

FINAL REPORT

VEGETATION STUDY
HOPEWELL FURNACE NATIONAL HISTORIC SITE

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March 1987

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4-28211 DI-NPS-Hopewell Village (Psuty/Russell)

Hopewell Furnace Vegetation Report: Errata
March 1, 1988

Throughout, change "green ash" to "white ash" and change references to the "American elm" forest type to "slippery elm" forest type, and all references to the elms in this type to slippery elm. Most other elms referred to in the report are not identified to species, and are either American elm or slippery elm. The specific changes are listed below.

On the vegetation map (Figure 2), on the first page, the area between Route 345 and French Creek on the northwest side of the road is red maple- sycamore forest type. On the second page in the lower righthand corner, there is a small triangular piece which should be white ash- tulip poplar forest type, and correct names of forest types.

Detailed Corrections

Change "green ash" to "white ash":

pages ii, iii, iv (l. 15), 12 (para. 2, l. 2; para. 3, l. 8), 13 (Type name; l. 1 under type name), 14 (ll. 2-3; under "Black Walnut Type, l. 2; last para., ll. 5-6), 15 (para. 3, ll. 10-11), 17 (para. 2, l. 3), 20 (l. 2)

Change "Fraxinus pennsylvanicum" to "Fraxinus americana":

page 10 (para. 5, l. 2

Change "American elm" to "elm":

pages 12 (para. 2, l. 1), 13 (para. 3, l. 7), 15 (para. 3, l. 10).

Change "American elm" to "slippery elm":

pages ii, iii, iv (l. 16), 13 (last heading), 16 (para. 3, l. 3), 17 (para. 2, l. 5), 18 (next to last line).

Change "Ulmus americana" to "Ulmus sp.":

page 11 (under "high density red maple, line 8)

Fix the following:

page 13, last para., l. 1: after the comma, "slippery elm (Ulmus rubra), at least, is a common ... Hopewell Furnace, and slippery elm trees ..."

page 18, para. 2, l. 6: after "saplings", add ",probably American elm,".

Tables: replace Fraxinus pennsylvanicum or Ulmus americana as follows:

1. page 29, Fraxinus americana

page 30, Ulmus sp.

2. page 31, Fraxinus americana

page 32, Ulmus glabra (Ulmus sp. in red maple-arrowwood type)

Tables 3 - 13, Frax. penns. to Frax. amer.

Table 3, Ulmus glabra

Correct titles for Tables 12 and 13

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SUMMARY

A forest cover map and a species list were prepared for Hopewell Furnace National Historic Site. Forests in areas previously cut for charcoal are dominated by several species of oaks. In the northern part of the park, scarlet, black and white oaks are the large canopy dominants although sweet birch, tulip poplar and red maple trees are more numerous. Sweet birch, tulip poplar and red maple saplings, plus blackgum and flowering dogwood, dominate the sapling stratum. Oak forests elsewhere in the park differ in the proportional representation of oak species, by the absence of sweet birch, and by the presence of yellow birch. Forested areas that were formerly agricultural fields have a much larger proportion of tulip poplar trees, or, in wet areas, red maple, to the virtual exclusion of other species in young successional stands. Some old field successional stands differ from this pattern; one is dominated by green ash and tulip poplar and another by American elm. Still others have fairly dense stands of red cedar. The forests adjacent to developed areas include large numbers of black walnut trees. Older swamp forests have an open canopy consisting primarily of red maple, with a dense cover of shrubs, such as spicebush, arrowwood and winterberry. Swamp forests along French Creek also include large old sycamore trees.

No federal or state threatened or endangered species were found. Non-native species are common in the developed areas and pastures, and are spreading aggressively along some field borders. Within the woods non-native species were primarily found in young successional stands and on old charcoal hearths.

ACKNOWLEDGMENTS

I would especially like to thank Erin McCarthy and Matthew Hayes for their assistance in the field, and Glenn Matlack, Division of Pinelands Research, Center for Coastal and Environmental Studies, for assistance in the field, advice on the project, and review of this report. The staff at Hopewell Furnace National Historic Site was very helpful throughout the project, especially Lee Boyle and John Apel. I also appreciate the assistance of the staff at Rutgers' Center for Coastal and Environmental Studies, especially the cartographers under the direction of Michael Siegel. Dr. Alfred E. Schuyler spent many hours compiling the flora of the site, and offered invaluable floristic advice to me as well. French Creek State Park provided us with free camping during the project; we were very appreciative of the lovely and quiet campground.

INTRODUCTION

Hopewell Furnace National Historic Site includes 350 ha (848 acres) of rolling countryside in eastern Pennsylvania. About three-fourths of the land is forested, with secondary and other disturbed forests (Hopewell Village NHS 1979). The site is located in the forest zone described as Appalachian Oak (Küchler 1964) or oak-chestnut (Braun 1950). Extensive and intensive changes in the forests throughout this zone following European colonization in the 18th century have included repeated logging and loss of a former dominant forest species, American chestnut (Castanea dentata), to an introduced disease. In some parts of the forest region, composition has been altered by these disturbances to include more sweet birch (Betula lenta) and/or red maple (Acer rubrum) than before, and such forests are still changing after the disturbances (Russell 1979, Watts 1979). In addition, a changing fire regime in the post-colonial period may have affected forest composition, especially the increase in fire frequency associated with the 19th century logging operations and near railroads, and the decrease in the 20th century due to improved fire-fighting techniques.

The forested landscape was an integral part of the Hopewell furnace operation in the late 18th and the 19th centuries, providing charcoal to fuel the furnace and agricultural products and grazing for the animals used in the furnace operation. Abandonment of the charcoaling industry and much of the farmland from the late 19th century to the present initiated secondary successional changes in the vegetation which have continued to the present. The present vegetation retains keys to its former use and to its future condition, so that analysis of present forest composition provides information to reconstruct the past and tentatively to predict changes in the future.

This report provides a forest cover map of the National Historic Site, with descriptions of each cover type and an analysis of factors responsible for the differences among the types. A species list is also included. The report includes a discussion of the general locations of the introduced and native species, interesting questions raised by the mapping and floristic studies, suggestions for future study, and some possible management implications.

Topography, Geology and Soils

Elevation ranges from just over 280 m (920') in the north to 140 m (460') at the low point where French Creek drains the area from west to east (Figure 1). The slope in the northern half of the park is to the south, toward French Creek. The topography is more dissected in the south, draining generally east, with one steep hill in the extreme south rising to 220 m (720').

Topography is closely related to the geology of the area. The northern, south-facing slope is underlain by Triassic conglomerate and shales (Bascon and Stose 1938). The low-lying area drained by

French Creek and its major tributary, Baptism Creek, is underlain by Cretaceous dolomite. To the south are crystalline, pre-Cambrian gabbro and gneiss, and a very resistant Cretaceous quartzite (the Chickies quartzite) which provides the basis for the steep hills in the area.

Soils mirror the topography and geology, ranging from deep and well-drained on the gabbro, to deep and poorly-drained along the major creeks, to very stony on much of the conglomerate of the north (USDA Soil Survey 1966, 1976). Some local areas of a hectare or less on the conglomerate and dolomite are virtual rock fields, with no soil exposed at the surface, the surface consisting of a jumble of large stones.

Land-use has accordingly followed topography and soils. The steeper, rocky slopes of the north were apparently cut over for charcoal rather than being cleared for agriculture. The same holds for the steep areas in the south and west on the Chickies quartzite. Much of the rest was cleared for agriculture in the past, and in parts drained. Much of this farmland has been abandoned at different times over the past century. One previously forested area, in the eastern corner near Bethesda Church (in field #13), has been cleared for pasture since 1966, leaving an island of old forest. The extensive cutting for charcoal has left its mark in the numerous charcoal hearths throughout the forest and in the remains of old roads probably used to haul wood to the hearths and charcoal to the furnace.

Stone walls and rows of old trees in the forest attest to the past history of cleared fields, some of which had reverted to forest by 1937 (Aerial Photograph 1937). Many fields which are apparent in the 1937 aerial photograph were forested by 1966, when an aerial photograph was taken for a soil survey. Other changes in the fields since 1937 include an invasion of brush along the borders, so that many fields are smaller now, and the shapes slightly different, than in the past.

Cutting for charcoal was intensive while the furnace was in operation from 1771-1883 (Hopewell 1983). In general, a stand would have been cut over at 25-30 year intervals (Hough 1882), and all stems in an area were cut, regardless of species. The vigorously sprouting species such as chestnut oak (Quercus prinus) and chestnut regrew quickly, as did species which flourish in openings, such as red maple (Society of American Foresters 1954).

Previous study

A map of the vegetation of "the French Creek Project" which included Hopewell was prepared in 1936 and a revised report issued in 1939 (Stearns 1939). The report but not the map was still available at Hopewell. One cannot thus pinpoint the specific areas at Hopewell in the report, but many of the general observations and the forest cover types apply to Hopewell as well as the rest of the project area, now French Creek State Park. The dominant forest types [based more or less on the Society of American Foresters

classification and field study of the dominant trees (Society of American Foresters 1954)] were "even-aged second growth oak consisting principally of scarlet oak [*Q. coccinea*], black oak [*Q. velutina*] and chestnut oak, white oak [*Q. alba*] and pin oak [*Q. palustris*] being of less common occurrence" (p.1). The report identified two different major cover types, scarlet oak-black oak and chestnut oak, plus 8 other types of minor importance, occupying less than 10% of the total acreage, as follows:

white oak-black oak	2%
red maple-sweet birch	3%
red maple-yellow birch (<i>Betula lutea</i>)	<1%
red maple-yellow poplar (<i>Liriodendron tulipifera</i>)	1%
red maple-pin oak	1%
yellow birch-yellow poplar	<1%
sugar maple (<i>Acer saccharum</i>)-beech- (<i>Fagus grandifolia</i>)-yellow birch	<1%
black ash (<i>Fraxinus nigra</i>)-American elm (<i>Ulmus americana</i>)-red maple	1%

METHODS

Aerial Photography

In 1986, infrared-color aerial photographs of the site were taken on March 12, before the trees leafed out, and again on August 25, before fall color change, at a negative scale of approximately 1:12,000. Black and white stereo coverage contact prints were prepared. False-color prints were made for the entire site, with stereo overlap for most of it, at a scale of 1:6,000.

The spring aerial photos, the USGS Elverson 7.5 min. quadrangle topographic map, a 1937 aerial photograph, and a detailed map of the site (scale of 1:2,400) were used in preparing a base map at a scale of 1:4,800 (1"=200'), and in preliminary vegetation mapping and planning. Reconnaissance by road and trail provided further preliminary information for planning the field sampling.

Field sampling

Most field sampling in the forested uplands was done by the point-centered-quarter method (Mueller-Dombois and Ellenberg 1974; Avery and Burkhart 1983). In this method points are established at regular intervals along a line through the forest. At each point the distance is measured to the nearest tree [>5 cm diameter at breast height (dbh)] in each of the four quadrants and the species and dbh are recorded. The distance to the nearest sapling and its species are also recorded for each quadrant at each point, except where there is no sapling within 25 m of a point. Saplings were defined as tree species less than or equal to 5 cm dbh and >2 m tall.

Lines were run parallel to slopes as much as possible to provide a sample of fairly uniform vegetation for each line, and were spaced to maximize sample variability. The distances between points were generally 50 m except in stands that were too small to provide enough points at this sampling interval; in these, the sampling interval was 25 m. Data from all points along a line were grouped to provide a sample of the vegetation along that line, except in cases where the line crossed an obvious change in prior land-use, signalled by a wall, old road, or other artifact.

The point-centered-quarter method provides an estimate of density (stems/hectare), frequency (proportion of points at which a species occurs), average basal area (average area of a cross section of the trunk at breast height), and dominance (in basal area/hectare) for each species, as well as total density for each stand. For calculation methods, see Mueller-Dombois and Ellenberg (1974). For saplings, only density and frequency were calculated.

Because of the large number of dead stems, an additional measurement was made in any quadrant in which the tree nearest the point was dead. Distance to this dead tree, dbh, and species or genus where possible were recorded. Recalculation of the density data allowed an estimate of the numbers of dead trees/hectare, and their frequency and basal areas were calculated where the data were available.

At each of 35 points a list was made of all herbaceous species and seedlings of woody species within a radius of 5 m around the point. These points were located in oak-dominated stands (21 points), tulip poplar-dominated stands (8 points) and red maple-dominated stands (6 points). The decision to locate points along a specific transect line was made by considering the taxonomic expertise of the sampling team and the exigencies of time. The specific locations of points along a given transect line were either regular or widely spaced. Identifications were occasionally difficult for species which were not flowering at the time of sampling, but because all lists were compiled over a 1 month period, the bias introduced by this problem should be consistent among the plots. These presence/absence data were especially useful in determining where tree seedlings were located.

In swamps, the tree density was low, while shrub cover was very high. For this reason, the vegetation there was sampled by a combination of long "belt" transects for trees and line intercepts for shrubs. A line was established through the center of the swamp, approximately parallel to the longest dimension. At approximately 50 meter intervals, a 25 m segment of line was marked. The distance along this line intercepted by each species of shrub or vine was recorded. The species and diameter of all trees within 5 m of the line on either side were recorded, giving a belt transect 10x25 m for trees. These sampling techniques provide estimates of percent cover and frequency of the shrubs, and by analyzing the gaps in cover along the lines, the total shrub cover of the stand. The tree measurements provide density, frequency and

dominance (basal area/hectare) as well as average basal area. The trees and saplings in a belt transect alone, 83x10 meters, were tallied along the south side of French Creek just below the dam to compare with the trees in other areas of swamp forest.

We made other, non-quantitative, observations throughout the sampling, of shrub cover in the forests, soil surface, exotic species, evidence of grazing or insect pests, etc. The reproduction in several gaps caused by the death of old trees was noted in different parts of the oak-dominated forest.

Extensive sampling of the flora was carried out from early spring until fall, in all types of habitats. Herbarium specimens were prepared of many species, as a permanent record and for comparative purposes.

There were 33 point-centered-quarter lines, totalling 267 points, with measurements on 1068 trees. Ten 25 m line intercepts and associated belt transects were measured. These lines provided samples of all types of forest (see Figure 2), with the exception of some very disturbed stands dominated by black walnut (Juglans nigra).

Analysis of these data provided the following descriptive statistics for each line (or part of a line as indicated above for lines that crossed cultural boundaries). (See Appendix 3 for further explanation of the terms used.)

For trees:

total

density in stems/hectare

density of dead trees in stems/hectare

by species

frequency in fraction of points

density in number of stems/hectare

average basal area

dominance in m^2 /hectare

From these were derived relative frequency, relative density, and relative dominance. The arithmetic mean of these three multiplied by 100 gave an "importance value" which indicates the overall representation of the species in the tree canopy.

For saplings the descriptive statistics were:

total

density in stems/hectare

by species

frequency

density

relative frequency

relative density

Importance Value [= (relative frequency + relative density)/2 x 100]

For shrubs the descriptive statistics were:

- total
 - %cover
- by species
 - frequency as fraction of intercepts
 - dominance as % cover
 - relative frequency
 - relative dominance
 - Importance Value [= (rel freq + rel dom)/2 x 100]

Using tables of these values, the lines with the most similar tree composition were grouped into "forest types." These are subjective groupings, distinguished by having the lines in one group more similar to each other than they are to others. In several cases the presence or absence of species, such as sweet birch, contributed to a classification. Some short segments of lines were somewhat different from the rest of the lines in the same vicinity, but they merely represented the range of variation in the type and patchiness of the environment. Field checking of most of these areas confirmed that they did not differ in any significant way from the surrounding forest. On the other hand, some differences that showed up on the lines were found on field checking to correspond to different site histories, and were thus classified as different forest types as appropriate.

After all lines and points were assigned with confidence to a "type," the descriptive statistics were recalculated for the type as a whole. The forest types were then mapped on the base map. In preparing the maps, boundaries were generally drawn as abrupt lines. While this is appropriate for lines which correspond with old field lines, it is only an approximation where one type blends with another along a natural gradient.

RESULTS

Twelve forest types are recognized based on forest canopy dominants. These fall into four categories: oak-dominated; tulip poplar-dominated; red maple-dominated; and miscellaneous old-field successional types (Tables 1 and 2). All categories except those dominated by oak and red maple-arrowwood (*Viburnum dentatum*) appear to have been cleared fields sometime in the last century. Charcoal hearths occur frequently in the oak-dominated forests, indicating that these were cut for charcoal in the past. Each type is described below and mapped on Figure 2.

Oak-dominated forest types (Types 1a, 1b, and 1c)

These are generally stands that were cut for charcoal, but not cleared for agriculture. They are dominated by various species of oaks and correspond generally with the oak types described in 1939 and by the Society of American Foresters (1954), but the relative proportions of the various species of oaks differ, as well as the associated species.

1a. Mixed oak-sweet birch type (Table 3)

This type of forest dominates the northern half of the park on well-drained soils derived from Triassic conglomerates and shales. Sweet birch dominates this forest type in terms of density, but the trees are generally small (average dbh = 22 cm) with only 9% of the trees more than 36 cm dbh. This is characterized as an oak type, however, rather than black birch, because the next two most important species are white and scarlet oaks (Quercus alba and Q. coccinea), and black oak is also important. Although no one oak species has more stems/hectare than sweet birch, each has greater dominance (basal area/hectare) than birch. Other important species in the forest are tulip poplar, black gum (Nyssa sylvatica), and red maple.

Black gum and red maple are generally small trees (average dbh 14 and 16 cm, respectively), but more than half the tulip poplar trees are large (dbh >36 cm) and a quarter of them are very large (dbh>56 cm).

In the sapling stratum, black birch, black gum, sassafras (Sassafras albidum), and tulip poplar dominate, associated with red maple and flowering dogwood (Cornus florida). Only 2 of the 167 saplings tallied were oaks. Chestnut (Castanea dentata) sprouts were also present, in greater numbers than the oaks or any other minor associates.

Variability in this vegetation type depends on local topography and land-use history. Extremely rocky areas, essentially rock fields, are dominated by sweet birch, while moist sites near streams have a much greater number of beeches (Fagus grandifolia). Transect 30, near the developed historic area, includes 2 dead red cedars (Juniperus virginiana), indicating that it was an agricultural field sometime in the past. It has significantly more dead trees than the rest of the area, 142 dead trees/ha, as compared with an average of 41 for the rest of the area. Various species of oaks make up 65% of the dead trees elsewhere, but only 25% of the dead trees along line #30. It was very noticeable that the gaps left by many of the dead trees are being filled with dense stands of tulip poplars, which are being attacked by a scale insect and probably thinned by it. Several of the major insect pests of tulip poplar are scales (Beck and Della-Bianca 1981).

1b. Chestnut oak-scarlet oak-black oak type (Table 4)

This type of forest is dominant in the southern third of the park, mainly on rugged terrain on crystalline rocks and some on dolomite. Oaks clearly dominate these forests, including chestnut oak, scarlet oak, and black oak. Sweet birch is rare; none was encountered of the 268 trees tallied in the forest type. However, yellow birch is present, and dominates locally in extremely rocky areas. The oaks are generally medium to large (dbh of 25-36 cm) and numerous (60-100/ha). Big-toothed aspen (Populus

grandidentata) is an indicator of this forest type. Mountain laurel (Kalmia latifolia) is also frequent in these forests. Other important associates are red maple and black gum, both small, and hickory (Carya spp., especially C. tomentosa), also fairly small (average dbh 17 cm).

Red maple and black gum dominate the sapling layer, accompanied by flowering dogwood, witch hazel (Hamamelis virginiana), chestnut and sassafras. Oak saplings are rare. Along the southern edge of field #11, the species invading at the edges is sweet birch, which is absent in the older forest.

The woods of this type on gabbro bedrock have very few, scattered dead trees, none along the sample lines. Dead trees on the vintage dolomite were found only along line #16 and the first part of line #17 (the point just south of line #16). The southernmost stand of this type of forest, mainly on the Chickies quartzite, has many dead trees, more than 150/ha, mainly oaks and especially chestnut oak. The hilltop just south of field #11 has a particularly high density of dead chestnut oaks, all about 14 cm dbh, probably killed by the gypsy moth. Sapling density is also very low on the hilltop, estimated at about 179/ha. At two points on this hilltop there were no saplings within 25 m of the point, so this estimate of 179/ha is an overestimate of the total sapling density.

1c. White oak type (Table 5)

A ridge of Vantage dolomite east of Rte. 345 is forested with a white oak-dominated forest. This distinctive forest appears quite open, with a scattered, low, mainly ericaceous shrub cover. In its lack of sweet birch and the presence of yellow birch and some big-toothed aspen it is more like the mixed oak forest than the oak-sweet birch type. Other important species are red maple, scarlet and black oaks, and tulip poplar.

Shadbush (Amelanchier canadensis) and red maple dominate the sapling layer, accompanied by black gum, yellow birch, black cherry (Prunus serotina) and flowering dogwood. Only a few oak saplings were found, none of which was white oak. In this forest type there are many multiple-trunked trees (23% of the total, as compared with less than 10% in any of the other forest types). This may suggest that this forest has been severely damaged in the past, perhaps by fire.

Tulip poplar-dominated forest types (Types 2a and 2b)

Tulip poplar comprises half or more of the basal area of trees in all of these areas, and occurs at well over half the sample points. It appears that all of the tulip poplar-dominated areas were previously cleared fields, judging by their similarity to those stands which we know from the 1937 aerial photograph were fields in 1937, the scattered occurrence of standing or down dead

red cedars in almost all stands, and the location of old roads, ruins and/or stone walls that may have been related to the fields. The difference in the two types is probably one of age since abandonment, although other factors such as topography may also be important. These other factors may, of course, be themselves related to the causes of abandonment of the fields.

2a. Tulip poplar-oak type (Table 6)

This type of forest is most common in the northern parts of the park, near the headquarters and in the vicinity of the site of the Brison House ruins in the Baptism Creek Area. A third stand of tulip poplar-oak forest is located along the Harrison-Lloyd Road, between it and a stone wall and old road running from near the intersection with Bethesda Road to about the middle of the south side of field #11. All of these areas were forested in 1937, so the woods are more than 50 years old.

Tulip poplar dominates these forests, more by its large size (average dbh 48 cm) than by its density (97 stems/ha, relative density = 0.26). In the northern sites (excluding the areas along Harrison-Lloyd Road) the major associate is sweet birch, which in many of these sites has more stems/ha than tulip poplar, but of considerably smaller size (average dbh 28 cm). As might be expected by the lack of sweet birch in the nearby oak forests, the tulip poplar wood along the Harrison-Lloyd Road has little or no sweet birch. All of the sites have some oak, of various species, and generally large trees, although none that was sampled appeared to be field-grown. Hickory is also a frequent associate, as well as red maple and black gum. A patch of white oaks along the Harrison-Lloyd Road is anomalous, and was also mentioned in the 1939 forest survey of the French Creek area (Stearns 1939).

Sweet birch is very common in the extremely rocky sites. For example, in a rocky area in the middle third of line #1, sweet birch accounted for over half the stems tallied. On the other hand, along streams, as in the oak woods nearby, beech is locally abundant. Along line #2, which followed Spout Brook (in fact, the line was taken up the middle of the brook) there were slightly more beech stems than tulip poplar (85 stems/ha compared with 76/ha), although the average size was considerably smaller (22 cm as compared with 54 cm).

There is an average of about 30 dead trees/ha in the tulip poplar-oak stands; half of these are oaks and a fifth red cedars.

As in the oak-dominated forests, sweet birch, red maple and black gum dominate the sapling layer, along with flowering dogwood. Beech saplings are locally abundant, especially along Spout Brook. Tulip poplar, oak and hickory saplings are rare (<2% of the saplings counted). The understory is similar to that in the oak wood, consisting of patches of ericaceous shrubs such as pinkster flower (Rhododendron nudiflorum) blueberry (Vaccinium spp.), viburnums, and spice bush (Lindera benzoin).

2b. Tulip poplar-red maple type (Table 7)

Tulip poplar clearly dominates these stands in all measures: frequency, density and basal area/ha (dominance). The areas northeast of Harrison-Lloyd Road were old fields just beginning to revert to forest in 1937, so by extrapolation, it appears that the areas along line #32 near the visitor center and along the old road adjacent to line #12 were also old fields. Much of the area along the Harrison-Lloyd Road was still mapped as non-forest by the USGS in 1956 (Elverson quadrangle), so the woods may be only 30 years old. They were forested by 1966 (Berks County 1967), so they are at least 20 years old.

The most abundant associate of the tulip poplar is red maple, with over one fourth of the stems (one-half are tulip poplar). There are no other associates of any importance in terms of numbers or dominance. In the Harrison-Lloyd Road area, pitch pine trees (Pinus rigida) are a rare but consistent component of this type of forest, as well as of the tulip poplar-oak forest across the road. There are also scattered white and Virginia pines (P. strobus and P. virginiana) in these woods. It seems possible that these were planted, a common practice in abandoned fields in the 1930's, but further detailed study of their distribution would be necessary for verification.

Only 4 of the 132 trees tallied in these stands were oaks. The two black oaks were large (>36 cm dbh), but the white oak and scarlet oak were considerably smaller (16 and 29 cm respectively). By contrast, 17 of the 156 trees tallied in the tulip-poplar stands were oak (11%) and most were >36 cm basal area. The tulip poplars were also smaller on average in this type of forest, 29 cm dbh as compared with 47cm, further suggesting that these are younger forests. With the exception of one shagbark hickory (Carya ovata) and the two black oaks, no species in the tulip-red maple stands had an average dbh greater than 36 cm, and most were considerably smaller. The average size of red maples was, however, slightly greater in the red maple forest types than in the oak types. The average size of the red maples in the tulip poplar-dominated forests was 22 cm dbh, over twice the size of red maples in the oak-dominated forests, but, as we shall see, well below the size of red maples in the older swamp forests.

No dead trees were found at points along lines #10, 12, or 32, where there were also no pines. The average density of dead trees along lines #7, 8, and 9 was 100/ha, mainly pines (probably pitch pine) (4 of 9) and black cherry (3 of 9). As in the other tulip poplar-dominated woods, we found no dead tulip poplars.

Red maple saplings dominate the sapling stratum, followed by green ash (Fraxinus pennsylvanicum), dogwood and black cherry. There was one hickory sapling (of 116 saplings) and no oaks along our lines. The density of saplings was very low, 174/ha. This value is an overestimate, because at 4 points there was no sapling within 25 meters of the point, so what would have been even lower densities were not included in the calculations of density.

There are three other points of particular interest in this forest type:

1) It appears that a high density of spicebush in the understory may inhibit sapling establishment. (In other areas as well where there is a lot of spicebush, saplings are rare.)

2) Compared with the oak-dominated forests, these stands have more exotics in the ground cover, especially Japanese honeysuckle (Lonicera japonica) and field garlic (Allium vineale).

3) The soils are hard and compacted, with little or no litter layer and a very poorly developed humus layer.

All of these factors may affect the future of these woods by preventing the establishment of seedlings and saplings of later successional genera such as oak and hickory.

Red maple-dominated forest types (Types 3a, 3b and 3c)

Although red maple is a common associate in all forested areas at Hopewell, it dominates the forests in wetter sites, forming almost pure stands in lowland forests less than 30 years old. Older stands are more diverse, in terms both of evenness and numbers of species, but are still dominated by red maple.

3a. High density red maple type (Table 8)

These young forests have a very high number of trees/ha: 759 as compared with about 500 for oak- or tulip poplar-dominated stands. Over ninety percent of the trees are red maples, with a few scattered shadbush, black gum and pin oaks (Quercus palustris). The shrub cover of spicebush is thick, and there are few saplings, about a third as many per hectare as trees, but the diversity is higher. While red maple is most important in the sapling layer, elm (Ulmus americana) and black cherry as well as shadbush also contribute significantly. No dead trees were encountered at any points in these stands.

3b. Red maple-arrowwood type (Table 9)

Along Baptism Creek and French Creek south of Hopewell Road and east of Rte. 345, older red maple swamp forests predominate. The density of stems is much lower than in any other forest type (292 stems/ha) and the diversity is greater than in the young red maple stands. The maples are also much larger (34 cm dbh as compared with 18). These forests are so open that a very dense shrub cover has developed, and is used in characterizing the forest type. Spicebush and arrowwood (Viburnum dentatum) dominate the shrubs, occurring along almost all of the 10 line intercepts, each with >30% cover on the intercepts. The other shrub found along half the intercepts is winterberry, but its cover is low (9%). It was listed as rare in 1939 (Stearns 1939). Grapevines (Vitis spp.) abound in

this open habitat, occurring along 6 of the 10 intercepts, with 10% cover. Poison sumac (Toxicodendron vernix) is a distinctive member of this community in the vicinity of lines #26a and 21, along with sedge tussocks (Carex stricta). This distinctive variant of the swamp forest is also present in a small area west of French Creek just west of where the creek crosses Rte. 345. Poison sumac was rare in the area in 1936.

In the tree canopy, other important species are American elm and green ash. Black ash (Fraxinus nigra) occurs also in these woods, especially near transect 21, but was not present along any sampled intercept. Few dead trees were found, only 28/ha, with a mix of species and sizes. No saplings were sampled along these intercepts, although saplings of shrub height but not in the tree canopy, were recorded along the lines. These included only an elm and a shadbush.

3c. Red maple-sycamore type (Table 10)

Along French Creek from of Rte. 345 to the dam, the swamp forest canopy is more closed, with 528 trees/ha. Sycamore (Platanus occidentalis) trees form a distinctive addition to the forest. Although there are relatively few of them (only 9% of the stems) their large size gives them considerable importance in the canopy (23% of the basal area). The sycamores do not, however, appear to be reproducing, and the major proportion of the saplings are green ash, American elm and hornbeam (Carpinus caroliniana). The major shrubs are spicebush, winterberry and blackhaw (Viburnum prunifolium) with many grapevines. The section of this forest that was sampled appears to be heavily grazed by deer, while the rest is in a pasture and grazed by domestic animals, which greatly decreases ground cover and reproduction.

Other successional stands (Types 4a, 4b, 4c and 4d)

Several local areas with evidence of prior agricultural land-use do not fall into any of the categories above. Each of these has distinctive characteristics which are related to the local site characteristics. No quantitative data were collected for the black walnut (Juglans nigra)-dominated stands, because it was not clear until the end of the field sampling that this constituted a distinct type of forest.

4a. Red cedar type (Table 11)

Red cedar is the dominant tree species in early post-agricultural succession in much of the Triassic piedmont of New Jersey and Pennsylvania. Abundant dead cedars were found in the tulip poplar-oak stand near the ruins of the Brison house, and scattered red cedars in other, younger tulip poplar-dominated stands. However, only one small, well-defined, stand of live red cedars was found by scanning the winter aerial photographs and by walking the area. A second showed up in the summer aerial

photograph, but this stand (near the power line parallel to Hopewell Road) was not sampled. There is also a stand of red cedars in a pasture near the visitor center and along the old road off the Harrison-Lloyd Road to the ruins of the Harrison-Lloyd house.

The patch sampled with line #27 is less than a hectare in area, and bounded along the southeast side by a shallow ditch. It shows up clearly on the 1937 aerial photograph as a distinctive patch amid old fields reverting to forest, mainly red maple. The woods southeast of the ditch appear to have grown in a formerly drained field, with shallow ditches perpendicular to the one along the cedar field. A soil analysis done in 1971 reported very low calcium in this "cedar pasture" and lower pH there than in the other fields tested (Berks County 1976).

It appears that deer have grazed the red cedar stand heavily, creating a "browse line" at about 1 meter. Possibly this followed grazing in the 1960's (and earlier?) and grazing pressure accounts for the dominance of red cedar, which can survive many years of cropping. The most important associates of the cedar are red maple and tulip poplar. Saplings are also mainly red cedar and red maple, but there are also American elm saplings, but not trees. We found no dead trees in this area. Shrubs are also distinctive, including sweet pepperbush (Clethra alnifolia) and large, productive, highbush blueberry bushes (Vaccinium corymbosum). The ground cover includes much grass, and lousewort (Pedicularis sp.), which we found to be abundant only here. Sweet pepperbush was rare in 1936.

There is a faint road leading out of this area to the northeast, suggesting that it is in some way a culturally induced feature.

4b. Green ash-tulip poplar type (Table 12)

The abundance of green ash distinguishes the tree stratum of this stand, but its most distinctive feature is the dense, choking growth of japanese honeysuckle, oriental bittersweet (Celastrus orbiculatus), and other weedy shrubs and vines. It was very difficult to penetrate because of the tangle of vines, including catbriar (Smilax spp.); shrubs, including viburnums, spicebush, and smooth sumac (Rhus glabra); and dead sapling-sized trees. There are many saplings (675/ha), but many are being killed by the vines, especially honeysuckle. Other trees, in addition to ash and tulip poplar, are sassafras, black walnut and red cedar. Ash dominates the living sapling layer, with black cherry and red cedar.

4c. American elm type (Table 13)

Despite the ravages of the Dutch elm disease, American elm is a common sapling in many areas of Hopewell Furnace, and elm trees dominate one hillside, on an east slope on gabbro bedrock. The elms are large, (average dbh 42 cm) and appear to be healthy.

Associated with them are red maple and tulip poplar. Elm also dominates the sapling size class, accompanied by red maple, green ash and black cherry.

Many scattered dead red cedars indicate that this stand was an agricultural field in the past. A few pin oaks indicate that the drainage is not as good as it superficially appears to be.

At the bottom of the slope we found the only basswood (Tilia americana) and sugar maple (Acer saccharum) that we encountered in the forests of Hopewell Furnace. There are no red cedars in this part of this forest, so it seems that this low point is an older forest than that on the slope. There was a sugar maple sapling at the first point, but because a sapling was omitted from this point, it was not included in the analyses.

These elm woods had abundant showy orchids (Orchis spectabilis) blooming in May, and a high diversity of spring flowers at the bottom of the slope.

4d. Black walnut type

Several disturbed areas near buildings have a high density of black walnut trees, mixed with tulip poplar, green ash, and scarlet and white oaks. It does not appear that the stands represent abandoned fields; rather, they seem to have invaded old lawns and the areas directly associated with the buildings. Black walnut responds favorably to nutrient rich sites, so these may be areas enriched by the wastes of humans and animals, which would be most concentrated near habitations.

Small areas

Several smaller areas within the major cover types deserve mention as well, as they are distinctive, and indicate present and past relationships among the cover types.

Old fencelines in woods or at the edges of woods

We sampled near several of these in fairly dry woods, either tulip poplar-red maple or mixed oak forest types. Along the southeast boundary of the park, running northeast from the Harrison-Lloyd Road, there is an old row of trees, mainly sassafras, black cherry, shagbark hickory, scarlet oak and green ash. A similar row forms an old line now submerged in the forest between field #14 and Reading Road, including large oaks and sassafras. Both of these rows are in marked distinction from the adjacent young tulip poplar woods. Another apparent old fenceline is found in the oak-tulip poplar woods near the Dam Road and the French Creek State Park sewer plant. The trees here are mainly white oaks, some of which clearly grew in an open fence row.

In wetter areas, the old tree lines also include white oaks, for example, between Rte. 345 and the county line, parallel to Rte. 345, where there is an old wall and tree line mainly of large white oaks and black gum. Nearby, between the stone wall and the road, there is also a chestnut tree, 19 cm. dbh, fruiting. An even wetter old stone wall and fence row is found in the woods south of Baptism Creek, near the county line. This row includes some very large swamp white oaks (Quercus bicolor) (one consisting of several fused trunks is 131 cm dbh), as well as large pin oaks, white oaks, red maples, and shagbark hickory.

All of these tree lines are quite distinctive: they are straight lines of very large trees relative to other nearby trees; the trees usually have an open-grown growth form with large low branches; and often there is a broken down stone wall and/or ditch alongside the trees.

The progenitors of these hidden fence lines are found in existing fence lines and in other long, narrow woodlots. For example, between field #7 and the pasture near the barns, there is a well-developed fence line of trees and shrubs, including scarlet and white oaks, black walnut and shagbark hickory, with a thick understory of shrubs and vines, such as black haw, flowering dogwood, blackberry (Rubus spp.), multiflora rose (Rosa multiflora) and Japanese honeysuckle. A wider strip of woods is found between field #11 and the Harrison-Lloyd Road. Here is a very mixed wood, with black gum, black walnut, American elm, tulip poplar, green ash, black cherry, sweet cherry (Prunus avium), sassafras and hackberry (Celtis occidentalis). Wild grape and oriental bittersweet clamber up these trees, and the grapevines are invading the trees in a gully across the Harrison-Lloyd Road. These two rows are typical of old, well-established fencelines. A distinctly younger hedgerow has formed on the boundary between fields #8 and #9; it consists mainly of tulip-poplar, like the local early successional stands.

These types of woodlots all provide seed sources for abandoned fields, and have also probably acted as refuges for species which could not survive in the woods cut for charcoal or in the agricultural fields. Some species, such as hackberry, seem to survive today mainly in such sites, and are rare in the interior of the forests.

Isolated woodlot near Bethesda Church (in field #13)

The composition of this recently isolated woodlot is most similar to the mixed oak cover type, although it has considerably more pignut hickory (Carya glabra) than other forested areas, and also more oak and hickory saplings. The woody reproduction in the field surrounding the forest, which has been cleared of forest for less than 10 years and is presently mowed, is of the same species as those found in the woods, though with abundant Japanese honeysuckle in large patches in the field.

Field edges

On one or more sides of most fields there is an edge of shrubs and small trees between the field proper and the old field edge, marked by an old hedgerow and/or stone wall. Several fields have a double edge, indicating that the field has shrunk twice, and that an intermediate edge was maintained sometime in the past. The most striking characteristic of these edges is the abundance of vines, especially the introduced oriental bittersweet and Japanese honeysuckle, but also native grapes, which seem to be smothering the trees and in places invading the forest itself. Tree saplings are generally of the same species as the fencerow trees, though around field #11 they are mainly sweet birch, which is rare in the adjacent forest. Near the top of this field, where it becomes narrower, most of the encroaching saplings are big-toothed aspen, an indicator species of the local mixed oak forest. The seeds of many of these shrubs, such as the native blackberries and spicebush and the exotic multiflora rose and barberry (Berberis thunbergii), are probably dispersed by birds.

Charcoal hearths

There is no single distinguishing vegetational or floristic characteristic of all charcoal hearths, as far as we could see. Some are very open, with no woody growth, or just small shrubs. These are often covered with an introduced grass, Microstegium vimineum, here dubbed "charcoal hearth grass." It is, however, not restricted to charcoal hearths and was found at several other sites, especially in wet areas. The general appearance of three charcoal hearths indicates the wide variety. First, one east of the Lenape Trail, in the oak-sweet birch forest type, has no woody reproduction at all, and a carpet of charcoal hearth grass. Also present are poke milkweed (Asclepias exaltata) (one of 2 plants of this species that we found) and comfrey (Symphytum officinale), an exotic not found elsewhere. Just outside the western park boundary between the county line and Rte. 345 is another hearth also carpeted with charcoal hearth grass, but with abundant spice bush, as well. Then at the other end of the spectrum of overgrowth, in the white oak forest type, a large charcoal hearth has a 33 cm dbh black oak growing in the middle, along with small tulip poplars and many dead flowering dogwoods. The reasons for the differences among these, and other hearths, were not apparent.

There are two other unusual patches of trees, one consisting of a few sugar maples and basswood west of French Creek at the bottom of the American elm-dominated slope, as discussed above. The other is a patch of hemlock and beech near the Hopewell Lake dam. This is the only hemlock we found in the park, although there are certainly others. It does not appear to be propagating widely.

Flora

Five hundred species, in 92 families, were identified at Hopewell Furnace National Historic Site, one-fifth of which are non-native (Appendix 1). The non-native species are concentrated near the developed areas and the pasture, as well as near old house ruins and along roadsides. No endangered or threatened species were found. Voucher specimens were obtained for 180 species, and are housed at the Academy of Natural Sciences, Philadelphia.

DISCUSSION

Effect of introduced plants and animals

Introduced vines appear to be especially noxious, particularly around field edges and along roadsides, and in the old field vegetation of tulip poplar-green ash. Although Japanese honeysuckle forms a ground cover in some tulip poplar stands and in the American elm stand, it seems to be succumbing to the shade there. It may, however, respond to gaps formed by dead trees and inhibit sapling growth.

Away from the developed areas and cultivated fields, the main herbaceous exotics are charcoal hearth grass, discussed above, and field garlic. Both occur in open disturbed sites, or in successional stands, i.e., field garlic in tulip poplar-red maple and American elm stands, and do not appear to be common pests in most of the older forest types. Few introduced trees have survived in the closed canopy forest, though we encountered an occasional apple (Pyrus malus) or sweet cherry (Prunus avium). Both are more common in open sites, such as fencelines. Near the site of the old Harrison-Lloyd house ruins are a few non-native trees, such as tree-of-heaven (Ailanthus altissima) and paper mulberry (Broussonetia papyrifera), which could conceivably spread.

The major introduced animal which is affecting the forest seems to be the gypsy moth. Dead oak trees are numerous, and it is likely that they were pushed over the brink by gypsy moth defoliation. This summer (1986) we found few gypsy moth egg cases or larvae, and noted no serious defoliation. Oaks and hickories around the edges seem to be filling in the gaps left by dead oaks in the western part of the oak forest, but the future in the south and north is not so clear, with gaps being filled by early successional trees or not at all.

Chestnut blight and Dutch elm disease are introduced diseases of considerable importance in eastern North American forests. The high density of chestnut sprouts and old stumps attests to the past importance of chestnut in these forests. It is likely that cutting for charcoal had even increased the numbers of chestnut trees, as they are vigorous sprouters. The forest has probably not yet recovered to a stable composition since the loss of this major tree in the early 20th century. On the other hand, the Dutch elm

disease does not appear to be serious here. There are vigorous, apparently undiseased trees of all sizes, and elm seems to be well established as a major species in some areas, and to have the potential for increasing in importance in the future. There is always the danger of an outbreak of the disease, which would severely damage the stand of that forest type, as well as elm reproduction in the swamp forests.

It is not only introduced species which affect regeneration of the oak forest; the human-induced spread of native species may also be causing dislocations in natural forest development. Deer are the most obvious culprits. Grazing damage is apparent throughout the park on many herbaceous plants; shrubs, such as strawberry bush (Euonymus americanus) and maple-leaved viburnum (Viburnum acerifolium); and trees, such as red cedar and dogwood. We did not notice grazing on tulip poplar, but elsewhere it has been found to be heavily grazed by deer (Beck and Della-Bianca 1981). The effects of this are unknown, but may be far-reaching. By comparison, rabbits grazing on oak seedlings in England completely prevent the regeneration of oaks in Sherwood Forest. This is demonstrated by an even-aged cohort of oak saplings which date from a minimum population of rabbits during an epidemic of a disease of the rabbits.

Two trees which seem to be more common now than they were in the past, for example in 1936 (Stearns 1939), are tulip poplar and black walnut. The tulip poplar has spread widely in abandoned fields, and seems to have supplanted red cedar as the dominant species in most upland old-field successional stands. Black walnut, which was widely planted near houses in the 18th and 19th centuries, often for dye, has spread into the woods around buildings, thus creating a black walnut-dominated forest. This is probably not a naturally occurring forest type in this region.

Spicebush may be more common now than it was in the past, especially in relation to the tulip poplar- and red maple-dominated forests, and it may suppress natural regeneration of tree species. If deer do not graze it, and little or no grazing damage was noticed, it may be spreading at the expense of more heavily-grazed shrubs, such as the viburnums, which have a less restrictive effect on tree seedlings and saplings.

A final native genus with some potential for local damage in sites opened up by human activities is grape. Grapevines spread in open areas, covering and often killing trees. It is likely that they are more common than in the past because of the proliferation of poorly maintained field edges.

Successional patterns

Judging by the high density of standing and fallen red cedar stems in the Baptism Creek area near the site of the Brison House ruins, in a small previously cultivated area north of the village and west of Rte 345, and in the American elm stand, it seems that in the past, red cedar was a major component of early old-field

succession, as it is in the few current red cedar stands at Hopewell and in many other areas on Triassic red shales and sandstones. On the other hand, the younger successional stands, especially the tulip poplar-red maple stands, have far fewer red cedars and a scattering of pines. These younger stands also have fewer, smaller oaks, and more, smaller tulip poplars than the older successional stands.

The tulip poplar-oak stands are similar to the oak-sweet birch stands. The oaks in the oak-dominated stands are, however, generally larger and more numerous than in the younger stands, while the tulip poplars are about the same size in both and are more numerous in the successional stands. Sweet birch has an almost identical distribution in the two types of forest, in frequency, size and density. These observations suggest that the tulip poplar-oak stands are an earlier successional stage on the way to the more stable oak-sweet birch stands, because 1) they have a similar species composition, 2) tulip poplar, which is very common in younger stands is more numerous but not larger in the tulip poplar-oak stands, so may have reached its maximum size and be thinning out, and 3) the oaks are fewer and smaller in the oak-tulip poplar stands, so may increase in importance. In addition, these results indicate that prior land-use is not especially important in affecting the basic forest cover type. Similarly, the tulip poplar-red maple type of forest could be successional to the tulip poplar-oak.

The hitch is that there are practically no oak saplings in any tulip poplar-dominated stands, so the path to oak dominance seems to be blocked. A change seems to have occurred in the successional patterns, so that instead of proceeding from red cedars to tulip poplars to oak, it starts with tulip poplars, and, to judge by sapling densities, will proceed to red maple and black gum. This may seem unlikely, but it is interesting to note that the red maples and black gums in the tulip poplar-oak forest are significantly larger than in the oak-dominated forest, indicating perhaps that the habitat is more appropriate for them.

There are several possible explanations for the change in pattern. One is grazing pressure, if red cedar and oak are preferred species for deer. A second is a decrease in fire frequency, so that more fire-sensitive species, such as red maple and tulip poplar (Brown 1960), can become established. Third, the soils may have been changed by agriculture, so that they are more appropriate for different species. The surface of the soil especially in the tulip poplar-red maple stands is hard, with little litter or humus layer, while that in the oak woods has generally well developed litter and humus horizons, although in many areas it is severely eroded. Such changes could increase the water-holding capacity of the soil, by increasing compaction and decreasing internal drainage, and thus favor species more tolerant of poor drainage, such as red maple and black gum. Finally, the oak reproduction may be sporadic, and there may be a flush of oaks sometime in the future.

On very poorly drained sites the climax vegetation appears to be an open, red maple-green ash stand with a thick understory of shrubs such as arrowwood and spicebush. In many areas there are tussocks of sedge. The young successional stands in these areas consist of dense red maple trees. The sedge tussocks seem to develop fairly soon in the successional sequence, for example, in the older areas along Hopewell Road, between it and the power line to the east. Drainage in the past has dried some of the wet areas to some degree, most noticeably in the stand just northwest of the park boundary where sampling line #28 is located. Because the drainage systems are no longer maintained, such areas are expected to become wetter with time.

The role of elm in these wet woods is unclear at this time. The one elm stand, though on a slope, seems to be poorly drained, as indicated by the presence of pin oak. Because of the slope, however, it presents a very different soil moisture condition from the flat lowland swamps. In the lowland swamps, however, elm saplings are very important, perhaps indicating an increase in their importance as trees in the future. These, plus occasional black ashes, put this forest type in the black ash-american elm-red maple type of the Society of American Foresters, a type more typical of wetlands farther north, e.g., in northern New Jersey (Society of American Foresters 1954).

Sycamore does not seem to be reproducing in the red maple-sycamore forests, either as seedlings or saplings. The future importance of this species is thus unknown, but appears to be declining.

Oak forests

The composition of the oak forests presents several questions. They do not fall clearly into any of the Society of American Foresters forest cover types, perhaps due to disturbance in the past. First, why are there three rather distinct types of oak forest? There are several possible answers, which could be tested by more extensive sampling in the general region and further study at the sites at Hopewell.

1) The difference in bedrock may be carried over into differences in soils: texture, pH, fertility, depth, or other soil characteristics. This could be tested by soil analyses and transplant experiments of the species which have very different distributions, e.g., sweet birch and big-toothed aspen.

2) The site histories may differ: in past fire frequencies, intensity of cutting, or other factors. The intensity of cutting for charcoal might be studied by a distribution map of the charcoal hearths and the amount of reproduction on them. Stearns(1939) noted that big-toothed aspen and mountain laurel were fire-indicators (pp. 3, 15), so it is possible that the mixed-oak type of forest has been burned more recently than the other two. Chestnut

oak was also regarded as a species that indicated past fires (p. 2). A combination of fire frequency, cutting and soils may be responsible for differentiating these different forest types.

The second major question presented by the old-growth oak forests is that of their future. As mentioned above under the discussion of the successional stands, there is a dearth of oak saplings, or even small trees, although there are numerous oak seedlings. Gaps left by dead trees in the oak-sweet birch stands are filled with a thick growth of the saplings of the early successional species tulip poplar and/or sassafras. In the other types of oak stands, on the other hand, there is very little regeneration in the gaps themselves; rather, canopy-sized hickory and oak trees seem to be filling these gaps from the edges. Regeneration in a few gaps is red maple. So neither is there "advance regeneration" in the form of saplings waiting for a chance to reach the canopy, nor in the gaps actually present is there regeneration of the oaks. The factors discussed for successional stands could also be acting in these older forests, especially deer grazing.

Suggestions for future study

Oak reproduction

What happens to the oak seedlings? If they do not grow, the forests will change drastically in the future. Direct and indirect human impact may be changing the very nature of the climax forest of the park, and perhaps more widely in the region.

Some useful studies would be:

- a. Soil analyses and comparison of soil types with juvenile performance.
- b. Exclosures to test the importance of deer, and possibly other herbivores, on growth of seedlings.
- c. Permanent plots, including detailed tracking of the fate of the seedlings. How old are "seedlings"? Some may have been nipped back for many years, and may actually be the age of saplings.
- d. Competition experiments, eliminating shrubs such as spicebush from some plots to assess their effects on germination and growth of tree seedlings and herbs.
- e. Transplant experiments and planting of seeds of oaks, hickories, etc. to test the importance of habitat factors on growth and germination of these species.

Reproduction in natural and man-made gaps

- a. What happens in small natural gaps over time?

b. How does reproduction on charcoal hearths and along old roads compare with that in natural gaps?

Distribution of herbs and shrubs

Do these reflect the tree cover types and can they shed light on the reasons for the differences in tree cover types?

Are herbs and shrubs distributed randomly in the forests or is their distribution related to the locations of trees. There was some evidence, for example, that ericaceous shrubs were clumped near oak trees, rather than tulip poplars where both were present.

Swamp forests

The state threatened Poa paludigena grows in nearby black ash-red maple swamp forests in Pine Swamp in French Creek State Park. It would be worthwhile to compare the red maple-arrowwood forest type with Pine Swamp, to determine whether improvement in habitat and/or protection of some sites might lead to the establishment of this species at Hopewell.

History of land -use and impacts on the forest

- a. What were the precolonial and 19th century forest types?
- b. How have they changed, and why?

Possible management implications

a. Most introduced species seem to be in pastures and near buildings. Details of this pattern could be refined to elucidate relationships between the species and human uses. Many of these plants were part of the historical scene, and are therefore not inappropriate there now in the context of the historical reconstruction.

b. The other major habitats of exotics are on field edges and roadsides. Clearing fields back to the old lines as started in 1986 would help control these.

c. More trail markers could greatly enhance the public's awareness of the critical role of natural resources in the functioning of the furnace, and the effects of the use of these resources on the natural environment.

d. A miniature version of charcoaling could be initiated to expand the scope of information about how the furnace operation actually worked.

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FIGURES AND TABLES

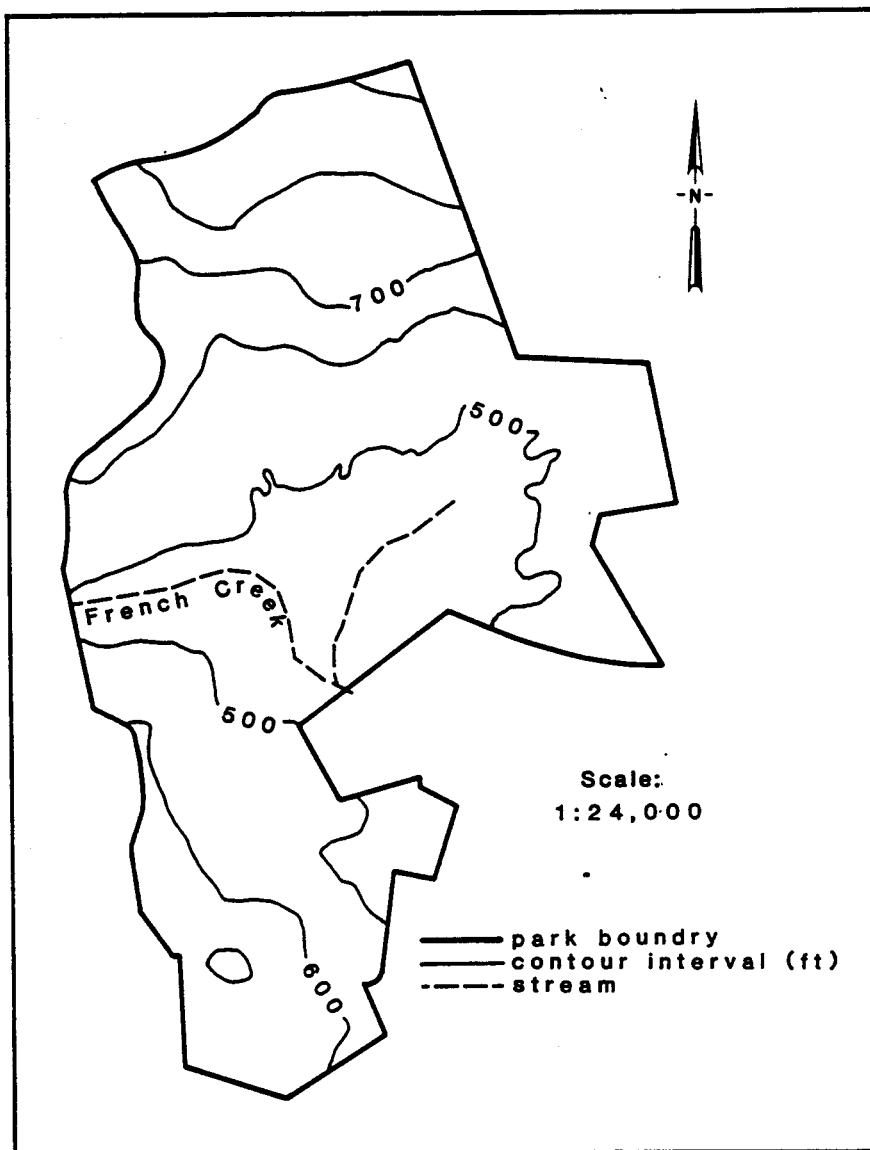
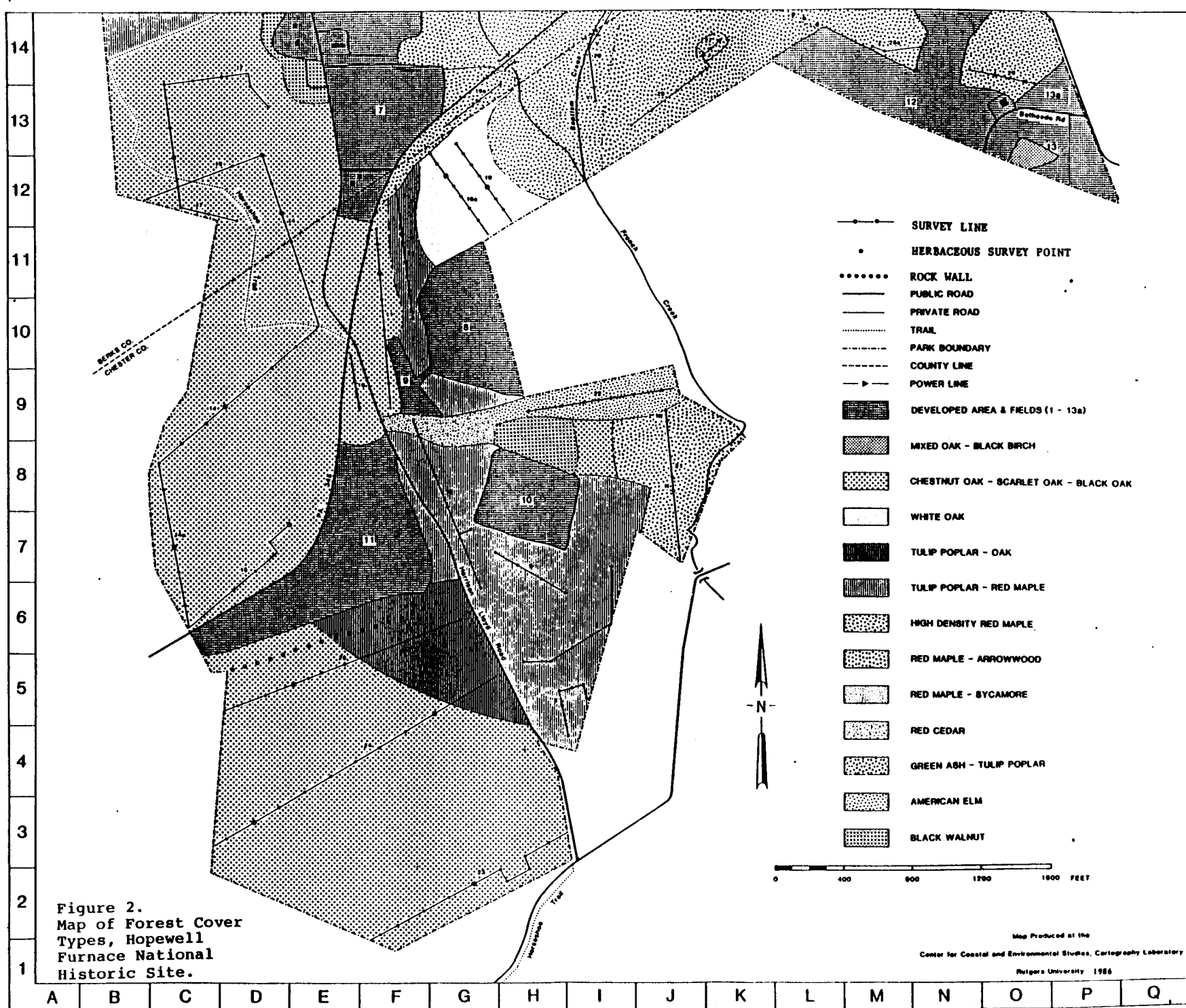


Figure 1. Hopewell Furnace National Historic Site, showing general features



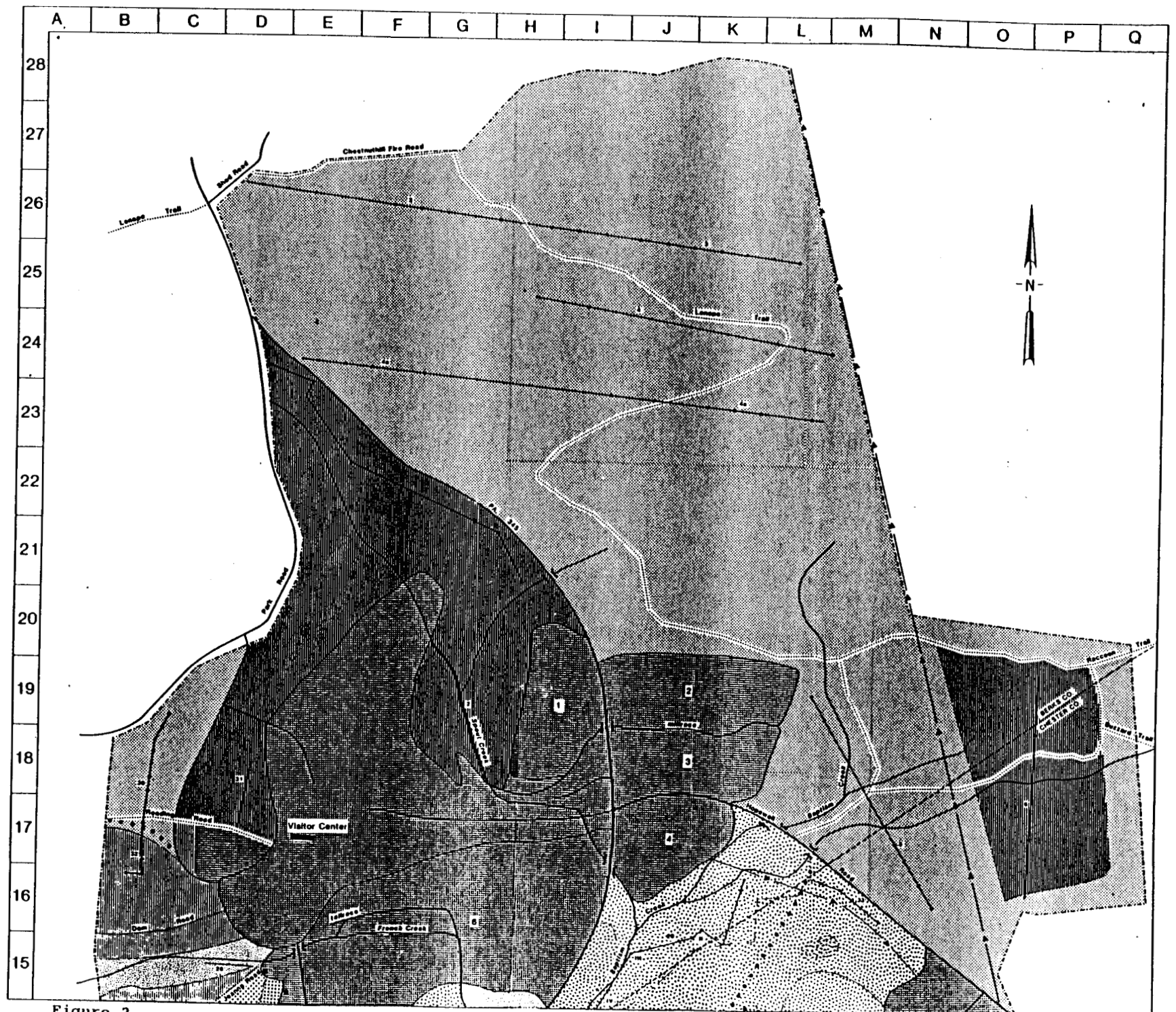


Figure 2.

Table 1. Summary of forest type characteristics. Forest types are as follows: 1a = mixed oak-sweet birch type; 1b = chestnut oak-scarlet oak-black oak type; 1c = white oak type; 2a = tulip poplar-oak type; 2b = tulip poplar-red maple type. np = none present, na = not available, + = less than 1.

Species	Cover type				
	1a	1b	1c	2a	2b
<u>Acer rubrum</u>					
IV tree ¹	11	15	17	9	26
tree basal area (cm ²)	212	150	151	341	395
IV sapling ²	10	26	20	12	28
<u>Amelanchier canadense</u>					
IV tree	+	1	3	np	np
tree basal area	98	36	121	na	na
IV sapling	3	1	26	4	2
<u>Betula lenta</u>					
IV tree	17	np	np	18	np
tree basal area	379	na	na	477	na
IV sapling	20	?2	np	15	4
<u>Cornus florida</u>					
IV tree	1	np	np	np	1
tree basal area	52	na	na	na	103
IV sapling	12	18	9	14	13
<u>Fraxinus pennsylvanicum</u>					
IV tree	+	+	np	2	4
tree basal area	55	27	na	412	661
IV sapling	2	2	np	9	14
<u>Juglans nigra</u>					
IV tree	np	+	np	np	1
tree basal area	na	844	na	na	94
IV sapling	np	np	np	np	2
<u>Juniperus virginiana</u>					
IV tree	np	np	np	np	np
tree basal area	na	na	na	na	na
IV sapling	np	np	np	np	np
<u>Liriodendron tulipifera</u>					
IV tree	10	2	8	31	48
tree basal area	1470	793	1020	1655	657
IV sapling	12	+	4	2	6
<u>Nyssa sylvatica</u>					
IV tree	12	8	4	4	1
tree basal area	147	73	102	380	102
IV sapling	16	18	14	6	np

<u>Platanus occidentalis</u>					
IV tree	np	np	np	np	np
tree basal area	na	na	na	na	na
IV sapling	na	na	na	na	na
<u>Prunus serotina</u>					
IV tree	np	np	3	np	4
tree basal area	na	na	1007	na	347
IV sapling	np	1	8	2	12
<u>Quercus alba</u>					
IV tree	13	2	30	5	1
tree basal area	1305	356	1270	1282	208
IV sapling	+	+	np	np	np
<u>Quercus coccinea</u>					
IV tree	12	15	10	7	1
tree basal area	1708	769	608	1361	670
IV sapling	np	+	2	np	np
<u>Quercus prinus</u>					
IV tree	5	19	4	1	np
tree basal area	945	531	248	1346	na
IV sapling	+	1	2	2	np
<u>Quercus velutina</u>					
IV tree	10	17	6	6	4
tree basal area	1444	1072	767	1769	1656
IV sapling	np	np	2	np	np
<u>Sassafras albidum</u>					
IV tree	3	5	5	2	2
tree basal area	221	135	167	180	190
IV sapling	14	5	np	1	4
<u>Ulmus americana</u>					
IV tree	np	np	np	np	1
tree basal area	na	na	na	na	211
IV sapling	np	np	np	np	9
Number of points	68	73	14	39	33
Tree stems/hectare	494	559	536	389	635
Saplings/hectare	654	434	413	368	174

¹IV tree = (rel. frequency + rel. dominance + rel. density)/3
x 100 (see text for more details).

²IV sapling = (rel. frequency + rel. dominance)/2 x 100

Table 2. Summary of forest type characteristics. Forest types are as follows: 3a = high density red maple type; 3b = red maple-arrowwood type; 3c = red maple-sycamore type; 4a = red cedar type; 4b = green ash-tulip poplar type; 4c = American elm type. np = none present, na = not available, + = IV less than 1.

Species	Cover type					
	1a	1b	1c	2a	2b	
	3a	3b	3c*	4a	4b	4c
<u>Acer rubrum</u>						
IV tree ¹	90	53	49	19	np	23
tree basal area	269	889	480	80	na	169
IV sapling ²	42	na	5	50	10	14
<u>Amelanchier canadense</u>						
IV tree	3	np	np	np	np	np
tree basal area	37	na	na	na	na	na
IV sapling	10	na	np	np	np	6
<u>Betula lenta</u>						
IV tree	np	np	np	np	np	np
tree basal area	na	na	na	na	na	na
IV sapling	np	na	2	np	np	np
<u>Cornus florida</u>						
IV tree	np	np	np	9	np	np
tree basal area	na	na	na	195	na	na
IV sapling	3	na	2	11	10	12
<u>Fraxinus pennsylvanicum</u>						
IV tree	np	7	15	np	40	8
tree basal area	na	196	318	na	152	2563
IV sapling	3	na	15	np	33	12
<u>Juglans nigra</u>						
IV tree	np	1	np	np	10	5
tree basal area	na	49	na	na	170	670
IV sapling	np	na	np	np	np	np
<u>Juniperus virginiana</u>						
IV tree	np	np	np	39	8	4
tree basal area	na	na	na	215	34	214
IV sapling	np	na	np	27	14	np
<u>Liriodendron tulipifera</u>						
IV tree	np	np	np	17	29	17
tree basal area	na	na	na	856	341	373
IV sapling	np	na	np	np	np	np
<u>Nyssa sylvatica</u>						
IV tree	4	1	np	8	np	np
tree basal area	138	94	na	170	na	na
IV sapling	np	na	12	np	np	np
<u>Platanus occidentalis</u>						
IV tree	np	np	16	np	np	np
tree basal area	na	na	148	na	na	na
IV sapling	np	na	np	np	np	np

<u>Prunus serotina</u>						
IV tree	np	4	2	8	np	np
tree basal area	na	182	300	127	na	na
IV sapling	12	na	5	np	24	np
<u>Quercus alba</u>						
IV tree	np	np	1	np	np	np
tree basal area	na	na	107	na	na	na
IV sapling	np	na	np	np	np	np
<u>Quercus coccinea</u>						
IV tree	np	np	np	np	np	9
tree basal area	na	na	na	na	na	2726
IV sapling	np	na	np	np	np	np
<u>Quercus prinus</u>						
IV tree	np	np	np	np	np	np
tree basal area	na	na	na	na	na	na
IV sapling	np	na	np	np	np	np
<u>Quercus velutina</u>						
IV tree	np	np	np	np	np	np
tree basal area	na	na	na	na	na	na
IV sapling	np	na	np	np	np	np
<u>Sassafras albidum</u>						
IV tree	np	np	np	np	12	np
tree basal area	na	na	na	na	66	na
IV sapling	np	na	12	np	np	np
<u>Ulmus americana</u>						
IV tree	np	12	np	np	np	25
tree basal area	na	164	na	na	na	1389
IV sapling	18	na	12	11	np	23
Number of points	13	10 ^a	1 ^b	3	3	6
Trees/hectare	759	292	528	392	546	356
Saplings/hectare	278	na	482	730	675	292

¹IV tree = (rel. frequency + rel. dominance + rel. density)/3
x 100 (see text for more details).

²IV sapling = (rel. frequency + rel. dominance)/2 x 100

*IV tree for this cover type = (rel. density + rel.
dominance)/2 x 100; sapling data are relative frequency
only

^a10 transects, 25 x 10 m each

^b1 transect, 83 x 10 m

Table 3. Statistics for mixed oak-sweet birch forest type
(sampling lines 3, 4, 4a, 5, 30; 68 points).

Descriptions of table headings:

freq = # of points species present/total # of points
#/ha = # of stems per hectare = density
ave ba = average basal area at 1.5 m in cm = dominance
ba/ha = total basal area/ha in m²
rel fr = freq/total frequencies for all species
rel de = density/total stems/ha for all species
rel do = dominance/total basal area/ha for all species
IV tree = (rel fr + rel de + rel do)/3 x 100
IV sapling = (rel fr + rel de)/2 x 100

+ = present, but averaged value would be 0

- = absent

Variations in totals result from rounding.

1. tree data

species	freq	#/ha	ave ba	ba/ha	rel fr	rel de	rel do	IV
<u>Acer rubrum</u>	.38	79	212	1.7	.13	.16	.05	11
<u>Amel. canad.</u>	.01	+	98	+	+	+	+	+
<u>Betula lenta</u>	.59	104	379	3.9	.20	.21	.11	17
<u>Carp. carol.</u>	.01	5	55	+	.01	.01	+	1
<u>Carya ovata</u>	.07	5	182	0.1	.02	.01	+	+
<u>Carya. sp.</u>	.03	5	325	0.2	.01	.01	+	1
Total <u>Carya</u>	.10	12	-	-	.04	.02	-	-
<u>Cast. dent.</u>	.03	5	102	+	.01	.01	+	1
<u>Cornus florida</u>	.03	5	52	+	.01	.01	+	1
<u>Fagus amer.</u>	.04	5	465	.2	.02	.01	.01	1
<u>Frax. penn.</u>	.01	+	55	+	+	+	+	+
<u>Juglans ciner.</u>	.01	+	516	+	+	+	+	+
<u>Lir. tulip.</u>	.21	40	1470	5.8	.07	.08	.16	10
<u>Nyssa sylvat.</u>	.47	82	147	1.2	.16	.16	.03	12
<u>Q. alba</u>	.32	49	1305	6.4	.11	.10	.18	13
<u>Q. coccinea</u>	.26	40	1708	6.7	.09	.08	.18	12
<u>Q. prinus</u>	.06	5	945	4.7	.02	.01	.13	5
<u>Q. rubra</u>	.01	+	1050	+	+	+	+	+
<u>Q. velutina</u>	.26	35	1444	5.1	.09	.07	.14	10
<u>Sass. albidum</u>	.12	15	221	0.3	.04	.03	.01	3
Totals		494		36.4	99	96	100	98

2. sapling data

species	freq	#/ha	rel fr	rel de	IV
<u>Acer rubrum</u>	.26	65	.11	.10	10

<u>Amel. canad.</u>	.09	13	.04	.02	3
<u>Betula lenta</u>	.46	131	.19	.20	20
<u>Carp. carol.</u>	.06	20	.02	.03	2
<u>Carya ovata</u>	.01	+	+	+	+
<u>Carya sp.</u>	.01	+	+	+	+
<u>Cast. dent.</u>	.13	26	.05	.04	4
<u>Cornus florida</u>	.28	72	.12	.11	12
<u>Fagus amer.</u>	.06	6	.02	.01	2
<u>Frax. penns.</u>	.04	20	.02	.03	2
<u>Lir. tulip.</u>	.31	78	.13	.12	12
<u>Nyssa sylvat.</u>	.37	105	.15	.16	16
<u>Ostrya virg.</u>	.01	+	+	+	+
<u>Quercus alba</u>	.01	+	+	+	+
<u>Q. prinus</u>	.01	+	+	+	+
<u>Sass. albidum</u>	.32	98	.13	.15	14
Totals		634	.98	.97	97

Table 4. Statistics for chestnut oak-scarlet oak-black oak forest type (sample lines 11, 14, 14a, 15, 16, 17, 18, 23, 24(1-9), 25(6-11); 67 points). For legend see Table 3.

1. tree data

species	freq	#/ha	ave ba	ba/ha	rel fr	rel de	rel do	IV
<u>Acer rubrum</u>	.45	89	155	1.4	.16	.16	.06	13
<u>Amel. canad.</u>	.03	6	36	+	.01	.01	+	1
<u>Betula lutea</u>	.04	6	540	0.3	.01	.01	.01	1
<u>Carp. carol.</u>	.04	11	49	0.1	.02	.02	+	1
<u>Carya glabra</u>	.04	6	455	0.3	.01	.01	.01	1
<u>C. ovata</u>	.07	11	831	0.9	.02	.02	.04	3
<u>C. tomentosa</u>	.12	22	218	0.5	.04	.04	.02	3
<u>Cast. dent.</u>	.05	6	40	+	.02	.01	+	1
<u>Frax. penns.</u>	.01	+	27	+	+	+	+	+
<u>Hamam. virg.</u>	.01	+	22	+	+	+	+	+
<u>Juglans nigra</u>	.01	+	844	+	+	+	+	+
<u>Lir. tulip.</u>	.10	17	691	1.2	.03	.03	.05	4
<u>Nyssa sylvat.</u>	.33	67	89	0.6	.11	.12	.02	8
<u>Popul. grand.</u>	.08	17	558	0.9	.03	.03	.04	3
<u>Q. coccinea</u>	.37	67	763	5.1	.13	.12	.20	15
<u>Q. prinus</u>	.44	95	548	5.2	.15	.17	.21	18
<u>Q. velutina</u>	.33	61	1098	6.7	.11	.11	.27	16
<u>Quercus alba</u>	.10	17	718	1.2	.03	.03	.05	4
<u>Sass. albidum</u>	.21	39	148	0.6	.07	.07	.02	5
unknown*	.04	6	-	-	.01	.01	+	1
Totals		559		25.0	.96	.97	1.00	98
*two unidentified trees								

2. Sapling data

species	freq	#/ha	rel fr	rel de	IV
<u>Acer rubrum</u>	.61	122	.24	.28	26
<u>Amel. canad</u>	.10	13	.04	.03	4
<u>Betula lenta</u>	.06	4	.02	.01	2
<u>Betula lutea</u>	.04	9	.02	.02	2
<u>Carp. carol.</u>	.06	4	.02	.01	2
<u>Carya ovata</u>	.01	+	.01	+	+
<u>C. tomentosa</u>	.07	9	.03	.02	2
<u>C. glabra</u>	.06	9	.02	.02	2
<u>Cast. dentata</u>	.20	22	.08	.05	6
<u>Cornus florida</u>	.39	78	.15	.18	16
<u>Crataegus sp.</u>	.01	4	.01	.01	1
<u>Frax. penns.</u>	.07	13	.03	.03	3
<u>Hamam. virg.</u>	.14	30	.06	.07	6
<u>Lir. tulip.</u>	.01	+	.01	+	+
<u>Morus rubra</u>	.01	+	.01	+	+

<u>Nyssa sylvat.</u>	.41	78	.16	.18	17
<u>Prunus serot.</u>	.06	4	.02	.01	1
<u>Quercus cocc.</u>	.01	+	.01	+	+
<u>Q. prinus</u>	.03	4	.01	.01	1
<u>Q. alba</u>	.01	+	.01	+	+
<u>Sass. albidum</u>	.16	17	.06	.04	5
Totals		420	1.02	.97	96

Table 5. Statistics for white oak forest type (sampling lines 18a, 19; 14 points). For legend see Table 3.

1. Tree data

species	freq	#/ha	ave ba	ba/ha	rel fr	rel de	rel ba	IV
<u>Acer rubrum</u>	.57	134	151	2.0	.18	.25	.07	17
<u>Amel. canad.</u>	.14	21	121	0.3	.05	.04	.01	3
<u>Betula lutea</u>	.29	48	143	0.5	.09	.09	.02	7
<u>Carp. carol.</u>	.07	11	32	+	.02	.02	+	1
<u>Carya ovata</u>	.07	11	717	0.8	.02	.02	.03	2
<u>Lir. tulip.</u>	.21	27	1020	2.8	.09	.05	.10	8
<u>Nyssa sylv.</u>	.21	27	102	0.3	.07	.05	.01	4
<u>Prunus serot.</u>	.07	11	1007	1.1	.02	.02	.04	3
<u>Quercus alba</u>	.57	113	1270	14.4	.18	.21	.51	30
<u>Q. coccinea</u>	.36	48	608	2.9	.11	.09	.10	10
<u>Q. prinus</u>	.14	21	248	0.5	.05	.04	.02	4
<u>Q. velutina</u>	.14	27	767	2.1	.05	.05	.07	6
<u>Sass. albid.</u>	.21	38	167	0.6	.07	.07	.02	5
Totals		537		28.3	1.00	1.00	1.00	100

2. Sapling data

species	freq	#/ha	rel fr	rel de	IV
<u>Lir. tulip.</u>	.07	8	.06	.02	4
<u>Acer rubrum</u>	.25	87	.19	.21	20
<u>Nyssa sylvat.</u>	.21	50	.17	.12	14
<u>Betula lutea</u>	.07	37	.06	.09	8
<u>Quercus cocc.</u>	.04	8	.03	.02	2
<u>Q. prinus</u>	.04	8	.03	.02	2
<u>Q. velutina</u>	.04	8	.03	.02	2
<u>Amel. canad.</u>	.29	120	.22	.29	26
<u>Prunus serot.</u>	.07	37	.06	.09	8
<u>Carp. carol.</u>	.07	21	.06	.05	6
<u>Cornus florida</u>	.14	29	.11	.07	9
Totals		413	1.02	1.00	101

Table 6. Statistics for tulip poplar-oak forest type (sampling lines 1, 2, 6, 24 (pts.10,11), 25 (pts.1-5), 31; 39 points). For legend see Table 3.

1. Tree data

species	freq	#/ha	ave ba	ba/ha	rel fr	rel de	rel ba	IV
<u>Acer rubrum</u>	.31	45	348	1.6	.12	.12	.05	10
<u>Betula lenta</u>	.51	105	477	5.0	.20	.28	.15	21
<u>Carp. carol.</u>	.05	7	78	0.1	.02	.02	+	1
<u>Carya glabra</u>	.05	4	584	0.2	.02	.01	.01	1
<u>C. ovata</u>	.10	11	824	0.9	.04	.03	.03	3
<u>C. tomentosa</u>	.05	4	140	0.1	.02	.01	+	1
<u>Cast. dent.</u>	.03	4	81	+	.01	.01	+	1
<u>Fagus amer.</u>	.18	30	361	1.1	.07	.08	.03	6
<u>Frax. pens.</u>	.10	11	412	0.5	.04	.03	.01	3
<u>Lir. tulip.</u>	.64	97	1762	17.1	.25	.26	.50	34
<u>Nyssa sylvat.</u>	.10	12	468	0.6	.04	.03	.02	3
<u>Quercus alba</u>	.10	12	1605	1.9	.03	.03	.06	4
<u>Q. coccinea</u>	.08	7	2327	1.6	.03	.02	.05	3
<u>Q. prinus</u>	.03	4	1329	0.5	.01	.01	.01	1
<u>Q. rubra</u>	.05	7	767	0.5	.02	.02	.01	2
<u>Q. velutina</u>	.10	12	2020	2.4	.04	.03	.07	5
<u>Sass. albidum</u>	.05	7	1347	0.1	.02	.02	+	1
Totals		379		34.2	.98	1.02	1.00	100

2. Sapling data

species	freq	#/ha	rel fr	rel de	IV
<u>Acer rubrum</u>	.25	37	.10	.10	10
<u>Amel. canad.</u>	.08	7	.03	.02	2
<u>Betula lenta</u>	.39	66	.16	.18	17
<u>Carp. carol.</u>	.19	52	.08	.14	11
<u>Carya glabra</u>	.06	4	.02	.01	2
<u>C. ovata</u>	.03	4	.01	.01	1
<u>C. tomentosa</u>	.03	4	.01	.01	1
<u>Carya sp.</u>	.03	4	.01	.01	1
<u>Cast. dent.</u>	.11	11	.05	.03	4
<u>Cornus florida</u>	.33	59	.14	.16	15
<u>Fagus amer.</u>	.19	37	.08	.10	9
<u>Frax. pens.</u>	.19	26	.08	.07	8
<u>Hamam. virg.</u>	.06	4	.02	.01	2
<u>Lir. tulip.</u>	.08	7	.03	.02	2
<u>Nyssa sylvat.</u>	.17	29	.07	.08	8
<u>Ostrya virg.</u>	.03	4	.01	.01	1
<u>Prunus serot.</u>	.03	4	.01	.01	1
<u>Quercus prinus</u>	.08	7	.08	.02	2
<u>Q. rubra</u>	.03	4	.01	.01	1

<u>Sass. albidum</u>	.03	4	.01	.01	1
Totals		374	1.01	1.01	99

Table 7. Statistics for tulip poplar-red maple forest type (sampling lines 7, 8, 9, 10, 12, 32; 33 points). For legend see Table 3.

1. Tree data

species	freq	#/ha	ave ba	ba/ha	rel fr	rel de	rel ba	IV
<u>Acer rubrum</u>	.70	178	395	7.0	.30	.28	.19	26
<u>Carya ovata</u>	.03	6	1217	0.7	.01	.01	.02	1
<u>Carya. sp.</u>	.09	13	127	0.2	.04	.02	.01	2
<u>Cornus florida</u>	.03	6	103	0.1	.01	.01	+	1
<u>Frax. penns.</u>	.12	19	661	1.3	.05	.03	.04	4
<u>Juglans nigra</u>	.03	6	94	0.3	.01	.01	.01	1
<u>Lir. tulip.</u>	.82	324	657	21.3	.35	.51	.59	48
<u>Nyssa sylvat.</u>	.03	6	102	0.1	.01	.01	+	1
<u>Pinus rigida</u>	.09	13	706	0.9	.04	.02	.02	3
<u>Prunus serot.</u>	.15	25	347	0.9	.06	.04	.02	4
<u>Quercus alba</u>	.03	6	208	0.1	.01	.01	+	1
<u>Q. coccinea</u>	.03	6	670	0.4	.01	.01	.01	1
<u>Q. velutina</u>	.06	13	1656	2.2	.03	.02	.06	4
<u>Sass. albidum</u>	.09	13	190	0.2	.04	.02	.01	2
<u>Ulmus amer.</u>	.03	13	211	0.3	.01	.02	.01	1
Totals		647		36.0	.98	1.02	.99	100

2. Sapling data

species	freq	#/ha	rel fr	rel de	IV
<u>Acer rubrum</u>	.59	56	.23	.32	28
<u>Amel. canad.</u>	.03	5	.01	.03	2
<u>Betula lenta</u>	.14	5	.05	.03	4
<u>B. lutea</u>	.03	2	.01	.01	1
<u>Carp. carol.</u>	.07	5	.03	.03	3
<u>Carya ovata</u>	.03	2	.01	.01	1
<u>Cast. dent.</u>	.03	2	.01	.01	1
<u>Cornus florida</u>	.34	21	.14	.12	13
<u>Frax. penns.</u>	.34	23	.14	.13	14
<u>Hamam. virg.</u>	.03	3	.01	.02	2
<u>Juglans nigra</u>	.07	3	.03	.02	2
<u>Lir. tulip.</u>	.17	10	.07	.06	6
<u>Prunus serot.</u>	.28	23	.11	.13	12
<u>Sass. albidum</u>	.10	5	.04	.03	4
<u>Ulmus amer.</u>	.24	14	.10	.08	9
Totals		179	.99	1.03	1.02

Table 8. Statistics for high density red maple forest type (sampling lines 19a, 26a (1 pt.), 28, 33; 13 points). For legend see Table 3.

1. Tree data

species	freq	#/ha	ave ba	ba/ha	rel fr	rel de	rel ba	IV
<u>Acer rubrum</u>	1.00	698	269	18.8	.81	.92	.96	90
<u>Amel. canad.</u>	.07	15	37	0.1	.06	.02	+	3
<u>Nyssa sylvat.</u>	.07	30	138	0.4	.06	.04	.02	4
<u>Quercus palus.</u>	.07	15	69	0.1	.06	.02	.01	3
Totals		758		19.4	.99	1.00	.99	100

2. Sapling data

species	freq	#/ha	rel fr	rel de	IV
<u>Acer rubrum</u>	.75	133	.37	.48	42
<u>Amel. canad.</u>	.17	33	.08	.12	10
<u>Quercus palus.</u>	.08	6	.04	.02	3
<u>Ulmus amer.</u>	.33	53	.17	.19	18
<u>Prunus serot.</u>	.33	22	.17	.08	12
<u>Cornus florida</u>	.08	6	.04	.02	3
<u>Frax. penns.</u>	.08	6	.04	.02	3
<u>Carp. carol.</u>	.08	11	.04	.04	4
<u>Ostrya virg.</u>	.08	6	.04	.02	3
Totals		276	.99	.99	98

Table 9. Statistics for red maple-arrowwood forest type (sampling lines 20, 21, 26a; 10 belt transects, 10x25 m each). For legend, see Table 3. No saplings were tallied for this cover type.

1. Tree data

species	freq	#/ha	ave ba	ba/ha	rel fr	rel de	rel ba	IV
<u>Acer rubrum</u>	.90	176	889	15.6	.30	.60	.70	53
<u>Carya ovata</u>	.10	12	472	0.6	.03	.04	.03	3
<u>Frax. penns.</u>	.40	20	196	0.4	.13	.07	.02	7
<u>Juglans nigra</u>	.10	4	49	+	.03	.01	+	1
<u>Nyssa sylvat.</u>	.10	4	94	+	.03	.01	+	1
<u>Prunus serot.</u>	.20	12	182	0.2	.07	.04	.01	4
<u>Pyrus malus</u>	.10	8	415	0.3	.03	.03	.01	3
<u>Quercus palus.</u>	.20	8	1456	1.2	.07	.03	.05	5
<u>Salix. sp.</u>	.10	4	8064	3.2	.03	.01	.14	6
<u>Ulmus amer.</u>	.60	36	164	0.6	.20	.12	.03	12
<u>U. glabra</u>	.20	8	396	0.3	.07	.03	.01	4
Totals		292		22.4	.99	.99	1.00	99

2. Shrub data

species	freq	%cover	rel fr	rel co	IV
<u>Alnus rugosa</u>	.30	.02	.06	.02	4
<u>Cornus racem.</u>	.30	.02	.06	.02	4
<u>Ilex vertic.</u>	.5	.06	.10	.06	8
<u>Lind. benz.</u>	1.00	.32	.20	.33	26
<u>Samb. canad.</u>	.20	+	.04	+	2
<u>Toxicod. ver.</u>	.20	.02	.04	.02	3
<u>Viburn. den.</u>	.90	.33	.18	.34	26
<u>V. prunifol.</u>	.20	.02	.04	.02	3
<u>Vitis spp.</u>	.60	.10	.12	.10	11
Other*	.70	.08	.14	.08	11
gaps			.27		

*other = species with less than 0.2 frequency. The species included in this category are Viburnum lentago, Rubus phoenocolasius, R. allegheniensis, Celastrus scandens, Lonicera japonica, Clematis virginiana, Parthenocissus quinquefolia, Corylus sp., Toxicodendron radicans, and Ulmus americana.

Table 10. Statistics for red maple-sycamore (belt transect 29, 10x83 m). For legend see Table 3.

1. Tree data

species	#/ha	ave ba	ba/ha	rel de	rel do	IV*
<u>Acer rubrum</u>	275	480	13.2	.52	.46	49
<u>Frax. penns.</u>	95	318	3.0	.18	.11	15
<u>Lir. tulip.</u>	74	705	5.2	.14	.18	16
<u>Plat. occid.</u>	48	1336	6.4	.09	.23	16
<u>Pop. grandid.</u>	11	148	0.2	.02	.01	2
<u>Prunus serotina</u>	11	300	0.3	.02	.01	2
<u>Quercus alba</u>	11	107	0.1	.02	+	1
Totals		525	28.4	.99	1.00	101

*IV = (rel. density + relative dominance)/2 x100

2. Sapling data

species	#/ha	rel de
<u>Acer rubrum</u>	24	.05
<u>Betula lenta</u>	12	.02
<u>C. amomum</u>	60	.12
<u>Carp. carol.</u>	157	.32
<u>Celtis amer.</u>	24	.05
<u>Cornus florida</u>	12	.02
<u>Frax. penns.</u>	72	.15
<u>Morus sp.</u>	12	.02
<u>Nyssa sylvat.</u>	12	.02
<u>Prunus serot.</u>	24	.05
<u>Sass. albidum</u>	12	.02
<u>Ulmus amer.</u>	60	.12
Total	481	.96

Table 11. Statistics for red cedar forest type (sampling line 27, 3 points). For legend see Table 3.

species	freq	#/ha	ave ba	ba/ha	rel fr	rel de	rel ba	IV
<u>Acer rubrum</u>	.67	98	80	0.8	.22	.25	.09	19
<u>Cornus florida</u>	.33	31	195	0.6	.11	.08	.07	9
<u>Juniper. vir.</u>	1.00	165	215	3.6	.33	.42	.42	39
<u>Lir. tulip.</u>	.33	31	856	2.7	.11	.08	.31	17
<u>Nyssa sylvat.</u>	.3	31	170	0.5	.11	.08	.06	8
<u>Prunus serot</u>	.33	31	127	0.4	.11	.08	.05	8
Totals		387		8.6	.99	.99	1.00	100

2. Sapling data

species	freq	#/ha	rel fr	rel de	IV
<u>Acer rubrum</u>	1.00	423	.43	.58	50
<u>Cornus florida</u>	.33	58	.14	.08	11
<u>Juniper. virg.</u>	.67	182	.29	.25	27
<u>Ulmus amer.</u>	.33	58	.14	.08	11
Totals		721	1.00	.99	99

Table 12. Statistics for green ash-tulip poplar forest type (sampling line 26, 3 points). For legend see Table 3.

1. Tree data

species	freq	#/ha	ave ba	ba/ha	rel fr	rel de	rel ba	IV
<u>Frax. penns.</u>	1.00	229	152	3.5	.43	.42	.36	40
<u>Juglans nigra</u>	.33	44	170	0.7	.14	.08	.08	10
<u>Juniperus vir.</u>	.33	44	34	0.1	.14	.08	.02	8
<u>Lir. tulip.</u>	.33	136	341	4.6	.14	.25	.48	29
<u>Sass. albidum</u>	.33	93	66	0.6	.14	.17	.06	12
Totals		546		9.5	.99	1.00	1.00	99

2. Sapling data

species	freq	#/ha	rel fr	rel de	IV
<u>Frax. penns.</u>	1.00	223	.33	.33	33
<u>Juniper. virg.</u>	.33	115	.11	.17	14
<u>Cornus florida</u>	.33	54	.11	.08	10
<u>Prunus serot.</u>	.67	169	.22	.25	24
<u>Ostrya virg.</u>	.33	54	.11	.08	10
<u>Acer rubrum</u>	.33	54	.11	.08	10
Totals		669	.99	.99	101

Table 13. Statistics for American elm forest type (sampling line 22; 6 points). For legend see Table 3.

1. Tree data

species	freq	#/ha	ave ba	ba/ha	rel fr	rel de	rel ba	IV
<u>Acer rubrum</u>	.67	117	196	2.3	.27	.33	.09	23
<u>A. saccharum</u>	.17	14	341	0.5	.07	.04	.02	4
<u>Frax. penss.</u>	.17	14	2563	3.6	.07	.04	.17	8
<u>Juglans nigra</u>	.17	14	670	0.9	.07	.04	.04	5
<u>Juniperus vir.</u>	.17	14	214	0.3	.07	.04	.01	4
<u>Lir tulip.</u>	.50	75	373	2.8	.20	.21	.11	17
<u>Quercus cocc.</u>	.17	14	2726	3.8	.07	.04	.15	9
<u>Tilia amer.</u>	.17	14	341	0.5	.07	.04	.02	4
<u>Ulmus amer.</u>	.33	75	1389	10.4	.13	.21	.41	25
Totals		351		25.1	1.02	.99	1.02	99

2. Sapling data

species	freq	#/ha	rel fr	rel de	IV
<u>Acer rubrum</u>	.20	58	.07	.20	14
<u>Amel. canad.</u>	.20	15	.07	.05	6
<u>Carya ovata</u>	.20	15	.07	.05	6
<u>Cornus florida</u>	.40	29	.14	.10	12
<u>Crataegus sp.</u>	.20	15	.07	.05	6
<u>Frax. penss.</u>	.40	29	.14	.10	12
<u>Prunus avium</u>	.40	44	.14	.15	14
<u>Sass. albidum</u>	.20	15	.07	.05	6
<u>Ulmus amer.</u>	.60	73	.21	.25	23
Totals		293	.98	1.00	99

Appendix 1

Vascular Flora of Hopewell Furnace National Historic Site

[] = non-native species

Collection housed, unmounted in Herbarium Curator's Office, Academy
of Natural Sciences, Philadelphia

Aceraceae

Acer negundo
Acer rubrum
Acer saccharinum
Acer saccharum

Alismataceae

Alisma subcordatum
Sagittaria australis
Sagittaria latifolia

Amaranthaceae

Amaranthus retroflexus

Amaryllidaceae

Hypoxis hirsuta

Anacardiaceae

Rhus copallina
Rhus glabra
Rhus typhina
Toxicodendron radicans
Toxicodendron vernix

Annonaceae

Asimina triloba

Apiaceae

Cryptotaenia canadensis
 [Daucus carota]
Hydrocotyle americana
Osmorhiza claytonii
Osmorhiza longistylis

Apocynaceae

Apocynum androsaemifolium
Apocynum cannabinum
 [Vinca minor]

Aquifoliaceae

Ilex verticillata

Araceae

Acorus calamus
Arisaema triphyllum
Symplocarpus foetidus

Araliaceae

Aralia nudicaulis
Panax trifolius

Aristolochiaceae

Asarum canadense

Asclepiadaceae

Asclepias exaltata
Asclepias syriaca

Asteraceae

Achillea millefolium
Ambrosia artemisiifolia
Ambrosia trifida
Antennaria neglecta
Antennaria neodioica
Antennaria plantaginifolia
 [Arctium minus]
Aster cordifolius
Aster divaricatus
Aster lateriflorus
Aster pilosus
Aster simplex
Bidens connata
Bidens frondosa
 [Carduus nutans]
 [Chrysanthemum leucanthemum]
 [Cichorium intybus]
 [Cirsium arvense]
 [Cirsium vulgare]
Erechtites hieracifolia
Erigeron annuus
Erigeron canadensis
Erigeron philadelphicus
Erigeron pulchellus
Erigeron strigosus
Eupatorium fistulosum
Eupatorium perfoliatum
Eupatorium rugosum
Eupatorium sessilifolium
 [Galinsoga ciliata]
Gnaphalium obtusifolium
 [Hieracium flagellare]
 [Hieracium pratense]
Hieracium scabrum
Hieracium venosum
Krigia biflora
Lactuca canadensis
Mikania scandens
Rudbeckia hirta
Rudbeckia laciniata
Senecio aureus
Solidago altissima
Solidago bicolor
Solidago canadensis
Solidago caesia
Solidago graminifolia
Solidago juncea
Solidago nemoralis
Solidago rugosa
 [Taraxacum officinale]
 [Tussilago farfara]

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Balsaminaceae	Viburnum acerifolium
<i>Impatiens capensis</i>	Viburnum dentatum
	Viburnum lentago
Berberidaceae	Viburnum prunifolium
[<i>Berberis thunbergii</i>]	
<i>Podophyllum peltatum</i>	
Betulaceae	Caryophyllaceae
<i>Alnus rugosa</i>	<i>Cerastium arvense</i>
<i>Alnus serrulata</i>	<i>Cerastium nutans</i>
<i>Betula lenta</i>	[<i>Dianthus armeria</i>]
<i>Betula lutea</i>	[<i>Lychnis alba</i>]
<i>Betula nigra</i>	[<i>Saponaria officinalis</i>]
<i>Carpinus caroliniana</i>	[<i>Silene cucubalus</i>]
<i>Corylus americana</i>	<i>Stellaria alsine</i>
<i>Ostrya virginiana</i>	<i>Stellaria longifolia</i>
	[<i>Stellaria media</i>]
	<i>Stellaria pubera</i>
Bignoniaceae	
[<i>Campsis radicans</i>]	Celastraceae
	[<i>Celastrus orbiculatus</i>]
Boraginaceae	<i>Euonymus americanus</i>
<i>Cynoglossum virginianum</i>	
[<i>Echium vulgare</i>]	Ceratophyllaceae
<i>Myosotis laxa</i>	<i>Ceratophyllum demersum</i>
[<i>Myosotis scorpioides</i>]	
[<i>Symphytum officinale</i>]	Chenopodiaceae
	[<i>Chenopodium album</i>]
Brassicaceae	<i>Chenopodium ambrosioides</i>
[<i>Alliaria officinalis</i>]	
[<i>Barbarea vulgaris</i>]	Clethraceae
<i>Cardamine bulbosa</i>	<i>Clethra alnifolia</i>
<i>Cardamine pennsylvanica</i>	
<i>Dentaria laciniata</i>	Clusiaceae
[<i>Lepidium campestre</i>]	<i>Hypericum mutilum</i>
<i>Nasturtium microphyllum</i>	[<i>Hypericum perforatum</i>]
[<i>Rorippa sylvestris</i>]	<i>Hypericum punctatum</i>
[<i>Sisymbrium officinale</i>]	
[<i>Thlaspi arvense</i>]	Commelinaceae
	[<i>Commelina communis</i>]
Callitrichaceae	
<i>Callitriche heterophylla</i>	Cornaceae
	<i>Cornus amomum</i>
Campanulaceae	<i>Cornus florida</i>
<i>Campanula aparanoidea</i>	
<i>Lobelia cardinalis</i>	Crassulaceae
<i>Lobelia inflata</i>	[<i>Sedum telephium</i>]
<i>Lobelia spicata</i>	
<i>Specularia perfoliata</i>	Cyperaceae
Caprifoliaceae	<i>Carex albolutescens</i>
[<i>Lonicera japonica</i>]	<i>Carex amphibola</i>
[<i>Lonicera morrowii</i>]	<i>Carex annectens</i>
<i>Sambucus canadensis</i>	<i>Carex artitecta</i>
[<i>Symphoricarpos orbiculatus</i>]	<i>Carex atlantica</i>
	<i>Carex blanda</i>
	<i>Carex bromoides</i>

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Carex cephalophora
 Carex convoluta
 Carex crinita
 Carex gracilescens
 Carex gracillima
 Carex granularis
 Carex gynandra
 Carex hirsutella
 Carex intumescens
 Carex laxiculmis
 Carex laxiflora
 Carex lupulina
 Carex lurida
 Carex normalis
 Carex pensylvanica
 Carex prasina
 Carex rosea
 Carex scoparia
 Carex stipata
 Carex stricta
 Carex swanii
 Carex vulpinoidea
 Cyperus rivularis
 Cyperus strigosus
 Dulichium arundinaceum
 Eleocharis acicularis
 Eleocharis erythropoda
 Eleocharis obtusa
 Eleocharis tenuis
 Rhynchospora capitellata
 Scirpus atrovirens
 Scirpus cyperinus
 Scirpus expansus
 Scirpus georgianus
 Scirpus hattorianus
 Scirpus polyphyllus
 Scirpus tabernaemontanii

Dioscoreaceae
 Dioscorea villosa

Eleagnaceae
 Eleagnus umbellata

Equisetaceae
 Equisetum arvense
 Equisetum sylvaticum

Eriaceae
 Gaylussacia baccata
 Kalmia latifolia
 Lyonia ligustrina
 Rhododendron nudiflorum
 Vaccinium corymbosum
 Vaccinium stamineum
 Vaccinium vacillans

Euphorbiaceae
 Acalypha rhomboidea
 Euphorbia supina

Fabaceae
 Amphicarpa bracteata
 Cassia nictitans
 Cercis canadensis
 [Coronilla varia]
 Desmodium canescens
 Desmodium nudiflorum
 Desmodium paniculatum
 Desmodium perplexum
 Desmodium rotundifolium
 Lespedeza intermedia
 Lespedeza repens
 Lespedeza virginica
 [Lotus corniculatus]
 [Medicago lupulina]
 [Melilotus alba]
 [Melilotus officinalis]
 [Robinia pseudoacacia]
 [Trifolium pratense]
 [Trifolium procumbens]
 [Trifolium repens]

Fagaceae
 Castanea dentata
 Fagus grandifolia
 Quercus alba
 Quercus bicolor
 Quercus coccinea
 Quercus palustris
 Quercus prinus
 Quercus rubra
 Quercus velutina

Gentianaceae
 Gentiana andrewsii
 Gentiana crinita

Geraniaceae
 Geranium maculatum

Hamamelidaceae
 Hamamelis virginiana

Hydrocharitaceae
 Elodea nuttallii

Hydrophyllaceae
 Hydrophyllum virginianum

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Iridaceae

Sisyrinchium angustifolium
Sisyrinchium mucronatum

Juglandaceae

Carya glabra
Carya laciniata
Carya ovata
Carya tomentosa
Juglans nigra

Juncaceae

Juncus effusus
Juncus marginatus
Juncus platyphyllus
Juncus tenuis
Juncus subcaudatus
Luzula multiflora

Lamiaceae

Collinsonia canadensis
Cunila origanoides
 [Glechoma hederacea]
 [Lamium amplexicaule]
 [Lamium purpureum]
Lycopus americanus
Lycopus virginicus
Lycopus uniflorus
Mentha arvensis
 [Mentha piperata]
 [Nepetha cataria]
 [Perilla frutescens]
Pycnanthemum tenuifolium
Pycnanthemum virginianum
Salvia lyrata
Satureja vulgaris
Scutellaria elliptica
Scutellaria integrifolia
Scutellaria lateriflora

Lauraceae

Lindera benzoin
Sassafras albidum

Lemnaceae

Lemna minor

Liliaceae

Allium canadense
 [Allium vineale]
 [Asparagus officinalis]
Erythronium americanum
 [Hemerocallis fulva]
Maianthemum canadense

Medeola virginiana

[*Ornithogalum umbellatum*]

Polygonatum biflorum

Smilacina racemosa

Smilax glauca

Smilax herbacea

Smilax rotundifolia

Smilax tamnoides

Uvularia perfoliata

Uvularia sessilifolia

Veratrum viride

Lycopodiaceae

Lycopodium digitatum

Lycopodium obscurum

Magnoliaceae

Liriodendron tulipifera

Malvaceae

[*Hibiscus trionum*]

Moraceae

[*Broussonetia papyrifera*]

[*Morus alba*]

Nymphaeaceae

Nuphar lutea

Nyssaceae

Nyssa sylvatica

Oleaceae

Fraxinus americana

Fraxinus nigra

Fraxinus pennsylvanica

[*Ligustrum obtusifolium*]

Onagraceae

Circaea quadrisulcata

Gaura biennis

Ludwigia alternifolia

Ludwigia palustris

Oenothera biennis

Ophioglossaceae

Botrychium dissectum

Botrychium oneidense

Botrychium virginianum

Orchidaceae

Cypripedium acaule

Goodyera pubescens

Habenaria lacera

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Isotria verticillata	[Digitaria ischaemum]
Orchis spectabilis	[Digitaria sanguinalis]
Spiranthes cernua	[Echinochloa crusgalli]
	[Eleusine indica]
Orobanchaceae	Eragrostis spectabilis
Epifagus virginiana	[Festuca elatior]
Orobanche uniflora	Festuca obtusa
	[Festuca rubra]
Osmundaceae	Glyceria melicaria
Osmunda cinnamomea	Glyceria septentrionalis
Osmunda claytoniana	Glyceria striata
Osmunda regalis	[Holcus lanatus]
	Leersia oryzoides
Oxalidaceae	Leersia virginica
Oxalis europaea	[Lolium multiflorum]
Oxalis stricta	[Microstegium vimineum]
	Muhlenbergia schreberi
Papaveraceae	Muhlenbergia sobolifera
Sanguinaria canadensis	Panicum anceps
	Panicum clandestinum
Phrymaceae	Panicum dichotomiflorum
Phryma leptostachya	Panicum dichotomum
	Panicum lanuginosum
Phytolaccaceae	Paspalum laeve
Phytolacca americana	[Phleum pratense]
	[Poa compressa]
Pinaceae	Poa pratensis
Juniperus virginiana	Poa trivialis
Pinus rigida	[Setaria faberi]
Pinus strobus	[Setaria glauca]
Pinus virginiana	[Setaria viridis]
Tsuga canadensis	Sorghastrum nutans
	Sphenopholis intermedia
Plantaginaceae	Tridens flavus
[Plantago lanceolata]	
[Plantago major]	
Platanaceae	
Platanus occidentalis	
Poaceae	
Agrostis hyemalis	
Agrostis perennans	
Agrostis stolonifera	
Andropogon scoparius	
Andropogon virginicus	
[Anthoxanthum odoratum]	
Arrhenatherum elatius	
Brachyelytrum erectum	
[Bromus inermis]	
Cinna arundinacea	
[Dactylis glomerata]	
Danthonia compressa	
Danthonia spicata	
	Polygonaceae
	Polygonum arifolium
	[Polygonum aviculare]
	[Polygonum cespitosum]
	Polygonum pensylvanicum
	Polygonum punctatum
	Polygonum sagittatum
	Polygonum scandens
	Polygonum virginianum
	[Rumex acetosella]
	[Rumex crispus]
	[Rumex obtusifolius]
	Polypodiaceae
	Adiantum pedatum
	Asplenium platyneuron
	Athyrium felix-femina
	Athyrium thelypteroides
	Dennstaedtia punctilobula

December 9, 1986

Dryopteris cristata
 Dryopteris intermedia
 Dryopteris marginalis
 Dryopteris spinulosa
 Onoclea sensibilis
 Polypodium virginianum
 Polystichum acrostichoides
 Pteridium aquilinum
 Thelypteris novaboracensis
 Thelypteris palustris

Portulacaceae

Claytonia virginica

Potamogetonaceae

[Potamogeton crispus]
 Potamogeton epihydrus
 Potamogeton foliosus

Primulaceae

Anagallis arvensis
 Lysimachia ciliata
 Lysimachia quadrifolia

Pyrolaceae

Chimaphila maculata
 Monotropa uniflora
 Pyrola rotundifolia

Ranunculaceae

Anemone virginiana
 Anemonella thalictroides
 Caltha palustris
 Cimicifuga racemosa
 Clematis virginiana
 Hepatica americana
 Ranunculus abortivus
 [Ranunculus bulbosus]
 Ranunculus hispidus
 Ranunculus recurvatus
 Thalictrum pubescens

Rosaceae

Agrimonia gryposepala
 Amelanchier canadense
 Fragaria virginiana
 Geum canadense
 Potentilla canadensis
 [Potentilla intermedia]
 Potentilla norvegica
 [Potentilla recta]
 Potentilla simplex
 [Prunus avium]
 Prunus serotina

Prunus virginiana
 [Pyrus malus]
 [Rosa multiflora]
 Rosa palustris
 Rubus allegheniensis
 Rubus enslenii
 Rubus hispidus
 Rubus occidentalis
 [Rubus phoenicolasius]

Rubiaceae

Cephalanthus occidentalis
 [Galium aparine]
 Galium circaezans
 Galium obtusum
 Galium triflorum
 Galium sp.
 Houstonia caerulea
 Mitchella repens

Salicaceae

Populus grandidentata
 Salix nigra

Saxifragaceae

Chrysosplenium americanum
 Heuchera americana
 Mitella diphylla
 Penthorum sedoides
 Saxifraga pensylvanica

Scrophulariaceae

[Chaenorrhinum minus]
 Chelone glabra
 Gratiola neglecta
 [Linaria vulgaris]
 Melampyrum lineare
 Mimulus alatus
 Mimulus ringens
 Pedicularis canadensis
 Pedicularis lanceolata
 [Penstemon digitalis]
 [Verbascum thapsus]
 [Verbascum blattaria]
 Veronica americana
 [Veronica arvensis]
 [Veronica officinalis]
 Veronica peregrina

Simaroubaceae

[Ailanthus altissima]

Solanaceae

Physalis subglabrata

Sparganiaceae

Sparganium americanum

Tiliaceae

Tilia americana

Ulmaceae

Celtis occidentalis

Ulmus americana

Urticaceae

Boehmeria cylindrica

Laportea canadensis

Pilea pumila

Violaceae

Viola affinis

Viola cucullata

Viola hirsutula

Viola pallens

Viola pubescens

Viola rostrata

Viola sororia

Viola triloba

Vitaceae

Parthenocissus quinquefolia

Vitis aestivalis

Vitis labrusca

Vitis riparia

Vitis vulpina

Verbenaceae

Verbena hastata

Verbena urticifolia

COLLECTIONS FROM HOPEWELL VILLAGE

December 10, 1986

Acalypha rhomboidea	Cornus amomum
Agrimonia gryposepala	Crataegus sp.
Agrostis hyemalis	Cryptotaenia canadensis
Agrostis perennans	Cunila origanoides
Allium canadense	Danthonia compressa
Amaranthus retroflexus	Danthonia spicata
Amelanchier canadensis	Dennstaedtia punctilobula
Antennaria neglecta	Desmodium paniculatum
Antennaria plantaginifolia	Desmodium perplexum
Apocynum cannabinum	Desmodium rotundifolium
Asimina triloba	Digitaria ischaemum
Asplenium platyneuron	Digitaria sanguinalis
Aster cordifolius	Dioscorea villosa
Aster divaricatus	Dryopteris intermedia
Aster lateriflorus	Dryopteris marginalis
Aster pilosus	Dryopteris spinulosa
Aster simplex	Eleagnus umbellata
Athyrium felix-femina	Erigeron annuus
Athyrium thelypteroides	Erigeron pulchellus
Bidens connata	Erigeron strigosus
Bidens frondosa	Euphorbia supina
Botrychium dissectum	Festuca elatior
Botrychium oneidense	Festuca obtusa
Brachyelytrum erectum	Festuca rubra
Bromus inermis	Fraxinus pennsylvanica
Callitriche heterophylla	Galinsoga ciliata
Cardamine pensylvanica	Galium circaezans
Carex albolutescens	Galium obtusum
Carex amphibola	Galium sp.
Carex annectens	Galium triflorum
Carex artitecta	Gaylussacia baccata
Carex blanda	Geum canadense
Carex bromoides	Glyceria melicaria
Carex cephalophora	Hieracium flagellare
Carex convoluta	Hieracium scabrum
Carex gracilescens	Hypericum mutilum
Carex gracillima	Isotria verticillata
Carex granularis	Juncus marginatus
Carex hirsutella	Juncus platyphyllus
Carex intumescens	Juncus subcaudatus
Carex laxiculmis	Juncus tenuis
Carex laxiflora	Krigia biflora
Carex lupulina	Leersia virginica
Carex normalis	Lepidium campestre
Carex prasina	Lespedeza intermedia
Carex rosea	Lespedeza repens
Carex swanii	Lolium multiflorum
Carex vulpinoidea	Lonicera morrowii
Cerastium nutans	Luzula multiflora
Ceratophyllum demersum	Lycopodium digitatum
Chaenorrhinum minus	Lycopodium obscurum
Chrysosplenium americanum	Lycopus americanus
Cinna arundinacea	Lycopus virginicus
Cirsium arvense	Lyonia ligustrina

COLLECTIONS FROM HOPEWELL VILLAGE
December 10, 1986

Muhlenbergia schreberi
Muhlenbergia sobolifera
Osmorhiza longistylis
Oxalis europaea
Oxalis stricta
Panicum anceps
Panicum dichotomiflorum
Panicum dichotomum
Panicum lanuginosum
Paspalum laeve
Penstemon digitalis
Perilla frutescens
Poa compressa
Poa trivialis
Polygonum aviculare
Polygonum persicaria
Potamogeton crispus
Potamogeton foliosus
Potentilla canadensis
Potentilla intermedia
Potentilla norvegica
Potentilla recta
Potentilla simplex
Prenanthes altissima
Prunus avium
Pycnanthemum tenuifolius
Pycnanthemum virginianum
Ranunculus bulbosus
Ranunculus hispidus
Ranunculus recurvatus
Rorippa sylvestris
Rosa palustris
Rubus enslenii
Rubus hispidus

Sanicula canadensis
Sanicula gregaria
Scutellaria integrifolia
Setaria glauca
Setaria viridis
Silene cucubalus
Sisymbrium officinale
Sisyrinchium angustifolium
Sisyrinchium mucronatum
Smilax herbacea
Smilax rotundifolia
Solidago altissima
Solidago bicolor
Solidago caesia
Solidago canadensis
Solidago nemoralis
Sphenopholis intermedia
Spiranthes cernua
Stellaria longifolia
Stellaria pubera
Symphoricarpos orbiculatus
Thalictrum pubescens
Thlaspi arvense
Vaccinium stamineum
Vaccinium vacillans
Veronica arvensis
Veronica peregrina
Viburnum dentatum
Viburnum lentago
Viburnum prunifolium
Viola affinis
Viola cucullata
Viola hirsutula
Viola sororia
Viola triloba
Vitis aestivalis
Vitis vulpina

Appendix 2

Species Lists from 5 Meter Diameter Plots

5 meter plot data

Plot 1: Transect 1, 500 m

Acer rubrum
Amphicarpa bracteata
Arisaema triphyllum
Aster divaricatus
Asteraceae sp.
Botrychium dissectum
Carex sp.
Carpinus caroliniana
Cimicifuga racemosa
Claytonia virginica
Fraxinus pennsylvanica
Galium 5 leaved
Galium circaezans
Geranium maculatum
Geum canadense
Impatiens capensis
Lindera benzoin
Liriodendron tulipifera
Maianthemum canadense
Osmorhiza claytonii
Oxalis sp.
Plantago major
Poa sp.
Poaceae sp.
Podoplyllum peltatum
Polystichum acrostichoides
Pyrola elliptica
Rosa multiflora
Smilax sp.
Solidago caesia
Tovara virginica
Toxicodendron radicans
Uvularia sessilifolia
Veronica officinalis
Viburnum acerifolium
Viburnum prunifolium
Viola sp.

Plot 2: tr. 11, 250 m

Acer rubrum
Cornus florida
Fraxinus pennsylvanica
Lysimachia quadrifolia
Melampyrum lineare
Mitchella repens
Parthenocissus quinquefolia
Podophyllum peltatum
Potentilla recta
Prunus serotina
Quercus alba
Quercus red
Rhododendron nudiflorum
Rubus sp.
Smilax sp.
Solidago caesia
Uvularia sessifolia
Vaccinium vacillans
Viburnum acerifolium
Viola sp.

Plot 3: tr. 12, 100 m

Acer rubrum
Aralia nudicaulis
Arisaema trifoliata
Dryopteris novaboracaensis
Lindera benzoin
Liriodendron tulipifera
Mitchella repens
Osmunda cinnamomea
Parthenocissus quinquefolia
Podophyllum peltatum
Rubus sp.
Smilacina racemosa
Sphagnum
Symplocarpus foetidus
Toxicodendron radicans
Vaccinium corymbosum

Plot 4: tr. 14a, 285 m.

Acer rubrum
Amphicarpa bracteata
Dryopteris marginalis
Galium circaezans
Geranium maculatum
Liriodendron tulipifera
Mitchella repens
Parthenocissus cinquefolia
Potentilla recta
Prenanthes trifoliata
Prunus serotina
Quercus red
Rhododendron nudiflorum
Rosa sp.
Rubus sp.
Sassafras albidum
Smilacina racemosa
Solidago caesia
Toxicodendron radicans
Uvularia sessifolia
Vaccinium vacillans
Viburnum acerifolium
Viola sp.

Plot 5: tr. 14, 485 m.

Acer rubrum
Amphicarpa bracteata
Galium circaezans
Gaylussacia baccata
Goodyera pubescens
Kalmia latifolia
Populus grandidentata
Quercus alba
Quercus prinus
Quercus red
Quercus velutina
Rhododendron nudiflorum
Smilacina racemosa
Solidago caesia
Viburnum acerifolium
Viburnum prunifolium

Plot 6: tr. 14, 684 m.

Acer rubrum
Aralia nudicaulis
Betula lenta
Gaylussacia baccata
Hamamelis virginiana
Mitchella repens
Prunus serotina
Rhododendron nudiflorum
Sassafras albidum
Smilcina racemosa
Smilax glauca
Vaccinium vacillans
Viburnum prunifolium

Plot 7: tr.14, 884 m.

Acer rubrum
Amelanchier canadensis
Aralia nudicaulis
Betula lenta
Dryopteris marginalis
Hamamelis virginiana
Lindera benzoin
Liriodendron tulipifera
Parthenocissus quinquefolia
Prenanthes trifoliata
Prunus serotina
Quercus prinus
Sassafras albidum
Smilacina racemosa
Vaccinium vacillans
Viburnum acerifolium

Plot 8: tr. 14, 135 m.

Apios americana
Botrychium sp.
Carex sp.
Cimicifuga racemosa
Circaea quadrisulcata
Fraxinus pennsylvanicum
Galium circaezans
Geranium maculatum
Geum canadense
Lindera benzoin
Panicum sp.
Parthenocissus quinquefolia
Polygonatum biflorum
Polygonum scandens
Polystichum acrostichoides
Quercus red
Rosa sp.
Rubus sp.
Sanguinaria canadensis
Sassafras albidum
Solidago caesia
Tovara virginiana
Uvularia perfoliata
Viburnum acerifolium
Viola sp.
Vitis sp.

Plot 9: tr. 15, 250 m.

Acer rubrum
Carya ovata
Galium circaezans
Lindera benzoin
Liriodendron tulipifera
Lysimachia quadrifolia
Parthenocissus quinquefolia
Potentilla recta
Quercus coccinea
Quercus red
Rhododendron nudiflorum
Rubus sp.
Sassafras albidum
Smilacina racemosa
Vaccinium vacillans
Viburnum acerifolium
Viburnum prunifolium

Plot 10: tr. 16, 197 m.

Acer rubrum
Amphicarpa bracteata
Aralia nudicaulis
Hamamelis virginiana
Parthenocissus quinquefolia
Quercus prinus
Quercus red
Rhododendron nudiflorum
Sassafras albidum
Smilax glauca
Uvularia sessilifolia
Vaccinium vacillans
Viburnum acerifolium

Plot 11: tr. 17, 100 m.

Acer rubrum
Aralia nudicaulis
Gaylussacia baccata
Lindera benzoin
Liriodendron tulipifera
Lycopodium complanatum
Maianthemum canadense
Medeola virginiana
Mitchella rep[ens
Nyssa sylvatica
Quercus prinus
Quercus velutina
Sassafras albidum
Smilacina racemosa
Toxicodendron radicans
Vaccinium vacillans
Viburnum acerifolium

Plot 12: tr. 17, 25 mS

Acer rubrum
Arisaema trifoliata
Dryopteris marginalis
Hamamelis virginian
Lindera benzoin
Maianthemem canadensis
Rubus sp.
Smilacina racemosa
Smilax glauca

plot 13: tr.18a, 75 m.

Acer rubrum
Amelanchier canadense
Aster divaricatus
Betula lenta
Carex laxiflorus
Fagus grandifolia
Goodyera pubescens
Lindera benzoin
Liriodendron tulipifera
Maianthemum canadense
Medeola virginiana
Microstegium vimineum
Mitchella repens
Osmunda cinnamomea
Parthenocissus quinquefolia
Prunus serotina
Quercus prinus
Quercus red
Rhododendron nudiflorum
Rubus pubescens
Rubus sp.
Smilax glauca
Smilax herbacea
Symplocarpus foetidus
Thelyperis palustris
Uvularia sessilifolia
Vaccinium corymbosum
Vaccinium vacillans
Viburnum dentatum
Viola sp.

Plot 14: tr. 19, 85 m.

Acer rubrum
Amelanchier canadense
Carex laxiflora
Maianthemum canadense
Mitchella repens
Prunus serotina
Quercus prinus
Quercus red
Rubus sp.
Sasafras albidum
Smilax rotundifolia
Smilax tamnoides
Vaccinium corymbosum
Vaccinium stamineum
Vaccinium vacillans

Plot 32: Tr. 12, 150 m.

Acer rubrum
Crataegus sp.
Dennstaedtia punctilobula
Dryopteris novaborcensis
Lindera benzoin
Lysimachia sp.
Medeola virginiana
Mitchella repens
Parthenocissus quinquefolia
Potentilla recta
Prenanthes trifoliata
Prunus serotina
Quercus red
Rubus sp.
Smilacina racemosa
Solidago caesia
Toxicodendron radicans
Viola sp.
Vitis aestivalis

Plot 15: tr. 19a, 135 m.

Amphicarpa bracteata
Apios americana
Arisaema trifoliata
Cryptotaenia canadensis
Dioscorea villosa
Dryopteris cristata
Dryopteris novaboracensis
Dryopteris spinulosa
Galium sp.
Impatiens capensis
Lindera benzoin
Liriodendron tylipifera
Lonicera japonica
Microstegium vimineum
Onoclea sensibilis
Parthenocissus quinquefolia
Pilea pumila
Podophyllum peltatum
Polygonum scandens
Ranunculus bulbosus
Rubus sp.
Rubus pubescens (?)
Sambucus canadensis
Symplocarpus foetidus
Thalictrum pubescens
Toxicodendron radicans
Viburnum dentatum (?)
Viola sp.
Vitis aestivalis

Plot 16: tr. 20, pt. #1

Apios americana
Arisaema atrorubens
Cryptotaenia canadense
Fraxinus pennsylvanica
Impatiens capensis
Lindera benzoin
Lysimachia quadrifolia
Parthenocissus quinquefolia
Potentilla sp.
Prunus serotina
Rorippa
Sambucus canadensis
Thalictrum pubescens
Toxicodendron radicans
Urtica dioica
Viburnum dentatum
Viola sp.

Plot 17: tr. 23, pt. #6

Acer rubrum
Gaylussacia baccata
Kalmia latifolia
Liriodendron tulipifera
Nyssa sylvatica
Quercus p[rinus
Rhododendron nudiflorum
Sassafras albidum
Vaccinium vacillans

Plot 18: tr. 24, 75 m.

Acer rubrum
Cypripedium acaule
Gaylussacia baccata
Kalmia latifolia
Nyssa sylvatica
Quercus prinus
Quercus velutina
Rhododendron nudiflorum
Sassafras albidum
Smilax tamnoides
Vaccinium corymbosum
Vaccinium vacillans
Viburnum acerifolium

Plot 19: tr. 24, 425 m.

Amphicarpa bracteata
Aralia nudicaulis
Asarum canadense
Cimicifuga racemosa
Circaea quadrisulcata
Cornus florida
Cryptotaenia canadense
Fraxinus pennsylvanicum
Galium aparine
Galium circaezans
Goodyera pubescens
Lindera benzoin
Liriodendron tulipifera
Mitchella repens
Osmorhiza longistylis
Parthenocissus quinquefolia
Podophyllum peltatum
Quercus velutina
Rosa multiflora
Rubus allegheniensis
Rubus flagellaris
Sassafras albidum
Sisyrinchium sp.
Smilax herbacea
Solidago caesia
Toxicodendron radicans
Uvularia perfoliata
Uvularia sessilifolia
Viburnum acerifolium
Viola sp.

Plot 20: tr. 25, 325 m.

Acer rubrum
Amelanchier canadense
Betula lenta
Gaylussacia baccata
Liriodendron tulipifera
Nyssa sylvatica
Quercus coccinea
Quercus prinus
Quercus velutina
Sassafras albidum
Vaccinium vacillans

Plot 21: tr. 30, 100 m.

Acer rubrum
Amphicarpa bracteata
Arisaema trifoliata
Cornus florida
Fagus grandifolia
Fraxinus pennsylvanicum
Lindera benzoin
Liriodendron tulipifera
Nyssa sylvatica
Parthenocissus quinquefolia
Prunus serotina
Quercus alba
Quercus coccinea
Quercus velutina
Rubus sp.
Sassafras albidum
Smilacina racemosa
Smilax sp.
Toxicodendron radicans
Uvularia sessilifolia
Vaccinium vacillans
Viburnum acerifolium
Viburnum prunifolium
Vitis riparia

Plot 22: tr. 21, pt. #1

Amphicarpa bracteata
Apios americana
Arisaema trifoliata
Asarum canadensis
Campanula aparanoides
Carex sp.
Cryptotaenia canadensis
Galium aparine
Galium sp.
Gartiola neglecta
Impatiens capensis
Lysimachia quadrifolia
Onoclea sensibilis
Parthenocissus quinquefolia
Polygonum arifolium
Ranunculus bulbosa
Ranunculus sp.
Sagittaria latifolia
Sambucus canadensis
Stellaria sp.
Symplocarpus foetidus
Thalictrum pubescens
Toxicodendron radicans
Urtica dioica
Uvularia sessilifolia

Plot 23: tr. 11, 35 m.

Acer rubrum
Amphicarpa bracteata
Arisaema trifoliata
Crypotaenia canadensis
Dryopteris novaboracensis
Galium circaezans
Galium sp.
Geranium maculatum
Geum canadense
Hamamelis virginiana
Lindera benzoin
Lonicera japonica
Mitchella repens
Oxalis sp.
Parthenocissus quinquefolia
Polystichum acrostichoides
Potentilla recta
Prenanthes trifoliata
Prunus serotina
Rosa multiflora
Rubus sp.
Smilacina racemosa
Toxicodendron radicans
Veronica officinale
Viburnum prunifolium
Viola sp.

Plot 24: tr. 11, 85 m.

Acer rubrum
Aralia nudicaulis
Betula lenta
Geranium maculatum
Hamamelis virginiana
Lindera benzoin
Parthenocissus quinquefolia
Prunus serotina
Quercus prinus
Quercus velutina
Rhododendron nudiflorum
Toxicodendron radicans
Vaccinium vacillans
Viburnum acerifolium
Vitis sp.

Plot 25: tr. 11, 135 m.

Acer rubrum
Fraxinus pennsylvanicum
Gaylussacia baccata
Goodyera pubescens
Liriodendron tulipifera
Lycopodium sp.
Medeola virginiana
Melampyrum lineare
Mitchella repens
Nyssa sylvatica
Panicum sp.
Potentilla recta
Prunus serotina
Quercus alba
Rhododendron nudiflorum
Rubus sp.
Vaccinium corymbosum
Vaccinium vacillans

Plot 26: tr. 11, 185 m.

Acer rubrum
Amelanchier canadensis
Aster divaricatus
Cornus florida
Fraxinus pennsylvanicum
Liriodendron tulipifera
Maianthemum canadense
Medeola virginiana
Mitchella repens
Prunus serotina
Quercus alba
Quercus velutina
Rhododendron nudiflorum
Rubus sp.
Sassafras albidum
Solidago caesia
Toxicodendron radicans
Uvularia sessilifolia
Vaccinium vacillans
Viburnum acerifolium
Vitis sp.

Plot 27: tr. 1, 550 m.

Allium vineale
Arisaema atrorubens
Circaea quadrisulcata
Fraxinus pennsylvanicum
Galium circaezans
Impatiens capensis
Lindera benzoin
Microstegium vimineum
Parthenocissus quinquefolia
Podophyllum peltatum
Poa sp.
Quercus red
Rubus sp
Sanguinaria canadensis
Solidago caesia
Uvularia perfoliata
Viburnum prunifolium
Viola sp.

Plot 28: tr. 1, 600 m.

Carex sp.
Cimicifuga racemosa
Fraxinus pennsylvanicum
Galium circaezans
Galium sp.
Geranium maculatum
Impatiens capensis
Mitchella repens
Orobranche uniflora
Parthenocissus quinquefolia
Podophyllum peltatum
Prunus serotina
Quercus alba
Quercus red
Rhododendron nudiflorum
Sassafras albidum
Smilax sp.
Solidago caesia
Uvularia sessilifolia
Vaccinium vacillans
Viburnum acerifolium
Viburnum prunifolium
Viola sp.

Plot 29: tr. 2, 0 m.

Allium vineale
Aralia nudicaulis
Arisaema trifoliata
Carex sp.
Chelone glabra
Claytonia virginiana
Fraxinus pennsylvanicum
Lindera benzoin
Medeola virginiana
Microstegium vimineum
Parthenocissus quinquefolia
Pilea pumila
Poa sp.
Polystichum acrostichoides
Prenanthes trifoliata
Quercus sp.
Ranunculus abortivus
Ranunculus sp.
Saxifraga micranthidifolia
Symplocarpus foetidus
Uvularia sessilifolia
Viola sp.

Plot 30: tr. 2, 100 m.

Acer rubrum
Amelanchier canadensis
Apios americana
Aralia nudicaulis
Arisaema atrorubens
Aster (divaricatus)
Botrychium sp.
Carex sp.
Claytonia virginiana
Dryopteris novaboracensis
Fagus grandifolia
Fraxinus pennsylvanica
Galium circaezans
Goodyera pubescens
Impatiens capensis
Lonicera japonica
Medeola virginiana
Osmunda cinnamomea
Prenanthes trifoliata
Prunus serotina
Quercus (red)
Ranunculus abortivus
Rhododendron nudiflorum
Sambucus candensis
Symplocarpus foetidus
Toxicodendron radicans
Uvularia sessilifolia
Veratrum viride
Viburnum acerifolium
Viola sp.

Plot 31: tr. 2, 50 m.

Arisaema trifoliata
Claytonia virginiana
Dryopteris novaboracensis
Fagus grandifolia
Pilea pumila
Podophyllum peltatum
Polystichum acrostichoides
Prenanthes trifoliata
Rhododendron nudiflorum
Rubus sp.
Symplocarpus foetidus
Toxicodendron radicans
Vaccinium vacillans
Veratrum viride
Viburnum acerifolium
Viburnum prunifolium
Viola sp.

Plot 33: tr. 20, pt. #3

Alliaria officinalis
Allium canadense
Apios americana
Arisaema trifoliata
Celastrus orbiculatus
Galium aparine
Geum canadense
Impatiens capensis
Lindera benzoin
Lonicera japonica
Microstegium vimineum
Onoclea sensibilis
Osmunda cinnamomea
Oxalis sp.
Parthenocissus quinquefolia
Polygonum sp.
Rubus phoenicolasius
Senecio aureus
Symplocarpus foetidus
Urtica dioica
Viburnum dentatum

Plot 34: tr. 20, pt. #4

Arisaema trifoliata
Dryopteris spinulosa
Impatiens capensis
Microstegium vineimeum
Onoclea sensibilis
Polygonum sagittatum
Sambucus canadensis
Symplocarpus foetidus
Thalictrum pubescens
Toxicodendron radicans
Veronica officinalis
Viburnum dentatum

Plot 35: tr. 20, pt. #5

Arisaema trifoliata
Carex sp.
Cimicifuga racemosa
Cornus racemosa
Dryopteris spinulosa
Galium aparine
Galium sp.
Glyceria sp.
Impatiens capensis
Lindera benzoin
Microstegium vimineum
Onoclea sensibilis
Parthenocissus quinquefolia
Polygonum arifolium
Polygonum sagittatum
Quercus red
Rubus sp.
Sambucus canadensis
Solidago sp.
Symplocarpus foetidus
Thalictrum pubescens
Toxicodendron radicans
Urtica dioica
Uvularia sessilifolia
Viburnum dentatum
Viola sp.

Appendix 3

Explanations of Vegetational Terms

All of these terms relate to estimates, derived from sampling the vegetation.

Density: The number of tree stems per unit area. "Tree stems" is used rather than "trees" because some trees have multiple stems, and each stem is counted as a separate tree. The density is calculated from the average distances of the stems from the points.

Frequency: The proportion of points at which a given species is found. For example, if there are 10 points along a line and species "a" is found at 3 of these, the frequency is 30%. This gives a measure of the evenness of distribution of the species in the forest. If the trees of a species are clumped in one part of the area, the frequency will be small, even if in that area, trees of this species are in all four quadrants of the points.

Example to explain these two terms and their differences:

Species "a": 20 trees found 5 each at 5 points,
average distance from the points of 3 m
Species "b": 20 trees found 2 each at 10 points,
average distance from the points of 3 m

The densities of these two species would be the same, but the frequency of species "a" is 50% and of species "b" is 100%.

Basal area: This is the area of a cross-section of the trunk of a stem at "breast height" - 1.3 m. It is calculated from the diameter at that height on the trunk. The average is calculated for each species in each forest cover type.

Cover: This is the area subtended by the branches of a plant. In this study it is used only for shrubs, and only in a relative sense. If shrub species "a" had branches extending over 5 meters of the 25 meter line, its relative cover was 20%, that is, of the total surface area being sampled, 20% of the area would be beneath the branches of species "a". Because the branches of trees and shrubs overlap, the total cover may be greater than 100%.

Dominance: This is the total basal area of a species per unit area. It is determined by multiplying the average basal area of the species by the density, or number of stems per unit area.

Relative frequency, density, and dominance: Each of these is calculated by adding the values for all species in the forest cover type and calculating the proportional representation of each species, the relative contribution. For example, if the total density of stems in a forest cover type is 500 stems per hectare, and the density of species "a" is 100, the relative density of species "a" is 20%.

Importance value: This is the average of the relative values for a species. It thus gives weight to a species with many small stems as well as to a species with few large stems.

April 12, 2002
52 School House Lane
Morristown, NJ 07960

Mr. Steve Ambrose
Hopewell Furnace National Historic Site
2 Mark Bird Lane
Elverson, PA 19520

Dear Steve,

This is what I have been able to come up with that would most likely be of use to you about my 1980's project. It seems that I gave advice on setting up the permanent plots, but that they were done by the park, so I don't have any details about where they are or the information on the vegetation. The overall system is described in a manual I wrote for the mid-Atlantic Region, Russell, E. W. B. Vegetation Monitoring with Permanent Plots: a Procedural Manual for the Mid-Atlantic Region, National Park Service. 1989. John Karish should have copies.

I had a good talk with Jim Thorne. He feels that Hopewell Furnace is itself a very important piece of the forest area and plays a vital role. I will pursue this further with him and the TNC folks. I am also working on finding out more about the Schuylkill River Heritage area, since it includes your park and Valley Forge.

Thanks very much for your time. I look forward to spending some time in the field. Maybe we could at least find the plot that Bill said that he had seen.

Emily

