot at the center of each plot.

^bThe number of subplots, each 1 m², which contained the species; there were four subplots for each of 15 plots, for a total of 60 subplots for each of the fenced and unfenced plots.

^cTotal number of woody stems for 60 subplots.

Table 12. Frequency and total number for eight species of shrub seedlings (≤ 1.5 m in height) in 15 20- x 20-m plots with a fenced 2- x 2-m subplot^a and 15 20- x 20-m plots with an unfenced 2- x 2-m subplot in the Chestnut Hill stand at Hopewell Furnace National Historic Site, 1991-92.

Species	Fenced plots		Unfenced plots	
	Frequency ^b	Number ^c	Frequency ^b	Number ^c
Azalea	11	111	15	62
Dogwood, flowering	1	1	2	2
Rubus spp.	21	61	13	28
Serviceberry	1	3	5	18
Spicebush	10	29	4	5
Vaccinium spp.	14	79	20	144
Viburnum, maple-leaved	42	208	33	124
Witch-hazel	1	2	0	0
Total		494		383

^aEach fence, 3- x 3-m square and 1.8-m high, enclosed the 2- x 2-m subplot at the center of each plot.

^bThe number of subplots, each 1 m², which contained the species; there were four subplots for each of 15 plots, for a total of 60 subplots for each of the fenced and unfenced plots.

^cTotal number of woody stems for 60 subplots.

Table 13. The number of subplots classified into seven categories of ground cover percent and seven categories of ground cover height, and percent cover of vines in 15 fenced plots in the Chestnut Hill stand at Hopewell Furnace National Historic Site, 1991-92.^a

Type of Ground Cover	Percent							Maximum height (cm)						
	0 ^b	1-4	5-25	26-50	51-75	76-95	96-100	0	1-25	26-50	51-75	76-100	101-125	126-150
Herbaceous	19	8	1	2	0	0	0	19	9	2	0	0	0	0
Rock/mineral soil	7	12	6	3	0	2	0	7	22	1	0	0	0	0
Litter ^c	0	0	2	2	1	5	20	0	17	4	3	3	3	0
Other woody (live and dead)	1	13	8	6	1	1	0	1	11	5	3	2	5	3
Non-woody	27	3	0	0	0	0	0	27	3	0	0	0	0	0
Vines ≤ 2 m high	14	1	0	0	0	0	0							
Vines > 2 m high	13	1	0	1	0	0	0							

^aHerbaceous, rock/mineral soil, litter, other woody (live and dead), and non-woody cover percentages and maximum height were calculated for 30 1-m² subplots (two for each of the 15 2- x 2-m subplots). Vine coverage was estimated for the 15 2- x 2-m plots.

^bIf the material was present but covered < 1% it was counted in cover class 0 and assigned to its respective height class.

^cLitter includes leaves and other unrooted woody material (e.g. branches) in contact with the forest floor.

Table 14. The number of subplots classified into seven categories of ground cover percent and seven categories of ground cover height, and percent cover of vines in 15 unfenced plots in the Chestnut Hill stand at Hopewell Furnace National Historic Site, 1991-92.^a

Type of Ground Cover	Percent							Maximum height (cm)						
	0 ^b	1-4	5-25	26-50	51-75	76-95	96-100	0	25	26-50	51-75	76-100	101-125	126-150
Herbaceous	14	10	6	0	0	0	0	1	24	3	2	0	0	0
Rock/mineral soil	16	8	6	0	0	0	0	4	25	1	0	0	0	0
Litter ^c	0	0	0	0	2	25	3	0	23	5	0	1	0	1
Combination ^d	29	1	0	0	0	0	0	29	1	0	0	0	0	0
Woody-Live ^e	3	13	12	2	0	0	0	2	13	9	2	1	1	2
Woody-Dead ^e	29	1	0	0	0	0	0	28	0	0	1	1	0	0
Non-woody	30	0	0	0	0	0	0	30	0	0	0	0	0	0
Vines $\leq$ 2 m high	14	1	0	0	0	0	0							
Vines > 2 m high	15	0	0	0	0	0	0							

^aHerbaceous, rock/mineral soil, litter, other woody (live and dead), and non-woody cover percentages and maximum height were calculated for 30 1-m² subplots (two for each of the 15 2- x 2-m subplots). Vine coverage was estimated for the 15 2- x 2-m plots.

^bIf the material was present but covered < 1% it was counted in cover class 0 and assigned to its respective height class.

^cLitter includes leaves and other unrooted woody material (e.g. branches) in contact with the forest floor.

^dThe category "combination" was included in 1992 to account for cases where litter was on top of exposed rock.

^eDuring 1992, the category "other woody" used in 1991 was separated into "live woody" or "dead woody" stems rooted in the soil.

Mount Pleasure

Trees: Black oak, chestnut oak, and red maple were dominant trees in the overstory (Table 15), and red maple, black-gum, and sassafras were dominant large saplings (Table 16) at fenced and unfenced plots in the Mount Pleasure stand. Catalpa and wild black cherry were present in the overstory in the fenced plots but absent in the unfenced plots whereas pin oak, shagbark and shellbark hickory, yellow birch, and scarlet oak were present in the overstory in the unfenced plots but absent in the fenced plots. Calculated importance values for overstory and large sapling trees (Appendix B) compared favorably with importance values reported by Russell (1987), indicating that the general profile of the stand had not changed between 1987 and 1991-92.

Average dbh and basal area for overstory and large sapling trees combined were not different ($P > 0.05$) between plots with and without fenced 2- x 2-m subplots (Figs. 12, 13). Average dbh for fenced plots was 14.4 cm compared to 12.9 cm for the unfenced plots. Average basal area for fenced plots was 28.7 compared to 26.0 for the unfenced plots. Average density for the fenced plots (0.04 ha) was 42.9 trees and was not different ($P > 0.05$) from an average density of 48.3 trees per unfenced plot. Mean canopy closure was 96% for the fenced plots and 93% for the unfenced plots.

Six small saplings were recorded in the fenced plots and 16 were recorded in the unfenced plots at Mount Pleasure. Small sapling densities averaged 10.0 per ha for the fenced plots and 27.7 per ha for the unfenced plots.

Shrubs: Fifteen shrub species were recorded at plots in the Mount Pleasure stand. Shrub coverage was estimated at 43% in the fenced plots and 33% in the unfenced plots. Spicebush, *Vaccinium* spp., flowering dogwood, and *rubus* spp. comprised 83% of the total shrub coverage in the fenced plots and 72% in the unfenced plots (Table 17).

Seedlings - Tree: Eight species of tree seedlings were recorded at the 15 fenced plots and 10 species were recorded at the 15 unfenced plots in the Mount Pleasure stand (Table 18). Red maple, white ash, and sassafras were the most common species recorded. A total of five oak (black and pin) seedlings were counted (Table 18).

Seedlings - Shrub: Shrub seedlings represented 88% of all seedlings recorded in the fenced and unfenced plots at Mount Pleasure. Spicebush and *Vaccinium* spp. were the most abundant shrub seedlings in the fenced plots, whereas *Vaccinium* spp. and maple-leaved viburnum were the most abundant shrub seedlings in the unfenced plots (Table 19).

The combined number of shrub and tree seedlings did not differ ($P > 0.05$) between fenced and unfenced plots. Mean number of seedlings per 2- x 2-m fenced plot was 40.7. Mean number of seedlings per 2- x 2-m unfenced plot was 43.1.

Table 15. Average dbh, basal area per hectare, and number of trees per hectare for overstory species (> 11.4 cm dbh) in 15 20- x 20-m plots with a fenced 2- x 2-m subplot^a and 15 20- x 20-m plots with an unfenced 2- x 2-m subplot in the Mount Pleasure stand at Hopewell Furnace National Historic Site, 1991-92.

Species	Fenced plots			Unfenced plots		
	Average dbh (cm)	Basal area (m ² /ha)	Number of trees/ha	Average dbh (cm)	Basal area (m ² /ha)	Number of trees/ha
Ash, white	31	0.4	5	33	0.1	2
Aspen, large-toothed	29	3.3	50	29	2.0	28
Birch, yellow	0	0	0	14	0.05	3
Black-gum	13	0.1	10	15	0.5	27
Catalpa	13	0.02	2	0	0	0
Cherry, wild black	18	0.2	7	0	0	0
Hickory, mockernut	17	0.8	32	18	0.4	13
Hickory, pignut	18	0.04	2	22	0.2	5
Hickory, shagbark	0	0	0	20	0.1	3
Hickory, shellbark	0	0	0	17	0.08	3
Maple, red	21	3.5	92	18	1.4	50
Oak, black	35	12.2	108	30	12.5	148
Oak, chestnut	24	2.2	45	24	2.9	55
Oak, pin	0	0	0	59	0.5	2
Oak, northern red	34	1.8	17	27	1.1	18
Oak, scarlet	0	0	0	31	0.1	2

Table 15 (Continued)

Species	Fenced plots			Unfenced plots		
	Average dbh (cm)	Basal area (m ² /ha)	Number of trees/ha	Average dbh (cm)	Basal area (m ² /ha)	Number of trees/ha
Oak, white	21	0.7	17	23	1.1	22
Poplar, yellow	34	0.9	7	26	0.09	2
Sassafras	18	0.8	32	16	0.7	33

^aEach fence, 3- x 3-m square and 1.8-m high, enclosed the 2- x 2-m subplot at the center of each plot.

Table 16. Average dbh, basal area per hectare, and number of trees per hectare for large sapling species (> 1.4 and ≤ 11.4 cm dbh) in 15 20- x 20-m plots with a fenced 2- x 2-m subplot^a and 15 20- x 20-m plots with an unfenced 2- x 2-m subplot in the Mount Pleasure stand at Hopewell Furnace National Historic Site, 1991-92.

Species	Fenced plots			Unfenced plots		
	Average dbh (cm)	Basal area (m ² /ha)	Number of trees/ha	Average dbh (cm)	Basal area (m ² /ha)	Number of trees/ha
Ash, white	5	0.03	10	0	0	0
Beech, American	6	0.02	5	4	0.03	18
Birch, black	4	^b	2	6	^b	3
Birch, yellow	8	^b	2	4	^b	3
Black-gum	5	0.6	237	6	0.7	223
Cherry, wild black	5	0.07	25	3	0.03	25
Hickory, mockernut	9	0.1	15	9	0.1	17
Hickory, pignut	7	0.02	3	6	^b	2
Hickory, shagbark	4	0.01	7	8	0.06	10
Hickory, shellbark	7	^b	2	9	0.04	7
Maple, red	6	0.7	188	6	0.8	272
Oak, black	7	0.01	3	9	0.05	8

Table 16 (Continued)

	Fenced plots			Unfenced plots		
	Average dbh (cm)	Basal area (m ² /ha)	Number of trees/ha	Average dbh (cm)	Basal area (m ² /ha)	Number of trees/ha
Oak, chestnut	11	0.03	3	6	0.04	13
Oak, white	0	0	0	9	0.03	5
Sassafras	6	0.2	50	6	0.2	63

^aEach fence, 3- x 3-m square and 1.8-m high, enclosed the 2- x 2-m subplot at the center of each plot.

^bBasal area < 0.01.

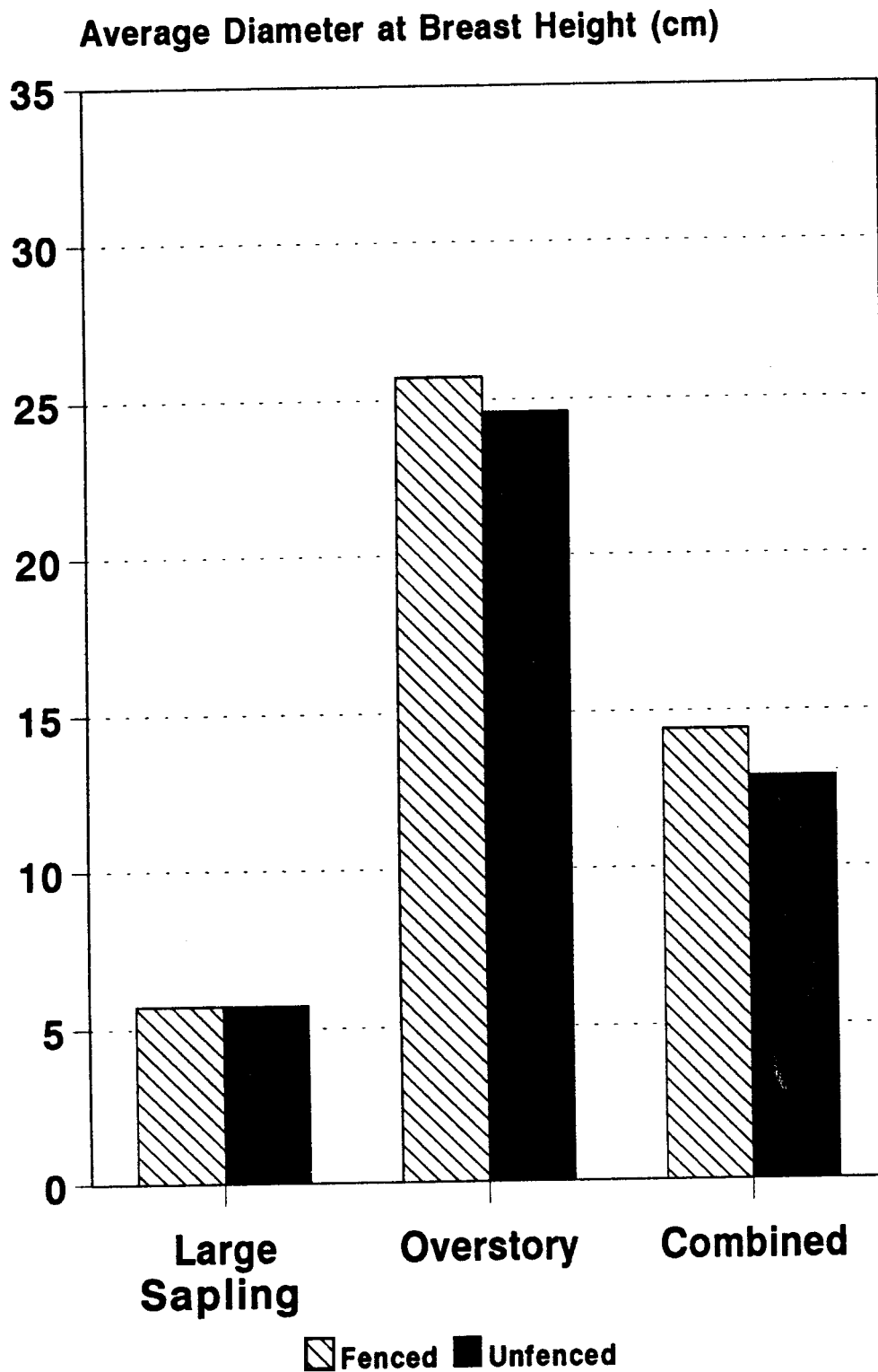


Figure 12. Average diameter at breast height (cm) of large saplings, overstory trees, and large sapling and overstory trees combined for 15 fenced and 15 unfenced plots in the Mount Pleasure stand, Hopewell Furnace National Historic Site, 1991-1992.

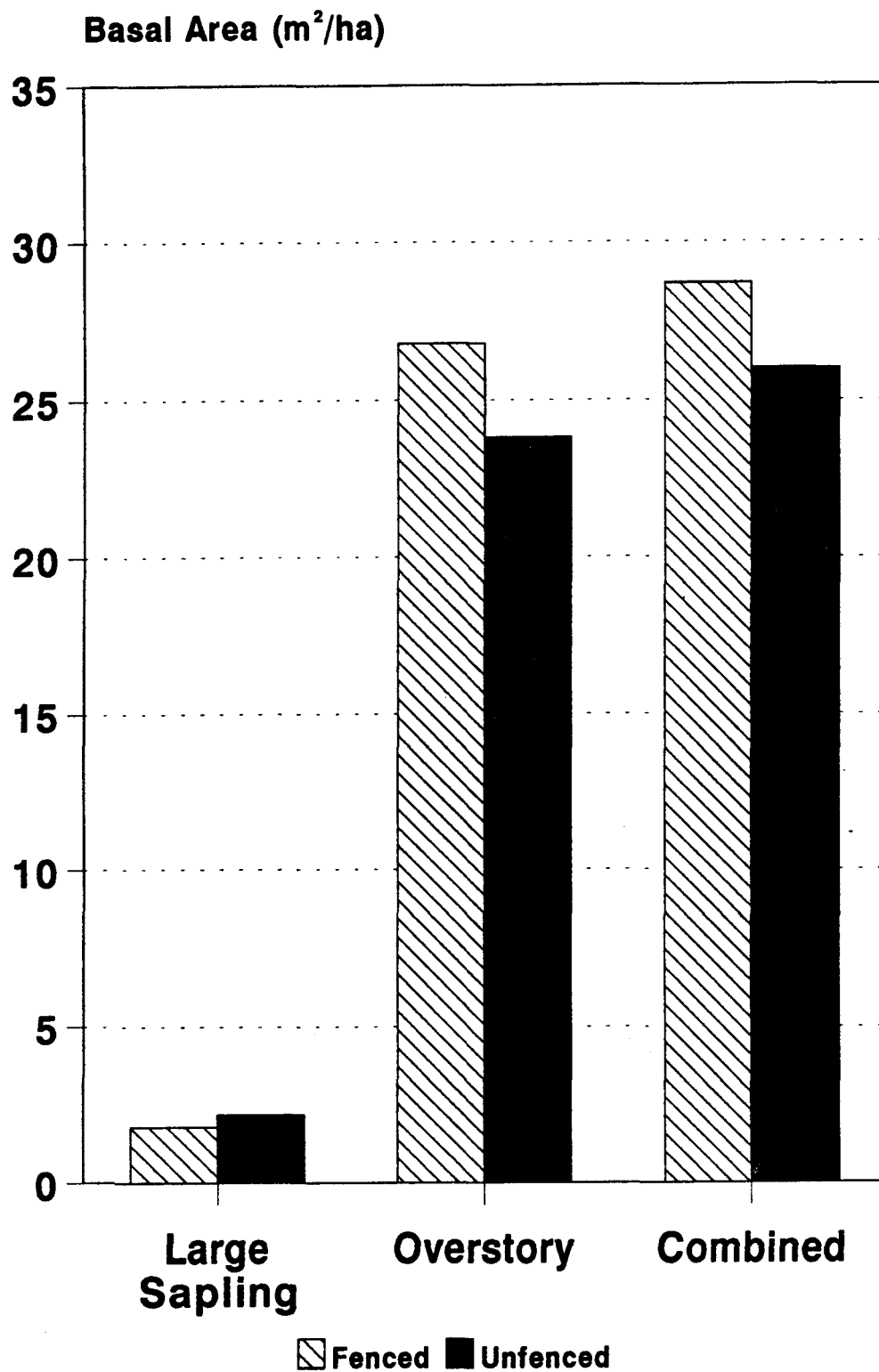


Figure 13. Basal area (m^2/ha) of large saplings, overstory trees, and large sapling and overstory trees combined for 15 fenced and 15 unfenced plots in the Mount Pleasure stand, Hopewell Furnace National Historic Site, 1991-1992.

Table 17. Percent cover for shrub species in 15 20- x 20-m plots, with a fenced 2- x 2-m subplot^a and 15 20- x 20-m plots with an unfenced 2- x 2-m subplot in the Mount Pleasure stand at Hopewell Furnace National Historic Site, 1991-92.^b

Species	Percent Cover	
	Fenced plots	Unfenced plots
Arrow-wood, southern	^c	0.0
Azalea	^c	0.0
Barberry, Japanese	^c	^c
Black-haw	2.0	0.0
Dogwood, flowering	4.4	3.7
Hawthorn	0.0	^c
Hop-hornbeam	3.4	^c
Ribes spp.	0.0	1.5
Rhododendron	0.0	^c
Rubus spp.	4.5	1.0
Serviceberry	0.0	2.6
Spicebush	18.4	5.4
Vaccinium spp.	8.2	13.5
Viburnum, maple-leaved	1.1	2.1
Witch-hazel	1.1	2.7

^aEach fence, 3- x 3-m square and 1.8-m high, enclosed the 2- x 2-m subplot at the center of each plot.

^bShrub cover was estimated within two 10- x 10-m subplots in each 20- x 20-m plot.

^cPresent but < 1% coverage.

Table 18. Frequency and total number for 11 species of tree seedlings (≤ 1.5 m in height) in 15 20- x 20-m plots with a fenced 2- x 2-m subplot^a and 15 20- x 20-m plots with an unfenced 2- x 2-m subplot in the Mount Pleasure stand at Hopewell Furnace National Historic Site, 1991-92.

Species	Fenced plots		Unfenced plots	
	Frequency^b	Number^c	Frequency^b	Number^c
Ash, white	9	28	2	2
Birch, black	0	0	1	1
Black-gum	2	3	1	1
Cherry, wild black	3	3	5	5
Hemlock, Canada	1	1	0	0
Hickory, shagbark	0	0	2	2
Maple, red	11	26	16	24
Oak, black	1	1	1	2
Oak, pin	0	0	2	2
Poplar, yellow	3	7	4	5
Sassafras	5	9	14	27
Total		78		71

^aEach fence, 3- x 3-m square and 1.8-m high, enclosed the 2- x 2-m subplot at the center of each plot.

^bThe number of subplots, each 1 m², which contained the species; there were four subplots for each of 15 plots, for a total of 60 subplots for each of the fenced and unfenced plots.

^cTotal number of woody stems for 60 subplots.

Table 19. Frequency and total number for 13 species of shrub seedlings (≤ 1.5 m in height) in 15 20- x 20-m plots with a fenced 2- x 2-m subplot^a and 15 20- x 20-m plots with an unfenced 2- x 2-m subplot in the Mount Pleasure stand at Hopewell Furnace National Historic Site, 1991-92.

Species	Fenced		Unfenced	
	Frequency ^b	Number ^c	Frequency ^b	Number ^c
Arrow-wood, Southern	3	4	0	0
Barberry, Japanese	3	5	0	0
Black-haw	3	5	0	0
Dogwood, flowering	0	0	1	1
Hawthorn	0	0	3	8
Hop-hornbeam	12	23	0	0
Rhododendron	5	14	0	0
Rubus spp.	14	42	7	40
Serviceberry	0	0	2	2
Spicebush	35	224	12	47
Vaccinium spp.	13	190	47	340
Viburnum, maple-leaved	8	27	27	136
Witch-hazel	0	0	1	1
Total		534		575

^aEach fence, 3- x 3-m square and 1.8-m high, enclosed the 2- x 2-m subplot at the center of each plot.

^bThe number of subplots, each 1 m², which contained the species; there were four subplots for each of 15 plots, for a total of 60 subplots for each of the fenced and unfenced plots.

^cTotal number of woody stems for 60 subplots.

Ground Cover: Litter occupied $> 50\%$ of the ground surface at the forest floor in 28 and 23 of the 30 1- x 1-m subplots sampled in each of the fenced and unfenced plots respectively in the Mount Pleasure stand (Tables 20, 21). Litter was present in all but one plot. Leaves were a major component of the litter layer in the 1-25 cm height category, whereas fallen branches and other unrooted woody material contributed to most of the upper height classes.

Fifty-five of 60 1- x 1-m subplots had $< 26\%$ of the ground cover in herbaceous material. Seven of 60 1- x 1-m subplots had herbaceous material > 25 cm in height.

Vine Coverage: Vine coverage within both height classes was $< 5\%$ in 14 of 15 fenced plots surveyed at Mount Pleasure (Table 20). In unfenced plots, vine coverage within both height classes was $< 5\%$ in 15 of 15 unfenced plots surveyed (Table 21).

Browse Availability and Use

Chestnut Hill

Thirteen of 19 tree and shrub species recorded in the Chestnut Hill stand displayed browse rates $\geq 80\%$ (Table 22). Maple-leaved viburnum (653 stems) had a 96% browse rate and spicebush (119 stems) had a 97% browse rate. Black-gum, red oak, *Rubus* spp., scarlet oak, and white oak all had browse rates of 100%.

Mount Pleasure

Seven of 10 tree and shrub species recorded in the Mount Pleasure stand displayed twig browse rates $> 60\%$ (Table 23). Spicebush, maple-leaved viburnum, and azalea displayed rates $\geq 90\%$.

Table 20. The number of subplots classified into seven categories of ground cover percent and seven categories of ground cover height, and percent cover of vines in 15 fenced plots in the Mount Pleasure stand at Hopewell Furnace National Historic Site, 1991-92.^a

Class	Percent							Maximum height (cm)						
	0 ^b	1-4	5-25	26-50	51-75	76-95	96-100	0	1-25	26-50	51-75	76-100	101-125	126-150
Herbaceous	14	6	7	0	0	2	1	11	13	6	0	0	0	0
Rock/mineral soil	8	11	5	3	3	0	0	8	19	3	0	0	0	0
Litter ^c	0	0	0	2	5	2	21	0	21	3	1	5	0	0
Other woody (live and dead)	4	11	7	3	2	3	0	2	10	3	6	2	2	5
Non-woody	29	1	0	0	0	0	0	29	1	0	0	0	0	0
Vines $\leq$ 2 m high	13	1	1	0	0	0	0							
Vines > 2 m high	14	0	0	1	0	0	0							

^aHerbaceous, rock/mineral soil, litter, other woody (live and dead), and non-woody cover percentages and maximum height were calculated for 30 1-m² subplots (two for each of the 15 2- x 2-m subplots). Vine coverage was estimated for the 15 2- x 2-m plots.

^bIf the material was present but covered < 1% it was counted in cover class 0 and assigned to its respective height class.

^cLitter includes leaves and other unrooted woody material (e.g. branches) in contact with the forest floor.

Table 21. Number of subplots classified into seven categories of ground cover percent and seven categories of ground cover height, and percent cover of vines in 15 unfenced plots in the Mount Pleasure stand at Hopewell Furnace National Historic Site, 1991-92.^a

Type of Ground Cover	Percent												Maximum height (cm)											
	0 ^b	1-4	5-25	26-50	51-75	76-95	96-100							0	1-25	26-50	51-75	76-100	101-125	126-150				
Herbaceous	12	9	7	2	0	0	0	0	0	0	0	4	25	0	1	0	0	0	0					
Rock/mineral soil	16	6	3	5	0	0	0	0	0	0	0	14	16	0	0	0	0	0	0					
Litter ^c	1	0	0	6	13	8	2	1	25	2	0	1	25	2	2	0	0	0	0					
Combination ^d	27	0	3	0	0	0	0	0	0	0	0	27	3	0	0	0	0	0	0					
Woody-Live ^e	2	3	15	9	1	0	0	0	0	0	0	1	5	13	8	0	1	2	2					
Woody-Dead ^e	27	2	1	0	0	0	0	0	0	0	0	27	0	1	0	0	0	2	2					
Non-woody	30	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0					
Vines $\leq$ 2 m high	14	1	0	0	0	0	0	0	0	0	0													
Vines $>$ 2 m high	15	0	0	0	0	0	0	0	0	0	0													

^aHerbaceous, rock/mineral soil, litter, other woody (live and dead), and non-woody cover percentages and maximum height were calculated for 30 1-m² subplots (two for each of the 15 2- x 2-m subplots). Vine coverage was estimated for the 15 2- x 2-m plots.

^bIf the material was present but covered < 1% it was counted in cover class 0 and assigned to its respective height class. ^cLitter includes leaves and other unrooted woody material (e.g. branches) in contact with the forest floor.

^dThe category "combination" was included in 1992 to account for cases where litter was on top of exposed rock.

^eDuring 1992, the category "other woody" used in 1991 was separated into "live woody" or "dead woody" stems rooted in the soil.

Table 22. The number of woody twigs sampled and the percent of woody twigs browsed at 10 browse plots in the Chestnut Hill stand at Hopewell Furnace National Historic Site, 1991-92.

Species	Number sampled	Percent browsed
Azalea	71	99
Beech, American	148	89
Birch, black	43	67
Black-gum	49	100
Black-haw	35	69
Vaccinium spp.	275	60
Cherry, wild black	19	16
Maple, red	155	69
Oak, chestnut	11	91
Oak, northern red	6	100
Oak, scarlet	2	100
Oak, white	5	100
Poplar, yellow	5	80
Rubus, spp.	4	100
Sassafras	19	95
Serviceberry	21	86
Spicebush	119	97
Viburnum, maple-leaved	653	96
Witch-hazel	41	61

Table 23. The number of woody twigs sampled and the percent of woody twigs browsed at nine browse plots in the Mount Pleasure stand at Hopewell Furnace National Historic Site, 1991-92.

Species	Number sampled	Percent browsed
Azalea	36	94
Barberry, Japanese	14	7
Black-gum	9	67
Cherry, wild black	4	50
Oak, black	3	67
Rubus spp.	24	83
Serviceberry	11	0
Spicebush	650	90
Vaccinium spp.	799	68
Viburnum, maple-leaved	216	97

Discussion and Conclusion

One area of concern at HOFU is the lack of regeneration of oak. The present survey indicated a noticeable absence of oak in the sapling stage. Several factors may adversely affect the regeneration of forest stands at HOFU. The lack of light reaching the forest floor is one factor that may adversely affect regeneration. Consistent densiometer readings in the high 90% range indicated a dense canopy that could prevent shade intolerant species (e.g. oak) from surviving.

In addition to the dense canopy, increased competition among seedlings may affect seedling survival. The large number of shrub seedlings recorded in the study plots may pose a problem for regenerating species such as oak. However, data are not available from the present study to draw conclusions about competition among different species of plants in the two stands.

The reasons for the lower density (18 per ha) of small saplings in Mount Pleasure sites compared to that (468 per ha) at Chestnut Hill are not clearly understood. Some of the sites sampled at Mount Pleasure were associated with talus slopes. The greater abundance of rocks at Mount Pleasure and differences between areas in soil conditions and feeding by deer and other wildlife may account for differences in abundance of small saplings between the two areas.

Over the next five to 10 years, resampling of the 60 plots established in the two stands will provide information to determine whether white-tailed deer are a major factor affecting regeneration of species such as oaks and hickories. Data collected from the Chestnut Hill and Mount Pleasure stands indicate stand structure and species composition were similar at fenced and unfenced plots for each area. Similar conditions among fenced and unfenced plots was a desirable condition at the onset of a long-term monitoring program to evaluate the effects of white-tailed deer on forest regeneration at HOFU.

Maintenance and Monitoring Actions

An annual inventory of all plots should be conducted to insure that stakes and aluminum tags remain intact to allow future identification of the study plots. Exclosures can be damaged from falling trees and deer could enter the study plots. Damage to the exclosures could adversely affect the design of the study. Maintenance of the exclosures should be conducted as soon as possible after any damage is detected.

Relocating plots and obtaining repeated measures of vegetative conditions is essential to monitor long-term ecological changes. Russell (1989) provided guidelines for repeating measurements as follows:

- 1. All measurements made during the original survey should be repeated if possible, and checking the condition of witness trees, corner stakes, and condition of exclosures is mandatory.**
- 2. Original measurements and remeasurements should be made during the same season of the year; May and June are preferred months in deciduous forests of eastern United States.**
- 3. A sampling interval of no more than five years is recommended, but measurements taken over a longer interval are still worthwhile for long-term monitoring.**
- 4. Frequent (annual and semi-annual) measurements are recommended for plant communities in early successional stages.**

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Appendix A. Common and scientific names of trees and shrubs referred to in the present report; trees defined as having a persistent woody stem, usually with a single stem, and commonly classified into seedling, sapling, pole, and sawtimber categories based on height and diameter at breast height (1.37 m); shrubs defined as having a persistent woody stem with relatively low growth form as compared to trees, and usually with multiple basal stems opposed to a single stem (see Petrides 1958).

Appendix A

Common Name ^a	Scientific Name ^a
Arrow-wood, southern	<i>Viburnum dentatum</i> †
Ash, white	<i>Fraxinus americana</i> †
Aspen, large-toothed	<i>Populus grandidentata</i> †
Azalea spp.	<i>Rhododendron</i> spp.‡
Barberry, Japanese	<i>Berberis thunbergii</i> ‡
Beech, American	<i>Fagus grandifolia</i> †
Birch	<i>Betula</i> spp.†
black	<i>Betula lenta</i> †
yellow	<i>Betula alleghaniensis</i> †
Blackberry, raspberry	<i>Rubus</i> spp.‡
Black-gum	<i>Nyssa sylvatica</i> †
Black-haw	<i>Viburnum prunifolium</i> †
Blueberry	<i>Vaccinium</i> spp.‡
Catalpa	<i>Catalpa speciosa</i> †
Cherry, wild black	<i>Prunus serotina</i> †
Chestnut, American	<i>Castanea dentata</i> †
Dogwood, flowering	<i>Cornus florida</i> †
Gooseberry	<i>Ribes</i> spp.‡
Hawthorn	<i>Crataegus</i> spp.†
Hemlock, Canada	<i>Tsuga canadensis</i> †
Hickory	<i>Carya</i> spp.†
mockernut	<i>Carya tomentosa</i> †
pignut	<i>Carya glabra</i> †
shagbark	<i>Carya tomentosa</i> †
shellbark	<i>Carya laciniosa</i> †

Appendix A. (Continued).

Common Name	Scientific Name
Hop-hornbeam	<i>Ostrya virginiana</i> [†]
Maple, red	<i>Acer rubrum</i> ^T
Oak	<i>Quercus</i> spp. ^T
black	<i>Quercus velutina</i> ^T
chestnut	<i>Quercus montana</i> ^T
Northern red	<i>Quercus rubra</i> ^T
pin	<i>Quercus palustris</i> ^T
scarlet	<i>Quercus coccinea</i> ^T
white	<i>Quercus alba</i> ^T
Poplar, yellow	<i>Liriodendron tulipifera</i> ^T
Rhododendron	<i>Rhododendron</i> spp. [‡]
Sassafras	<i>Sassafras albidum</i> ^T
Serviceberry	<i>Amelanchier arborea</i> [†]
Spicebush	<i>Lindera benzoin</i> [‡]
Viburnum, maple-leaved	<i>Viburnum acerifolium</i> [‡]
Witch-hazel	<i>Hamamelis virginiana</i> [‡]

^aNomenclature follows that of Rhoads and Klein (1993).

^T = Tree.

[†] = Growth form may be typical of small tree but classified as shrub for this report.

[‡] = Shrub.

Appendix B. Importance values for overstory and large sapling trees for Chestnut Hill and Mount Pleasure stands, Hopewell Furnace National Historic Site.

Table B1. Frequency, average dbh, basal area, number of trees, relative frequency (RF), relative dominance (RC), relative density (RD), and importance value (IV) for 16 overstory tree species (> 11.4 cm dbh) based on the combined data for 15 plots with fenced 2- x 2-m subplots in the Chestnut Hill stand at Hopewell Furnace National Historic Site, 1991-92.^a

Species	Freq- uency ^b	Average dbh (cm)	Basal area (cm ²)	Number of trees	RF	RC	RD	IV
Oak, black	21	50	55,427	26	0.14	0.30	0.11	0.55
Birch, black	20	26	19,584	33	0.13	0.11	0.17	0.41
Maple, red	25	19	12,359	35	0.17	0.07	0.17	0.41
Oak, white	13	43	31,222	19	0.09	0.17	0.08	0.34
Black-gum	19	20	10,387	29	0.13	0.06	0.14	0.33
Oak, chestnut	10	31	12,194	15	0.07	0.07	0.08	0.22
Poplar, yellow	8	53	20,509	8	0.05	0.11	0.03	0.19
Beech, American	6	26	5,449	9	0.04	0.03	0.06	0.13
Hickory, pignut	8	22	3,578	9	0.05	0.02	0.06	0.13
Oak, northern red	4	44	6,571	4	0.03	0.04	0.02	0.09
Sassafras	8	18	2,289	8	0.05	0.01	0.03	0.09
Hickory, mockernut	4	23	2,070	5	0.03	0.01	0.02	0.06
Ash, white	1	20	314	1	c	c	c	0.02
Hickory, shagbark	2	18	534	2	0.01	c	c	0.02
Hickory, shellbark	1	18	255	1	c	c	c	0.02
Oak, scarlet	1	28	616	1	c	c	c	0.02

^aTotal area for 15 plots was 0.6 ha.

^bThe number of subplots, each 100 m², that contained the species; there were four subplots for each of the 15 plots, for a total of 60 subplots.

^cValue was < 0.01.

Table B2. Frequency, average dbh, basal area, number of trees, relative frequency (RF), relative dominance (RC), relative density (RD), and importance value (IV) for 12 overstory tree species (> 11.4 cm dbh) based on the combined data for 15 plots with unfenced 2- x 2-m subplots in the Chestnut Hill stand at Hopewell Furnace National Historic Site, 1991-92.^a

Species	Freq- uency ^b	Average dbh (cm)	Basal area (cm ²)	Number of trees	RF	RC	RD	IV
Oak, black	31	43	68,288	43	0.18	0.39	0.16	0.73
Birch, black	30	23	25,484	54	0.17	0.15	0.21	0.53
Maple, red	31	18	14,287	50	0.18	0.08	0.19	0.45
Oak, white	13	36	20,131	18	0.08	0.11	0.07	0.26
Black-gum	16	17	6,335	25	0.09	0.04	0.09	0.22
Poplar, yellow	9	29	14,476	16	0.05	0.08	0.07	0.20
Oak, chestnut	11	31	10,064	12	0.06	0.06	0.05	0.17
Hickory, mockernut	8	19	3,246	10	0.05	0.02	0.05	0.12
Sassafras	9	17	2,416	10	0.05	0.01	0.05	0.11
Oak, northern red	6	32	6,258	7	0.04	0.04	0.02	0.10
Hickory, pignut	5	22	2,794	7	0.03	0.02	0.02	0.07
Beech, American	3	20	2,415	7	0.02	0.01	0.02	0.05

^aTotal area for 15 plots was 0.6 ha.

^bThe number of subplots, each 100 m², that contained the species; there were four subplots for each of the 15 plots, for a total of 60 subplots.

Table B3. Frequency, average dbh, basal area, number of trees, relative frequency (RF), relative dominance (RC), relative density (RD), and importance value (IV) for 14 large sapling tree species (> 1.4 cm and ≤ 11.4 cm dbh) based on the combined data for 15 plots with fenced 2- x 2-m subplots in the Chestnut Hill stand at Hopewell Furnace National Historic Site, 1991-92.^a

Species	Freq- uency ^b	Average dbh (cm)	Basal area (cm ²)	Number of trees	RF	RC	RD	IV
Birch, black	42	4	2,225	144	0.27	0.23	0.22	0.72
Maple, red	34	5	2,654	120	0.22	0.28	0.22	0.72
Poplar, yellow	18	3	1,442	159	0.12	0.15	0.32	0.59
Black-gum	26	6	1,589	51	0.16	0.17	0.10	0.43
Sassafras	18	5	959	44	0.12	0.10	0.08	0.30
Cherry, wild black	5	3	152	23	0.03	0.02	0.04	0.09
Beech, American	3	6	195	5	0.02	0.02	c	0.05
Hickory, mockernut	2	10	142	2	0.01	0.02	c	0.03
Hickory, pignut	3	4	45	3	0.02	c	c	0.03
Ash, white	2	2	17	4	0.01	c	c	0.02
Oak, chestnut	1	7	117	3	c	0.01	c	0.02
Oak, northern red	1	10	79	1	c	c	c	0.02
Oak, black	1	2	3	1	c	c	c	0.01
Oak, white	1	6	28	1	c	c	c	0.01

^aTotal area for 15 plots was 0.6 ha.

^bThe number of subplots, each 100 m², that contained the species; there were four subplots for each of the 15 plots, for a total of 60 subplots.

^cValue was < 0.01 .

Table B4. Frequency, average dbh, basal area, number of trees, relative frequency (RF), relative dominance (RC), relative density (RD), and importance value (IV) for 12 large sapling tree species (> 1.4 cm and ≤ 11.4 cm dbh) based on the combined data for 15 plots with unfenced 2- x 2-m subplots in the Chestnut Hill stand at Hopewell Furnace National Historic Site, 1991-92.^a

Species	Freq- uency ^b	Average dbh (cm)	Basal area (cm ²)	Number of trees	RF	RC	RD	IV
Birch, black	48	4	3,917	242	0.26	0.30	0.36	0.92
Black-gum	39	6	4,267	137	0.21	0.32	0.18	0.71
Maple, red	36	6	2,663	89	0.19	0.20	0.18	0.57
Poplar, yellow	18	4	1,171	99	0.10	0.09	0.18	0.37
Sassafras	22	4	744	37	0.12	0.06	0.06	0.24
Beech, American	7	4	106	7	0.04	c	c	0.06
Oak, chestnut	6	5	229	7	0.03	0.02	c	0.06
Hickory, pignut	3	4	54	4	0.02	c	c	0.03
Chestnut, American	2	3	30	3	0.01	c	c	0.02
Hickory, mockernut	2	6	63	2	0.01	c	c	0.02
Cherry, wild black	1	4	13	1	c	c	c	0.01
Oak, black	1	3	7	1	c	c	c	0.01

^aTotal area for 15 plots was 0.6 ha.

^bThe number of subplots, each 100 m², that contained the species; there were four subplots for each of the 15 plots, for a total of 60 subplots.

^cValue was < 0.01.

Table B5. Frequency, average dbh, basal area, number of trees, relative frequency (RF), relative dominance (RC), relative density (RD), and importance value (IV) for 14 overstory tree species (> 11.4 cm dbh) based on combined data for 15 plots with fenced 2- x 2-m subplots in the Mount Pleasure stand at Hopewell Furnace National Historic Site, 1991-92.^a

Species	Freq- uency ^b	Average dbh (cm)	Basal area(cm ²)	Number of trees	RF	RC	RD	IV
Oak, black	34	35	73,188	65	0.23	0.45	0.24	0.92
Maple, red	27	21	20,794	55	0.18	0.13	0.21	0.52
Oak, chestnut	16	24	13,053	27	0.11	0.08	0.12	0.31
Aspen, large-toothed	9	29	19,520	30	0.06	0.12	0.12	0.30
Hickory, mockernut	17	17	4,551	19	0.11	0.03	0.07	0.21
Sassafras	12	18	4,934	19	0.08	0.03	0.07	0.18
Oak, northern red	8	34	10,989	10	0.05	0.07	0.05	0.17
Oak, white	9	21	3,960	10	0.06	0.03	0.05	0.14
Poplar, yellow	3	34	5,217	4	0.02	0.03	0.02	0.07
Black-gum	5	13	778	6	0.03	c	0.02	0.06
Cherry, wild black	3	18	1,308	4	0.02	c	0.02	0.05
Ash, white	2	31	2,565	3	0.01	0.02	0.01	0.04
Hickory, pignut	1	18	255	1	c	c	c	0.02
Catalpa	1	13	133	1	c	c	c	0.01

^aTotal area for 15 plots was 0.6 ha.

^bThe number of subplots, each 100 m², that contained the species; there were four subplots for each of the 15 plots, for a total of 60 subplots.

^cValue was < 0.01.

Table B6. Frequency, average dbh, basal area, number of trees, relative frequency (RF), relative dominance (RC), relative density (RD), and importance value (IV) for 17 overstory tree species (> 11.4 cm dbh) based on combined data for 15 plots with unfenced 2- x 2-m subplots in the Mount Pleasure stand at Hopewell Furnace National Historic Site, 1991-92.^a

Species	Freq- uency ^b	Average dbh (cm)	Basal area(cm ²)	Number of trees	RF	RC	RD	IV
Oak, black	44	30	75,168	89	0.28	0.52	0.42	1.22
Oak, chestnut	21	24	17,250	33	0.13	0.12	0.13	0.38
Maple, red	18	18	8,661	30	0.11	0.06	0.11	0.28
Aspen, large-toothed	10	29	12,058	17	0.06	0.08	0.06	0.20
Sassafras	15	16	4,343	20	0.10	0.03	0.06	0.19
Black-gum	12	15	2,771	16	0.08	0.02	0.06	0.16
Oak, northern red	9	27	6,821	11	0.06	0.05	0.04	0.15
Oak, white	10	23	6,442	13	0.06	0.05	0.04	0.15
Hickory, mockernut	6	18	2,265	8	0.04	0.02	0.02	0.08
Hickory, pignut	3	22	1,305	3	0.02	c	0.01	0.04
Oak, pin	1	59	2,734	1	c	0.02	c	0.03
Ash, white	1	33	855	1	c	c	c	0.02
Birch, yellow	2	14	310	2	0.01	c	c	0.02
Hickory, shagbark	2	20	654	2	0.01	c	c	0.02
Hickory, shellbark	2	17	460	2	0.01	c	c	0.02
Poplar, yellow	1	26	531	1	c	c	c	0.02
Oak, scarlet	1	31	755	1	c	c	c	0.02

^aTotal area for 15 plots was 0.6 ha.

^bThe number of subplots, each 100 m², that contained the species; there were four subplots for each of the 15 plots, for a total of 60 subplots.

^cValue was < 0.01.

Table B7. Frequency, average dbh, basal area, number of trees, relative frequency (RF), relative dominance (RC), relative density (RD), and importance value (IV) for 14 large sapling tree species (> 1.4 cm and ≤ 11.4 cm dbh) based on the combined data for 15 plots with fenced 2- x 2-m subplots in the Mount Pleasure stand at Hopewell Furnace National Historic Site, 1991-92.^a

Species	Freq- uency ^b	Average dbh (cm)	Basal area (cm ²)	Number of trees	RF	RC	RD	IV
Maple, red	29	6	4,092	113	0.28	0.39	0.37	1.04
Black-gum	24	5	3,614	142	0.24	0.35	0.37	0.96
Sassafras	15	6	986	30	0.15	0.09	0.09	0.33
Cherry, wild black	9	5	422	15	0.09	0.04	0.06	0.19
Hickory, mockernut	6	9	575	9	0.06	0.06	0.04	0.16
Ash, white	3	5	182	6	0.03	0.02	0.02	0.07
Hickory, shagbark	4	4	57	4	0.04	c	0.01	0.06
Beech, American	3	6	98	3	0.03	c	c	0.05
Oak, chestnut	2	11	174	2	0.02	0.02	c	0.05
Hickory, pignut	2	7	91	2	0.02	c	c	0.04
Oak, black	2	7	79	2	0.02	c	c	0.03
Birch, black	1	4	13	1	0.01	c	c	0.02
Birch, yellow	1	8	50	1	0.01	c	c	0.02
Hickory, shellbark	1	7	39	1	0.01	c	c	0.02

^aTotal area for 15 plots was 0.6 ha.

^bThe number of subplots, each 100 m², that contained the species; there were four subplots for each of the 15 plots, for a total of 60 subplots.

^cValue was < 0.01 .

Table B8. Frequency, average dbh, basal area, number of trees, relative frequency (RF), relative dominance (RC), relative density (RD), and importance value (IV) for 14 large sapling tree species (> 1.4 cm and ≤ 11.4 cm dbh) based on the combined data for 15 plots with unfenced 2- x 2-m subplots in the Mount Pleasure stand at Hopewell Furnace National Historic Site, 1991-92.^a

Species	Freq- uency ^b	Average dbh (cm)	Basal area (cm ²)	Number of trees	RF	RC	RD	IV
Maple, red	42	6	4,780	163	0.28	0.38	0.44	1.10
Black-gum	36	6	3,989	134	0.24	0.32	0.30	0.86
Sassafras	24	6	1,338	38	0.16	0.11	0.09	0.36
Hickory, mockernut	9	9	697	10	0.06	0.06	0.03	0.15
Beech, American	7	4	181	11	0.05	0.01	0.03	0.09
Cherry, wild black	6	3	157	15	0.04	0.01	0.04	0.09
Oak, chestnut	7	6	258	8	0.05	0.02	0.02	0.09
Hickory, shagbark	4	8	333	6	0.03	0.03	0.02	0.08
Hickory, shellbark	4	9	256	4	0.03	0.02	0.01	0.06
Oak, black	3	9	317	5	0.02	0.03	0.01	0.06
Oak, white	3	9	196	3	0.02	0.02	^c	0.05
Birch, black	2	6	48	2	0.01	^c	^c	0.02
Birch, yellow	2	4	23	2	^c	^c	^c	0.01
Hickory, pignut	1	6	28	1	^c	^c	^c	0.01

^aTotal area for 15 plots was 0.6 ha.

^bThe number of subplots, each 100 m², that contained the species; there were four subplots for each of the 15 plots, for a total of 60 subplots.

^cValue was < 0.01 .



As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.