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VEGETATION OF THE MORRISTOWN
NATIONAL HISTORICAL PARK :

ECOLOGICAL ANALYSIS AND
MANAGEMENT IMPLICATIONS

Joan G. Ehrenfeld

NATIONAL PARK SERVICE
COOPERATIVE RESEARCH UNIT

CENTER for COASTAL and ENVIRONMENTAL STUDIES



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VEGETATION OF MORRISTOWN
NATIONAL HISTORIC PARK:

ECOLOGICAL ANALYSIS AND
MANAGEMENT ALTERNATIVES

Final Report

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EXECUTIVE SUMMARY

1. Scope of the Project

The purpose of this study is to describe the current woody vegetation of the Jockey Hollow section of Morristown National Historical Park, to analyze the successional trends evident in the vegetation, and to describe the pre-settlement vegetation and land-use history in the area. The information is presented in the technical report and on four maps (at a scale of 1:6,000), three of which show the distributions of the plant communities in the Park, and the fourth of which depicts the historical aspects of the natural and cultivated vegetation.

2. Maps and Data

The woody plant communities in the Park fall into two general categories: successional forests and mature forests. Each of these general types is represented by several subtypes. In order to clearly display the distributions of the subtypes, three vegetation maps have been prepared. Map #1 shows the distribution of the mature and successional general types, as well as the areas of non-forested land and the areas of conifer plantations; and archeological sites delimited by Rutsch and Peters (1976) are also shown on this map. Map #2 shows the distributions of the subtypes of the successional forest, and Map #3 displays the mature forest subtypes.

Appendix 2 of the Technical Report provides a description of each of the general forest types and each of the subtypes, and Table 5-1 lists the areal extent (in hectares) of each subtype.

Particular features of the vegetation (e.g., types of non-forest vegetation, distribution of heavy vine growth, etc.) are shown on maps (at a scale of 1:15,240) incorporated in the text.

The Land-Use History Map shows the assembled information on the historical aspects of the vegetation on the same base map as Vegetation Maps #1-3. Appendix 3 provides guiding information for the use and interpretation of this map.

All other technical data is incorporated in the report.

3. Management Recommendations

A general philosophy of passive management is recommended for the Park's natural features. The rationale for this recommendation rests on 1) the historical character of the Park, which argues against the use of high-technology, energy-intensive methods of management, 2) the orientation of the National Park Service towards promotion of natural processes, 3) the ecology of eastern deciduous forests, in which disturbances and catastrophes are a normal and perhaps necessary part of the forest environment.

Specific management problems that are discussed in detail include the growth of vines in the successional stands, the impact of deer on the forest, the presence of gypsy moths, the impact of tree diseases, and the

presence of exotic species. No problems warranting active intervention (in the form of spraying, tree removal, forest cleaning, etc.) are foreseen. Gypsy moth infestations may cause renewed tree mortality; however, the results of the study of previous gypsy moth-related mortality (described in Ehrenfeld, 1977) support a management policy of non-intervention.

Other management issues that are addressed include the potential clearing of forest cover from sites of archeological importance, the management of non-forested areas, the preservation and/or reconstruction of stands that approximate the original forest in composition, and the potential for further research. Clearing of forested areas for archeological preservation would not be incompatible with the ecological integrity and the scenic value of the woodlands. A mowing schedule for the fields and orchards is recommended to increase their carrying capacity for birds and other wildlife.

A series of permanent quadrats should be established in both mature and successional stands to facilitate future research on the vegetation of the Park.

4. Physical Environment of the Park

The Jockey Hollow area is situated on the Pre-Cambrian gneiss that composes the New Jersey Highlands; this bedrock has resulted in a topography of rounded hills with narrow valleys, and has supplied the residual material from which the soils are derived. The soils include excessively drained, stony soils on the steep slopes, moderately well drained, deep loams on the mid-slopes, and poorly drained soils along the watercourses. The climate in the Park is characterized by the cool temperatures of northern New Jersey, but also by higher rainfall than any other part of northern or central New Jersey. The northeast-trending ridges permit some microclimatic differentiation, but because the prevailing winds parallel the ridges, and because there are few north- and south-facing slopes, there is less climatic variability than might otherwise be expected in such hilly terrain. The history of climatic changes suggests that the present oak domination of the forests reflects the past warm-dry climate, and that the cool-moist shift that occurred in the last few centuries may be mirrored in the rising importance of beech, maple and hemlock.

5. Woody Plants and Plant Communities

Ninety-two species of woody plants were found in the Park, of which 68 are native and the rest are exotics. There are slightly more species of northern affinity than of southern affinity. Exotic species have followed human settlements into the area, but it is possible that visitors may help introduce and maintain these plants. No endangered species of plants were observed during this study. A map was prepared of the distribution of abundant sprouts of the American chestnut (Castanea dentata), and eight saplings were treated with hypovirulent strains of Endothia parastica (the chestnut blight fungus).

Twenty forest communities were recognized in the Park; the dominant tree species in each stand were used to distinguish and name the types. Eleven of the communities belonged to the Successional Forest type; they ranged from stands of mixed white ash, yellow poplar, red maple, black locust, black birch, and others, to pure stands of each of the above species. Two small areas support pure stands of Ailanthus, an exotic species. Eight kinds of mature forest were described. In the Mixed Oak - Black Birch, the Mixed Oak - Yellow Poplar, and Mixed Oak - Beech types, red, white and black oaks predominated together with the other species in the type name; in the Mixed Oak type, no other species shared dominance with the oaks. The Mixed Hardwoods stands were characterized by the absence of a dominating species. The Chestnut Oak communities occupied the excessively drained sties. The Mixed Hemlock-Hardwood forest occupied a single north-facing cove stie. The Stream Thicket community was characterized by the absence of a tree canopy in patches along the streams; tree saplings and shrub species form a dense thicket instead. The Coniferous forests comprised several plantations of introduced species that were established during the 1930's.

6. Structure of the Vegetation

Representative stands of eight of the community types were sampled to determine precise species composition, the age structure of the stand, and the successional trends evident from the composition of the understory. Three stands were sampled using the point-quarter method; five others were sampled using 0.04 ha quadrats. The selected communities were: Mixed Oak - Yellow Poplar, Chestnut Oak, Mixed Oak - Beech, Mixed Hardwoods, Successional, Yellow Poplar, Stream Thicket, and Conifer plantations.

The successional forests are all characterized by an even-aged canopy a paucity of tree reproduction in the understory and ground strata, and a dense shrub stratum. No change in the structure of the vegetation is foreseen in these stands for the next few decades; the forests that replace these stands when the current dominants begin to die will be determined by environmental conditions at that time, and cannot be well predicted from the current vegetation. These stands occupy former pastures and grain fields. The various species of hedgerow trees that bordered the fields have controlled the forest successions by supplying the seeds from which the stand arose. The importance of these hedgerow trees is reflected in the diversity of successional forest types encountered in the Park: each field was dominated by the species that dominated its border.

The planted conifer stands are not reproducing themselves, and will slowly decline in importance in the Park.

The most striking aspect of the mature forest is the paucity of oak reproduction. Except for the dry Chestnut Oak stands on the eastern side of the Park, where they are reproducing abundantly, oaks are fated to become a minor element in the canopy. This trend parallels the trends in forest development that have been observed throughout the Northeast. Beech, red maple and black birch are gaining in prominence throughout the Park; this is demonstrated in the J-shaped population curves observed in the mature stands. On the lower slopes and valley bottoms, the diversity of the species accompanying vegetation is greater than on the upper slopes.

Site-indices prepared for beech, yellow poplar, black birch and the mesic oaks (black, white and red) indicate that the growth rates of these species are moderate to good in the Park, as compared with reported site-indices for these species in the literature.

7. History of the Vegetation

The reports of travellers, soldiers and residents in the Morristown area during the eighteenth century were examined for descriptions of the original forest cover in Jockey Hollow. The early land deeds for the area were searched for references to boundary trees. The accumulated shreds of information suggest that an oak-dominated forest, similar to the mature woods of today, was growing when the Wicks and Kembles first cleared the land. Substantial portions of the Park area, on the steeper slopes and in the areas distant from the homesteads, have never been cleared or cultivated, but have been harvested at varying intensities for fuelwood and sawtimber. Land was cleared for crops and pasture probably until the early part of the nineteenth century; the scanty evidence indicates that farming activity reached its zenith by about 1850, and slowly decreased after that. Most of the agricultural areas were abandoned to old-field succession during the first twenty years of the twentieth century, and, except for the existing areas of non-forest land, the remainder reverted to forest after the Federal Government took over the land.

8. Successional Trends of the Vegetation

The vegetation of the Park has been interpreted from a theoretical framework centered on the idea that woody species are distributed independently from each other, but that species groups tend to re-occur in particular habitat types and can therefore be recognized as community types. The history of disturbance in a given region and local variations in microhabitat and vegetation will influence the expression of these species groupings on particular sites.

From this point of view, it appears that the mature forests in Jockey Hollow are developing towards a Mixed Hardwood forest type, in which beech, red maple, and black birch are the most prominent species and in which many other hardwood species are present. The more mesic sites support a more diverse forest than the xeric sites, and well-differentiated habitats will support distinctive species (e.g. hemlocks in north-facing coves, red maple in swampy areas). The present domination of oaks can be expected to decrease.

The fate of the successional stands is hard to predict because of the virtual absence of tree reproduction. Unless environmental conditions change markedly during the next few decades, it is likely that mixed hardwood forests will eventually succeed these young forest stands.

The present-day vegetation has been strongly influenced by the history of land-use in the Park and the history of natural catastrophes (disease and pest outbreaks, windstorms, etc.). The local dominance of beech and black birch in some portions of the forest can be attributed to these influences.

CHAPTER 1. INTRODUCTION

This report summarizes the results of a study of the woody vegetation in the Jockey Hollow section of the Morristown National Historical Park. The Jockey Hollow area comprises about 466 hectares (ha) land, seven miles south of Morristown. It is the land on which nine brigades of the Revolutionary Army were cantonned during the winters of 1779-1780 and 1780-1781; a tenth brigade, the New Jersey Brigade, was situated about a mile to the south, and General Washington resided in the Ford Mansion in Morristown, also now a part of the Park. The Jockey Hollow area is now almost entirely forested; a Visitor Center near the Wick Farm, and a reconstruction of some of the Soldiers' Huts are the principal visitor attractions, but numerous trails wind through the woods, and invite hikers and horse-back-riders.

1.1 Scope of the Final Report

The purpose of the study was to describe the structure and dynamics of the current forest, analyze the probable successional trends in forest composition, estimate the degree to which the current vegetation resembles that of the original forest cover, and identify policies for the most ecologically sound management of this natural resource. The assembled information has been presented by means of three vegetation maps; detailed analyses of the major types of plant communities; a synthesis of information on land-use history and the original forest composition which is displayed on a fourth map; and a discussion of a variety of forces affecting the forests. The recommendations for management have been derived from a consideration of the assembled information, and have been based on the premise that a minimum of human interference in natural processes is the management philosophy most appropriate to a National Park.

In this Final Report, I have omitted subjects that were discussed in detail in the Mid-Year report. This material includes the description of the work done on the effects of the past gypsy moth infestation on forest structure and the work done on the distribution of gypsy moth parasites within the forest, and some of the information on plant species and plant communities. Material from the Mid-Year Report has been repeated, however, where it was deemed necessary to the understanding and utilization of this Report.

The study was conducted within the Jockey Hollow section of the Park; however, the New Jersey Brigade Tract and Jarvis Estate properties were not included. Although the exact distributions of the plant communities have not been documented for these recent additions to the Park, it is likely that the general conclusions regarding successional trends, community types, and management policies presented in this report are applicable to these areas.

The organization of this Report is designed to foster its frequent use. Management considerations are addressed in Chapter 1; for each subject, the factual and analytic bases for the recommendations are

merely outlined, and the locations in the text of more extensive discussions are given. The following text includes the descriptions of physical environment, the woody flora, methods of study of the vegetation, and the detailed analyses of plant communities. Tree growth is discussed, and the results of the study of land-use history and the original vegetation are presented. The final chapter of the text presents an analysis of the successional trends of the plant communities, in the context of current theories of ecological succession. Reference information and guides to the maps are given in the Appendices which follow the text. The list of woody plant species is given in Appendix 1. The plant communities of the Park are shown on three large-scale maps; a diagnostic description of each mapping unit is given in Appendix 2. The accumulated information on land-use history is shown on a fourth large-scale map; a guide to the information on this map is given in Appendix 3. Thus, the portions of the Report likely to be used frequently are segregated from the textual description of the findings. Details of vegetational interest (e.g., the distribution of dense vine growth) are shown in small scale maps included in the text.

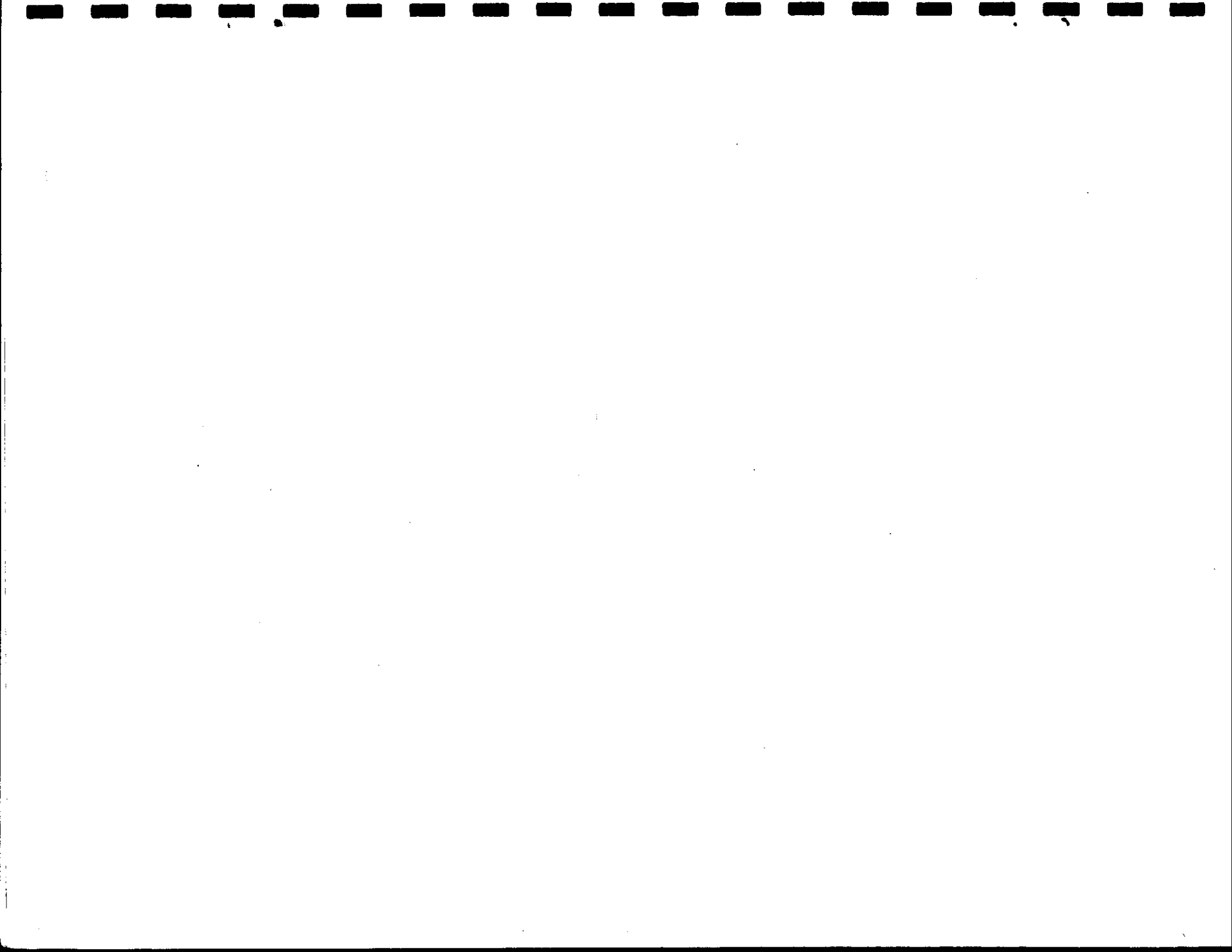
1.2 Notes on Reference to Source Materials

Considerable use has been made of the vegetation, project, and other maps prepared during the first five years of the Park's history. Unfortunately, few of these maps bear the names of their creators, and thus it has been difficult to reference them properly in the text and the bibliography. In order to clarify this situation, a standard set of textural and bibliographic forms have been adopted; these are listed in Table 1-1, together with an identifying description of the map.

Material in the Mid-Year Report has been referred to in the text as "Ehrenfeld, 1977."

Table 1-1. Early Park Maps: Textual and Bibliographic References.

<u>Text Ref.</u>	<u>Bibliog. Ref.</u>	<u>Map Description</u>
Project Map, 1933	M.N.H.P., Anon, 1933 Project Map Map No. MO-6007	Base map at scale 1"=400' with info. on planting, forest manipulations, archeological work, per enrollment period.
Road Map, 1933	M.N.H.P., Smith and Setzger(?), 1933 Road Map Map No. MO-1000	Map at scale 1"=400', showing field/forest boundaries in Park and to Mt. Kemble Ave, and prob- able road system of 1799.
Vegetation Map, 1937	M.N.H.P., Anon, 1937 Vegetation Map, Map No. NHP-MOR-8012A	Map at scale 1"-800', showing distribution of 14 plant com- munities in old Park area.
Trail Map, 1933	M.N.H.P., Anon. 1933 Path System;; New Jersey Brigade Area, Map. No. MO-1015	Mylar copy of original map, at scale 1"=100', showing proposed trail system on New Jersey Brigade Area, and field/forest lines with notes on species present.
Topographic Map, 1934	M.N.H.P., G.E. Sisson, 1934, Topography of the Jockey Hollow Area. (No Number)	Mylar copy of original map, drawn at scale 1"-800' but reprinted at 1"=500' showing 5-foot contour inter- vals for Jockey Hollow.



CHAPTER 2. MANAGEMENT ISSUES AT JOCKEY HOLLOW

In this chapter, a series of issues concerned with the management of the vegetation in the Jockey Hollow section of the Park is discussed. The issues include potential problems and potential sources of concern, as well as potential sources of interpretive material for depicting eighteenth century environments.

2.1 General Comments on Management of the Vegetation

Morristown National Historical Park is dedicated to the memory of the Army that camped there during the Revolutionary War, and thus its mission is to create an environment in which visitors can appreciate the life and times of the ordinary soldiers who comprised the Army. (Morristown National Historical Park, 1976). This goal is particularly important in the Jockey Hollow segment of the Park, where these soldiers endured several severe winters in small huts, away from the more comfortable conditions in Morristown. In accordance with these aims, heavy emphasis should be placed on minimizing the role of twentieth-century technology in managing the natural resources of the Park; in other words, natural processes should be given the highest priority in shaping the biotic communities. It is from this viewpoint - that non-interference is the best possible management plan for the most situations - that the following issues have been addressed.

The Park has, over the years, evolved from a philosophy of active intervention to a philosophy that emphasizes the important role of natural environment of the Park. Thus, during the 1930's, a variety of disease control measures were taken for locust borers and for Dutch elm disease, and "forest stand improvement" was undertaken (Project Map 1933). Similarly, the Park was sprayed with DDT in 1950 after the arrival of the gypsy moth (Weig, 1971). By the late 1960's, the Park management was sufficiently convinced of the importance of emphasizing natural processes that it withstood considerable public pressure to spray when gypsy moths again became a serious problem. Subsequent justification for that position, in terms of the ultimate lack of effect of the gypsy moth infestation on the forest community was described in Ehrenfeld (1977). In the sections of this chapter which follow, management issues will be pinpointed where a policy of non-interference in natural events can be expected either to maintain the status quo of the forest, or even improve the ecological conditions.

It should be understood that non-interference refers principally to active management: cuttings, forest cleanings, extensive spraying of insecticides, etc. Passive management techniques can often be used to achieve a desired end without drastic impacts on the natural community. For example, in Ehrenfeld (1977) a recommendation was made to keep the number and structural complexity of trail-side signs to a minimum, because they have been implicated in precipitating gypsy moth outbreaks by providing safe pupation sites for the larvae. Similarly, limitation of the number of maintained trails may serve to control the influx and spread of exotic species (see Chapter 4 and below).

Utilization of hand labor, or small-scale equipment for trail erosion control or right-of-way clearance (such as that crossing the Primrose Brook basin near Jockey Hollow Road) would be more aesthetic, more historically representative, and considerably less destructive to the soil and surrounding vegetation than is the utilization of large bulldozers. Thus, in Jockey Hollow, historically appropriate methods of landscape management coincide with ecologically sound management strategies.

In defending a passive management strategy with respect to the woodlands, it should be remembered that periodic catastrophe is the natural state of affairs in temperate zone forests (Oliver and Dearing, 1977; see Chapter 9): the death and destruction of trees, on both a large and a small scale, was characteristic of these forests long before the Wicks and Kembles came to the land. Indeed, these events can be considered as crucial to the maintenance of a vigorous, diverse forest. Therefore, the mortality that accompanies major storms or insect outbreaks should not be viewed with dismay, nor with plans to prevent such mortality with insect or disease control measures. Efforts to contain or eradicate major forest tree diseases, such as the chestnut blight, the Dutch elm disease, or gypsy moths have uniformly failed, and thus massive control measures have accomplished at best a delay in the natural adjustment to these perturbations, and at worst, the dissemination of powerful and poorly understood chemicals throughout the ecosystem. Thus, should new outbreaks of disease threaten the Park, the most ecologically sound management plan would be to let natural forces establish a new equilibrium in species composition as rapidly as possible.

Individual trees (for example, those near the visitor attractions) can be more actively protected, should the need arise. However, the utilization of chemical sprays should be kept to a minimum.

2.2 Growth of Vines in the Successional Forests

The successional forests in the Park support moderate to extremely dense growths of vines, which blanket shrubs and trees alike with a dense cover of foliage, and which produce an impenetrable thicket of tangled stems on the forest floor. Figure 2-1 shows the distribution of dense vine growth in the Park; their role in community composition is discussed in Chapter 6 and Appendix 2, and the species composition of the populations is given in Appendix 1.

There has been relatively little study of the role of vines in temperate forest ecology. Lutz (1943) described the morphological response of tree stems constricted by twining vines, Featherly (1941) noted a decrease in growth associated with the coverage of the trees' canopies, Bard (1952) observed that vines were the most abundant species present in 60-year-old red cedar stands, and Siccama et al. (1976) found that dense vine growth in 40-60-year-old forests made the trees more susceptible to crown breakage during severe winter storms. Bard (pers. comm.) has suggested that the abundance of vines in this area is related to the high rainfall and resulting lush environment in this part of New Jersey (see Chapter 3). Thus, the

extensive vine growth in most of the successional forests is an expected feature of these forest stages, and can be expected to have some detrimental effect on the forests of which they are a part. The effect on growth and form are of little significance for the Park, in that the trees are not being grown for timber; the effects on the physical structure of the trees may have more serious implications in terms of a set-back of the successional process. Siccama *et al.* (1976) noted that the most heavily infested areas were also at earlier successional stages than the less heavily infested areas, despite the fact that their study area had reverted to forest at a uniform time.

In Ehrenfeld (1977), it was suggested that the vine growths will eventually disappear as succession proceeds, and evidence of declining vine populations in the Park was cited to support this statement. Since then, however, consideration of all available evidence, re-examination of some of the vine-infested areas, and conversations with Drs. Benjamin Stout and Boris Zeide (Department of Horticulture and Forestry, Cook College, Rutgers University) have combined to suggest an alternative course of events in some of the most densely overgrown areas.

A comparison of Fig. 2-1, the Land-Use History Map, and the current vegetation maps (Maps #1-3) showed that some of the vine-infested areas, for example the corner of Jockey Hollow Road and old Tempe Wick Road, have remained in successional forest for at least eighty years, with little evidence of change to a mature type in the offing. Casual inspection of the glades formed when tree crowns and their vine cover fall to the ground suggests that the glades perpetuate the growth of vines and early successional stands, by promoting the frequent removal of trees that could shade out the vines. If this speculation is true, the presence of dense vine growth may delay succession and serve to retain the early successional type indefinitely.

Because no economic or interpretive reason is evident why the early successional forest types should be discouraged, there should be no effort made to control the growth of these vines. Should it become desirable to produce a mature forest aspect near the Visitor Interpretive Center, however, it would be necessary to remove the vines to allow succession to proceed at a more rapid pace.

2.3 The Impact of Deer on the Forest

The status of the deer populations in Jockey Hollow was discussed in Ehrenfeld (1977). The conclusion at that time was that the deer population level was in balance with the available resources, and that no cause for concern was evident. That conclusion remains unaltered in this Final Report, and derives additional support from: 1) observations made by Dr. Stout that although a browse line is evident in scattered locations in the Park, and sprout clumps of browsed shrubs are not uncommon, there is no sign in the vegetation of excessive browsing, and 2) the statement by Dr. Leonard Wolgast, Assistant Professor of Wildlife Ecology at Cook College, Rutgers University, that the appearance of healthy deer, with adequate fat reserves, is the best indication that excessive populations are not present. Therefore, no justification is seen at present for active management of the

deer populations; the effects of the deer on ornamental plantings both within and outside of the Park cannot be taken as an indication of excessive populations, but simply as a feeding preference of the animals. Efforts to protect particular ornamentals from predation should take precedence over the more drastic measures that would be required to alter the population size of the deer herd.

Should a decision be made to clear the archeologically important areas of forest and substitute herbaceous cover (Rutsch and Peters, 1976), an impact on the deer populations should be anticipated (Wolgast, pers. comm.). The population can be expected to increase in proportion to the amount of area cleared. The increase in field and edge habitat might provide a temporary decrease in the browsing pressure in the forest; however, the deer population size would eventually equilibrate at a new, increased level, at which relative amounts of browsing similar to those at present could be expected. More detailed predictions of the response of deer population size to this kind of habitat alteration would require a quantitative study of the current deer herds. It should be noted that the production of several new small fields within the woods could also be expected to benefit the abundance and diversity of most other wildlife.

2.4 Gypsy Moths in Jockey Hollow

The effects of the 1967-69 gypsy moth infestation on the forest structure, the distribution of gypsy moth parasites in the forest, and management recommendations based on the findings of Campbell (Campbell et al., 1976, Campbell and Sloan, 1976), were described in Ehrenfeld (1977). Although plans were initially made to continue the study of parasite distribution in the Park, the time and manpower resources available for the major portion of this project (the vegetation study) proved inadequate to be able to continue the parasite work. Conversations with entomologists familiar with these insects and observations of the moth populations during 1977 (see below) suggest that no change in management alternatives would have resulted from extension of last year's study.

The most immediate management consideration derived from the past gypsy moth problems is the presence of dead oak trees along the trails. This dangerous situation was noted in Ehrenfeld (1977); since then, some of the threatening trees have been removed, but many others still stand. During the past year, many of the dead oaks fell, and increasing numbers can be expected to succumb to winter storms. Figure 2-2 shows general areas of high oak mortality; some of these areas are far removed from trails, and do not warrant further attention, but in those areas which are intersected by trails, trees that could potentially fall on the trail should be cut down, and the pieces left to decay naturally on the forest floor.

The presence of standing dead trees away from trails is of some benefit to the Park, insofar as these trees provide food and shelter for an abundance of wildlife (Egler and Foote, 1975). One pair of pileated woodpeckers was found to be nesting in a partially dead

white oak near the upper reaches of the Primrose Brook (East Branch), and the common sighting of this spectacular bird in the Park is probably attributable to the presence of the dead trees along the watercourses (Conner and Adkisson, 1976).

During the summer of 1977, the gypsy moth populations in northern New Jersey reached much higher densities than had been forecast from the previous year's experience. Although some observers speculated that the population explosion resulted from the wind dispersal of larvae from the outbreak conditions in nearby Pennsylvania (Balaam, pers. comm.), the pattern of population increase is so widespread, and in some places so remote from the possible influence of events in Pennsylvania, that other factors, as yet unknown, may have been of primary importance. According to Mr. Peter Mina of the New Jersey Department of Agriculture Mobile Laboratory in Jockey Hollow, the phenomenon is widespread throughout the East Coast, but no one has been able to offer a coherent explanation of the unexpected outbreak. Eggmass counts and casual inspection by Mr. Mina and his co-workers, both in Jockey Hollow and elsewhere in northern New Jersey, strongly suggest that conditions in 1978 will be worse than the past summer. Therefore, moderate to heavy defoliation should be anticipated for 1978. According to Mr. Mina, parasite populations are well established throughout the Park; it remains to be seen to what extent these biological controls will limit a new outbreak. Some workers feel that the introduced parasites are incapable of preventing outbreaks (Campbell, 1977; Forgash, pers. comm.). It is entirely possible that the moth populations will (or are) entering a new outbreak phase, which will last for two to three years, and will result in renewed oak mortality. In light of: 1) the findings of the study done here (Ehrenfeld, 1977) on the effects of the previous episode of oak mortality on stand structure, 2) the successional evidence throughout the mature woods away from oak-dominated forest (see Chapters 6 and 9), 3) the important role of catastrophic mortality in the ecology of deciduous forests (see Chapter 9), 4) the lack of economic value attached to timber in the Park, and 5) the detrimental effect on sprays on the established parasites (Forgash, pers. comm.) there is no justification for the use of chemical insecticides to combat a new gypsy moth infestation. In addition, work by Campbell (1973a, 1973b) suggest that local population densities of the moth are keyed to regional trends, and therefore an increase in the populations throughout the area would counteract any spray region within the Park itself. Should extensive oak mortality once again occur, it should be viewed as an acceleration of a naturally occurring trend, and as noted above, as providing habitat for a diversity of wildlife. Indeed, conspicuous tree mortality could be used as an opportunity for explaining to the public the nature and dynamics of the forest in which the Revolutionary Army camped.

2.5 Forest Pathology in Jockey Hollow

The forest in Jockey Hollow appears very healthy, with no evidence of problems other than the gypsy moth defoliation discussed above.

The tree mortality data collected as part of the intensive vegetation sampling effort (Chapter 6) also indicate that normal levels of mortality associated with forest succession are present, and that no one species of tree dominates the observed mortality. In this section, therefore, comment will be made on questions of tree pathology that have arisen during the course of the work.

1) Several small areas of dense black birch mortality were observed during the transect studies (Chapter 5); the most notable of these is in the pure Black Birch stand near Old Camp Road (Map #2). Consultations were held with Drs. Eugene Varney and Spencer Davis of the Department of Plant Pathology, Rutgers University; no important pests or diseases of black birch are known to be present in New Jersey, but similar die-off of black birch in other areas have been attributed to winter damage. Thus, it is probable that the observed mortality in Jockey Hollow reflects climatic conditions; however, the area of the above-mentioned stand should be observed yearly by a Park Ranger knowledgeable about forestry, for signs of spread of the mortality.

2) Mortality and die-back in dogwood was observed in scattered places throughout the Park during the summer of 1977. As with the black birch, mortality was attributed to climatic conditions rather than pathological agents by Dr. Davis and Mr. Donald Lacey, Extension Specialist for Tree Disease, Cook College, Rutgers University. Although some dogwood mortality from borers damage has rarely been found, and much of this death could have been the result of inclement weather (pers. comm. Mr. R. Shay, Forest Management Office, New Jersey Department of Environmental Protection).

3) The advent of the beech bark disease was mentioned as a potential problem in the Research Proposal written for this work. According to Dr. Davis and Mr. Shay, however, there has been no sign of this disease in New Jersey in recent years, and it is not considered a threat to the forests of the area.

4) Dutch elm disease is present within the Park, and several dead or dying elms were observed. However, young elms are abundant in several of the successional forest stands bordering on moist areas (for example, the mixed successional stands southwest of new Tempe Wick Road, and the stand at the corner of Jockey Hollow Road and old Tempe Wick Road, and in part of the stand sample in the intensive study (Chapter 6-6). A number of large elms (over 25 cm DBH) are present that are still in good health. Thus, elm appears to be maintaining itself as a significant species in wet sites and young stands, despite the disease. Mr. Shay (pers. comm.) has suggested that the drastic decrease in the regional density of elms, following the original outbreak of the disease, has led to a decrease in the density of the insect dispersal agent, and a concomitant decrease in the rate of spread of the disease.

Thus, there are no indications of tree pathology that would require management consideration. Should such problems arise unexpectedly in the future, the ecological considerations presented in Section 1 of this chapter should be weighed heavily before any spray programs are undertaken. Suggestions of tree pathology should be carefully checked with Dr. Davis and Mr. Lacey in the Department of plant Pathology, Cook College, Rutgers University, before any assumptions of causation (such as the putative dogwood borer) are accepted and spray programs instituted.

2.6 Exotic Plants in Jockey Hollow

The distribution of exotic plants in the Park was described and mapped in Ehrenfeld (1977), and discussed in Chapter 4; a list of exotic species is given in Appendix 1. As stated in the Mid-Year Report, the exotics include several aggressive species, and a number of non-aggressive species. Management policies should be formulated with the following points in mind:

A) The most aggressive species (Ailanthus and honeysuckle) cannot be eradicated without the use of chemical weed-killers (pers. comm.; Dr. Bruce Hamilton, Professor of Horticulture, Cook College, Rutgers University). Because the use of such agents should be avoided as much as possible in the Park, any such control programs should be restricted to historically important sites on public display, and should be scrupulously kept out of the forest community. As described in the text section referred to above, Ailanthus is restricted in distribution and incapable of invading closed forest, and the honeysuckle has at present a widespread distribution but a low biomass in relation to native species of vines. Therefore, these species do not warrant active intervention. Surveillance of road and trail-sides should be maintained, however, to prevent their establishment in undesirable areas.

B) Two species of shrub (privet and barberry) have become disseminated throughout the woods; these populations arose from plantings around the homesteads in the Park area. It would be futile to attempt to eradicate these species completely; however, removal of some of the larger clumps along the trails might help to control the spread of the plants (Hamilton, pers. comm.; see Figure 4-1 in Ehrenfeld [1977] for sites of major aggregations). Since these species are not known to carry diseases significant to the forest community, nor to be sufficiently aggressive to outcompete the native vegetation (see below) however, there is no urgent need to attempt to control them.

As described in Ehrenfeld (1977), a population of privet on the eastern slope of Sugar Loaf Hill is apparently preventing the native understory plants from exerting dominance. Any attempts to remove these privet plants should be done in slow stages, so as to prevent formation of a large area of bare soil. Such an area might invite the establishment of dense honeysuckle or Ailanthus populations, which would be considerably more difficult to remove.

C) Minor exotic species pose no threat to the native community. They can be expected to disappear over time, or at most to persist as isolated individuals.

D) The importance of the visitor use of the forests in promoting the influx of exotics (see Chapter 4) should be borne in mind in planning new trails or new interpretive displays along existing trails. It is recommended that interpretive material promoting the use of the forest by the public be kept, as much as possible, to one area so that surveillance can be effective in preventing new exotics from becoming established.

E) Periodic surveillance of roadsides and trails, especially where they traverse open areas, and rapid removal of any exotics found to be there, is likely to be the most effective means of limiting the role of exotic species in the forest.

2.7 Preservation of Archeological Artifacts

Rutsch and Peters (1976) strongly suggested that the forest should be cleared from the cantonment sites that contain artifacts in an identifiable matrix. The distribution of these sites is shown in relation to the forest type cover in Map #1. According to Rutsch and Peters, these archeological resources are the only remaining undeveloped source of information about Revolutionary life and time extant in the country, and such, deserve special efforts of preservation. In my opinion, their management suggestion should be implemented. Although such clearing would destroy some areas of mature forest, this loss would be a small fraction of the mature forest present both in the Park and in the surrounding protected lands, and no qualities of unusual importance are known to me that distinguish the areas of the cantonments from the surrounding forest. Formation of several small openings (circa 2-3 ha apiece) would permit the development of a richer herbaceous flora than appears to be present in the Park now (see Section 2-8 below) and could favor a diversity of wildlife, with suitable management of the field-forest edge. As noted in Section 2-3, such clearings might result in an increase in the deer population; this side-effect would have to be more carefully considered in the formulation of plans for clearing the sites.

Should the sites be cleared for preservation purposes, it is strongly suggested that the clearing be done in conjunction with a study of forest history (see Chapter 8-4).

2.8 Management of Open Areas

The non-forested lands in Jockey Hollow were not intensively studied in this project, because the major emphasis of work was on the woody vegetation. Nevertheless, several management considerations became apparent in the course of the work, and are here presented. The general philosophy behind the recommendations below is that: 1) the presence of some non-forested areas greatly enhances the biotic interest of the Park, by providing a diversity of habitats for plants and animals, and 2) fields of grasses and forbs were certainly part of the historic aspect of the land at the time of the encampments (albeit

during the summer, when few troops were present), and therefore deserve some representation among the biotic communities of the Park.

The locations of the open areas were shown in general in Map #1; Fig. 2-3 shows the distribution of the different classes of open areas found in the Park.

1) Mowed fields represent a substantial fraction of the open area, and are the dominant kind of field around the visitor attractions. The dominant vegetation is grass, with few forbs present. There is no obvious reason why these areas should be maintained essentially as lawns: the aspect has no historical validity, the vegetation is not very suitable for use as food or shelter by wildlife, and the frequent mowings are expensive. These areas should be allowed to develop an old-field herbaceous flora, like that found in the unmowed fields on Mt. Kemble. This would permit a greater diversity of birds, small mammals and reptiles, as well as a more interesting and esthetic array of flowering plants; it would also reproduce more closely the appearance that the fields must have had when the soldiers first came to the Wick Farm. By maintaining paths through the field in front of the Soldiers' Huts, through the nearby field where the trail crosses Sugar Loaf Road, and through the Grant Parade field, visitor access to the Park attractions would be unaffected. Picnicing would also be discouraged by a tall herbaceous community; small selected areas could be kept mown in accordance with the desire to promote such activity.

The transformation from lawn to old-field can be accomplished either rapidly, by plowing up the grass, or slowly, by ceasing to cut the grass every year, and permitting forbs to gradually invade. Plowing of the fields would result in the typical stages of old-field succession, in which ragweed could be anticipated the first year, and goldenrod and aster the second year; following this a diverse array of perennial plants would invade over the course of the next four to five years. An alternative to both complete plowing of the fields and the slow invasion of the grass community could be to plow a small number of strips across each field; this approach would bring the desired perennials into proximity with the grass at a faster rate than would occur with no plowing. In either case, the resulting vegetation would be considerably more interesting biologically than the present lawns.

Mowing with a sickle-bar mower should be done in each field at four to five year intervals to maintain the areas as fields. All mowing should be done in August, so as not to interfere with the breeding activities of ground-nesting birds.

2) Unmowed fields are present on the summit and eastern flanks of Mt. Kemble, and on the northern slope of Sugar Loaf Mountain. These areas are characteristic of the kinds of community that should be encouraged in the mowed fields discussed above. The field on the summit of Mt. Kemble is particularly rich in wildflowers. The field on Sugar Loaf Mountain is proceeding towards a woody community more rapidly than those on Mt. Kemble, and therefore, should receive top priority for mowing. All of these fields, however, should be mown

at four to five year intervals, in order to keep them in the old-field state of succession.

3) Two orchards are at present being maintained in the Park (Fig. 2-3). The ground-level vegetation in these fields should be managed as described above (although the grazing of the horses in the Wick Farm Orchard will produce an entirely different vegetation from that of the ungrazed fields and will reduce the need for mowing). The fruit trees are presently being treated with a series of chemical sprays including Sevin, Diazinon, Kelthane, and Zneb, designed to protect the apple crop. Consideration should be given to the possibility of utilizing sprays compounded of "naturally" derived insecticides (rotenone, pyrethrum, etc.). These sprays offer the advantage of introducing no highly toxic chemicals into the Park environment, thereby adhering more closely to the historically accurate representation of the Wick Farm, and causing less disruption to the rest of the insect fauna of the Park. Such sprays and treatment programs are available from Mr. Louis Netscherett (Princeton Junction, New Jersey).

4) Two small marshes are present within the Park. One, on the West Branch of Primrose Brook, represents a grass-sedge state in the hydric succession initiated when the holding pond of the Morristown Aqueduct Society was drained in the 1930's. It is currently being colonized by black willows and other wet site trees and shrubs. It can be expected to revert to forest during the next fifty years or less. The other marsh, below the extant pond on the East Branch of Primrose Brook, appears to be a permanent feature of the vegetation. Reference to "Cat Swamp" by Pitney (1938) prior to the development of the aqueduct system, the character of the soil in the area (see Chapter 2, Ehrenfeld, 1977), the current lack of colonization by trees, and the topographic relations between the marsh and the surrounding hill-sides (Stout, pers. comm.) all suggest that this marsh is an edaphic "climax" community. Because of the evident suitability of the vegetation, inquiries were made with Mr. Keith Hawthorne, graduate student, Rutgers University-Newark, and Mr. Robert Zappalorti, Associate Curator of Reptiles at the Staten Island Zoo, concerning the suitability of this marsh as a habitat for the endangered Muhlenberg's turtle (Clemmys Muhlenbergi; Anon., 1975); both of these scientists are presently conducting studies on the ecology of this animal. Unfortunately, these inquiries were made too late in the season for reconnaissance efforts to be useful. However, from their descriptions of suitable habitat, it is possible that this marsh could contain the bog turtle; bog turtle populations are known from southern Morris County on sites with similar soils. Search for these animals should be conducted in April or May; Mr. Zappalorti would be able to provide assistance, if necessary.

No active management is recommended for either of the marshes. If the natural marsh proves to be the home of a bog turtle colony, scrupulous protection of the site would clearly be required. Erosion should be prevented on the trails leading to the area. Work on these trails should, if at all possible, be done without the use of the heavy

machinery which churns up the soils bordering the marsh and could cause siltation and erosion to destroy the character of the site.

5) The only open water in the Park is the pond just upstream from the above-mentioned marsh. This pond has no natural drainage, being connected to Primrose Brook solely by a pipe in the eastern edge of the pond. The outlet of this pipe is above the water level during most of the year, with the result that there is no circulation or turnover of the water in the pond. The pond is presumably being maintained by contact with a high water table and by the surrounding walls; marsh or stream thicket communities would probably be the natural vegetation if the walls were removed. At present, the pond is remarkably devoid of flora and fauna. The influx of leaf litter has produced tannin-stained waters, which are probably highly acidic, and the lack of turnover of the water has probably resulted in deoxygenated conditions. These factors are probably responsible for the absence of aquatic vegetation and an associated fauna.

These observations are mentioned simply to inform Park personnel about the nature of the pond. The pond is doing no damage to the surrounding ecosystem, and thus any management plans should be related to aspects of historical reconstruction, rather than natural resource management. Any attempt to convert the pond to a more biologically productive body of water would require major alterations of the stream course, dredging of the pond bottom, etc.; in view of purpose of the Park as a historical site, rather than a biologic preserve, no justification for such management is apparent.

2.9 Forest Stands Approximating the Original Forest Cover

The nature of the original forest cover present when the soldiers arrived is analyzed in Chapter 8. The evidence suggests that oak-chestnut forests covered the lower slopes and gentle hills, and oak-hickory forest was present on the higher, steeper slopes and hilltops. Coniferous trees were minor elements, if indeed they were present at all. Major differences between today's forest and the original forest appear to be: 1) a much greater abundance of beech than previously, probably because of selective logging, and a much lower abundance of hickory for the same reason, 2) higher abundances of red maple and black birch, probably as a response to the disturbance of the forest from both chestnut blight and the logging, and 3) the absence of chestnut from the canopy. Species composition has changed very little in quality over the past 200 years, but has changed in the relative abundance of the species.

Thus, stands which contain a high percentage of oaks of which few are sprout clumps, relatively abundant hickories, and low percentages of beech, red maple, and black birch are roughly similar to original upland forests. Although there is no documentary evidence concerning the historic streamside vegetation, the vegetational evidence supports the idea that there has been minimal disturbance of these communities. Therefore, it is likely that some beech - yellow birch communities

were present on the ravines around the Primrose Brook. Figure 2-4 shows the locations of stands that conform to these characteristics. In Figure 2-4 areas are indicated that have been segregated from the larger mapping units used in Maps #1-3; this has been done using the transect data (Chapter 5) to delimit areas of hickory abundance.

Because there is no intent in Park policy at present to actively attempt to replicate the original forest, no specific silvicultural recommendations are made here for perpetuating these stands. The ravine communities are likely to be self-perpetuating in any case (see Chapter 9). The upland stands are slowly moving away from oak-dominated forests; however, the rate of change is likely to be very slow, because of the longevity of the species involved, and any disturbance that opens the forest, such as major storms or pathology, would tend to favor the regeneration of oaks. However, the possible long-term climatic trend favoring the northern beech and birches may work against the perpetuation of oak forests (see Chapter 3).

Figure 2-4 also shows those areas that have probably been used continuously as woodlot since the time of the Wicks. As discussed in Chapter 5 and in parts of Chapter 6, most of the mature oak forest show evidence of never having been cleared for agriculture, but of having been continuously forested since the time of settlement. Some of the Mixed Hardwood stands, however, were thought to have possibly represented areas that reverted to forest after some agricultural use early in the nineteenth century; these stands were eliminated in preparing Fig. 2-4. As discussed in Chapter 8, the available evidence does not permit separation of those areas clearcut by the troops, and those areas selectively cut by them for the most useful trees. Considering the strong tendency for oak woods to replace the original species composition after clearcutting (Stout, pers. comm.; Ward, 1966), it is probably that the above distinction between clearcut and selectively cut areas would not have affected the subsequent kind of forest on the site. Therefore, "continuously forested lands" here refers to lands that have undergone a variable intensity of logging, but have never been maintained as nonforested land.

2.10 Miscellaneous Management Issues

1) Vegetation Data Preservation: One of the most frustrating aspects of this investigation was the loss from (or in) the Park files of the records of vegetation manipulations, storm damage, and C.C.C. work during the 1930's, and other documents containing significant information on the past history of the forests. Although these records may be present in the files, several days of intensive searching failed to reveal them. The maps and records from the 1930's that were found, and used in this study, are an important resource for future studies of the vegetation in the Park, both for Park purposes, and for the general study of plant succession (Knapp, 1974). These documents should be carefully maintained in the Park files, so that further losses of information on the vegetation of the Park do not occur.

2) The chestnut sprouts treated with the hypovirulent fungus cultures should be checked for survival and diameter growth at yearly intervals (see Chapter 4 for map of tree sites and tree descriptions);

the observations should be made by a Park Ranger with background in forestry.

3) Trail erosion should be prevented by appropriate installation of log steps, etc. Forest clearing for the maintenance of pipe, power-line or other rights-of-way should be kept minimal; organizations contracted to such work should be required to restore some vegetation cover before completing their work. Erosion has been observed, for example, in the swath of forest cleared during work on the power-line crossing the Primrose Brook, east of Jockey Hollow Road. Should it be necessary to maintain non-forested land in rights-of-way, the methods for promoting stable, diverse shrub communities should be applied (Niering and Goodwin, 1974; Egler and Foote, 1973). Specific management techniques for this kind of vegetation management can be obtained from Dr. William Niering, Botany Department, Connecticut College, New London, Connecticut 06320.

2.11 Recommendations for Further Research in Jockey Hollow

The value of this study of the woody vegetation could be enhanced by two further research projects on the vegetation of the Park.

First, a series of permanent vegetation quadrats should be established, representing the major community types shown on the vegetation maps. The purpose of establishing these quadrats would be to provide detailed, quantitative data on defined areas for comparison with data gathered during future studies of the vegetation. Although the vegetation maps prepared in 1937 were of great importance in analyzing the current data, much speculation was needed in interpreting the general community descriptions used in that project. The data gathered for this investigation contain representatives of eight of the vegetation types, with no replication of the types; in addition, it would be impossible for future workers to accurately identify ex post facto the boundaries of the quadrat plots. Permanent quadrats would allow the fates of individual trees to be followed, so that growth rates and mortality rates could be measured. They would also allow quantitative estimates of the rate of change in vegetation composition to be developed. Finally, the scientific value of such plots would be great, insofar as accurately dated vegetation data from permanent sampling sites represents the best possible kind of data for the analysis of succession, and yet is the least common kind of data available for study (Knapp, 1974).

These goals could be met by establishing eight to ten quadrats in the mature forests and a similar number in the successional forests, with each quadrat about 20m x 20m in size.

Second, a study of the herbaceous vegetation of the Park would provide an important complement to the study of the woody vegetation reported here. In addition to documenting the flora of the Park, such a study could accomplish several goals important to the management and interpretation of the Park, as follows: 1) the presence of rare and endangered species could be definitely studied, 2) the distribution of exotic weedy, and agriculturally-associated species could substantially augment the understanding of land-use history, and 3) the

richness of the herbaceous flora compared to that expected for the original forest could be estimated, and recommendations could be made for restoring the herbaceous component of the vegetation. The proximity of the Bowman's Hill Wildflower Preserve in Pennsylvania could serve as a source of seeds or plants for any restoration projects. (A restoration project of this kind was indeed carried out by the C.C.C. during the 1930's [Weig, pers. comm.] ; however, the plants introduced by them have all died out since then).

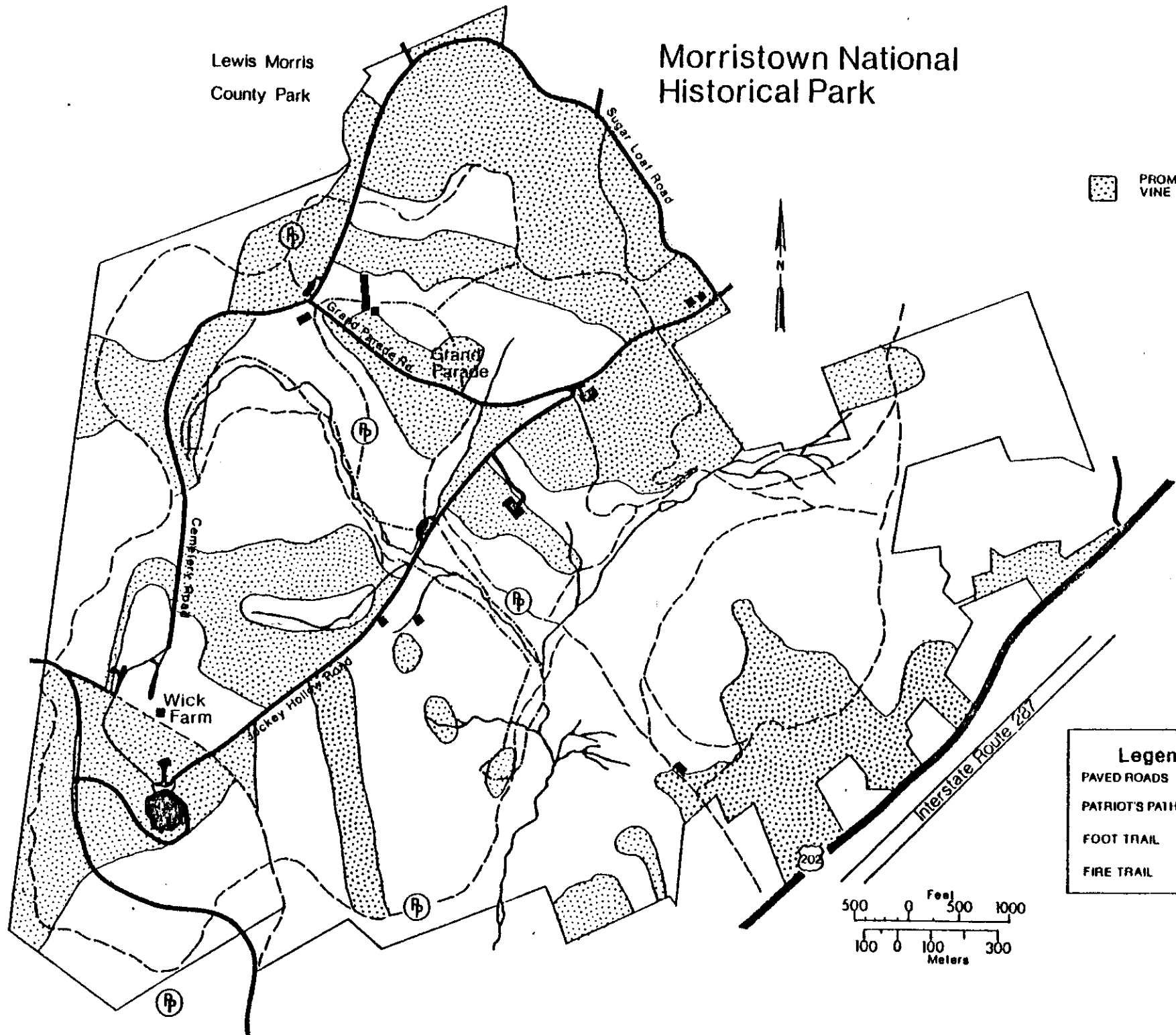
An ancillary research project of considerable interest to the Park, as well as the purely scientific concerns, is the reconstruction of forest history to be done in association with clearing of archeological sites for artifact preservation. This project has been described in more detail in Chapter 2-7 and Chapter 8; it basically involves analysis of growth and mortality patterns from felled trees in a small area, and detailed study of remnant woody materials on the forest floor, in order to reconstruct the history of forest changes. It should be considered as an auxiliary aspect of the primary archeological management plans.

Figure 2-1. Distribution of Prominent Vine Growth

Lewis Morris
County Park

Morristown National Historical Park

 PROMINENT
VINE GROWTH



Legend	
PAVED ROADS	
PATRIOT'S PATH	
FOOT TRAIL	
FIRE TRAIL	

500 0 Feet 500 1000
100 0 100 300
Meters

Figure 2-2. Areas of Heavy Oak Mortality

Lewis Morris
County Park

Morristown National Historical Park

Super Loaf Road

Grand Parade Rd

Grand Parade

Cemetery Road

Wick
Farm

Jockey Hollow Road

HEAVY OAK
MORTALITY

Legend

PAVED ROADS

PATRIOT'S PATH

FOOT TRAIL

FIRE TRAIL

500 0 Feet 500 1000
100 0 100 300
Meters

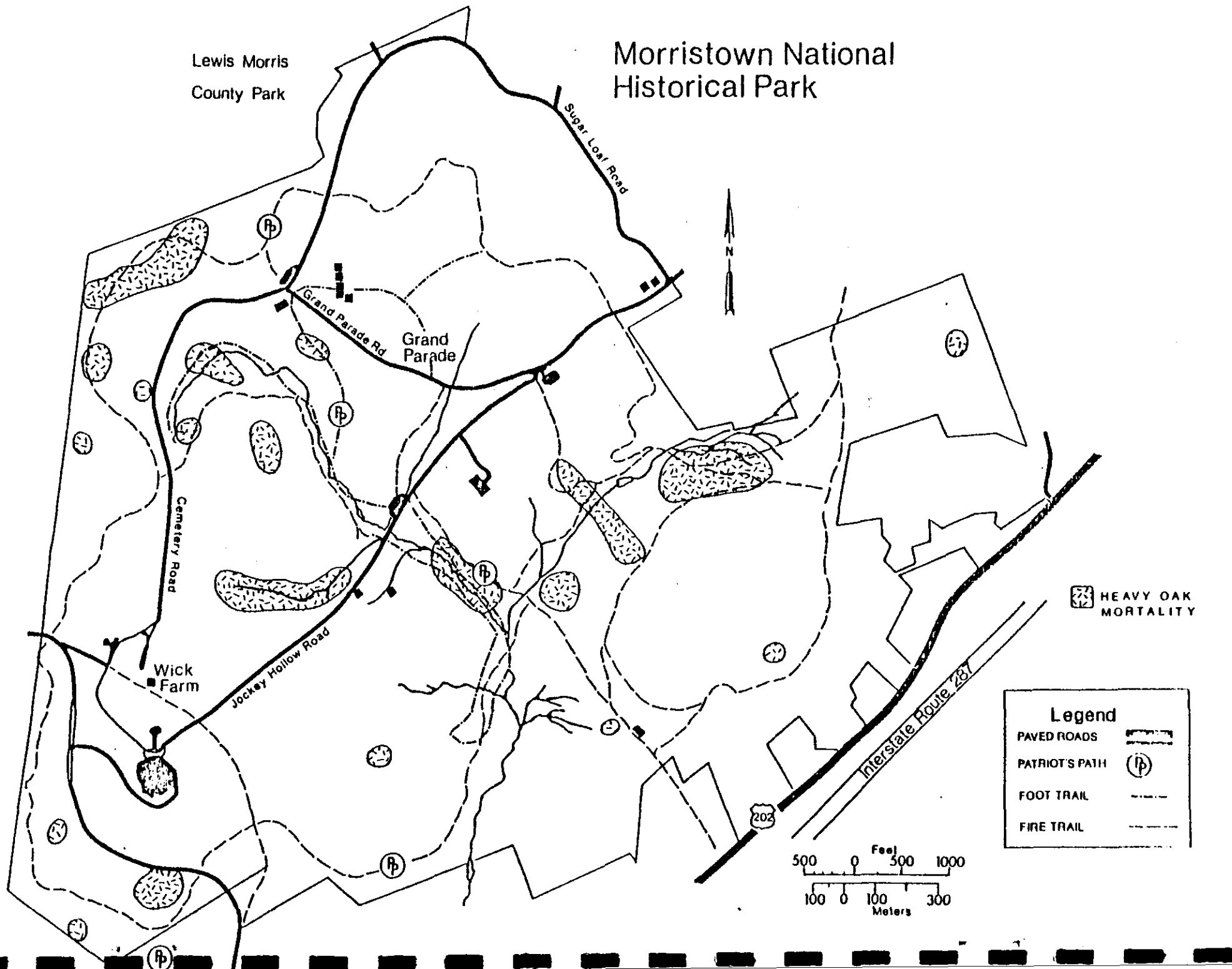


Figure 2-3. Non-Forest Communities in Jockey Hollow

Lewis Morris
County Park

Morristown National Historical Park

NON-FOREST COMMUNITIES



ORCHARDS



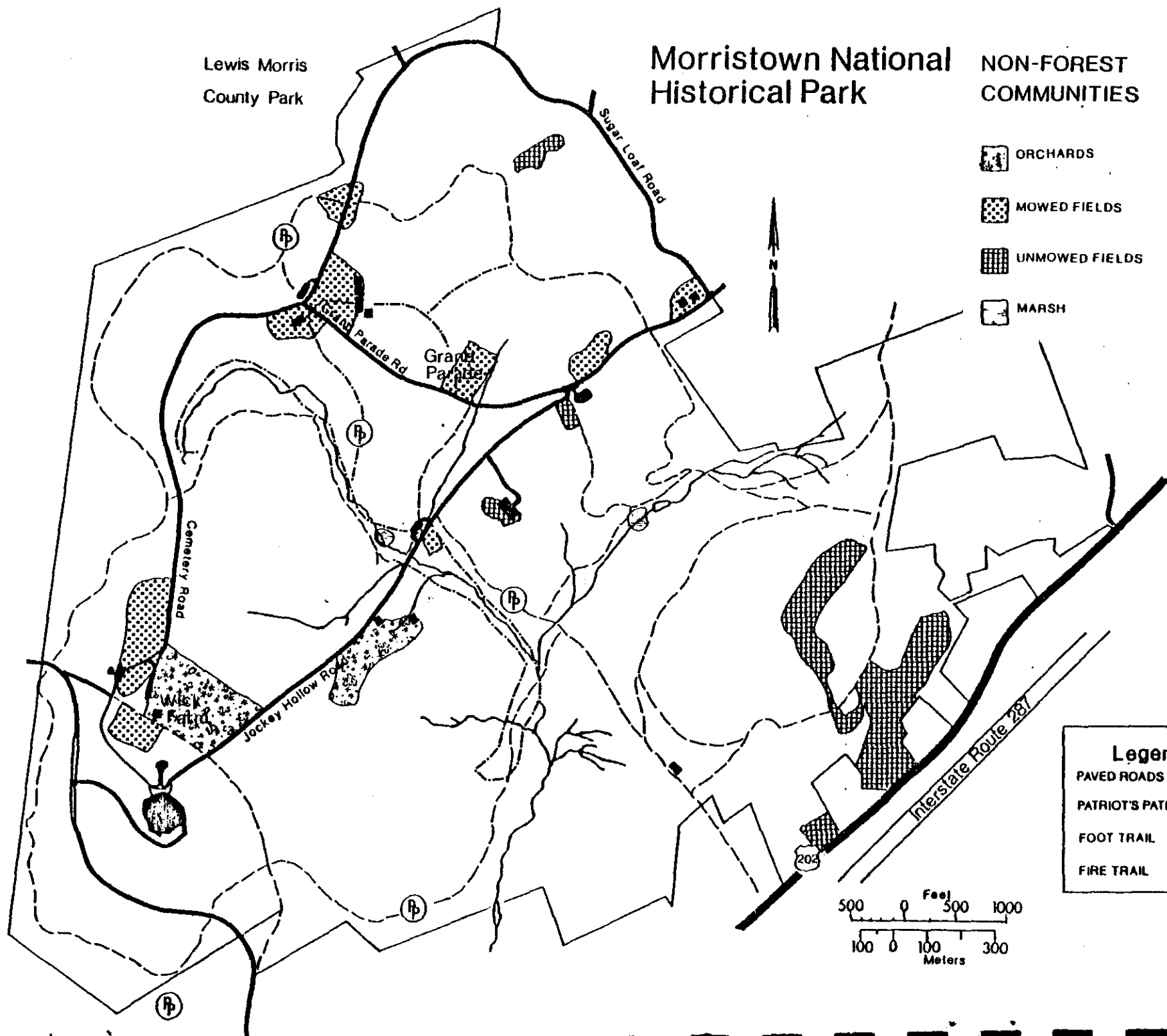
MOWED FIELDS



UNMOWED FIELDS



MARSH



Legend

PAVED ROADS



PATRIOT'S PATH



FOOT TRAIL



FIRE TRAIL

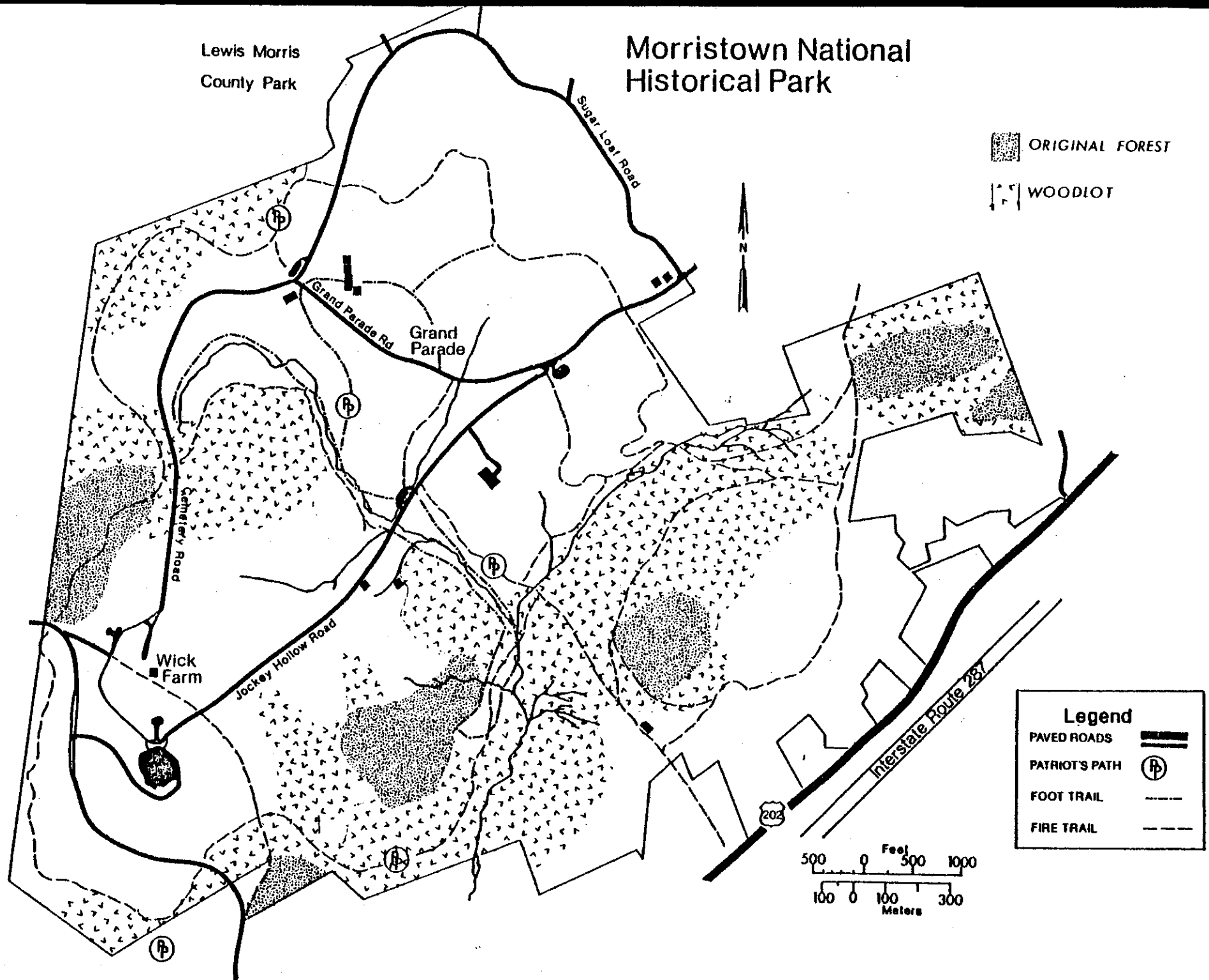


Figure 2-4. Woodlots that have been continuously forested and areas whose vegetation resembles the original forest in composition.

Lewis Morris
County Park

Morristown National Historical Park

ORIGINAL FOREST
WOODLOT



CHAPTER 3. PHYSICAL ENVIRONMENT IN JOCKEY HOLLOW

The geology, hydrology, and topography of the Jockey Hollow Area were described by Rutsch and Peters (1976); the soils and climate are discussed below, and the physical environment is related to the nature of the vegetation of the Park. Further information concerning the general geologic nature and history of the region can be found in Widmer (1964), Kummel (1940), and Wolfe (1976).

3.1 Geology, Hydrology, and Topography

The Jockey Hollow area lies in the Highlands physiographic province, which is, in turn, a portion of the Reading Prong of the New England Upland. The gneisses which underlie the Park are Pre-Cambrian in age, and are hard and relatively impermeable to water. They contain groundwater, in aquifers well below the water table in scattered locations, wherever faults and fissures in the rock occur. This hardness of the bedrock contributes to the dendritic pattern of streamflow noted by Rutsch and Peters, and also contributes to the excessive drainage of the steeper slopes and ridgetops which is reflected in both the soils and the vegetation. The Park area lies on the eastern boundary of the Province, with the transition to the Piedmont Province occurring abruptly in the vicinity of Route 202.

According to Kummel (1940), the Jockey Hollow area was covered by the ice sheets of the Jerseyan and Illinoian glaciations, during the Pleistocene, but was just south of the glacier during the Wisconsin phase (the most recent glaciation). Deposits of old till, dating from these two earlier events, are evidently scattered through central Jersey; thick deposits, are known, for example, to occur in Bedminster and Basking Ridge. Thus, some of the large boulders found in Sections may be remnants of the till deposited by these glaciers; however, the soils are evidently those derived from the parent material.

The Park consists of several broad, rounded or flat-topped ridges that border generally narrow valleys. The topographic relief is low, relative to other portions of the Highlands province; this reflects the position of the Park on the southeastern border of the province (Robichaud and Buell, 1973). However, the long parallel ridges, the frequent rock outcrops on the hills, and the stoniness of the soil are typical features of the Highlands. The main narrow ridges (Mt. Kemble-Tea Hill, and Sugar Loaf Hill) trend northeasterly, and thus much of the forest has either southeast or northwest exposures. Smaller areas, on the side of Blatchley's Hill and on part of Sugar Loaf Hill, face northeast. Fort Hill, and the plateau upon which the Wick House and orchard and the Visitor Center are located, provide a more gently sloping terrain. Thus, although the Park encompasses slopes of all grades and aspects, the major part of the land consists of steep slopes facing east and west.

As with the hills, the valleys are mostly long and narrow, but a few broad, flat places along the streams exist. Such areas are the Cat Swamp, the portion of the Primrose Brook, east of Jockey Hollow Road, where stream meanders have created a habitat favorable to lowland plant

associations, and the ground surrounding the upper portion of the Jersey Brook which also supports plant associations typical of wet ground. However, other branches of the Primrose Brook have carved narrow north-facing ravines, and these areas can support stands of the northern hardwoods, which typically are found in cool, moist habitats.

In summary, the topography of the Park is diverse, but some habitats are limited in extent, and others occupy much of the area of the Park. The impact of the topography and geology on the vegetation is thus likely to be 1) greater development of upland, xeric communities than of mesic communities, 2) limited development of riparian or stream-side communities, and limited development of swamp or other wetland communities, 3) little differentiation of communities on opposite sides of the hills, because there is less contrast in micro-climate between east and west slopes (the prevailing mode) than between north and south slopes (more sparsely represented).

3.2 Soils

Four soil series are represented in the Park; their distribution is shown in Figure 3-1, their main characteristics are given in Table 3-1, and the members of each series present in Jockey Hollow are listed in Table 3-2. The soils are all in the catena of soils derived from granitic gneiss bedrock or colluvium; the entire catena (excessively drained to poorly drained) is represented in the Park. Thus, the soils of the Jockey Hollow area are uniform in mineral composition; there are no areas of sharply contrasting material (such as limestone) that would effect a change in the vegetation.

The Califon and Cokesbury soils are found in low-lying areas, and support the wetland associations of red maple and yellow birch found near the streams. They are distinguished by the presence of the fragipan, which is a subsurface layer that becomes very hard and brittle upon drying, and prevents roots from penetrating deeply into the soil. The Edneyville soils underlie much of the Wick Farm area, and are, not surprisingly, the soils most suitable for agriculture found in the Park. Of the soils in the Park, these soils are also best suited to support mesic woodlands in which oaks, yellow poplar, and hickories grow well. The Parker series are poor soils for plant growth altogether; their present stoniness implies that the original occupants of the farms were well aware of this fact, and made no attempt to clear them for agriculture. Upland woods, containing the species of oaks that prefer xeric conditions (especially chestnut oak), hickory, and black birch, are supported on these soils, but tend to form open stands, with small, poorly developed trees (Robichaud and Buell, 1973).

In summary, the soils of the Park are similar in parent material, and the related characteristics of chemical composition, acidity and stoniness. They vary largely in their moisture characteristics, ranging from excessively drained rock outcrops to moderately to poorly drained areas in which water accumulates in pools during the spring.

3.3 General Characteristics of the Climate

The climate in Jockey Hollow is determined in part by regional factors influencing the flows of air, and in part by the topographical and geographical variations within New Jersey that cause local modifications of the regional trends. Superimposed on these determinants of climate are, on the one hand, the microclimatological differences associated with slope, aspect and position, and, on the other hand, the longterm trends in climate that characterize extensive areas (Biel, 1958; Dunlap, 1967; Robichaud and Buell, 1973).

The climate in New Jersey is controlled by continental masses of air, moving down from the northwest during winter, and up from the southwest during the summer. The continental source of air precludes a significant modification of the weather by the ocean, despite the coastal position of the state. Thus, the weather is characterized by greater extremes than would be expected for a coastal area. The winter air is predominantly cold and dry, and the summer air derives from an alternation of cold, dry polar air and warm, wet tropical air. Precipitation is well distributed throughout the year, and droughts during the growing season are very rare; there are also infrequent periods of extended cloudiness. Table 3-3 lists some of the characteristics of the climate in Morris County, which extend this general picture of the weather.

The position of the Park along the southwest boundary of the Highlands geographic province is strongly reflected in the character of the climate. A series of charts in Robichaud and Buell (1973) displays the distributions of the various climatological indices throughout the state, and from these, the significance of the boundary position of the Park is clearly shown. Differences in average annual precipitation, monthly temperature, first frost date, length of the frost-free period, and length of the growing season occur more or less abruptly at the junction of the Highlands and Piedmont provinces, so that the Jockey Hollow area has a climate more similar to the northwest corner of the state than to the nearby lowlands of the Piedmont. However, the climate is not as extreme as that near the northwest border of the state. Finally, the interaction of the topographic boundary between mountains and lowlands, the patterns of air circulation, and the proximity of the ocean have resulted in the region of the Park receiving more rainfall on a yearly basis than any other portion of northern New Jersey. Thus, the area of the Park has a climate intermediate in temperature regime between the northern mountains of the state and the southern lowlands, but wetter than either of these two adjacent regions. This climatic character is reflected in the vegetation (Chapter 2-2 and 4-1).

Several other regional factors affect the climate of the Park. Tropical storms are responsible for much of the precipitation that falls in New Jersey; destructive storms are sporadic but not uncommon, and average about 10 per century (Dunlop, 1967). The regularity of these storms has had a major impact on the vegetational history by favoring forests capable of rapid recovery from drastic disturbance (see Chapter 9). Freezing precipitation is a common element of the climate during winter, and the resulting glaze can cause considerable damage to trees (Siccama et al., 1976). Although severe droughts are rare, short periods

of moderate drought are common (Dunlap, in Eby (1976) p. 108). and periods of regional drought have probably always occurred at 5-10 year intervals (Cook and Jacoby, 1977).

3.4 Microclimate in the Park

The pronounced relief in the Jockey Hollow area causes important local modifications of the prevailing weather, which in turn influence the kind of vegetation to be expected on a particular site. In general, the valleys are characterized by having greater extremes of temperature (hotter during the day, colder at night) than the upper slopes, a considerably shorter frost-free period (up to half as long as on the hill-top area), the least amount of wind, and the least amount of evaporation (Daubenmire, 1974; Mowbray and Oosting, 1968; Spurr, 1957; Biel, 1958). These differences between the tops and bottoms of hills may be less pronounced in Jockey Hollow, however, because the major valley of the Primrose Brook lies parallel to the prevailing winds (in summer), and therefore the topography fosters mixing of air along the slopes. It is significant in this regard that hemlock and yellow birch, species with northern affinities, are found in any numbers only in the pockets formed by the branches of the Brook. The development of the forest canopy can produce major microclimatological changes by allowing greater amounts of heat radiation in open stands, with concomitant decreases in soil and air temperatures compared to closed stands at similar topographic locations. This difference may in part account for the abundant reproduction of oaks only in the open Chestnut Oak and Mixed Oak - Black Birch communities on Mt. Kemble (Chapter 9).

The aspect of a slope has equally important effects on microclimate. The angle of insolation, which can vary by as much as 56° (Mowbray and Oosting, 1968), combines with the steepness of the slope and the variation in the height of the sun during the year, to produce widely different microclimates (Geiger, 1965). Southwest-facing slopes are the warmest, partly because of greater insolation, and partly because of the weather and ground conditions in the late afternoon that foster heating; east-facing slopes receive more insolation, but are cooler because more heat goes into evaporating dew in the morning. North-facing slopes are cool, and, if sufficiently steep, may receive no direct insolation at all during the winter; this combination of microclimatological factors may be responsible for the presence of a Hemlock-Mixed Hardwood stand (see Map #3). Most of the slopes in Jockey Hollow are facing northwest or southeast; these exposures are more similar to each other in temperature regime than any other set of opposing exposures. One significant difference between them, however, is that southeast slopes have considerably more insolation than do northwest slopes; this may affect the phenology of the vegetation. Slope angle and exposure also influences the development of upslope daytime winds, and downslope nighttime winds, with greater speeds and gustiness being associated with slopes of greater steepness. The various microclimatological differences between slopes of different aspect combine in their effects on soil weathering. This was found to be the most significant aspect in microclimate in the study by Mowbray and Oosting (1968); the clay/sand ratio was the environmental factor most strongly correlated with growth and importance value

of the tree species growing on north - and south-facing slopes. Finally, Cantlon (1953) and Mowbray and Oosting (1968) have shown that microclimatological differences are more pronounced at ground level than at tree-top level, thus altering community composition more drastically among the herbs and cryptogams.

Therefore, the microclimatological differences between the basin of the Primrose Brook, the slopes of different aspect and angle, and the summits of the hills are likely to maintain some differentiation of the mature plant communities. Because most of the slopes are northwest - southeast ridges, though, community differentiation will be less well developed than on the sites where north - south slopes are found. Indeed, few relationships were discovered when the distributions of the major species were compared with topographic features, and those found involved the species, such as hemlock, with the most pronounced climatological requirements. The Hemlock-Mixed hardwood forest (Map #1) on a northeast-facing concavity, occupies an unusual topographic feature in the area of the Park, and although it may remain there, other sites are unlikely to develop a similar community. The other community types are likely to remain altitudinally zoned, with open, chestnut oak-dominated associations along ridges, and beech -birch-maple associations ringing the lower slopes.

3.5 Climatic Change and its Impact on the Vegetation

The climate has undergone a number of significant fluctuations since retreat of the Wisconsin glaciers; these fluctuations may have had an important influence on the development of the vegetation. The largest-scale variation has involved the progressive amelioration of climate, following the last (Wisconsin) glaciation, to a culminating warm, dry period occurring from about 3000 B.C. to about 1300 B.C. (Fisher, 1935; Raup, 1937). Following this climatic optimum, a cooling trend began, which reached its greatest development in the period from 900 B.C. to 400 A.D.; this period was marked by minor glacial advances. During the warm period and the subsequent cold period mean annual temperature differed from current values by $+3 - 4^{\circ}\text{F}$. Smaller fluctuations have occurred in the past thousand years. A warming trend began c. 500 A.D., and was followed by a cooler period beginning about 1600 A.D.; this last cool spell culminated in a glacial advance during the late 1700 - early 1800's (the "Little Ice Ages"), and minimum temperature during the period 1814 - 1819. Beginning in the mid-1800's the weather improved again, and reached a peak of warmth during the period 1940 - 1950 (Wahl, 1968; Wahl and Lawson, 1970; Haven, pers. comm.). Current data indicate the possible return to cooler conditions (Wahl, 1968; Haven, pers. comm.), or perhaps simply a continuation of a long-term cooling trend, but the data are incomplete, and the effects of man's activities on global climate are a matter of controversy (Wahl, 1968).

Raup (1937, 1938), and Spurr (1953) believed that the climatic history sketched above has had a major impact on the diversity and distribution of plant communities in the Northeast. Thus, Raup believed that the prevalence of western-type, xeric oak-hickory forests in New York could be attributed to the climatic affects of the warm period that ended about 1600 A.D.; the combination of burning by Indians and by natural agents, and a slow rate of invasion by the northern hardwoods, could account for the persistence of the warm-climate vegetation during the

succeeding cool spell. He further believed that the successional trend to a "transitional" forest, very similar in composition to the Mixed Hardwood forests recognized in Jockey Hollow, signalled the continuing retreat of the warm, dry oak forests and expansion of the cool, moist, beech-birch-maple forests. Spurr (1953) likewise stated that changes in mean annual temperature of 2°F. could, if prolonged over several centuries, result in fundamental changes in community composition; in particular, he pointed out that the climatic regime in southern Connecticut was close to the southern extreme of the northern hardwoods community type, and also close to the northern extreme of the oak-hickory type, and that therefore small climatic changes could engender large changes in vegetation.

The significance of these fluctuations for the vegetation in Jockey Hollow is problematical. The successional analysis (Chapter 9) points to a conclusion similar to that of Raup; namely, the northern element in the flora is increasing at the expense of the southern element, and any trend toward cooler climates will accentuate this change. The successional analysis of other northern New Jersey stands by Buell *et al.* (1966) also indicates a trend toward the northern community types. The prevalence of beech and the low density of hemlock may reflect the extended cool, moist period that began three hundred years ago; however, the effects of land-use history may outweigh the significance of climatic change in these vegetational trends. The presence of two individual pitch pine trees (above the Wick Farm; see Appendix 1), also suggests a relict distribution of species characteristic of warm-dry climates. From the available information, it is unclear whether the most recent warm spell has had any effect on the character of the vegetation. Without undertaking a more extensive analysis of the literature on postglacial vegetational history than time permits, it is not possible to analyze further the importance of these climatic changes in determining the current structure of the vegetation. This brief discussion has been presented solely to alert the reader to the possible importance of long-term climatic change in determining the character of the vegetation (see Chapter 2-9).

Table 3-1 Characteristics of the Major Soils Series Found in the Jockey Hollow Area

CHARACTERISTIC	CALIFON	COKESBURY	EDNEYVILLE	PARKER
Depth to bedrock	6'+	6'+	6' - 10'	6' - 10'
Locations	waterways; seepage areas at the base of slopes	waterways; long areas at base of slopes	gently rolling hills; slopes and ridges	ridgetops, steep slopes
Consistency	loam; some gravel and cobbles	loam; some cobbles and stones	gravelly loam; gravel, cobbles and stones	abundant coarse fragments; thicker humus layer than others
Important structural elements	fragipan restricts root growth	fragipan restricts root growth	good mix sand, gravel and clay promotes deep root growth	extreme stoniness limits plant growth
Drainage	moderate above & below fragipan	moderate above & below fragipan	well-drained	excessively drained
Water capacity; permeability; water table	moderate; seasonal high water table	moderate; seasonal high water table	moderate; water table low	low, very permeable; water table low
Topsoil	fair to poor	poor	poor; excessive stoniness	poor; excessive stoniness
Reaction	Acid; pH 5.1-6.0	Acid; pH 5.1-6.0	Acid; pH 4.5-5.5	Acid; pH 4.5-5.5
Suitable Uses	Pasture, crops, woodland	woodland	cropland	woodland

Table 3-2. Component Soils of the Major Soils Series Found
in the Jockey Hollow Area.

I Califon Series

Califon loam; 3-8% slopes; these soils are subject to erosion
Califon very stony loam, 2-8% slopes; these are often wet sites,
very poorly drained
Califon loam, friable subsoil variant, 3-8% slopes

II Cokesbury Series

Cokesbury extremely stony loam, 0-8% slopes; stones cover 5-15% of
the surface, limiting use

III Edneyville Series

Edneyville gravelly loam, 3-8% slopes, good soil for crops
Edneyville gravelly loam, 8-15% slopes; used for pasture and crops
Edneyville gravelly loam, 15-25% slopes; subject to severe erosion

IV Parker Series

Parker gravelly sandy loam, 3-15% slopes
Parker very gravelly sandy loam, 15-25% slopes; this soil is
40-50% stones and gravel, and is poor for agriculture
Parker extremely stony sandy loam, 3-15% slopes; mixed with Edney-
ville soils, very rocky and unsuitable for crops
Parker extremely stony sandy loam, 15-25% slopes; as above
Parker rock outcrop, 2-35% slopes; ground is 10-35% rock outcrop,
otherwise very stony and steep

Table 3-3. Climate Near Jockey Hollow. Data From Regional Maps, and From Weather Station at Morris Plains.

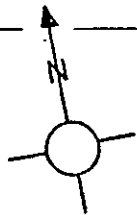
Variable	Value	Source
Av. annual temp.	50.3°F.	Dunlap (1967)
Av. annual ppt.	48"	Robichaud and Buell (1973)
Av. rel. humidity	68%	Dunlap (1967)
Mean max. temp., Jan.	42°F	" "
Mean min. temp., Jan.	22°F	" "
Mean max. temp., July	86°F	" "
Mean min. temp., July	60°F	" "
No. frost-free days	165	Robichaud and Buell (1973)
Length of growing season (days)	250	" "
Earliest freeze	Oct. 9	" "
Latest freeze	May 9	" "

Figure 3-1. Soils of the Jockey Hollow Section of the Morristown National Historic Park. The map has been simplified from that in Eby (1976) by showing only the major soil series, and not the subtypes of each series.

MORRISTOWN NATIONAL
HISTORICAL PARK

Jockey Hollow

1:15840



PARKER-EDNEYVILLE

EDNEYVILLE

COKESBURY

CALIFON

Cemetery

Jockey Hollow Road

Grand Parade Road

Sugar Loaf Road

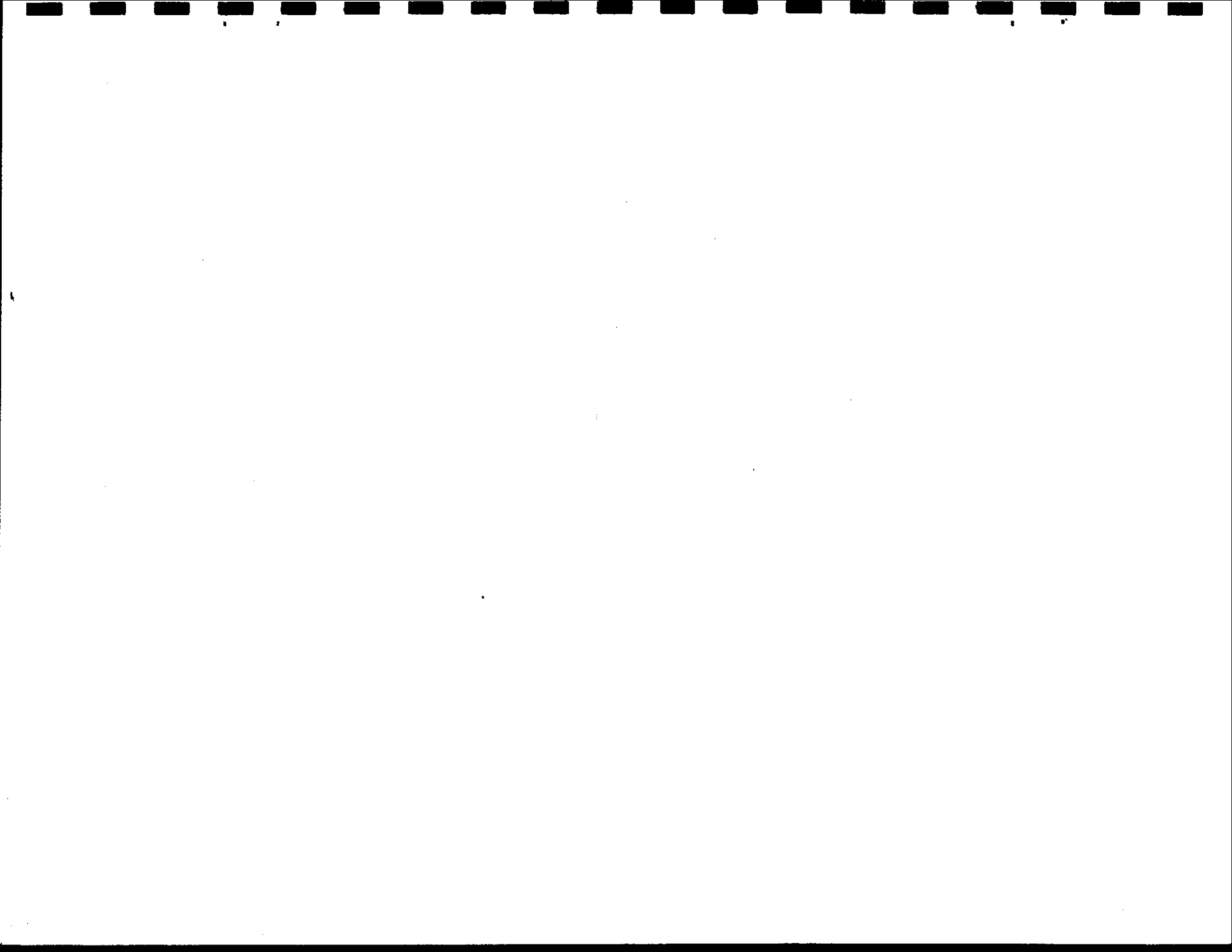
Jersey Road

U.S. Route 202

- Park Boundary
- Road
- Horse & Foot Trail
- Connecting Trail
- Foot Trail
- Stream
- Pond

0 .25 .5 mile
1000 500 0 1000 2000 feet

FEBRUARY 1977



CHAPTER 4. WOODY PLANTS OF THE JOCKEY HOLLOW AREA

The woody plants of the Park were listed in Ehrenfeld (1977) where their ecological affinities were discussed. The species list is included again here (Appendix 1), with a few additional species identified since the preparation of the Midyear Report, in order to maximize the utilization of this report. The distribution and ecology of the exotic species and the status of endangered species were discussed in some detail in Ehrenfeld (1977); supplementary information is appended below, but the reader is referred to that Report for the general discussion.

4.1 Species Composition of the Park Vegetation: Floristic Considerations

The final list of woody species is given in Appendix 1. Nomenclature follows Gleason and Cronquist (1963), and Graves (1956) for exotics not included in Gleason and Cronquist. A total of 92 species was found, of which 68 are native to the area, and 24 are exotic, either to the state or to the country. In terms of life-form, 58 species are trees, 26 species are shrubs, and 8 species are vines. This diversity of species compares well with a nearby old-growth stand of oak-hickory forest (Frei and Fairbrothers, 1963), which contains 79 species of woody plants of which 12 are exotic. The topographic and historical factors contributing to the species diversity in the Park were described in Chapter 3 and Ehrenfeld (1977); they included the hilly terrain, the presence of a stream channel (albeit one lacking a flood plain), and the patchwork of old and new communities resulting from the progressive abandonment of the farms and estates.

Included in Appendix 1 is the geographical affinity of each native species. This information was taken from Frei and Fairbrothers (1963) and Gleason and Cronquist (1963). Of the 66 species for which information was available, 43 (66%) are common to both northern and southern phytogeographic areas, 13 (20%) have a northern affinity, and 10 (15%) have a southern affinity. These percentages can be compared with those from the Hutcheson Forest, located in the Piedmont province and about 20 miles south of the Park. Here, only 6% of the woody flora had northern affinities, while 21% had southern affinities, and 72% were common to both northern and southern areas. Clearly, the macroclimatic and microclimatic differences between the rolling hills of the Piedmont and the steeper hills of the Highlands have had a major impact on the floristic composition of the Park, pushing it towards a northern-type forest. However the forest lacks white birch, an important component of the northern hardwoods community, and has only token representation of white pine, another dominant element of northern forests. Thus, the forest in Jockey Hollow must be considered as transitional between the Mid-Atlantic to southern forest type and the northern hardwoods type. The unusual abundance of yellow poplar, a tree more commonly found as a dominant in southern areas, may be attributable to the particularly high rainfall which characterizes this area (Chapter 3-1). It should be noted, however, that the lack of data on herbaceous species in the Park may bias these conclusions; at the Hutcheson Forest, northern and southern herbaceous

species were almost equally represented, which differed considerably from the situation of the tree and shrub strata.

The proportion of species that are exotic to the Park is very high. In a study of species diversity of oak woods in central New Jersey, Forman and Elfstrom (1975) found a total of eight species of exotic trees in the woods under investigation, with the stands ranging from 6% to 17% exotic in species composition. Although these data are not directly comparable to those of this study because small shrubs and vines were not included, they do indicate a generally lower level of exotic species in these other stands. The only factor in this study which was correlated with a high percentage of exotics was the frequent presence of visitors to the woods. Moreover, the greatest influx of exotics had occurred in an undisturbed old-growth stand (the Hutcheson Forest) so that neither agricultural history nor opening of the stand from disturbance could be invoked to explain the results. Clearly, the exotic species in Jockey Hollow are mostly escaped from horticultural and agricultural activities in the recent past of the Park, and from the conifer plantations of non-native species; however, the implications of the findings of Forman and Elfstrom for Park management should be appreciated. Increased visitor access to the forests, through increased utilization of existing trails and construction of new trails, is quite likely to maintain, or increase, the populations of exotic species in the Park.

Detailed consideration of the management of exotic species present was given in Ehrenfeld (1977), and will not be repeated here. In general, the exotic species are typical of disturbed areas, rather than mature forest communities, and thus they can be expected to slowly disappear as the successional forests mature and the traces of past logging activities disappear. A few species, notably barberry, privet and Japanese honeysuckle, have, however, spread through the forest, and are likely to remain locally prominent members of the vegetation in the near future. Frei and Fairbrothers (1963) also found barberry and Japanese honeysuckle to be both abundant and widespread in the Hutcheson Forest. Most of the successional areas and adjacent disturbed edges of mature forests have been densely colonized with native species of vines and shrubs, and this fortuitous development has probably been significant in keeping the role of exotics as low as it is, given a large number of species involved.

The conifer plantations are not self-reproducing (Chapter 6-8). Although some nearby old-fields were colonized by some of the species from these stands, the number of such colonists is small, and the sizes of the trees are uniform, suggesting an initial period of colonization when the fields were newly abandoned. Many of the individuals appear overtopped and weak and not likely to survive. It thus seems most unlikely that these stands will do more than slowly disappear, as deciduous successional species come to dominate the stands.

Ironically, one of the most abundant species in the Park - black locust - is not native to New Jersey. Its natural range extends from western Pennsylvania, south along the Appalachian Mountains to Georgia, and westward through the Mississippi basin (Britton and Brown, 1913). According to McClintock (1894), black locusts were planted by John Wick

on the grounds of the purported cemetery shortly after the beginning of the nineteenth century, in order to commemorate the soldiers that died during the cantonments. It cannot be ascertained whether this was the first introduction of the species into the Park area. However, it may be comforting to know that the presence of this non-native tree is closely linked to the significant historical events for which the Park was formed.

4.2 Endangered Species

The possibility of the presence of rare or endangered plant species in the Park was discussed in Ehrenfeld (1977). During the field work conducted during the spring and early summer of 1977, observations were made in suitable habitats to check for the presence of any of the plants listed in Table 4-4 of Ehrenfeld (1977). None was found, and indeed, the herbaceous flora did not appear as rich as might be expected (see Chapter 2-11). However, because the major emphasis of this study was the woody vegetation of the Park, it is possible that isolated individuals of rare herbaceous plants are indeed present. In view of the recent compilation of rare and endangered plant populations in New Jersey (Fairbrothers and Hough, 1973, emended 1975), it is likely that the botanists consulted previously (Ehrenfeld, 1977) would know of any nearby populations of such plants. Because they know of none it seems likely that only a large-scale investigation and survey would provide definitive information on the presence or absence of endangered plant species in the Park, which project was judged to be outside the scope of this study.

It is recommended that intensive studies be made of particular areas as the need arises for management or interpretative purposes.

Although no systematic investigation of rare and endangered animal species was made, the possible suitability of the Cat Swamp area for bog turtle habitat was examined with two herpetologists knowledgeable about this creature. Their recommendations are given in Chapter 2-8. The presence of other endangered or rare reptiles and amphibians was ascertained at the same time. None of the listed species or amphibians are known to occur in the Park; however, wood turtles (Clemmys insculpta) are present in the Park, and are considered to be threatened in New Jersey.

4.3 The American Chestnut in the Forest in Jockey Hollow

Because of the recent development of a treatment for the chestnut blight, special consideration was given to the status of this tree species. In this section, the historical importance of the species in the forest is examined, and the treatments applied are described.

The importance of American chestnut trees in the native vegetation of Jockey Hollow can be inferred from several lines of evidence. Most important is the abundance of living chestnut sprouts in several portions of the mature forest (Fig. 4-1); these attest to a high density of chestnut trees in these areas at the beginning of the century. The abundance of cut chestnut stumps similarly shows that the species was common in Jockey Hollow. Although no attempt was made to estimate the original density of the species, the sprouts and stumps indicate that chestnut probably varied from being a dominant tree on the lower slopes near the Primrose

brook and elsewhere, to a principal associate on the thinner soils near the ridgetops. The importance of the species in the colonial-era forest is equally apparent from the frequency of chestnuts among the boundary trees noted by surveyors (Chapter 8), and from the mention of the species in accounts of the construction of huts, fences, and wood products in the Revolutionary War accounts (Rutsch and Peters, 1976). The regional prominence of the species is, finally, apparent in the forest type maps devised by Braun (1950) to classify the Eastern Deciduous Forest, the presence of chestnut pollen in bog cores taken in the area (Harmon, 1968; Potzger and Otto, 1943), and the numerous studies of replacement of dead chestnuts that have been done since its demise which indirectly demonstrated its high density (Good, 1968; Mackey and Sevic, 1973; Keever, 1953; Korstian and Steckel, 1927; Woods and Shanks, 1959).

Many of the sprouts in the areas shown in Fig. 4-1 attain sizes up to 15 cm DBH; however, most of the larger stems are succumbing to the blight. In order to preserve at least some representative specimens of this historically significant tree, a newly developed treatment for the blight was applied to eight sprouts. The treatment involves application of cultures of a hypovirulent strain of fungus to the cankers of infected trees; the hypovirulent strain appears to outcompete the virulent fungus present in the canker, so that the canker heals over and evidence of tree pathology disappears (Van Alfen *et al.*, 1975; Jaynes 1975). It is as yet unclear whether the hypovirulent fungal strains will spread naturally through the forest; although there is some evidence from European work that this does happen, there is no evidence of natural dissemination in American stands. Thus, the immediate goal of the treatment program that was undertaken was the preservation of representative specimens; should methods be developed for promoting natural spread of the curative strains, these trees will, with luck, provide a focus for the reestablishment of chestnut as a dominant component of the forest.

Cultures of the hypovirulent strains were obtained from Dr. Richard Jaynes, of the Connecticut Agricultural Experiment Station, and were propagated on potato dextrose agar containing 0.1 g L-methionine/liter medium. Agar plugs of four strains (EP-14, EP-50, EP-60, and EP-90) were introduced into each treated tree; the four strains were used in order to minimize possible incompatibility reactions (Elliston, pers. comm.). The trees selected for treatment were at least 6 cm D.B.H., and appeared healthy and vigorous. Unfortunately, the largest chestnuts in the Park, including one that had set fruit in 1976, were dead when the treatment became available. None of the treated trees appeared to have reproduced. The dimensions of the cankerous areas on each tree were recorded, as were the height and D.B.H. of the tree; this information is given in Table 4-1, and the locations of the treated trees are shown in Fig. 4-1. Bark plugs were removed at 5-8 cm intervals around the canker, and agar plugs of the fungal colonies were inserted and covered with masking tape. The trees were treated in June, 1977 and reexamined in September, 1977.

The fate of these trees should be followed with yearly observations on their condition. At some point during the growing season, height and diameter measurements should be taken on those trees that survive, and their general condition and vigor should be noted.

Table 4-1. Chestnut Trees Treated with Hypovirulent
Fungus: Condition as of September 1977.

Tree*	DBH (cm)	HGT (m)	Condition at Time of Treatment
A	10.4	9.1	Good, but encircling canker at 3 m. some epicormic sprouts
B	11.9	12.8	Fair, no large canker evident, but close to dead chestnut
C	7.6	8.0	Fair, lower branches dead, but no extensive canker
D	5.3	5.2	Fair, one large branch dead, but otherwise vigorous; 3 small cankers
E	5.8	9.4	Good, one small canker
F	8.9	7.6	Poor, large canker around root collar and lower trunk
G	6.9	6.1	Fair, moderate canker
H	7.6	11.3	Good, large canker at base of tree, but stem not girdled

* Letters refer to locations in Fig. 4-1.

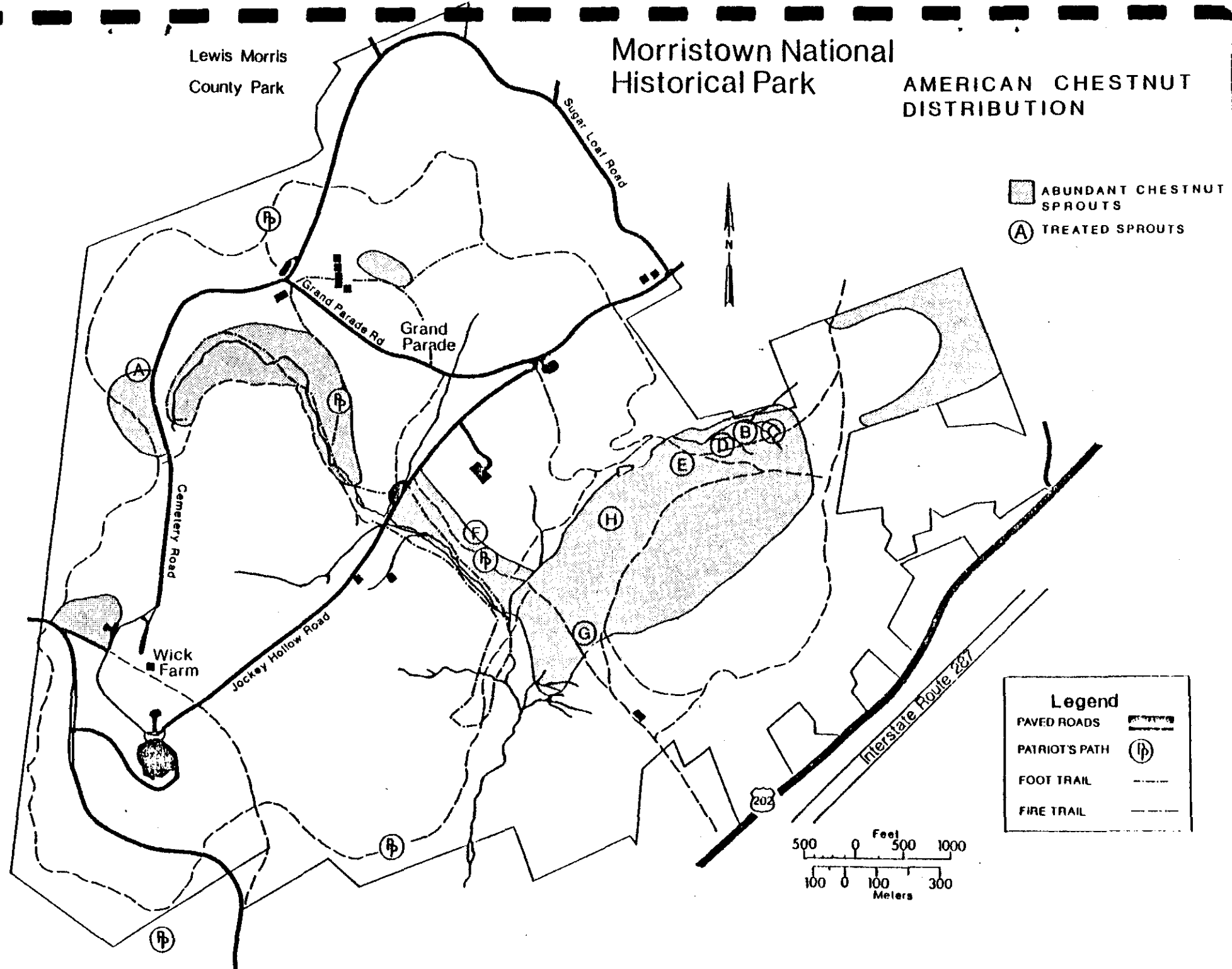
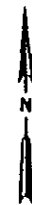
Fig. 4-1. Distribution of Abundant Chestnut Sprouts,
and Locations of Treated Chestnut Saplings

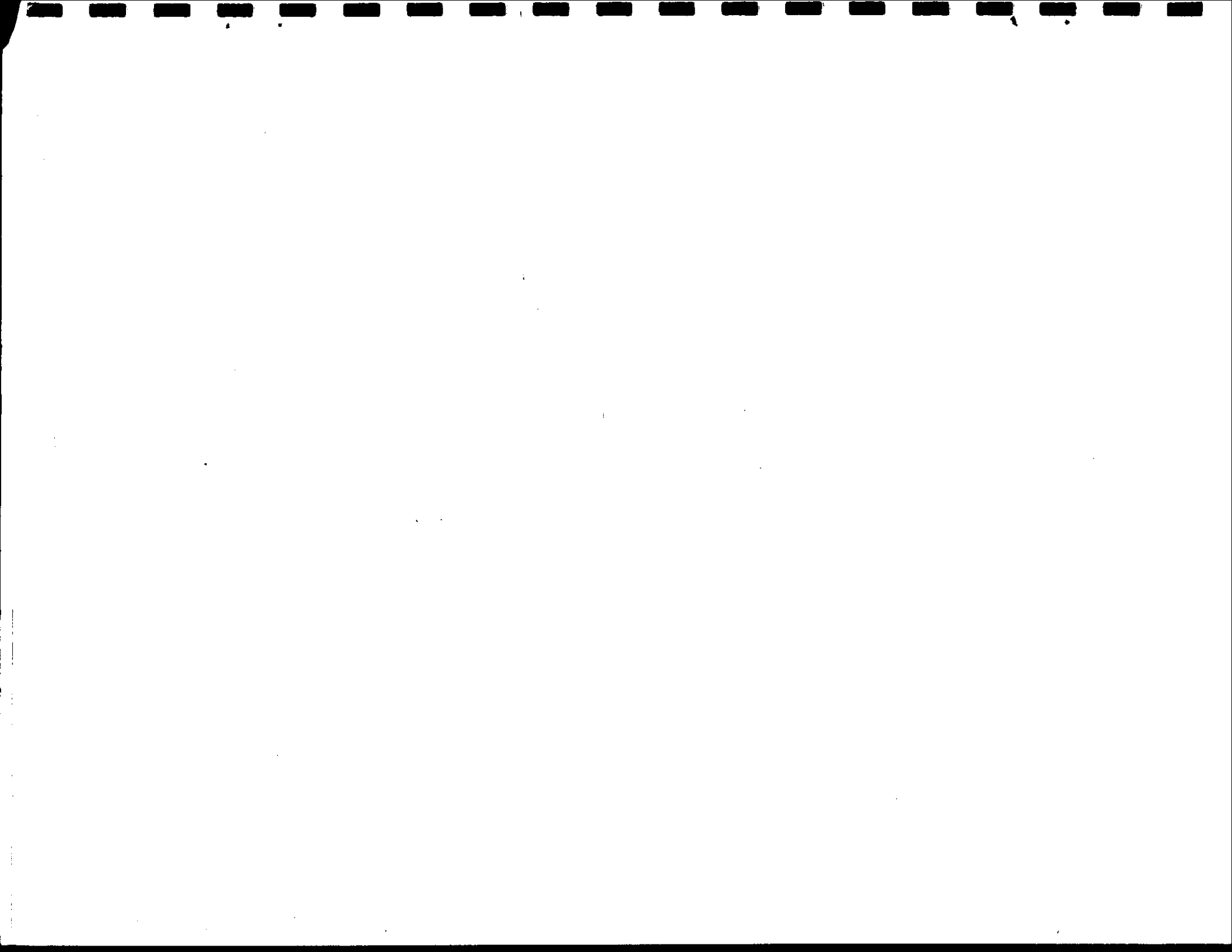
Lewis Morris
County Park

Morristown National Historical Park

AMERICAN CHESTNUT DISTRIBUTION

- ABUNDANT CHESTNUT
SPROUTS
- A TREATED SPROUTS





CHAPTER 5. THE MAPS OF THE VEGETATION OF THE JOCKEY HOLLOW AREA

In this chapter, I outline the methods used to produce the maps of the current vegetation, present the final classifications of the vegetation types, and comment on the vegetation types found in the Park.

5.1 Methods of Data Collection and Map Construction

The methods used to obtain the base data for the maps were described in the Mid-year Report; a summary will be presented here, with a description of the methods used to assemble the maps.

The Jockey Hollow area was divided into sections, and transects were drawn on a base map across each section, perpendicular to the major topographic feature of the section. The transect lines were 61m (200 ft.) apart. At 15 pace intervals (approx. 20m) along each transect, the dominant and subordinate canopy tree species were noted, and observations were made concerning the type and development of the understory, the presence of vines, and the presence of noteworthy botanic features such as exceptionally large trees, species indicative of early successional status, species unusual in the area, and exotic species. The presence of old walls, hedgerows, logging roads and cut stumps, areas of extensive gypsy moth-caused oak mortality, and cultural artifacts such as remnants of the Morristown Aqueduct System were also noted down. The transects were run using a hand-held compass, and the distances were measured by pacing. Distances along roads and trails between the ends of the transects were measured, in order to help orient the transect lines on the base map.

It was recognized at the outset that the pacing and hand-held compass methods employed would result in some inaccuracy in the positions of the boundary between the communities. Two factors induced us to use this system, however, as follows:

- 1) The boundaries between vegetation types are rarely abrupt; in most cases, there is a zone of intergradation between types that were judged to be larger than the likely error of the methodology. For example, although many of the junctions between the mature and successional forests are abrupt (occur over a distance of less than 20m), some of the junctions between mature and successional forests were found to occur over a distance of several hundred feet (that is, over two to three data points). In these places, oaks and other mature hardwoods were scattered among the young ash, black locust, and other successional species, and thus made the placement of the boundary between types arbitrary at best. The junctions between the subtypes of the successional and mature forests were even more markedly gradual and the drawn lines were, therefore, arbitrarily placed within the transition zone.

2) Preliminary surveys of the Park indicated that there was considerable variation in the plant communities, and that this variation occurred over relatively short distances. In order to describe this variation, and yet leave time and manpower resources for the intensive community sampling effort, it was necessary to use a method that was not overly time-consuming. A variety of combinations of transect spacings and chain-and-compass methods were tried, and the method used was selected as that providing the maximum amount of information for the amount of time and effort that was available.

The data were assembled on the base map drawn by Rutsch and Peters (1976) by placing each transect line on the map and listing the dominant vegetation at each data point. The transect lines were oriented as precisely as possible using the landmarks observed during the traverse (trails, old roads shown on the 1933 topographic map, buildings, drainage, Morristown Aqueduct system artifacts, etc.), and the measured distances between the transects along the boundaries of each section.

After transfer of the transect lines to the base map, the data on the dominant trees at each observation point were examined, and the most common groups of associated species were identified. Species groups that were observed at a small number of data points were dropped from the list of community types, and were incorporated in the surrounding community type. The data were examined to ascertain whether understory trees or shrubs served to distinguish particular communities more clearly than did the overstory trees; they were found to identify only the Stream Thicket type (see below and Chapter 6). The minimum size area considered for mapping was 0.1 ha (0.25 acre).

Boundary lines between species associations were then drawn, using the plotted data points to locate the limits of each stand. The locations of the boundary lines were then checked against: 1) the locations of landmarks recorded in the transect data and shown on the base map or the 1933 topographic map, 2) regions of different forest types evident on aerial photographs (1974 flight) viewed stereoscopically, and 3) the locations and configurations of open fields shown on the 1937 Vegetation Map. These checks assisted in accurately locating borders in the areas between transects, and in placing the boundaries in regions where the composition of the vegetation changed gradually. Areas of questionable composition were rechecked in the field before assignment to a vegetation type.

In designing the vegetation maps for presentation, following the determination of all type boundaries, it was decided that the information could be most usefully conveyed in a set of three maps, so that the subtypes of each major category could be more easily distinguished from each other. Thus, a base map (Map #1 of 3) shows the distribution of the major categories of communities, a second map (Map #2 of 3), shows only the subtypes of the Successional Forest category (see below), and the third map (Map #3 of 3) shows only the subtypes of the Mature Forest category. The areas of

archeological and historical importance given on Maps 1-4 of Rutsch and Peters (1976) were placed on the base map (Map #1) to assist management decisions in the future.

5.2 Plant Community Types in Jockey Hollow

The community types found in the Jockey Hollow section of the Park are listed in Table 5-1, together with the area occupied by each type. A brief description of each type is given in Appendix 2.

In defining these types, I attempted to strike a balance between practicality and accuracy. Several criteria were used to establish the vegetation classes: 1) clearly recognizable species associations, well differentiated from other associations, were accepted as types; examples of such stands include the introduced conifer stands (Map #1) and the hemlock-mixed hardwood stand (Map 3); 2) species associations that occurred over substantial areas, but that included some variations within the area, were recognized; examples of such types would be the Mixed Oak - Black Birch stands, which include Oak-Hickory associations, and White Ash - Black Locust, in which red maple, yellow poplar, or other successional species may be prominent in small patches; 3) species associations presenting some outstanding characteristic, such as the low stature of the Stream Thicket community, or the successional communities that are dominated by a single species. These criteria gave rise to a set of community types which reflect the diversity in forest composition which exists in the Park, and yet are not too numerous to be useful to Park personnel.

The definition of the community types does not coincide with the cover type classes of the Society of American Foresters (Eyre, 1954), or with the community types described in several other studies of New Jersey forests (Niering, 1953; McDonough and Buell, 1956). Nor do the community types correspond closely with the types used in the 1937 Vegetation Map. On the one hand, the classifications of the Society of American Foresters and the Vegetation Map of 1937 seemed too broad to adequately depict the kinds of forest found. For example, almost all the mature forest on the 1937 map was described as "Yellow poplar - Red oak", in which a wide variety of other species were listed as associates. The clear distinctions between the upland stands in which black birch is the major associate of the oaks, and the lower slope stands in which beech is the major associate of the oaks, warranted recognition of a more detailed classification than that used in 1937. On the other hand, the kinds of forest described in other studies of New Jersey did not correspond well with the kinds of forest occupying substantial areas in Jockey Hollow. Finally, the proportion of forest that is in early stages of succession is high, and thus warranted more detailed classification than was to be found in these published works.

The forest classification settled upon reflects several of the factors influencing forest development (see Chapters 6,9). Edaphic factors - the effects of soil, topography, slope, and aspect - account for the distinctions among some of the types. Thus, the hemlock - mixed hardwood stand occupies a north-facing steep slope, the mixed

oak communities occur on moderately sloping, excessively drained soil, the mixed oak-beech communities are restricted to steep lower slopes and ravines, and the chestnut oak-black birch communities are found mainly on steep upper slopes. Human disturbance is a second major factor responsible for some of the types: the planting of hedgerow trees has produced some of the single-species successional stands, logging has produced some of the Mixed Hardwoods forests, and of course the introduced conifer stands reflect human activity. Finally, the major categories -- open land, successional forest and mature forest -- reflect the inexorable change associated with natural succession.

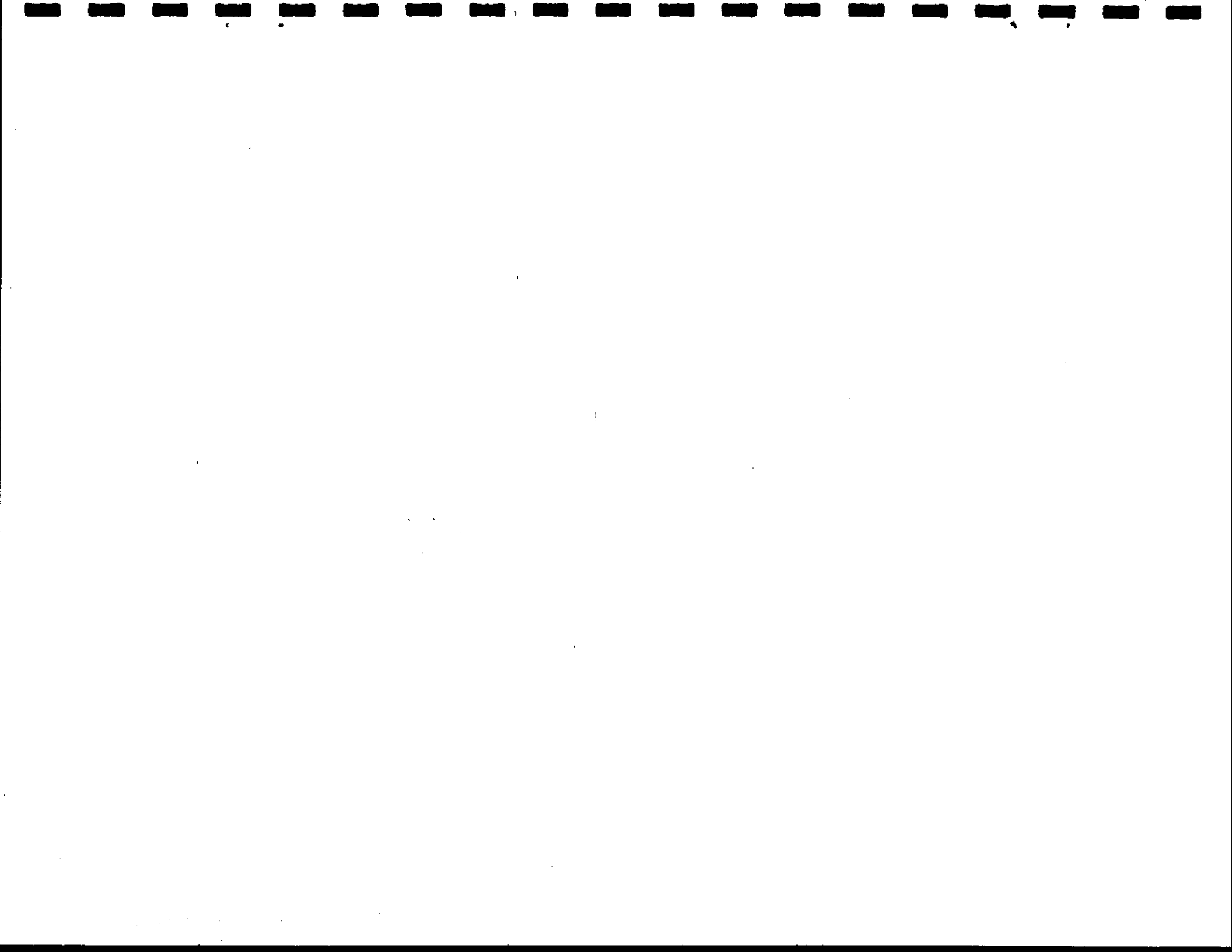
5.3 Use of the Maps

In using the vegetation maps, several of the subjects touched upon should be kept in mind, as follows:

- 1) Boundaries between types have been arbitrarily placed in some cases; this is particularly true where boundaries separate subtypes within the two principal forest types (Mature and Successional).
- 2) Community composition varies within each type, so that not all points within a stand will necessarily correspond with the descriptions given in Appendix 1 and Chapter 6.
- 3) In order to keep the number of mapping units to a convenient number, different kinds of open land have been mapped together; they are distinguished in Figure 2-3.

Table 5-1. Community Types of the Jockey Hollow Area, and Area Mapped in Each Type

Type	Area (ha)	%
<u>Successional Broadleaf Forest: Total</u>	<u>186.1</u>	<u>37.5</u>
Mixed Successional	67.8	13.7
White Ash - Black Locust	37.6	7.6
White Ash - Yellow Poplar	29.5	5.9
Pure Stands		
Yellow Poplar	31.8	6.3
White Ash	3.8	0.8
Black Locust	3.5	0.7
Red Maple	6.1	1.2
Sassafras	2.3	0.5
Black Walnut	2.2	0.5
Black Birch	1.1	0.2
Ailanthus	0.6	0.1
 <u>Mature Broadleaf Forest</u>	 <u>275.8</u>	 <u>55.7</u>
Mixed Oak - Black Birch	67.0	13.5
Mixed Oak - Yellow Poplar	90.4	18.2
Mixed Oak - Beech	23.6	4.8
Mixed Oak	27.9	5.6
Mixed Hardwood	39.5	8.0
Chestnut Oak	14.8	3.0
Mixed Hemlock - Hardwood	0.9	0.2
Stream Thicket	11.7	2.4
 <u>Coniferous Forest</u>	 3.1	 0.6
 <u>Open Areas</u>	 30.8	 6.2
 TOTAL	 495.8	 100.0



CHAPTER 6. STUDIES ON STAND STRUCTURE

In this chapter, I present the result of the intensive community sampling that was undertaken to characterize the structure and compositional dynamics of the various kinds of communities in the Park. Eight communities were sampled, including representatives of both mature and successional types. Although the initial work plans called for sampling of four community types, the diversity of the vegetation was such that a greater effort was deemed necessary to interpret the kinds of man-induced and natural changes that are occurring the the Park.

6.1 Methods

The community samples were taken using two approaches: three communities were sampled using the point-quarter method (Mueller-Dombois and Ellenberg, 1974), and five communities were sampled with quadrats. The point-quarter samples were taken in the larger stands, and the quadrat samples were taken principally in smaller stands, or where available time did not permit the use of the more lengthy point-quarter approach. All sampling sites are shown in Fig. 6-1.

In the point-quarter samples, transects were established perpendicular to the slope of the stand, and at 60.6m (200 ft) intervals along a base line. The number of transects was determined by the shape of the community, and they were distributed in such a manner that the stand was completely represented. At 20 m intervals along each transect, a sample point was established, and the following data collected: 1) the diameter and distance to the nearest tree (stems over 20.3 cm d.b.h.) and sapling (stems 2.5 cm to 20.3 cm d.b.h.) in each quarter, 2) the basal area of standing dead trees (using a B.A.F. 10 prism), and 3) the woody plant seedlings (less than 2.5 cm d.b.h.) found in two 1 m² quadrats placed at random distances from the point along the transect. The percentage cover of the transect line by shrubs was recorded for the 20 m interval between sample points. Forty points were measured for each stand. The two tree classes were defined so that all understory species (such as dogwood or serviceberry) were represented solely in the smaller class.

In the quadrat samples, two 0.1 acre (0.04 ha) quadrats were established in each stand. The orientation of the quadrats was determined by the geometry of the sample area; in all cases, they were placed within the central portion of the largest stand of each community type. The placement of the quadrats was guided by subjective evaluation of the sites, so that they were within representative regions. Because the available time and resources did not permit study of replicate samples from different stands of each type, this subjective approach was deemed more likely to give data representative of the community type than a more objective method based on random choice for sample points. These constraints were particularly pronounced in the small, narrow communities, such as the Stream thicket and the Conifer stand, in which careful placement of the quadrats was necessary to exclude portions of neighboring communities.

The quadrats were 100 ft. (30.3m) X 42.5 ft. (12.9m). These dimensions were chosen in order to accommodate the narrow strip-like distributions of some of the types. Within each quadrat, the diameter and identity

of all stems over 2.5cm DBH were recorded, the identity of all standing dead trees was noted, the percentage shrub cover was estimated visually, and the woody plant reproduction was counted in 10 1 m² quadrat placed randomly along the center line of the quadrat. Using this sampling design, approximately 100 trees were measured per stand, and 20 m² seedling samples were taken. The accuracy of the quadrat was roughly compared to that of the larger point-quarter samples by calculating the relative frequency of each tree species in the subsample of 13 points (104 trees) from the Mixed Oak-Yellow poplar stand and comparing them to the relative frequencies calculated for the complete sample of 40 points. The differences ranged from 19% to 5%, which indicates that the quadrat sample data are sufficient to give a general description of the community, but should be supplemented with further data if management or interpretational plans require precise information for these types.

Because most of the community sampling was carried out during the late fall (1976) and early spring (1977), no data were collected on herbaceous cover.

Analysis of data followed the methods outlined in Mueller-Dombois and Ellenberg (1974). Density, frequency, basal area, and relative values are given for the quadrat samples. Importance Value (the sum of the relative values) has been scaled to a range of 1 - 100 for all communities, so that the communities may be compared with each other. In the tables which follow, D = density, R.D. = relative density, F = frequency, R.F. = relative frequency, DO = dominance, R.DO. = relative dominance, I.V. = importance value. In discussing the data, the land-use history of the area has been taken into account, and an attempt has been made to relate the characteristics of the community to the history of disturbance.

Tables 6-1 and 6-2 summarize the characteristics of the vegetation and the Importance Values of the tree species in each community type, respectively.

6.2 Mixed Oak - Yellow Poplar Community

6.2.1 Stand Composition

The sampled stand was located on the northeast-facing slope of Fort Hill; it extends from the base of the hill near Primrose Brook nearly to the summit of the hill, and extends down the eastern slope to the trail (Map #3). The area sampled (Fig. 6-1) is at an average elevation of 144 m and covers an 11° slope. The soil is an Edneyville gravelly loam; it is deep and well-drained, contains granitic gneiss, stones and cobbles, and permits root growth throughout the soil profile; it is among the most fertile soils in the Park (Eby, 1976).

The mixed oak - yellow poplar forests are among the most beautiful at Jockey Hollow. The canopy is 22 - 27m high, with the tall yellow poplar crowns rising above the oaks and other hardwoods. The canopy and sub-canopy layers are moderately dense and are multi-layered. The

lower strata also are varied in size and composition, so that the forest does not have the conspicuous levels that typify the stands with dense Cornus growth (e.g., the chestnut oak stand) or dense Lindera growth (e.g., the successional yellow poplar stands; see below). There is a moderately well-developed herbaceous layer, which varies in composition with the changes in microtopography in the stand.

Table 6-3 shows the composition of the tree canopy in the stand. The Importance Value for all species of oaks together is 21.5, thus making them second in importance to yellow poplar in the stand. The four species of oak present are approximately equally important. Yellow poplar is clearly the dominant tree species in the stand; it contributes the largest share of the density and the basal area, and its high frequency indicates that it is widely dispersed throughout the stand. The oaks owe their high I.V. to their size (high total relative dominance - 25.74), rather than their numbers (low total relative density - 18.11). Beech and black birch are clearly the important associate species; black birch rivals the oaks in importance, but largely because of the greater number of smaller trees. Red maple, a dominant or associate species in many other kinds of communities, is here a minor component of the vegetation.

Table 6-4 shows the composition of the understory vegetation. It differs from the canopy in several important ways. First, oaks are absent from the understory, and yellow poplar is of secondary importance compared to such species as beech, black birch, and red maple. Thus, it would seem that in the absence of disturbance, the character of this stand will change. Second, several other species, notably sugar maple, blackgum, and white ash, are considerably more important in the advance regeneration than in the canopy. Dogwood is less prominent than it appeared in the chestnut oak stand, and although it has the greatest relative density of any species, it contributes a minor fraction of the basal area.

Figure 6-2 shows the size distribution for the dominant and associate species of this stand. The distributions of oaks and yellow poplar are approximately uniform, with only a slight peak among the oaks in the 13" - 17" classes. These distributions suggest that the populations of these species contain several age classes, but none originating in the last 10 - 20 years (see below). Beech, on the other hand, shows a size-class distribution typical of a species that is maintaining itself; that is, the smaller size-classes are more abundant than the large classes. The two associate species, however, have size-class distributions suggestive of increasing importance of the species in the future.

Table 6-5 shows the density of seedlings in the stand. Dogwood shoots dominate this component of the community; however, seedlings of all the dominant and associate species were found in moderate numbers. Although dogwood density is as high here as in the chestnut stand, the data indicate that a richer understory layer, containing Vaccinium, Hamamelis, Viburnum acerifolium, Carpinus, and Lindera, is characteristic of this community, and is perpetuating itself.

Dead trees comprised $2.0 \text{ m}^2/\text{ha}$ in the stand; this represents 7.9% of the total basal area of living trees per hectare. Of the dead trees, oaks represented 72% of the total basal area. Ash, black birch, yellow

birch, and aspen accounted for the rest of the observed mortality. As in the chestnut oak stand, the high proportion of oaks among the standing dead trees is probably attributable to the gypsy moth infestation.

The dominant shrub is Viburnum acerifolium; it was found continuously along the line transects, and on average formed 25-50% cover of the line. Hamamelis virginiana, Lindera benzoin, Viburnum prunifolium, and Vaccinium vacillans were more sparsely present, contribution up to 25% cover over about one-fifth of the area of the stand.

Vine cover is low; Vitis was found at only three of the forty sample points. In view of the absence of vine reproduction, and the closed nature of the canopy of the stand it is unlikely that vines will have any impact on this community.

6.2.2 Stand History and Successional Trends

The mixed oak - yellow poplar forest that rings the northern and eastern slopes of Fort Hill is a mature forest which dates back at least 150 years and possibly earlier. Several lines of evidence point to this conclusion. First, one of the oaks cored in the growth rate study (see Chapter 7) was 142 years old; several other oaks, beeches and yellow poplars measured in that sample are of sufficient diameter to be between 110 and 130 years old. Secondly, observations made by Pitney (1930), Vermeuil and Stock (1900), and Tuttle (1971) indicated that the area was forested in the 1890's. Third, the vegetation map prepared in 1937 indicated that the hillside supported an all-aged oak - white oak - yellow poplar forest. Fourth, photographs of the Connecticut Brigade site taken in 1905 (Sherman, 1905) and in 1859 (Hoskins, pers. comm.) show oak-dominated forest growing on the site. In view of the proximity of the Connecticut line, Hand's Brigade, and Second Maryland Brigade (Rutsch and Peters, 1976), and the fortifications placed on the top of the hill, it is likely that Fort Hill was completely cleared during the Revolutionary encampments. The mature character of the woods indicates however, that the land was allowed to revert to forest after the troops left; assuming that about 50 years would elapse during which the old-field, shrub and young forest stages of succession would occur (Bard, 1952), the mature forest should be about 150 years old, which seems to be the case.

The boundary trees recorded for this site (Land-Use History Map) support these conclusions. Oaks and yellow poplars were recorded through 1840, indicating both that the area was forested at the time, and that the forest that returned after the encampments was like that found there now.

This stand has suffered little disturbance. Aside from the roads and trails indicated on the 1933 topographic map, no network of paths and logging roads was found comparable to those on Mt. Kemble (see below). Occasional cut tree stumps can be found, however, which indicate that both blight-struck chestnuts and some oaks were removed from time to time. The density of these stumps is far lower than that found on, for

example, the western lower slopes of the Tea Hill and Mt. Kemble. The paucity of chestnut stumps also implies that this species was not a dominant species in the pre-blight forest. Therefore, the chestnut blight probably had a smaller impact on this community than it did on the chestnut oak community. The gypsy moth infestation of 1967-69 also had minimal effects on the forest; although dead oaks are present and indeed account for much of the observed tree mortality, the large majority of them occur as isolated trees surrounding intact canopy trees. In other words, the canopy was not significantly opened up through the death of numerous contiguous tree crowns.

Thus, the sampled stand evidently represents the mature forest type which develops on the mesic sites in the Park. A comparison of the distribution of the community type with the topography of the sites and their soils indicates that this community occurs on both Edneyville and Parker-Edneyville soils and occurs on all slope exposures, but is primarily found on the lower slopes of the hills, especially on slopes of low or moderate grade, and around stream channels or in ravines, and where the soil is not excessively stony. Yellow poplar, the dominant species distinguishing this community from the other oak communities, is floristically associated with southern forests (Braun 1950; Frei and Fairbrothers, 1963; Eyre, 1954; Lull, 1968), and in northern areas is characteristically found on the more mesic sites. Day and Monk (1974) found that its abundance in Tennessee was correlated with distance from the stream channel, and they cited other studies that also suggested that yellow poplar is most abundant on moist sites. Good (1968) found that in a similar part of New Jersey, yellow poplar attained significance only in the community of the lower northwest slope of the study site.

Although this community type accounts for a substantial fraction of the oak forest in the Park, it has been rarely described in other parts of northern New Jersey. Studies by Buell et al. (1966), Niering (1953), McDonough and Buell (1956), and Forman and Elfstrom (1975) mention yellow poplar as, at most, a minor constituent of New Jersey upland forests. Indeed, the mixed oak - yellow poplar forests in the vicinity of the Park are sufficiently noteworthy as a northern representative of a typically southern Appalachian forest type that they receive mention in several definitive descriptions of eastern deciduous forest (Lull, 1968; Robichaud and Buell, 1973).

As indicated above, the successional trend in the sampled stand is toward a decrease in the present dominants, oaks and yellow poplar, and an increase in beech, black birch, red maple, and, to a lesser extent, sugar maple and yellow birch. Yellow poplar is generally considered an intolerant species, and would not be expected to maintain itself as a dominant in competition with more tolerant species. Although the oaks range from moderately tolerant to intolerant, and might be expected to reproduce in these stands, little oak reproduction was noted. Several factors may account for this condition: 1) The data on understory composition show a clear increase in importance of mesic, tolerant species (beech, sugar maple, etc.); this trend may indicate that the site is inherently more moist than is suitable for most oak forests. Indeed, several hemlocks (Tsuga canadensis), a species whose presence indicates good, moist, conditions, are growing along the branches of Primrose Brook draining the

eastern face of Fort Hill. 2) Oaks have been found to reproduce best under xeric, open conditions (Raup, 1937; Carvell and Tryon, 1961; Minckler et al., 1961). 3) Deer browsing, evident on Cornus and Viburnum sprouts, may damage those oak seedlings which do begin growth. 4) Reproduction in oak forests often appears to be episodic: seedlings and saplings of canopy species only become abundant following a natural catastrophe such as a major windstorm (Stout, per. comm.), and therefore an increase in oak and yellow poplar might well result from a major storm.

In summary, the mixed oak - yellow poplar community is apparently slowly changing in composition and approaching a variant of the typical cove community, but could be maintained in its present state by occasional opening of the stand by natural catastrophes.

6.3 Mixed Oak - Beech Community

6.3.1 Stand Composition

The stand selected for study is located on the northwest-facing slope of Tea Hill, above the Primrose Brook drainage area, and near the concrete huts left by the Morristown Aqueduct Company (Fig. 6-1). The hill slopes at an angle of about 12° , and averages 135 m in elevation. The soil is Parker-Edneyville extremely stony sandy loam, which is excessively drained and has a low water capacity, and has a large content of stones, cobbles and boulders. The stand extends as a belt along the lower portion of the western face of the hill, sandwiched between the Stream Thicket community and the Mixed Oak - Black Birch community.

The stand presents an aspect considerably different from the other oak communities. The dense crowns of the dominant beeches form a thick multilayered canopy, within which the more open oak crowns are scattered only in the top layers. The understory is weakly developed (see below), as is the shrub layer. The most conspicuous elements in the understory are the sprout clumps of beech which surround each mature tree. The forest floor is nearly bare, with a poorly developed litter layer and few herbs (Fig. 6-4A).

Table 6-6 shows the canopy composition of the stand. Beech is the dominating element in the stand; indeed, the canopy has fewer species than the other kinds of oak-associated forests. Together, beech and the oaks comprise 93% of the canopy trees and over 95% of the basal area.

The understory (Table 6-7) is more diverse because of both the presence of understory species (dogwood, witchhazel, serviceberry) and a larger number of canopy species (yellow birch, yellow poplar and red oak, in addition to the species present in the overstory) in the pole-size stem classes. Beech sprouts account for about half the understory growth, both in density and basal area. Red maple and yellow birch are the second most important group of understory plants. Understory species are minor contributors to the structure of the stand, in comparison to their role in, for example, the Chestnut Oak community, or the Mixed Hardwood community.

Figure 6-3 shows the size distributions of the major species. Beech, red maple and black birch all show an approximately inverse J-shaped curves, indicative of their persistence in the future at relative densities comparable to the present. Both white oak and chestnut oak appear to be even-aged populations that are fated to disappear from the community (unless conditions conducive to their reproduction become reestablished).

Table 6-5 shows the seedlings found in the square-meter samples. Beech, black birch, red maple and red oak are all reproducing; however the red maple seedling population is low, and may indicate that the importance of red maple may be at its peak at present, and is likely to decline in the future. The data in Table 6-5 for red oak may be misleading; all the observed seedlings were located within one quadrat, and the paucity of oak reproduction elsewhere in the stand was striking. It seems unlikely that the high density found in the one quadrat indicates continuing successful replacement of oak in the community.

Shrub cover by maple leaf viburnum and blueberry was about 25%. Sparser cover was also provided by witch-hazel. Four dead trees were observed in the 0.2 acre sample (giving a density of 49 trees/ha); of these dead trees, three were oaks.

6.3.2 Stand History and Successional Trends

The composition of this stand, and the restriction of this community type to the steep lower slope bordering the Primrose Brook, indicate that it is a variant of the Northern Hardwoods forest (Eyre, 1954; Niering, 1953; Ohmann and Buell, 1968), also referred to as a segregate of the Mixed Mesophytic Association (Braun, 1950). The high importance of red maple and black birch in the understory may reflect the disturbance associated with logging, insofar as these two species commonly increase in density after partial opening of the canopy from disturbance (Ohmann and Buell, 1968). Braun (1950) describes similar stands in which beech and white oak together account for about 70% of the trees, and the associate species include sugar maple, yellow poplar, red oak, red maple, yellow birch, and others. In another variant of this type, beech contributes 50-70% of the trees, and the oaks are mixed with sugar maple, yellow poplar, chestnut, hickories, and others in the associate class. Niering (1953), Keever (1973), Buell et al. (1966) and Ohmann and Buell (1968) describe related communities in New Jersey and nearby Pennsylvania. The stand in Jockey Hollow departs from these related communities in part through the presence of chestnut oak and black oak in the canopy, and in part through the low abundance of sugar maple, yellow birch, and hemlock, which are typical species of the Northern Hardwoods or cove communities. The latter two species are more commonly found in other patches in the area mapped as Mixed Oak - Beech; scattered individuals of hemlock can be found on the lower slopes of Forest Hill, and sugar maple is locally abundant on both sides of Primrose Brook. The distribution of sugar maples follows a striking pattern: individuals of all size classes can be found in the vicinity of large, mature trees, but the species is rare or absent in areas lacking mature specimens. This observation strongly suggests that the low density of sugar maple in the Park is attributable to the absence of a sufficient seed source at the time that forest was regenerating after logging. Sugar maple can be found in abundance, for example, in the region

at the foot of Tea Hill, between the Old Camp Road and Primrose Brook; several very large sugar maples are growing near the road here, clearly remnants of former plantings or left over from early cuttings. Sugar maple has also invaded the successional forest stands near the New York Brigade parking area; several mature trees at the National Park Service residence on Jockey Hollow Road have evidently provided seed. Again, sugar maple is abundant on the north-facing slope below the former Stroley house, and is associated with a very large tree standing near the site of the reputed bake oven. Thus, it is likely that this species will continue to spread through suitable parts of the forest, in particular, the Mixed Oak - Beech stands, as young trees mature and increase the seed supply in adjoining areas.

This projected increase in the abundance of sugar maple underlies the classification of the Mixed Oak - Beech community as a variant of the cove community type described by other authors. The absence of chestnut oak and black oak reproduction, together with the ingrowth of yellow birch and yellow poplar noted above, the nearby presence of hemlock in other segments of the community, and the evident increase in sugar maple elsewhere in the community, all argue for an increasing affinity of this community for the typical mesic associations of the cove community, and a decreasing similarity to the more xeric or early successional community indicated by the presence of chestnut and black oak. (The presence of these trees in the sample may also indicate a broad ecotone between the Mixed Oak - Black Birch community of mid-slope, that borders the sample area; see Map #3.)

The openness of the shrub and ground layers of vegetation noted above is similar to that observed in other beech-dominated communities. Niering (1953) noted that shrubs covered about 14% of the ground, and that herbaceous species were very sparse. Braun (195) related the low density of herbaceous plants to the slow rate of decomposition of beech leaf litter. The poor development of these layers probably reflects both the dense shade cast by the dominant beeches, and the intense root competition from the beech sprouts.

Review of the available land-use history data (Chapter 8) shows that the areas mapped as Mixed Oak - Beech were not part of the system of fields present at the turn of the century, and have probably been continuously wooded since the area was settled. The stoniness of the soil at the base of Tea Hill, the presence of sprout clumps, and the pit-and-mound microtopography all suggests that this area has never been ploughed, and the steepness of the hill at the base of Fort Hill also suggests that ploughing was not attempted here. The size of some of the beech trees found in this community indicate that they are all over 100 years old; because beech does not colonize old fields, it can be presumed that these areas were forested 100 years ago, thus permitting beech to establish itself in the abundance seen today. Logging has clearly been a continuing source of disturbance; old trails are clearly visible (and some are shown on the 1933 topographic map), and so are logging paths used for hauling timber out of the stands. Stumps of chestnut and oak are sprinkled throughout, and many of the mature beeches and oaks are sprout clumps, indicative of their origin from cut trees.

In the absence of information concerning the actual land cleared by the Revolutionary soldiers and in the absence of old-growth trees, it may be postulated that much of this community was cut for firewood by the troops of the nearby Connecticut and Hand's Brigades. The history outlined above leads to the conclusion that the forest was allowed to regenerate following the Revolution, and has permitted a modified succession to occur, so that the tolerant species typical of the climax cove-type forest are now becoming prominent, as the oaks, representative of the drier, more open character of a young stand, are decreasing in importance. However, the continual disturbance of the canopy, as trees were removed, has fostered a density of red maple and black birch that is atypical for this kind of forest. A study of seedling growth in another part of the New Jersey Highlands (Good and Good, 1972), showed that black birch seedlings, although more long-lived, have very slow rates of growth. It therefore seems probable that in the absence of disturbance, the aggressively increasing sugar maple will join beech, yellow birch, and other mesic canopy species, and will reduce black birch and red maple to subordinate positions in the stand.

6.4 Mixed Hardwoods

6.4.1 Stand Composition

The stand selected for study is in the area between the Aqueduct Trail and Grand Parade Road (Fig. 6-1). This area is the largest single stand mapped as Mixed Hardwoods, and it shows few signs of disturbance comparable to those seen in some of the other Mixed Hardwood stands (see Appendix 2 and below). It is situated on Edneyville soil, on nearly level land around the upper reaches of the Primrose Brook, and on low slopes on the eastern side of the stand. The two quadrat samples were placed so as to record the species composition on both the hillside (9° slope facing west, 165m elevation), and in the level upper portion of the stand (159m elevation) (see Fig. 6-1). Although this placement of samples was likely to yield heterogeneous results, the variation between quadrats would give a more representative picture of the variability in stand composition noted during the line transect work and therefore was chosen in preference to the placement of the quadrats in narrow subtypes of the community.

More than any other community type of the Park, the Mixed Hardwood type presents a multi-layered, complex appearance. The shrub layer, the understory and the canopy all consist of a variety of species, each present in a variety of age-classes, so that the foliage is not separated into distinct strata, as in the Chestnut Oak or the Yellow Poplar types, but occupies most of the space between the forest floor and the top of the canopy. In both the overstory and the understory layers, no tree or small group of tree species is dominant, as is seen in the other mature forest communities. Indeed, the richness in species is directly responsible for the complex distribution of layers of vegetation (Fig. 6-4B).

Table 6-8 shows the composition of the overstory. Black birch and beech contribute most heavily to both the density and basal area of the stand. The oaks (white and chestnut) are represented by relatively few but large specimens. The associate species - red maple, hickory, yellow birch and yellow poplar - are about equal in importance in the stand. It

should be noted that although black birch and beech appear to dominate this particular stand, this species group in no way dominates the entirety of the mapped community type; the dominating species vary over short distances, so that no clear dominant emerges for the stand as a whole. Indeed, the hillside quadrat of this sample contained most of the black birch and oaks, and the bottomland sample contained most of the beech, red maple and yellow poplar.

Table 6-9 shows the composition of the understory. This stratum is impressive both for its species richness and for its total density of stems: it is rivalled only by the Stream Thicket community for numbers of species, and it exceeds all other communities sampled for its stem density. As in the overstory, the importance values are spread out over many species, so that no clear dominant emerges. Hardwood reproduction is equal in Importance Value to growth of understory species, a feature which also distinguishes this community from most of the other mature forest communities. Red maple, beech, and black birch are apparently maintaining themselves in importance in the community, whereas the oaks and hickories are much less important in the understory than in the overstory. The community also shows a trend toward increased species diversity, as is evident from the presence of several canopy-member species as saplings and young trees (sassafras, white ash, red oak, and blackgum fall into this class).

Figure 6-5 amplifies these conclusions. Beech, black birch, red maple, yellow poplar and yellow birch all show approximate J-shaped curves, indicating that they are self-reproducing populations. The beech and black birch both show a dip in the 3" to 5" size-class; the yellow poplar curve dips in the 5" to 7" class. Considering the rapid growth rate of yellow-poplar (Fowells, 1965), these dips most probably represent a uniform response to a period of adverse conditions for seedling establishment. The available information is insufficient to indicate what event is reflected here; however, it is evident that reproduction has resumed since that time. As was evident in the tabular data, the chestnut and white oaks constitute relict populations that are not replacing themselves.

Table 6-5 shows the observed seedlings in the stand. The total density of tree and shrub reproduction is greater than that of any other community. The presence of red oak, white ash, beech, and red maple seedlings support the stand analysis above, insofar as they indicate stable populations of beech and red maple, and increasing populations of red oak and white ash. The absence of seedlings of black birch, yellow birch and other canopy and understory species growing in the stand may indicate a recent decrease in recruitment of these species, or may simply reflect the small size of the sampled areas.

Shrub cover averaged 25% to 50% of the ground area. The cover consisted of a mixture of species in which mapleleaf viburnum and spicebush were dominant, and witchhazel, high-bush blueberry, and blackhaw viburnum were secondary. The ground layer community was well developed, consisting of a variety of flowering plants and ferns.

Eight dead standing trees were observed in the sample, (yielding an estimate of 98 dead trees/ha), and included dogwood, (15%), white oak (15%), black birch (42%) red maple (28%), and witchhazel (14%). The relative densities of the species suggest that natural mortality factors are more important than moth-caused mortality in accounting for tree mortality. However, gypsy moth-caused mortality is significant in patches in both this stand and many of the other mapped Mixed Hardwoods stand. Within these patches the absence of a dominating species of tree in the over-story results from this mortality, for the observed dead oak trees clearly contributed both high densities and high basal areas prior to their demise.

6.4.2 Stand History and Successional Trends

The trees in this stand are notably smaller in diameter than those of the other mature forest communities sampled (see, for example, the Mixed Oak - Yellow Poplar stand). This may reflect the fact that the growth of hardwoods is known to be better on well-drained slopes (such as that on which the sampled Mixed Oak - Yellow Poplar community was situated) than on either upper ridges or flat bottomlands (Zeide, pers. comm.). It could also indicate that this stand is younger than those on the east site of Fort Hill or on Tea Hill. The suitability and quality of the soil for agriculture (Eby, 1976), and the presence of farmers on the land throughout the 1800's (Rutsch and Peters, 1976), lend support to the notion that this area was cultivated for some time after the Revolutionary War. Vermeule (1900) states that in c. 1850 more land in New Jersey was cleared for agriculture than at any other time, and that much of this land was abandoned shortly afterwards. It thus seems possible that the land around the West Branch of the Primrose Brook was part of these trends. However, the presence of sprout clumps among the larger trees now growing requires the presence of a native forest of approximately the same species composition as now to have been growing on the site about sixty years ago. This places the upper limit at about 1850 for the time at which reversion to woods occurred.

Like most of the Park, this area was logged prior to the establishment of the Park. Cut stumps of oaks and chestnut and frequent sprout clumps of red maple attest to the activity of the loggers. Sprouts of American chestnut are common throughout the stand, which implies that the forest had attained mature status well before the advent of the blight in 1909. The 1937 Vegetation Map shows this area as being a "Yellow-poplar - Red Oak - White Oak" stand of 60-80 years of age; if correct, this age would support the suggestion above that the area reverted to forest in the mid-1800's.

The patterns of tree reproduction and mortality suggest that this community is nearing a stable composition ("climax" composition), and that this community will contain a mixture of mesic species, notably beech, yellow birch, red maple, white ash, red oak, yellow poplar, and several others. It thus appears to be approaching a cover type forest similar to that predicted for the Mixed Oak - Beech community. In the latter type, the cove forest is evolving through a loss of oak species, and a relative decrease in the representation of beech coupled with an increase in the importance of other mesic species. In the Mixed Hardwoods

community, the present species composition is closer to the cove type, and the continued loss of the more xeric species of oaks (here, white and chestnut), coupled with the maturation of the diverse understory, will serve to produce the cover type. The closeness of the present-day forest to the projected "climax" is reflected in the similarity of the understory transgressives to the overstory trees. Finally, similar communities are described in the literature, occupying sites analogous to the sampled stand, which are considered to represent variants of a climax state. In these literature examples (Niering, 1953; Braun, 1950; Raup, 1938; Ohmann and Buell, 1968; Good, 1968), the communities occupy the lower portions of slopes or the sloping valleys near stream basins; they contain a complex set of species comparable to that of this stand, and no one species or set of species is apparent as a dominating element.

The Mixed Hardwood stands on the summit of Sugar Loaf Mountain, on the east-facing slope of Tea Hill, and the east-facing slope of Mt. Kemble are somewhat different in composition, and deserve some explanatory comment. All three stands lack a clearly dominating group of species; hence their inclusion in this community type. The stand on Sugar Loaf contains a mixture of red oak, hickories, black birch, and ash, and has an aspect more similar to those of the successional communities which surround it than of the other mature hardwood forests. Dense herbaceous vegetation, abundant vine growth, and patches of brambles are common beneath the mature oaks and hickories, which is an unusual combination of characteristics. It seems most likely that the cattle which were maintained on the surrounding fields prior to the establishment of the Park (Weig, 1977) were permitted to graze in the woodland, and the removal of the grazing pressure has permitted a young successional community to arise in the interstices of the mature oak woodland. The stands on Tea Hill and Mt. Kemble also present an aspect of intermingled mature oak-dominated forest with young successional forest (young ash, black locust, and other successional species, vines, brambles and tall herbaceous vegetation). There is no evidence available to determine whether grazing, or more intensive logging, or both, were responsible for these stands.

6.5 Stream Thicket Community

6.5.1 Stand Composition

This community type is distributed in patches along Primrose Brook and its main tributaries. Its distribution coincides closely with the distribution of Cokesbury soils which are extremely stony, poorly drained, and have a fragipan at a depth of 20-30". The soil surface has standing water during much of the spring and early summer, and is mucky through much of the rest of the year. The stream channels and surrounding thicket communities are on land with a low slope, ranging from 0-8°; the samples community (Fig. 6-1) was on a broad area of 1° slope at 120 m elevation adjoining the main channel of Primrose Brook.

The community presents a unique aspect among the vegetation types in the Park. The canopy is low and open, and may be lacking entirely, and what canopy-member trees are present are generally small. The shrub layer, however, is very densely developed: a rich mixture of species,

growing in high density, form a thicket over the ground. The ground layer also contains a luxuriant community in which ferns and skunk cabbage predominate. Where the soil is less saturated, a rich community of tall trees covers the shrub layer. The true thicket community thus reflects small variations in soil properties, and the canopied and canopy-less regions intermingle to some extent. Thus, the area mapped as Stream Thicket community actually contains a patchwork of canopy-less, partly-canopied and fully-canopied communities, all possessing a thick shrub layer and ground vegetation (Fig. 6-6A).

The quadrats established for sampling this community necessarily included both canopied and canopy-less segments. Although the sample area was thus heterogeneous, the sample reflects the average composition of the mapped community. Quadrat I was placed on a slightly drier site bordering the brook, where the soil was not water-logged; Quadrat II was placed on a wetter site, where the soil was mucky and skunk cabbage covered the ground. In the description which follows, the composition of the two quadrats will be contrasted where differences between them reflect the segments composing the vegetation type.

Table 6-10 shows the composition of the canopy in the sampled stand (both 0.04 ha quadrats). The dominants, beech, red maple and yellow birch, are typical of moist to wet sites. The relative basal area of each species is proportional to the relative density, which indicates that no species dominates through unusually large size or high density. The presence of several of the species differed between the two quadrats, however. Beech was virtually restricted to Quadrat I (88% of beech stems over 8" DBH), whereas all the yellow birch trees occurred in Quadrat II. This difference reflects the tolerance of yellow birch seedlings to temporary flooding, and the intolerance to flooding to beech (Fowells, 1965).

Table 6-11 shows the composition of the understory layer in the stand. Total density approaches only that of the Mixed Hardwood community, and species richness exceeds that of any other sampled community (Table 6-1). All species in the canopy with the exception of white oak are reproducing, and several new species may be expected to enter the canopy; these include sugar maple, red oak, hickory, sassafras, and blackgum. However, sugar maple, sassafras, yellow poplar, black birch, and hickory do not generally grow well in wet sites, but rather need moist, well-drained sites. Therefore, it is likely that these species will never become major elements in the canopy.

The distribution of the canopy-member tree species in the understory differed between the two quadrats. In Quadrat I, 86% of the beech reproduction, 69% of the yellow birch reproduction and 68% of the red maple reproduction were found, together with all the observed reproduction of the more typically upland species (black birch, red oak, hickory). Quadrat II contained all of the white ash reproduction, and representatives of the other species. Quadrat II however contained 80% of the stems of shrub and understory tree species.

Figure 6-7 shows the size-class distribution of the dominant and associate species. The three dominant species show the same kind of distribution, in which the abundance of trees in the intermediate size-

classes are lower than would be expected for a stable, self-reproducing population. The presence of moderate densities in the large size classes for all three species coupled with the very high densities of the lowest size classes, suggests that either mortality of saplings is unusually severe in the community, or reproduction was interrupted for unknown reasons some time within the last few decades. The trees that survive, however, are evidently capable of attaining large size in the drier segments of the community. Indeed, one of the largest beech trees seen in the Park, a specimen 74 cm DBH, was included in Quadrat I.

Table 6-5 gives a seedling data collected for this stand. As expected, red maple and beech have produced abundant seedlings. The absence of yellow birch seedlings is notable; it may be due to the absence of the quadrats of the kind of disturbed areas which are crucial to the survival of yellow birch seedlings (Fowells, 1965): rotten logs or windthrow mounds that bring up soil over the litter. It is likely that yellow birch seedlings are present in other patches of this community where these conditions are found. It is also likely that the fall of the dead oaks that are prevalent along the streams (see Chapter 2; Fig. 2-2) will provide abundant habitat for yellow birch. Interestingly, the data in Table 6-5 indicate that oak reproduction is better developed here than in some of the oak-dominated stands. More extensive sampling would be required to determine if these data were anomalous.

Shrub cover ranged from 50-75% in Quadrat I to 100% in Quadrat II. As is evident from Table 6-11, the shrub layer included many species, ranging from tall species like witchhazel to small azaleas and blueberries. Maple-leaf viburnum contributed a lower level to the shrub stratum in the drier portions of the quadrats. Reproduction of all shrub species was abundant.

Dead trees were observed at a density of 99 tree/ha. They included sassafras, ash, white oak, black birch, and two unidentifiable trees. The dead tree species were equally abundant.

6.2.2 Stand History and Successional Trends

This stand lies at the bottom of Tea Hill and Fort Hill, and within the land managed by the Morristown Aqueduct Company. In the chapter sections on the samples of the Mixed Oak - Beech community (on Tea Hill) and the Mixed Oak - Yellow Poplar community (on Fort Hill), evidence was presented suggesting that both of these hillsides have been forested since the early to mid-1800's, and have been disturbed since then only by selective logging. The Vermeule and Stock map of 1900 shows this portion of Primrose Brook in forest at that time. Because of the narrowness of much of the lower stream valley, and the extreme stoniness of the soils both in the valley and on the adjoining steep slopes, it seems unlikely that this area was ever cleared for agriculture; the broader portions of the Primrose Brook valley downstream, however, probably were cleared for fields and pastures. Although the Morristown Aqueduct Company laid pipes through the area to carry the spring water to Morristown, there is no evidence of either extensive clearing of the land, nor of major changes in the vegetation associated with the disruption in water supply. As illustrated above, large specimens of wet site trees,

particularly red maple, ash and yellow birch, are common, as are large specimens of trees characteristic of moist areas, such as beech. The average diameter increment calculated for beech (see Chapter 7) can be used to give a rough indication of the age of these trees; they range from 100-130 years. Although the relation between age and tree diameter is notoriously inconstant between species, it is most probable that the ash, yellow birch, and red maples that are in the 17" to 19" size-class are also at least 100 years old.

The close correspondence between canopy-member tree reproduction and the canopy composition suggests that the present-day community is approaching a stable composition. The only trends that are evident are (1) an increase in species richness, as sugar maple, red oak, ash, and blackgum reach the canopy, and (2) a possible replacement of white oak by red oak. The presence of the canopy-less patches probably reflects patches of particularly prolonged seasonal flooding, which would prohibit the growth of most tree seedlings (Zeide, pers. comm.). This interpretation in turn suggests that the pattern of canopied and canopy-less patches is likely to remain a prominent feature of the community type.

6.6 Successional Communities

Because of the diversity and extent of successional forests, one stand was sampled intensively (point-quarter method described above), and thirteen additional stands were sampled using a basal area prism.

6.2.1 Stand Composition: Intensive Sample

The stand selected for intensive sampling was the type mapped as "white ash-yellow poplar"; however, it contained most of the species representative of the other successional stands in the Park. It was located on the south-eastern face of Sugar Loaf Hill, which averages 9° slope angle, and covers an altitudinal range from 165 to 200 m. Most of the stand is located on Edneyville gravelly loam soils, which are, as noted above, among the best in the Park; a small portion of the stand is located on Cokesbury soil, which is poorly drained, stony, and contains an impermeable layer near the surface which restricts root growth of trees.

The successional forests of the Park are those which reclaimed the fields and orchards abandoned between the beginning of the century and the inception of the Park, or, in parts of the Jenks property section added in 1964, abandoned in the 1950's. Thus, they range from about sixty to about twenty years of age. They are quite varied in their composition, ranging from mixtures of four or five co-dominant species to nearly pure stands of single species. Despite the variation in species composition of the overstory, the stands are quite similar in appearance (Fig. 6A). The canopy trees are small in diameter and height and form an open canopy. A dense shrub or herb layer is present: spicebush completely covers the ground on moist sites, blackhaw viburnum and dogwood dominate the understory on drier sites, and the perennial herb Eupatorium rugosum (white snakeroot) forms dense stands where shrubs are absent. The canopy of many of these stands is covered with a growth of vines (grape, American bitter-sweet, poison ivy, catbrier, and Virginia-creeper are the common species): these vines are often sufficiently dense to completely mask the trees.

The presence of these vines is marked by areas in which fallen or broken trees have created large openings in the canopy 20-30 m wide; the debris and shrubs on the forest floor in these openings themselves have become covered with vines, and forming an impenetrable mass of vegetation. Brambles often are found in these openings, and sometimes extend past the openings beneath the surrounding open canopy. Many of the successional stands contain "wolf trees," large open-grown trees that had been allowed to grow up in the pasture or along the hedgerow while the field was in use.

Table 6-12 shows the canopy-member trees in the stand. Ash and yellow poplar strongly dominate the stand, and both attain this dominance through a combination of numerous and large stems. Sassafras and black locust are subordinate, and the remaining species contribute minor amounts to the density and total basal area of the stands. The dominant species tended to occur in small single-species patches such that only one species of tree would be recorded at several consecutive points on a transect. This pattern was typical of many of the successional stands observed in the Park; in few of the stands mapped as "mixed successional communities" are the various species spatially well mixed.

Table 6-13 shows the composition of the understory vegetation. Ash dominates this stratum, and dogwood ranks second in importance. The comparison of relative density and relative dominance shows that the dogwood population consists of numerous small stems, whereas the ash population contains a greater proportion of large stems. Understory species (dogwood, blackhaw viburnum) represent over one-third of all the stems. All species observed in the canopy were found in the understory, and except for yellow poplar, were similar in importance in the two strata. The presence of fruit trees on the northern transects of the sample (Fig. 6-1) identifies this area as a former orchard.

The age structures of the dominant and associate species are shown in Fig. 6-8. Ash is clearly maintaining itself, as is evident from the inverse J-shaped curve; however, the low density of young reproduction suggests that a decline in the amount of ash may be starting. Irrespective of whether the dip in the curve implies a temporary inhibition of reproduction or a long-term decline in the dominance of this species, there is little doubt that ash will remain the most important species in this stand for several decades. The size-class of yellow poplar are more evenly distributed and form two plateaus of stem density. Part of the population consists of old hedgerow individuals comprising the lower plateau of large individuals found at low density. The higher plateau consists of individuals of 22-42 cm DBH, which are growing at a higher uniform density. Using the average annual increment calculated from increment cores (See Chapter 7), these trees range in age from about 75 years; these ages correspond closely to the time since the land was last maintained as pasture and cropland. The 1933 Vegetation Map recorded this area as supporting a growth of young hardwoods; a constant rate of tree establishment from the time of abandonment until the closure of the canopy would account for the observed plateau. The graph shows that yellow poplar is continuing to regenerate, albeit at a rate too low to maintain the population at constant size. The size-class

distribution of the associate species, black locust, suggests that it has been unsuccessful in competing with the other species present. The small size of the stems indicates that the population consists of overtopped, suppressed individuals which are likely to be soon eliminated from the closed stand (Fowells, 1965). Sassafras has an age distribution similar to that of white ash, which suggests that it, too, is maintaining itself and is likely to retain its current importance value in the future.

Table 6-5 shows the seedling reproduction in the stand. These data suggest the same trends in forest development associated with the understory composition. Understory species are regenerating rapidly, and the overstory-species reproduction belongs to those species currently comprising the canopy.

Dead trees contributed an average of $2.15 \text{ m}^2/\text{ha}$ basal area; of this mortality, dead sassafras stems accounted for 26% of the total, ash accounted for 13%, and the remaining basal area consisted of black locust, black cherry, dogwood, blackhaw viburnum, apple, and unidentifiable stems. The basal area of standing dead trees is 11% of the total living basal area of the stand. The relatively high mortality of sassafras may be attributable to 1) its poor growth on the wet Cokesbury soil within the sample area, and 2) its rapid mortality following overtopping by other canopy species (Fowells, 1965).

Shrub and vine cover is generally dense throughout the stand. Spicebush is a major shrub species; it covered an average of 50% of the ground. Blackhaw viburnum and grape vine both averaged between 25% and 50% coverage of the ground. Other species present included blackberry, elderberry, rose, bayberry, privet, poison ivy, bittersweet, honeysuckle, and Euonymus; although each of these species covered less than 25% of the ground on average, each was patchily distributed, and where present often covered in excess of 75% of the ground. The shrub layer in this community is notable not only for its density, but also for the importance of exotic species in its composition. No other sampled stand contained such a large number or peak density of exotic plants.

Another important aspect of the community structure apparent in these data is the role of vines. As with the shrubs, local coverage of vines was more frequently 100% than lesser amounts. Completely vinecovered areas presented an impenetrable mass of vegetation, and were often associated with high mortality of trees and total absence of a canopy layer. This kind of dense vine growth is typical of the successional stands throughout the Park (See Fig. 2.1).

6.2.2 Stand History and Successional Trends

The eastern slope of Sugar Loaf Hill has long been an agricultural area. The Vermeule and Stock map (1900) and the photographs in Sherman (1905) show that these areas were in fields, albeit with well-developed hedgerows, at the turn of the century. According to Weig (1977), the long field behind the Blanchard house (now Park employee housing) was used to raise hay, corn and oats, and cattle were grazed on this and adjacent fields. The Blanchards farmed the area in this way until 1932, when the land was donated to the Federal Government for the Park.

According to Rutsch and Peters (1976), the "field office" building was erected by Andrew Tuttle in 1869. Although specific documentation for land-use in the area is lacking, it is likely that these fields were used for agriculture at that time, and most probably earlier. In view of the clearing of part of the area for the Grand Parade, and probable clearing of the rest of the area for the construction and heating of the Pennsylvania Brigade huts, it seems likely that these fields were kept open after the war, and thus have been cultivated or used for pasture continuously since Revolutionary times. During the years intervening between the Revolution and the construction of the house by Andrew Tuttle, any growth of timber would have been harvested while still young (Vermeule, 1900). Because the dominant trees in the present-day forest (white ash and yellow poplar) are both demanding of high nutrient content and deep, well-drained soils for establishment, it may be presumed that the years of agriculture did not deplete the soils of nutrient, nor did the cattle grazing evidently cause excessive soil compaction.

The current forest evidently originated from seeds from the hedgerow trees (mostly yellow poplar) and nearby stands of mature timber on the summit of Sugar Loaf Hill (which contain much ash). Because few red-cedars or gray birch were seen during the field work, it is evident that this forest did not replace a typical post-agricultural successional stand of short-lived trees, but grew up directly from the old fields. It is clear from the data on reproduction presented above that little change in species composition can be anticipated in this stand. The absence of oak reproduction is particularly noteworthy; it seems unlikely that this area will develop into one of the variants of the mature oak forests found elsewhere in the Park. Rather, this forest is likely to move slowly towards a mixed hardwood community. Considering the extensive establishment of red maple and black birch in nearby parts of the Park (on the old Thompson farm site, and on Sugar Loaf Hill), it is surprising that these species are not prominent in the community; however, they are the most likely invaders. Because oak reproduction is so scanty in the oak-dominated woods, oaks are unlikely to become a dominant portion of the forest in the foreseeable future.

6.6.3 Other Successional Communities in Jockey Hollow

Because of the tremendous diversity of successional forest types in the Park, especially those dominated by a single species of tree, and because of the large percentage of the Park area that is covered with these forests, some further study of these communities was undertaken to better characterize this vegetation. Thirteen stands were selected, representing all of the community types displayed on Map 3, and including some replication of stand types. In each stand, transects were established parallel to the long dimension of the stand, and sample points were taken at 40m intervals; at each sample point, a census was made with a 10 B.A.F. prism. Table 6-14 shows the average basal area per tree species recorded in each stand. Oak, hickory and sugar maple are the most common late successional species; however, they are present in low amounts in all but one of the Mixed Successional Forest stands. White ash, yellow poplar, red maple, and sassafras are the most abundant species and have the highest presence, occurring in most of the stands

in which they are not dominants. Black locust, elm, black birch, and black cherry are more sporadic in their occurrence. Dogwood is an important element of many of the stands. The species present in minor amounts are in some cases indicative of the significant factors shaping the development of the stands: pin oak and sycamore are found in the red maple stand, implicating the wetness of the site as the edaphic factor controlling the community, and beech, yellow birch, and hornbeam are found in the black birch stand, indicating the strong influence of the surrounding mature oak - yellow poplar and oak - beech forests.

The importance of the surrounding vegetation in determining the composition of these stands was further analyzed in Table 6-15, in which the surrounding community types, and the species of wolf trees in or bordering the stand, are listed. The correspondance between the dominant species and the kinds of wolf trees found in the stand is clear. This relation is similar to that noted by Buell *et al.* (1971) in studying succession near a virgin oak-hickory stand in New Jersey. However, Buell found that red cedar became dominant in portions of the fields distant from the forest edge, whereas here the presence of hardwood seed source everywhere dominated the successional process. Golley (1977) has similarly noted the crucial role played by seed sources in setting the course of succession.

Red cedar is the species most commonly associated with old-field succession in the middle Atlantic states (Braun, 1950; Bard, 1952). In Jockey Hollow, this species was found only occasionally in some of these stands (insufficiently frequently to be tabulated separately in Table 6-14), and was absent entirely from many of them. As discussed above (and see also Chapter 6-8), the hardwood trees present in the successional stands today are mostly those that seeded in directly in the old-fields in conjunction with the red cedar, rather than after the formation of a closed canopy by the redcedar and other shortlived species. Clearly, wind-dispersal of seeds from wolf trees was the dominant process accounting for the variability in these stands. Secondary factors affecting both the initial species composition and the kinds of successional change anticipated for the stands include the edaphic factors of site, and the seed sources present in the surrounding vegetation.

Another aspect of the species composition of these stands that is worthy of note is the prevalence of species characteristic of late successional forests among the old-field invaders. White ash, yellow poplar, black birch, red maple, and dogwood are the most prominent. This phenomenon has two implications for the discussion of successional forests: 1) because these species are relatively long-lived, successional change will be slowed, since it will depend on the process of stand maturation discussed previously, and 2) successional change will involve relatively little change in species composition (probably mostly involving a change in the relative proportions of species already present). These implications support the theoretical arguments of Drury and Nisbet (1973) and Egler and Foote (1975) that succession is frequently not a function of successively self-obliterating groups of species, but is often largely determined by the "initial floristic composition" of the area, with proportional changes in species frequency reflecting biotic differences and competitive processes among the trees (Pickett, 1975).

Inspection of the stands in this survey revealed little or no oak reproduction in particular, and levels of canopy-tree reproduction in general commensurate with the more intensively sampled stands. Therefore, the conclusions discussed above regarding the even-age structure of the stand, the episodic phasing of reproduction and change, and the likely trend toward a mixed-hardwood rather than an oak forest, can all be applied to the successional forests in the Park.

6.7 Yellow Poplar Community

6.7.1 Stand Composition

This community type is a variant of the Successional Forest; it is characterized by the dominance of a single species, yellow poplar, with only minor contributions made by other successional species. This variant of the Successional Forest was chosen for detailed analysis in part because it represents a strikingly different kind of forest from the mixed species type, in part because it is the most extensive of the single-species forest types (see Chapter 5, Table 5-1), and in part because such extensive stands of pure yellow poplar are more typical of southern Appalachian forests than they are of the forests of northern New Jersey (Robichaud and Buell, 1974; Eyre, 1954).

The stand chosen for analysis lies on the southeast-facing slope of 9° above the parking lot at the Soldiers' Hut exhibit, at an average elevation of 175m. The soils belong to the Edneyville gravelly loam type, which is deep, well-drained and fertile. The stand presents a striking aspect, compared to the other forest types in the Park: the yellow poplars rise above the forest floor with tall, very straight, large stems, and form a moderately dense canopy containing but one layer. Beneath this canopy, there is a sparse understory of suppressed hardwoods and dogwood, and beneath this stratum is a thick stratum of spicebush. Thus, the layering of the stand is both simpler and more prominent than either that of the other kinds of successional forest or that of the mature forest types. This feature of the yellow poplar community is well displayed in this stand, when viewed from the trail along the upslope community boundary. The ground is virtually bare, with only sparse herbaceous plants and sprouts of the shrub species present.

Table 6-16 shows the composition of the canopy layer. The overwhelming dominance of yellow poplar is obvious, as is the low diversity of species that have reached the canopy. The understory (Table 6-17) differs from the overstory more in the increase in species richness than in a change in species dominance. Although dogwood has the highest Importance Value, yellow poplar remains the dominant species of canopy-member tree in the understory through its high basal area. Spicebush is numerous, and dominates the shrub layer through high cover rather than by stem basal area. The species of canopy trees present in the understory include the species common to the other successional stands; however, they are small and sparse throughout this community.

The data for seedlings amplify the data for stand composition (Table 6-5). Virtually all the woody plant reproduction observed belongs to low shrubs and vines. The few tree seedlings seen were small

and unlikely to survive. No seedlings were seen intermediate in size between the newly established ones recorded in the quadrat data and the saplings observed in the understory data, and this feature of forest composition usually indicates a failure of the small seedling to survive for more than a few years (Zeide, pers. comm.).

Figure 6-9 shows the size-class distribution of the dominant yellow poplar and two of the subordinate species. Yellow poplar shows an approximately normal distribution of size classes, which indicates an even-aged population (Schmelz and Lindsey, 1964). Thus, the smaller size-classes represent suppressed individuals, and the distribution can be expected to narrow as these trees are eliminated from the stand. Neither of the subordinate species shows evidence of increasing populations, but rather a low rate of establishment coupled with complete suppression.

The density of dead standing trees was found to be 321 trees/ha. Of these, 38.5% were white ash, 15.4% were yellow poplar, 11.5% were black cherry, and the remainder were dogwood, sassafras, black locust, and unidentifiable stems. This mortality represents the natural thinning of the young stand.

6.7.2 Stand History and Successional Trends

The land on which this stand is located has long been cleared for agriculture. The proximity of the stand to the area of the Pennsylvania Brigades suggests that the hillside was cleared initially by the troops during the Revolutionary War. There are no available data from the nineteenth century, however, to indicate whether the area was allowed to revert to forest during the early and middle parts of the century, or whether it was maintained as fields during this time. The photograph in Sherman (1905) demonstrates, however, that the area had been under cultivation for at least several decades prior to the turn of the century, judging by the maturity of the orchard trees and hedgerows in the picture. These fields were used for pasture during the 1890's and early 1900's (Weig, 1977). The fields and orchard were abandoned shortly after the turn of the century, for the area had reverted to a young forest by the time of 1937 vegetation map of New Jersey.

Although the 1937 Vegetation Map assigns the area of the sample stand to a black locust - ash - yellow poplar association, it is likely that yellow poplar was the predominant species at that time, with greater densities of black locust towards the area of the former locust grove of the Cemetery site. The presence of mixed oak - yellow poplar forest uphill from this stand suggests that nearby yellow poplar in the mature forest served as the seed source for this stand. The presence of small amounts of black locust in the canopy, the absence of abundant dead locust stems, and the absence of locust in the suppressed understory stratum all support these deductions.

This reconstruction of stand history supports the interpretation of the vegetation as an even-aged stand of 60 to 70 years of age. Reproduction in this stand will clearly require either a disturbance which removes much of the canopy, or the eventual aging of the stand (which will have much the same effect on the density of the canopy). Because yellow poplar

seeds require mineral soil and full sunlight for germination and growth, it is unlikely that this species will regenerate itself in these stands without cutting or equivalent natural disturbance. Therefore, the stand will retain its present composition for at least several decades (barring the occurrence of catastrophic storms).

Yellow poplar is commonly reported to be an invader of old-fields that are sufficiently moist (Braun, 1950; Fowells, 1965), and this is well borne out in the Park. The yellow poplar stands are on well drained soils, on moderate slopes, or in north-facing coves. All observed stands have a composition similar to the one described, and can thus be expected to behave in a similar fashion in the future.

6.8 Conifer Community

6.8.1 Stand Composition

The exotic conifer stand selected for study is that paralleling Old Camp Road (Fig. 6-1). This area was selected because it contains most of the species introduced into the Park, because it is the most extensive of the introduced stands, and because it is near one field in which conifers species have entered the early successional forest. The stand is on ground with a slight slope (3°) to the southeast, at an elevation of 155 m in the saddle between Tea Hill and Mt. Kemble. The soil is Parker-Edneyville extremely stony sandy loam, excessively drained, and has a low water table.

The stand presents an unusual facies, in which species typical of Northern coniferous and Western forests are intermingled with the early successional hardwood species typical of northern New Jersey. The conifers were planted under the auspices of the W.P.A., probably in the early 1930's; no records relating to these plantations could be found in Park files. The nature of the stand testifies to a lack of active management of the plantation after its inception. The planted trees have matured, and natural mortality has substituted for management thinnings in opening up the stand. The open canopy has allowed a mixed successional community to invade, and this community shares dominance of the smaller size-classes with suppressed individuals of the conifers. Because of this mix of plant types, there are no well-defined foliage strata, but rather an uneven mix of trees of all heights; similarly, canopy coverage ranges from high beneath patches of large, mature pines and spruces, to low in patches of young successional trees and dead conifer trees. Although the overstory conifers are arranged in rows typical for these plantations, many of the understory conifers are randomly scattered (see below for discussion of this). The understory is equally variable: a shrub layer is lacking from the more densely shaded areas, is well-developed in the deciduous tree patches, and is sporadic in the rest of the stand. The ground layer supports vine and shrub sprouts and herbaceous plants in the vicinity of the hardwood trees; where the conifer canopy is closed, the ground has a thick layer of needle litter and little or no vegetation.

Table 6-18 shows the overstory composition, and Table 6-19 that of the understory. In the overstory, dominance is shared by two conifers, white spruce and red pine, and three successional species, black locust, white ash, and yellow poplar. The same species are prominent in the understory, together with arborvitae, white fir, red maple, and spicebush. Also present in the understory are small populations of black birch, red oak, sugar maple, and black cherry; their presence implies that succession towards a mixed hardwood forest is in progress. The high importance values of the conifers in the understory are mostly due to large basal area, rather than high density.

Figure 6-10 shows the size-class distributions of the dominant and principal subordinate species. The conifers all clearly have an even-aged population structure, in which the smaller individuals (and all individuals of white fir, and probably arborvitae) are suppressed trees dating to the original planting. White ash and black locust show a similar even-aged pattern, suggesting that they become established shortly after the plantation was started, and will be an ephemeral part of the stand as it matures. Yellow poplar, however, shows an approximate reverse-J-shaped distribution, implying that this species will persist as an important element in the mature woods. In as much as the surrounding forest is a Mixed Oak - Yellow Poplar type (see Map 3), the persistence of yellow poplar past the early successional stage would not be surprising.

The seedling population (Table 6-5) consists mostly of shrub and vine species, with only small numbers of black cherry and red maple seedlings representing canopy-tree reproduction. These results are similar to those obtained in the other young forest stands. As in these stands, the results imply that mature forest trees will become established sporadically, following disturbances or stand maturation.

Dead standing trees were found at a density of 815 trees/ha. Of these trees, 63% were conifers; half of the conifers were arborvitae, and red pine, white fir, white spruce, and Douglas-fir comprised the rest. The remaining 37% of the dead trees were mostly black locust, with small amounts of white ash. This observed mortality supports the inference made on the basis of size-class distribution that these two species invaded the plantation at the time of establishment, and are now starting to disappear from the stand.

6.8.2 Stand History and Successional Trends

The region in which this stand is located was shown as non-forested land on the 1900 Forested Lands map of Vermeule and Stock, and also was shown as open land on the Road Map (1933). There is no information available concerning land use history during the 1800's; however, several references to the Kemble property state that most of the land was open and used for agriculture or pasture. In view of the nearly level topography of the area, and its proximity to the Old Camp Road, it is likely that the area had been kept open for some time prior to the turn of the century when the Morristown Aqueduct Company reopened that road (Pitney, 1934) as one of the better sites for agriculture in the estate. However, in the absence of better historical data on the Kemble estate, further speculation on nineteenth century land use patterns is idle.

It is clear, however, that the plantation was established on land that had been used for pasture and/or crops for at least thirty years previously. Forest development has been rapid, with several yellow poplars attaining diameters over 38 cm, and some of the conifers reaching diameters of 31 cm. Rapid tree growth on previously cultivated land is common (Zeide, pers. comm.), and this stand exemplifies this observation.

It can be expected that the conifers will slowly die off, leaving a hardwood forest comparable to the surrounding forests. It appears that successional development of the hardwood component of the forest is proceeding independently of the development of the coniferous element. The influx of black locust, white ash, and some yellow poplar when cultivation of the field ceased and the plantation was established, and the trend in species composition towards a mature mixed hardwood community show that this succession can occur in small gaps within the coniferous canopy, as well as in the large uniform stands described earlier. It is also evident that the coniferous litter is having no permanent effect on the vegetation through modification of the soil, as a successional community comparable to the others in the Park has become established.

The other conifer stands in the Park are more uniform in the species composition of the conifer elements: the stand near the summit of Mt. Kemble is composed mostly of red pine, and the stand at the base of the Christmas tree plantation is composed mostly of hemlock. It is unclear why the sampled plantation was made with such an unlikely collection of species. It is possible that some of the species may have seeded in naturally from plantings around nearby homesteads during the early years of the plantation; evidence of such seeding-in in old fields adjoining the plantation (downslope from the Loop Trail) can be seen in the small, overtopped red pine, Douglas-fir, white spruce, and Norway spruce scattered among the other early successional trees. Such seedling-in would account for the irregular distribution of the smaller trees, which would probably not have been planted in a random array.

Conifer plantations with similar structure and dynamics have been described from Voorhees State Park (McDough and Buell, 1956, and have been observed in Stokes State Forest (Schallock, pers. comm.), and are a common feature in New Jersey. The plantations in the present Park appear to be less dense than some, and are proceeding towards a hardwood forest more rapidly than those in which the coniferous canopy is dense and continuous, thereby successfully preventing hardwood invasion.

6.9 Chestnut Oak Community

6.9.1 Stand Composition

The chestnut oak stand selected for sampling is situated on a north-east-facing slope between the Aqueduct Trail and Cemetary Road (Site A, Fig. 6-1). The community extends from about 180 m on the ground above the Primrose Brook (13 m vertical elevation above the Brook) along a 7° slope uphill. The soil belongs to the Edneyville Series (see Chapter 3-2); it is moderately permeable, well-drained, and contains gneiss gravel, cobbles and stones. Evidence of logging operations prior to the

establishment of the Park are abundant throughout in the form of cut stumps of chestnut and oaks.

Table 6-20 shows the composition of the canopy-layer trees in the stand. Three groups of trees can be distinguished on the basis of the importance values. Chestnut, black birch and oak are codominant, and are approximately equally important in the stand. There are fewer chestnut oaks, but they represent a larger fraction of the basal area than does black birch. Red maples are common (high absolute density, high frequency), but they are relatively small (low dominance). A second group of trees, here called the associate species, including beech, yellow poplar, hickory, white oak and red oak, have importance values less than half those of the dominant species. The two species of oak are represented chiefly by a few large specimens, which accounts for their low relative density and high dominance; they are most likely left from logging operations. The third group of species, ash, yellow birch, and black oak, are minor components of the canopy.

Table 6-21 shows the composition of the understory trees. The understory is strikingly dominated by dogwood, a species which is never part of the canopy of the forest. Of the dominant species in the overstory, black birch and red maple are reproducing, but chestnut oak apparently is not replacing itself. Beech and red oak are also important contributors to the overstory reproduction.

Figure 6-11 shows the size distribution of the dominant and principal associate species in this stand. There is a prominent difference in the curves for the two groups of species. The codominants, chestnut oak, black birch and red maple, are clearly even-aged, and invaded the site at about the same time. The associate species, beech and red oak, do not show the same maximum in frequency of the 23 cm to 33 cm DBH size classes, but are more uniformly distributed. The size-class distribution of red oak, in particular, suggests that this species is composed of three separate populations, i.e., old remnants left after logging operations, trees established at about the same time as the co-dominants, and recently established reproduction.

The amount of reproduction in the stand is much lower than that normally encountered in hardwood stands (for example, comparable forests in the Catskills (McIntosh, 1972), New Jersey (Good and Good, 1972) and Pennsylvania (Mackey and Sivec, 1973)). This may be due to a combination of several factors. First, the high density of dogwood in the understory may provide shading too dense for the establishment of seedlings. Second, the presence of vines in the canopies of some of the trees may prevent, or seriously reduce, the production of seed. Third, deer browsing, which was abundantly evident on Viburnum acerifolium shoots, may account for the destruction of small seedlings. Because tree reproduction is ample in other parts of the Park (for example, on the west slope of Mt. Kemble), and because the entire area of the Park is within the foraging range of individual deer herds (Lund, pers. comm.), it is probable that deer browsing is the least important factor in the suppression of tree reproduction.

Table 6-5 shows the density of seedlings recorded in the square-meter samples. These data suggest that red oak and beech have been reproducing more abundantly in the recent past than have the tree codominant species (chestnut oak, black birch, and red maple). The reproductive pattern of dogwood strongly implies that its abundance in the forest will not alter in the future; the logarithm of stem density as a function of size (Fig. 6-12) is approximately J-shaped, which usually implies a stable population structure (Jackson and Faller, 1973).

Standing dead trees were encountered throughout the stand, contributing an average of $2.4 \text{ m}^2/\text{ha}$ basal area. This represents 8% of the total live basal area of the stand ($29.4 \text{ m}^2/\text{ha}$). The mortality was concentrated among the oaks; 41% of the dead trees were red oaks, 25% were chestnut oak, 15% were white oaks, and 6% were undetermined species of oaks. It is highly probable that much of this oak mortality can be attributed to the gypsy moth infestation of 1967-69.

The shrub layer consisted primarily of Viburnum acerifolium; on average, 25-50% of the line transects between sample points was covered by this species. Hamamelis virginiana and Lindera benzoin were present, but sparse. The Viburnum showed signs of extensive deer browsing; most terminal buds had been removed, and the twigs chewed back to the larger stems. This kind of understory is typical of the well-drained upland forests throughout the Park (as well as throughout the region).

Vines are present in low to moderate density in this stand; one large Vitis stem was noted at about half the sample points. As suggested above, these vines may have a detrimental effect on the reproductive effort of the canopy-member trees. However, they do not impose a serious strain on the trees in this stand. They are probably declining in importance, because only large stems were encountered, and no signs of vine reproduction were seen.

6.9.2 Successional Trends

According to the Vermeule and Stock map of areas forested in 1900, as well as the Base Map of Revolutionary Camp Area, 1933, Morristown National Historic Park, the area of this stand has been wooded since at least the middle of the last century. The Vegetation Map (1937) lists this area as a chestnut oak community, approximately 60-80 years of age. This would place the time since last clearing at a minimum of 100 years. According to land-use records documented in Rutsch and Peters (1976), hilly portions of the Wick Farm were retained as woodlots during the tenure of Tempe Wick and her descendants; however, the information available to date does not permit us to state whether this particular slope was one of those retained in woods. The present stoniness of the soil implies that the ground was never used for crops, since such stones were necessarily removed prior to ploughing and planting. However, the area may have been cleared for pasture by the Wicks, or more probably, was cleared by the troops of the nearby Pennsylvania and Maryland brigades.

Further evidence that the stand is a mid-successional one comes from the character of the co-dominant species. Chestnut oak is a commonly found entering disturbed areas, and sprouts prolifically following cutting,

and thus is often found in forests logged during the 19th century (McIntosh 1972; Smiley, pers. commun.; Fowells 1965). Chestnut oak is also typically found on dry, rocky soils, such as those underlying the sampled stand. Thus, its importance in this stand is indicative of both excessively drained soils and past disturbance to the vegetation. Red maple has a wide ecological amplitude, growing well in habitats ranging from dry ridges to swampy bottomlands; it also sprouts prolifically and commonly invades and dominates areas of disturbance and logging (Fowells, 1965). Black birch produces seed prolifically, and is moderately tolerant of shade, and can grow under a wide range of ecological conditions. Although black birch is a component species of old-growth stands, and thus can persist throughout successional change, it is not found as a dominant or co-dominant species in such communities (S.A.F., 1954). Good (1968) has linked its presence to areas in which disturbed soil or rotting stumps are present, as these sites favor germination of seeds; it thus can behave as a pioneer species in taking advantage of disturbance to the forest community. Good (1968) noted that it was the major species to invade gaps left by dead chestnut trees; at Jockey Hollow, it has evidently taken advantage of extensive logging to greatly increase its density over that typical of undisturbed woodland. Thus, all three co-dominants are typical member of post-disturbance communities, rather than old-growth communities.

A major source of disturbance to this stand was the chestnut blight. From the large number of stumps present throughout the stand, and the tendency of chestnut to dominate dry, rocky habitats (Braun, 1950), it may be presumed that chestnut was a major component of the stand growing here at the turn of the century. The death and removal of these trees would have opened up the stand to invasion by red maple, black birch, and chestnut oak. Mackey and Sivec (1973) have described a similar stand in Pennsylvania, in which red maple, black cherry, and black birch formed a mid-successional community following the removal of the dying chestnuts. Augenbaugh (1935) also reported increases in the abundance of chestnut oak and red maple following the chestnut blight. In the Park, chestnut oak has substituted for black cherry; the multiple-stemmed trees strongly suggest that chestnut oak was a co-dominant species being the blight arrived. The presence of the few large-diameter red, white and black oaks further suggest that these species were of greater importance in the past, but were extensively removed by loggers prior to the establishment of the Park.

Thus, it seems likely that late in the last century and early in this century, this site supported a typical oak-chestnut forest as described in Braun (1950): oaks, principally chestnut, red and black oaks, and chestnut dominated the stand, and lesser numbers of red and sugar maple, white oak, black birch and beech were present. Logging removed many of the oaks, and the blight removed all of the chestnut. During the long period over which these disturbances acted, sprouting ability (in the chestnut oak and red maple) and ability to colonize old stumps and disturbed soil (black birch) were the principal factors shaping the nature of the forest that is growing on this site today.

Based on the observed reproduction in the stand, and the species composition noted in other previously chestnut-dominated stands (Keever, 1953; Nelson, 1955; Woods and Shunks, 1959), trends can be predicted for the future: 1) Chestnut oak is likely to decline in importance, in the absence

of logging because of its evident failure to reproduce. However, this species is moderately long-lived (Forbes, 1956) and a noticeable change in its abundance might require another 50-100 years without disturbance. 2) Red maple and black birch are likely to remain prominent in the intermediate-term future, because of their abundant reproduction. Fewer seedlings were seen than would be expected for a stable age-distribution and so their abundance in the lower canopy classes may be misleading with response to their importance as the forest ages. 3) Beech and red oak are evidently increasing in importance. A long-term increase in the dominance of mesic, tolerant species following the chestnut blight has been documented in several areas (Woods and Shanks 1959), and has been shown to occur as a secondary wave of species replacements following an initial increase in dominance of chestnut oak, hickory, red maple, and other species tolerant of the open conditions immediately following the chestnut mortality. The oak mortality resulting from the recent gypsy moth infestation is not expected to produce any major changes in the forest community (see Ehrenfeld, 1977). 4) The great density of dogwood is likely to promote the growth of beech and any other highly tolerant species that manage to invade the stand. Dogwood seems certain to dominate the understory in the future.

Table 6-1. Summary of Stand Characteristics

Stand*	Site	# Species Canopy	# Species Understory	Total Density #/HA	Total B.A. M ² /HA	Total Density Seedlings, Canopy Spp. #/HA
MO-YP	Moderate, mesic slopes	13	13	1015.8	25.20	9,855.2
CO	Rocky, steep slopes, ridges	11	14	1865.1	30.37	6,123.
SUCC	Various	9	12	985.5	19.30	7,683.0
MO-BE	Moderate, mesic slopes	6	10	1,418.3	32.68	20,065.
MH	Various	8	19	2,567.5	29.08	52,500.0
YP	Mesic, lower slope	3	9	1,445.0	62.39	49,000.0
CON	Various	9	16	1,919.6	48.50	22,000.
ST	Along	7	21	2,151.9	35.42	43,500.

* Community abbreviations above and in following tables: MO-YP = Mixed Oak - Yellow Poplar; CO = Chestnut Oak; SUCC = Successional; MO-BE = Mixed Oak - Beech; MH = Mixed Oak - Hardwoods; YP = Yellow Poplar; CON = Coniferous; ST = Stream Thicket.

Table 6-2. Importance Values of Overstory Trees in Eight Community Types

	MO- YP	CO	MO BE	MH	ST	SUCC	CON	YP
Red Maple	1.9	17.4	2.3	8.1	20.30	2.6	2.6	
Black Birch	21.3	25.9	2.3	33.7	2.95			
Beech	11.8	5.0	56.3	15.7	40.13			
Yellow Birch	7.4	1.2		5.0	20.71			
Yellow Poplar	26.7	6.1		7.5	3.20	41.1	15.7	91.3
Red oak	6.7	8.5						
White oak	5.6	7.4	18.7	11.5	4.80			
Black oak	2.6	1.3	4.8					
Chestnut oak	6.6	22.6	14.7	12.6				
Hickory	1.9	3.9		5.6				
Sugar maple	2.6							
White ash	3.5	0.8			7.86	35.7	12.3	
Sassafras	1.1					8.2		1.8
Elm						0.7		
Black Locust						5.7		3.3
Black Cherry						2.8		
Apple						2.1		
All exotic conifers						0.7		
							59.5	

Table 6-3. Overstory Composition (trees > 20.3 cm DBH) in the Mixed Oak - Yellow Poplar Community.

Species	D.	R.D.	F.	R.F.	DO.	R.Do.	I.V.
Beech	24.48	11.87	.3000	10.52	2.53	13.19	11.8
Sugar Maple	5.16	2.50	.1000	3.50	0.24	1.26	2.6
Black Birch	50.26	24.37	.6500	22.80	3.24	16.89	21.3
Yellow Birch	16.75	8.12	.2500	8.77	1.0023	5.22	7.4
Red Maple	3.86	1.87	.0750	2.63	0.268	1.39	1.9
Chestnut Oak	14.18	6.87	.1500	5.26	1.49	7.77	6.6
Black Oak	3.86	1.87	.0750	2.63	0.6677	3.48	2.6
Yellow Poplar	54.14	26.25	.6250	21.92	6.127	31.93	26.7
Hickory	3.86	1.87	.0750	2.63	0.25	1.29	1.9
White Ash	7.73	3.76	.1250	4.38	0.4826	2.51	3.5
Sassafras	2.57	1.25	.0500	1.75	0.1022	0.53	1.1
Red Oak	10.30	5.00	.2000	7.01	1.5709	8.18	6.7
White Oak	9.01	4.37	.1750	6.14	1.2107	6.31	5.6
<u>Total</u>	206.15		2.8500		19.187		

Table 6-4. Understory Composition (trees 2.59-20.3 cm DBH) in the Mixed Oak - Yellow Poplar Community.

Species	D.	R.D.	F.	R.F.	Do.	R.Do.	I.V.
Beech	187.25	23.12	.5250	19.81	0.82	13.64	18.86
Sugar Maple	40.48	5.00	.1750	6.60	0.20	3.41	5.00
Black Birch	131.60	16.25	.4750	17.92	1.60	27.11	20.43
Blackgum	30.38	3.75	.1250	4.71	0.30	5.06	4.50
Red Maple	75.88	9.37	.3000	11.32	0.53	8.83	9.84
Yellow Birch	20.25	2.50	.1000	3.77	0.26	4.36	3.54
Dogwood	207.48	25.62	.5500	20.75	0.58	9.66	18.68
Yellow Poplar	25.27	3.12	.1000	3.77	0.45	7.50	4.80
Hickory	10.13	1.25	.0500	1.88	0.10	1.66	1.60
Hornbeam	50.61	6.25	.1500	5.66	0.08	1.39	4.43
Am. Chestnut	5.01	0.62	.0250	0.94	0.03	0.51	0.69
Ash	10.13	1.25	.0250	0.94	1.00	16.67	6.29
Witchhazel	15.14	1.87	.0500	1.88	0.01	0.16	1.31
<u>Total</u>	809.62		2.6500		5.9896		

Table 6-5. Seedling Density in all Sampled Communities (Number/Hectare).

Species	MO-YP	MO-BE	CO	MH	ST	SUCC	YP	CON
Red Oak Group	259	6,500	500	1,000	1,000			
White Oak					1,500			
Chestnut Oak								
Beech	649	5,000	125	1,000	12,500			
Sugar Maple					500			
Black Birch	649	2,500	125					
Red Maple	649	500	125	500	2,500			500
Ash	909		125	1,500		732	1,000	
Yellow Poplar	259						500	
Black Cherry						122		2,500
Ironwood	519		125	1,500				
Dogwood	4,805		4,373	4,500		854	500	
Spicebush	649			29,500	11,500	3,658	15,000	10,000
Witch hazel	649	500		5,000	4,000			
Maple-leaf viburnum	909	38,000	(a)	57,500	12,500			500
Azalea				3,500	4,000			
Blackhaw viburnum						2,196	3,000	500
Blueberry	779	9,000			5,500			
Blackberry (<u>Rubus</u> spp)				2,000			1,000	4,000
Grape						122		
Virginia Creeper				3,000			17,500	
Poison-ivy				3,000			4,000	500
Rosa							6,000	4,000
Barberry							500	
TOTAL	11,684	62,000	6,123	110,000	56,000	7,684	53,500	22,500

(a) Data for maple-leaf viburnum inadvertently not collected for this stand.

Table 6-6. Overstory Composition in the Mixed Oak - Beech Community

SPECIES	D.	R.D.	Do.	R.Do.	I.V.
Red Maple	12.23	3.44	0.59	2.11	2.3
Beech	220.07	62.06	14.15	50.69	56.3
White Oak	48.90	13.79	6.61	23.67	18.7
Black Birch	12.23	3.44	0.46	1.64	2.3
Chestnut Oak	48.90	13.79	4.38	15.67	14.7
Black Oak	12.23	3.44	1.73	6.19	4.8
<u>Total</u>	354.56		27.92		

Table 6-7. Understory Composition in the Mixed Oak - Beech Community

SPECIES	D.	R.D.	Do.	R.Do.	I.V.
Red Maple	244.5	22.98	1.69	35.41	29.2
Witchhazel	48.9	4.59	0.04	0.93	2.8
Yellow Birch	85.6	8.04	0.11	2.19	5.1
Beech	501.3	24.12	2.44	51.23	49.2
Yellow Poplar	36.68	3.44	0.11	2.33	2.9
White Oak	12.23	1.14	0.09	1.24	1.2
Serviceberry	12.23	1.14	0.01	0.15	0.7
Black Birch	97.81	9.19	0.17	3.60	6.4
Dogwood	12.23	1.14	0.03	0.70	0.9
Red Oak	12.23	1.14	0.10	2.18	1.7
<u>Total</u>	1063.71		4.76		

Table 6-8. Overstory Composition of the Mixed Hardwood Community

SPECIES	D.	R.D.	Do.	R.Do.	I.V.
Red Maple	24.45	9.52	1.19	6.75	8.1
Black Birch	97.81	38.09	5.17	29.33	33.7
Hickory	12.23	4.76	1.13	6.40	5.6
White Oak	24.45	9.52	2.36	13.38	11.5
Beech	36.68	14.28	3.02	17.13	15.7
Chestnut Oak	24.45	9.52	2.78	15.79	12.6
Yellow Birch	12.23	4.76	0.98	5.58	5.0
Yellow Poplar	24.45	9.52	0.99	5.60	7.5
<u>Total</u>	256.75		17.63		

Table 6-9. Understory Composition of the Mixed Hardwoods Community

SPECIES	D.	R.D.	Do.	R.Do.	I.V.
Red Maple	330.10	14.28	1.58	13.80	14.0
Dogwood	501.27	21.69	2.29	20.05	20.8
Spicebush	48.90	2.11	0.02	0.23	1.2
Black Birch	220.07	9.52	1.24	10.80	10.1
Witchhazel	61.13	2.64	0.05	0.42	1.6
Hickory	24.45	1.05	0.20	1.70	1.4
Beech	256.75	11.11	1.31	11.45	11.3
Chestnut Oak	24.45	1.05	0.03	0.22	0.6
Ironwood	183.39	7.93	0.65	5.67	6.8
Yellow Birch	110.03	4.76	1.17	10.21	7.5
Sassafras	36.68	1.58	0.21	1.84	1.7
Yellow Poplar	48.90	2.11	0.14	1.25	1.7
Azalea	12.23	0.52	0.01	0.06	0.3
Amelanchier	110.03	4.76	0.29	2.57	3.7
White Ash	146.71	6.34	1.54	13.48	9.9
Hop-hornbeam	134.49	5.82	0.65	5.64	5.7
Red Oak	12.23	0.52	0.01	0.06	0.3
Blackgum	24.45	1.05	0.04	0.31	0.7
Blueberry	24.45	1.05	0.01	0.10	0.6
<u>Total</u>	2310.73		11.45		

Table 6-10. Overstory Composition or the Stream Thicket Community

SPECIES	D.	R.D.	Do.	R.Do.	I.V.
Beech	97.81	34.78	13.36	45.48	40.13
Red Maple	61.13	21.73	5.54	18.87	20.30
Yellow Birch	61.13	21.73	5.79	19.70	20.71
White Oak	12.23	4.34	1.55	5.27	4.80
Ash	24.46	8.69	2.07	7.03	7.86
Black Birch	12.23	4.34	0.61	1.56	2.95
Yellow Poplar	12.23	4.34	0.61	2.06	3.20
<u>Total</u>	281.22		29.37		

Table 6-11. Understory Composition of the Stream Thicket Community

SPECIES	D.	R.D.	Do.	R.Do.	I.V.
Beech	268.97	14.37	0.56	9.31	11.8
Red Maple	268.97	14.37	2.36	3.91	26.7
Witchhazel	195.62	10.45	0.15	2.43	6.4
Spicebush	256.75	13.72	0.21	3.42	8.6
Yellow Birch	158.94	8.49	0.64	10.61	9.6
Dogwood	12.23	0.65	0.01	0.12	0.4
Azalea	61.13	3.26	0.05	0.90	2.1
Grape	12.23	0.65	0.01	0.12	0.4
Sugar Maple	61.13	3.26	0.14	2.37	2.8
Blueberry	61.13	3.26	0.04	0.69	2.0
Ironwood	183.39	9.80	0.39	6.57	8.2
Red Oak	12.23	0.65	0.08	1.40	1.0
Ash	97.81	5.22	0.58	9.60	7.4
Hickory	12.23	0.65	0.05	0.86	0.8
Black Birch	61.13	3.26	0.24	4.00	2.6
Yellow Poplar	36.68	1.96	0.21	3.42	2.7
Sassafras	24.46	1.30	0.06	0.94	2.1
Elderberry	12.23	0.65	0.01	0.10	0.4
Alder	24.46	1.30	0.09	1.49	1.4
Amelanchier	24.46	1.30	0.10	1.66	1.5
Blackgum	24.46	1.30	0.05	0.80	1.0
<u>Total</u>	1870.67		6.05		

Table 6-12. Overstory Composition of Successional Forest.

SPECIES	D.	R.D.	F.	R.F.	Do.	R.Do.	I.V.
Elm	1.09	0.63	.025	1.14	0.04	0.35	0.7
Ash	77.71	44.93	.850	39.08	2.67	23.10	35.7
Sassafras	15.31	8.86	.175	8.04	0.89	7.74	8.2
Black Locust	10.92	6.32	.150	6.89	0.48	4.13	5.7
Yellow Poplar	56.91	32.91	.700	32.18	6.74	58.30	41.1
Black Cherry	4.37	2.53	.100	4.59	0.18	1.57	2.8
Red Maple	3.26	1.89	.100	4.59	0.17	1.51	2.6
Walnut	2.17	1.26	.050	2.29	0.33	2.84	2.1
Apple	1.09	0.63	.025	1.14	0.05	0.41	0.7
<u>Total</u>	172.83		2.175		11.56		

Table 6-13. Understory Composition of the Successional Forest.

SPECIES	D.	R.D.	F.	R.F.	Do.	R.Do.	I.V.
Dogwood	206.32	26.25	.550	22.91	0.94	12.11	20.4
Elm	4.87	0.62	.025	1.04	0.023	0.30	0.7
Ash	250.58	31.87	.625	26.04	3.26	42.24	33.4
Sassafras	88.43	11.25	.300	12.50	1.11	14.36	12.7
Blackhaw	63.83	8.12	.225	9.37	0.22	2.78	6.8
Black Locust	44.16	5.62	.125	5.20	0.69	8.89	6.6
Yellow Poplar	49.13	6.25	.150	6.25	0.64	8.32	6.9
Black Cherry	34.36	4.37	.175	7.29	0.45	5.86	5.8
Red Maple	14.70	1.87	.075	3.12	0.15	1.96	2.3
Pear	4.87	0.62	.025	1.04	0.13	1.68	1.1
Apple	19.66	2.50	.100	4.16	0.11	1.38	2.7
Hawthorne	4.86	0.62	.025	1.04	0.01	0.06	0.6
<u>Total</u>	785.66		2.400		7.71		

Table 6-14. Basal Area Survey of Selected Successional Stands.
(All data in ft²/acre)

SPECIES	Community Type (Stand Number)							
	WA-BL (1)	WA-BL (2)	WA-YP (3)	WA-YP (4)	MIX (5)	BL (6)	BL (7)	BW (8)
Yellow Poplar	4.5	7.5	5.20	28.6	32.7	9.0	9.0	6.9
White Ash	45.5	32.5	41.0	42.9	34.5	16.0	36.0	23.1
Black Locust	40.9	48.8				66.0	100.0	
Black Walnut	9.1	3.1	1.0	1.4				66.9
Red Maple	2.7	6.3	43.0	5.0	8.2	3.0		
Sassafras	7.3	0.6	5.0	5.0	2.7	2.0		
Black Birch					9.1			0.8
Elm	5.5	1.3	2.0	1.4	1.8	1.0		0.8
Black Cherry	8.2	3.1		0.7	1.8	3.0		
Dogwood	16.4	1.3	2.0	19.3	21.8	18.0		0.8
Oak (all spp)			3.0		26.4	3.0		
Hickory		3.1			7.3			
Sugar Maple			1.0		3.6			
Spicebush	8.2	2.5	17.0					7.7
Blackhaw		0.6	2.0	3.6				1.5
Grape		1.3		2.1				
Other		3.1		1.4	3.6		1.0	2.3
<u>Total B.A.</u> <u>— (ft²/acre)</u>	148.3	115.1	169.0	111.4	153.5	121.0	146.0	110.8

Table 6-14 cont'd.

Species	RM (9)	SA (10)	YP (11)	BB (12)	WA (13)
Yellow Poplar	5.4	11.4	87.0	17.0	14.2
White Ash	3.6	18.6	20.0		85.5
Black Locust		5.0		1.0	
Black Walnut		1.4	2.0		8.3
Red Maple	65.5			5.0	
Sassafras	1.8	50.0	11.0		3.3
Black Birch	2.7		1.0	99.0	
Elm	1.8	1.4			
Black Cherry	1.0	5.7			0.8
Dogwood	1.8	15.7	2.0	13.0	6.7
Oak	15.5	2.1	1.0	9.0	3.3
Hickory	3.6				
Sugar Maple		2.9	12.0	2.0	0.8
Spicebush	11.8	0.7	4.0		1.6
Blackhaw		3.6			0.8
Grape	1.0		1.0		4.2
Other	7.3*	2.1		11.0**	7.5
TOTAL B.A. (ft ² /acre)	122.8	120.6	151.0	159.0	

* Includes sycamore, pin oak

** Includes beech, yellow birch, hornbeam, maple-leaf virburnum

Table 6-15. Vegetation Associated with Successional Stands.
(see Table 6-14 for identification of stand numbers.)

STAND NUMBER	DOMINANT SPECIES	"WOLF" SPECIES	SURROUNDING COMMUNITIES
1	WA, BL	BL, YP	WA-BL; MH (downslope), Mix
2	BL, WA	BL, WA	BL-WA
3	YP, RM	YP, RM	YP; MO-BB
4	WA, YP	WA, YP	WA-YP; Mix, WA, WA-BL down- slope
5	WA, YP, OAK	OAK	Large Succ Mix surrounds on all sides
6	BL	None	Mix all around, MO-BB nearby
7	BL	Apple	WA-YP; WA-BL, fields; MH
8	BW	None	WA-BL; Mix; YP
9	RM	OAK, RM	RM, MH; WA-BL
10	SA, WA	SA, WA, YP, BW, BC	YP; WA-BL; Mix
11	YP	YP, WA, BB, SM	SAS; WA-YP
12	BB	BB	Mis; MO-BE; MO-YP
13	WA	YP, WA, BW, SA BC	WA; (?Mix)

Table 6-16. Overstory Composition of the Yellow Poplar Community

SPECIES	D.	R.D.	Do.	R.Do.	I.V.
Yellow Poplar	501	93.18	56.89	96.49	91.3
Sassafras	61	2.27	0.806	1.36	1.8
Black Locust	122	4.54	1.258	2.13	3.3
<u>TOTAL</u>	234		58.952		

Table 6-17. Understory Composition of the Yellow Poplar Community

SPECIES	D.	R.D.	Do.	R.Do.	I.V.
Yellow Poplar	111	9.09	1.67	48.43	28.8
Red Maple	61	5.05	0.479	13.92	9.5
Dogwood	734	60.60	1.07	31.01	45.8
Ash	37	3.03	0.045	1.31	2.2
Spicebush	134	11.11	0.089	2.60	6.9
Grape	37	3.03	0.022	0.65	1.8
Am. Elm	24	2.02	0.001	0.02	1.0
Black Cherry	61	5.05	0.061	1.78	3.4
Blackhaw	12	1.01	0.009	0.25	0.6
TOTAL	1211		3.444		

Table 6-18. Overstory Composition of the Conifer Community.

SPECIES.	D.	R.D.	Do.	R.Do.	I.V.
Black Locust	73.36	12.00	3.40	10.15	11.1
White Spruce	97.80	16.00	4.36	13.04	14.5
Yellow Poplar	73.36	12.00	6.49	19.39	15.7
White Ash	73.36	12.00	4.22	12.61	12.3
Red Pine	232.29	38.00	10.86	32.46	35.3
White Fir	12.23	2.00	1.13	3.37	2.7
Red Maple	12.23	2.00	0.397	1.18	1.6
Douglas Fir	24.45	4.00	2.10	6.26	5.3
Scotch Pine	12.23	2.00	0.50	1.50	1.7
<u>TOTAL</u>	611.31		33.45		

Table 6-19. Understory Composition of the Conifer Community

SPECIES	D.	R.D.	Do.	R.Do.	I.V.
Black Locust	73.36	5.60	1.63	10.81	8.2
Arborvitae	122.3	9.34	1.35	8.94	9.2
Sugar Maple	24.45	1.86	0.36	2.40	2.1
White Spruce	73.36	5.60	1.07	7.11	6.3
Yellow Poplar	73.36	5.60	0.34	2.27	3.9
Black Birch	12.23	0.93	0.03	0.18	0.6
Grape	48.90	3.73	0.06	0.04	2.6
White Ash	183.39	14.01	3.09	20.53	17.3
Red Pine	134.49	10.28	3.00	19.95	15.1
Spicebush	220.07	16.82	0.19	1.23	9.0
White Fir	110.03	8.41	1.50	9.96	9.2
Red Maple	146.71	11.21	1.37	9.11	10.1
Douglas Fir	36.68	2.80	0.77	5.12	3.8
Red Oak	12.23	0.93	0.14	0.94	0.9
Black Cherry	12.23	0.93	0.115	0.76	0.8
Virginia Creeper	24.45	1.86	0.03	0.21	1.0
<u>TOTAL</u>	1308.24		15.05		

Table 6-20. Overstory Composition of the Chestnut Oak Community

SPECIES	D.	R.D.	F.	R.F.	Do.	R.Do.	I.V.
Chestnut Oak	44.5	22.0	60.0	21.1	5.04	24.7	22.6
Black Birch	61.0	30.2	67.5	23.7	4.87	23.8	25.9
Red Maple	40.7	20.1	57.5	20.2	2.47	12.1	17.4
Beech	10.2	5.0	20.0	7.0	0.61	3.0	5.0
Yellow Poplar	11.4	5.7	20.0	7.0	1.18	5.8	6.1
Hickory	7.6	3.8	12.5	4.4	0.72	3.5	3.9
White Oak	8.9	4.4	20.0	7.0	2.22	10.8	7.4
Red Oak	11.4	5.7	17.5	6.2	2.77	13.6	8.5
Ash	1.3	0.6	2.5	0.9	0.14	0.7	0.8
Yellow Birch	2.5	1.3	5.0	1.8	0.11	0.5	1.2
Black Oak	2.5	1.3	2.5	0.9	0.32	1.6	1.3
<u>TOTAL</u>	202.0				20.44		

Table 6-21. Understory Composition in the Chestnut Oak Community

SPECIES	D.	R.D.	F.	R.F.	Do.	R.Do.	I.V.
Chestnut Oak	10.4	0.6	2.5	1.2	0.11	1.1	0.9
Black Birch	124.8	7.5	22.5	10.5	0.99	9.9	9.1
Red Maple	197.5	11.9	40.0	18.6	1.65	16.7	15.7
Yellow Poplar	20.8	1.3	5.0	2.3	0.09	0.9	1.5
Beech	93.1	5.6	17.5	8.1	1.03	10.4	8.0
Red Oak	41.6	2.5	10.0	4.7	0.45	4.6	3.9
White Oak	10.4	0.6	2.5	1.2	0.06	0.6	0.8
Hickory	10.4	0.6	2.5	1.2	0.14	1.4	1.1
Ash	10.4	0.6	2.5	1.2	0.01	0.1	0.6
Yellow Birch	41.6	2.5	7.5	3.5	0.68	6.8	4.2
Blackgum	10.4	0.6	2.5	1.2	0.01	0.1	0.9
Dogwood	1085.1	65.3	92.5	43.0	4.64	46.7	51.7
Ironwood	20.8	1.3	5.0	2.3	0.02	0.2	1.3
Serviceberry	10.4	0.6	2.5	1.2	0.05	0.5	0.8
<u>TOTAL</u>	1687.7				9.92		

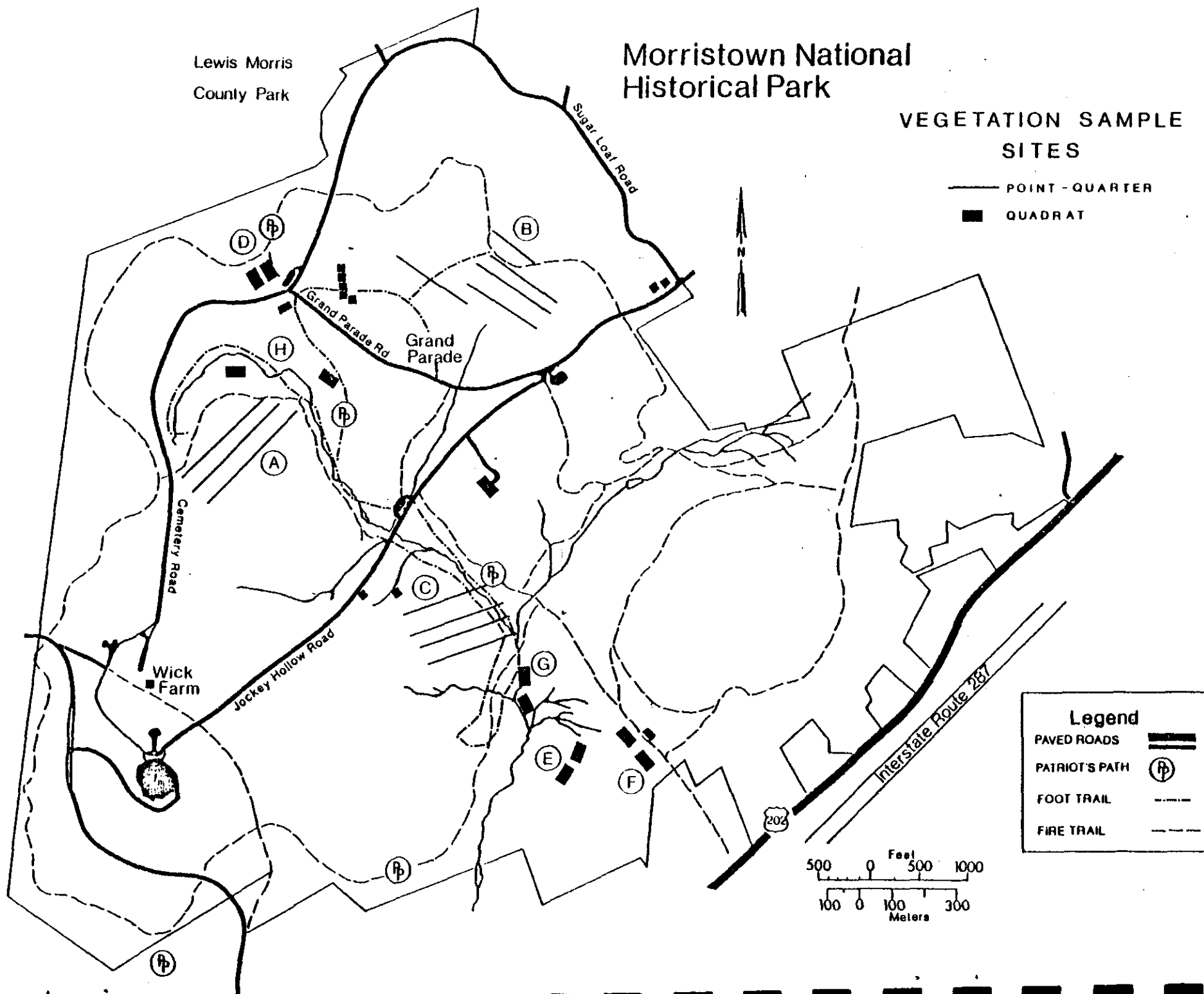
Fig. 6-1. Locations of Sites of Intensive Vegetation Samples:
A: Chestnut Oak-Black Birch; B: Successional;
C: Mixed Oak - Yellow Poplar; D: Yellow Poplar;
E: Mixed Oak - Beech; F: Conifer; G: Stream
Thicket; H: Mixed Hardwoods.

Lewis Morris
County Park

Morristown National Historical Park

VEGETATION SAMPLE SITES

— POINT - QUARTER
■ QUADRAT



MIXED OAK - YELLOW POPLAR

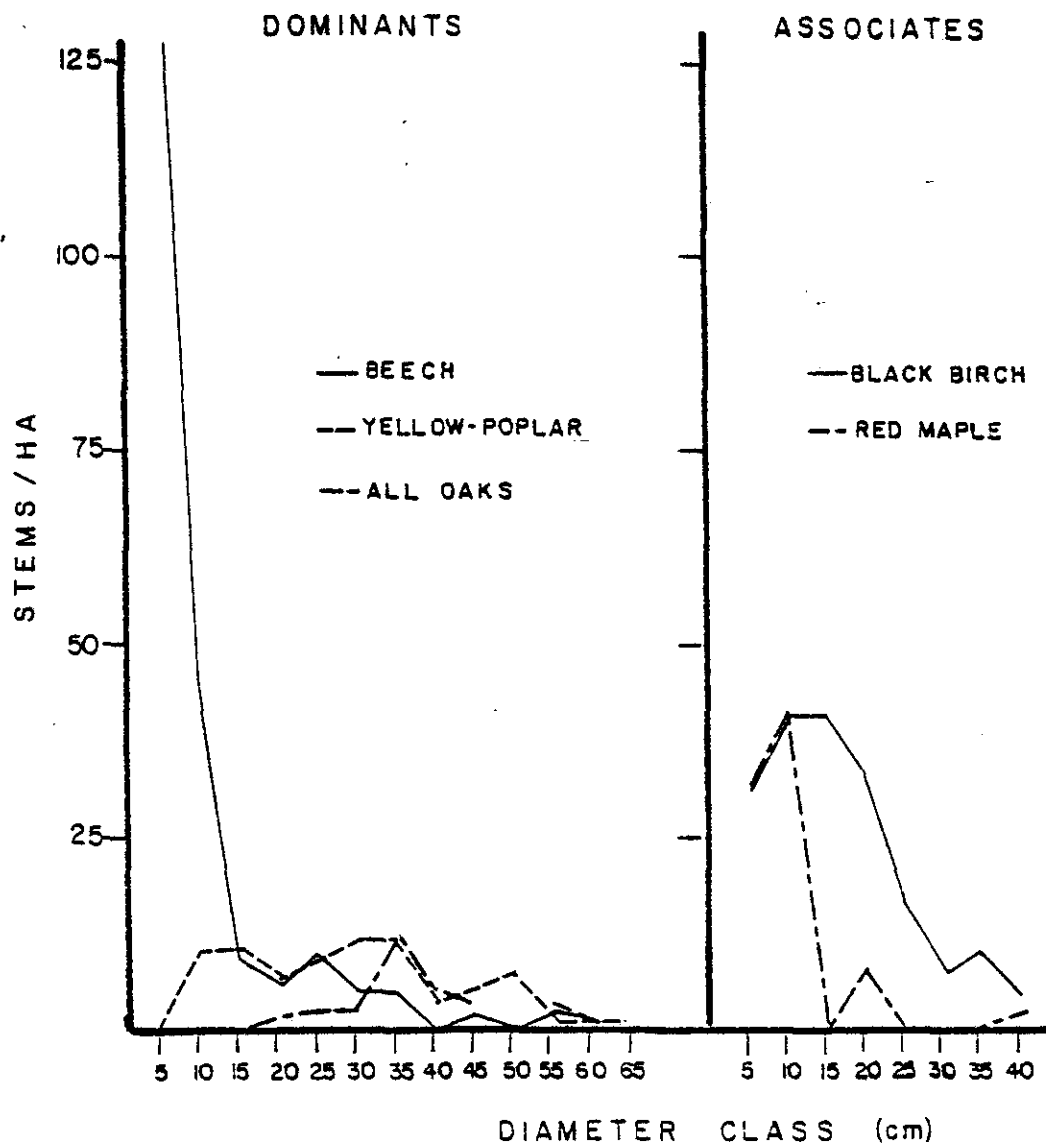


Fig. 6-2. Size-Class Distriubtions of Trees in the Mixed Oak - Yellow Poplar Community. Diameter classes given by class midpoint.

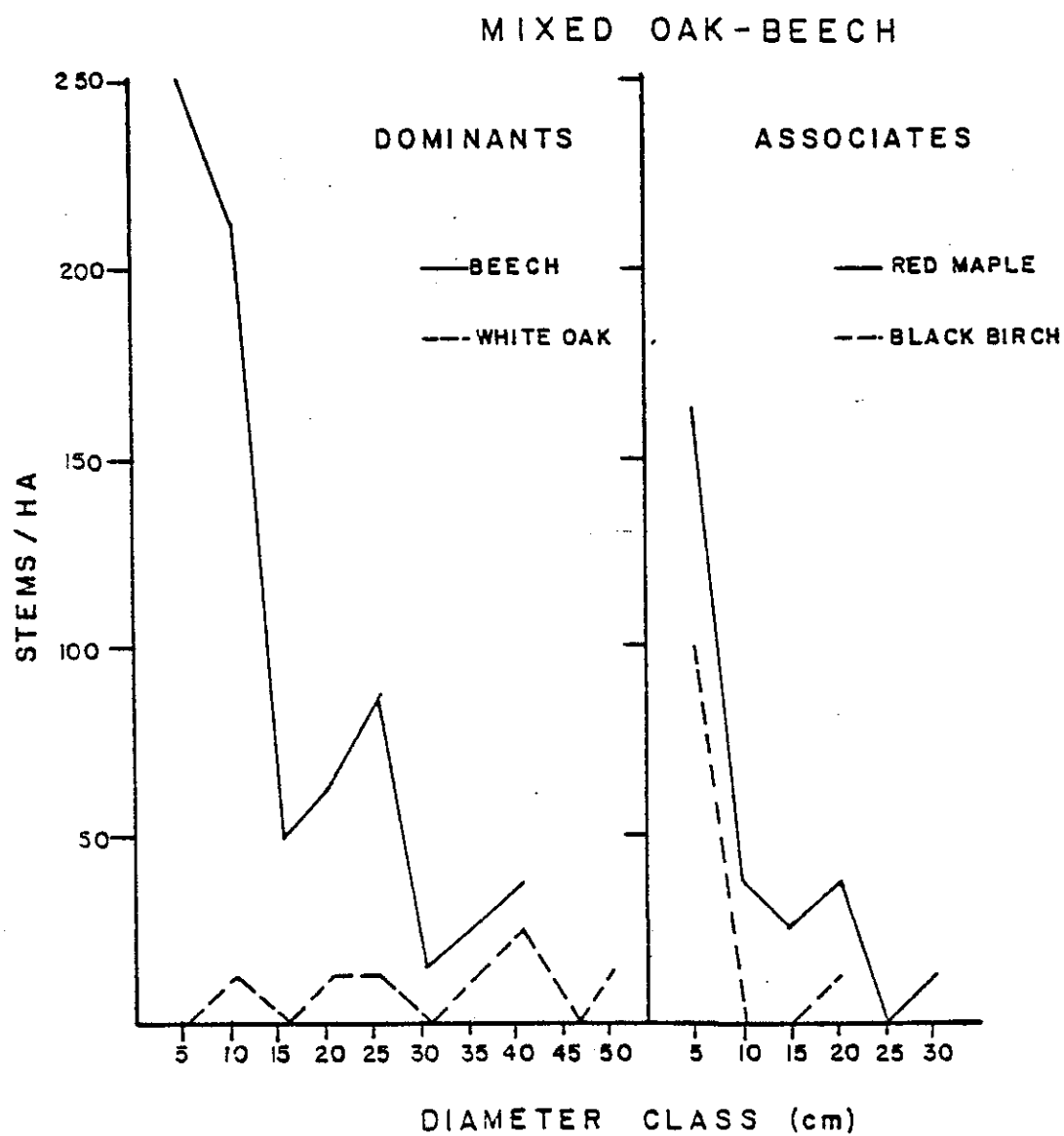


Fig. 6-3. Size-Class Distributions of Trees in the Mixed Oak-Beech Community.



Fig. 6-4. A. Appearance of the Mixed Oak - Beech
Community
B. Appearance of the Mixed Hardwoods Com-
munity



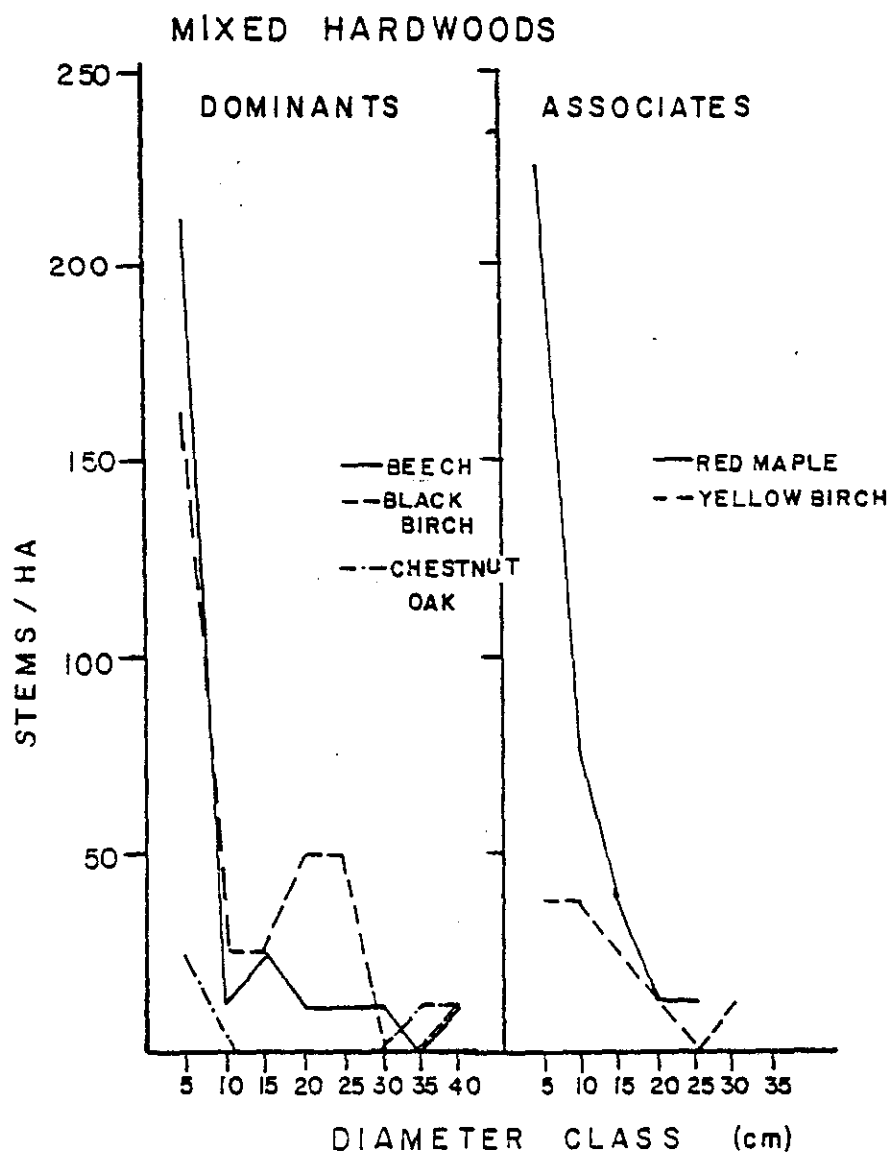
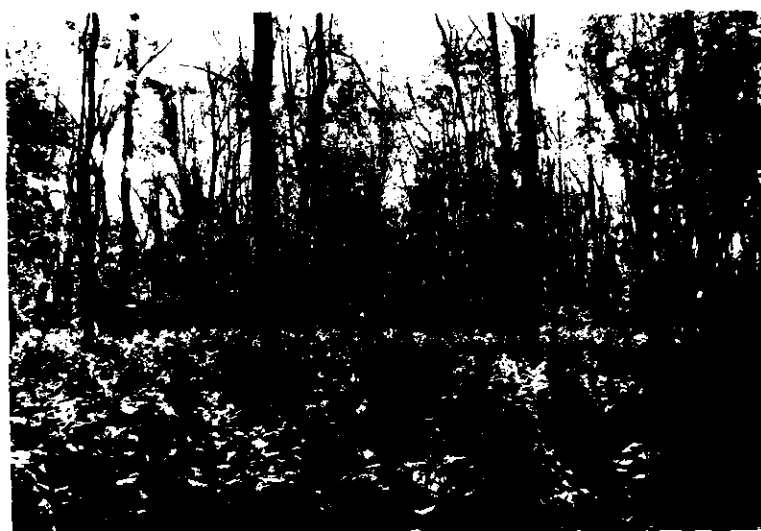


Fig. 6-5. Size-Class Distributions of Trees in the Mixed Hardwoods Community.



Fig. 6-6. A. Appearance of the Stream Thicket
Community
B. Appearance of the Successional Forest
Community



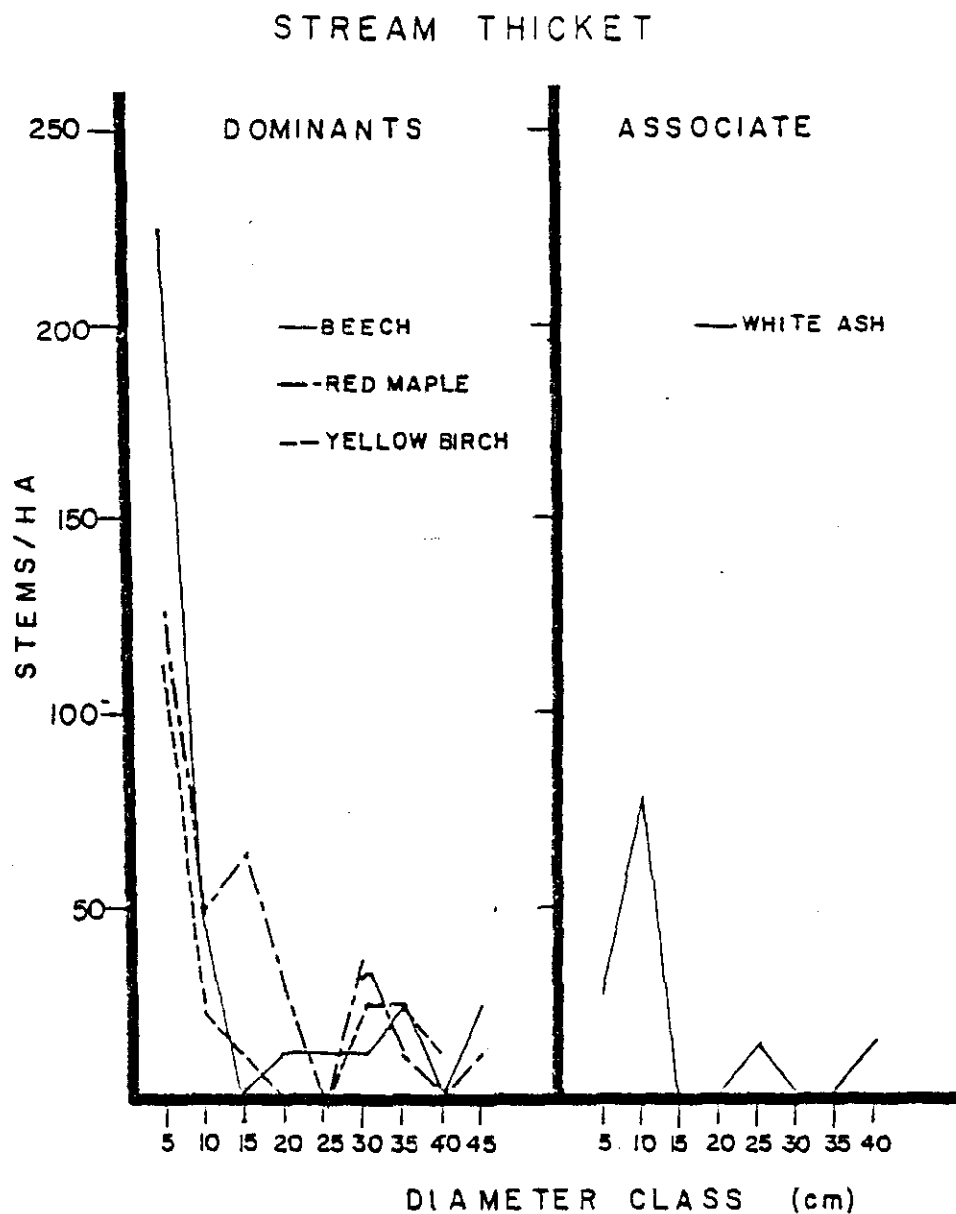


Fig. 6-7. Size-Class Distributions of Trees in the Stream Thicket Community.

SUCCESSIONAL

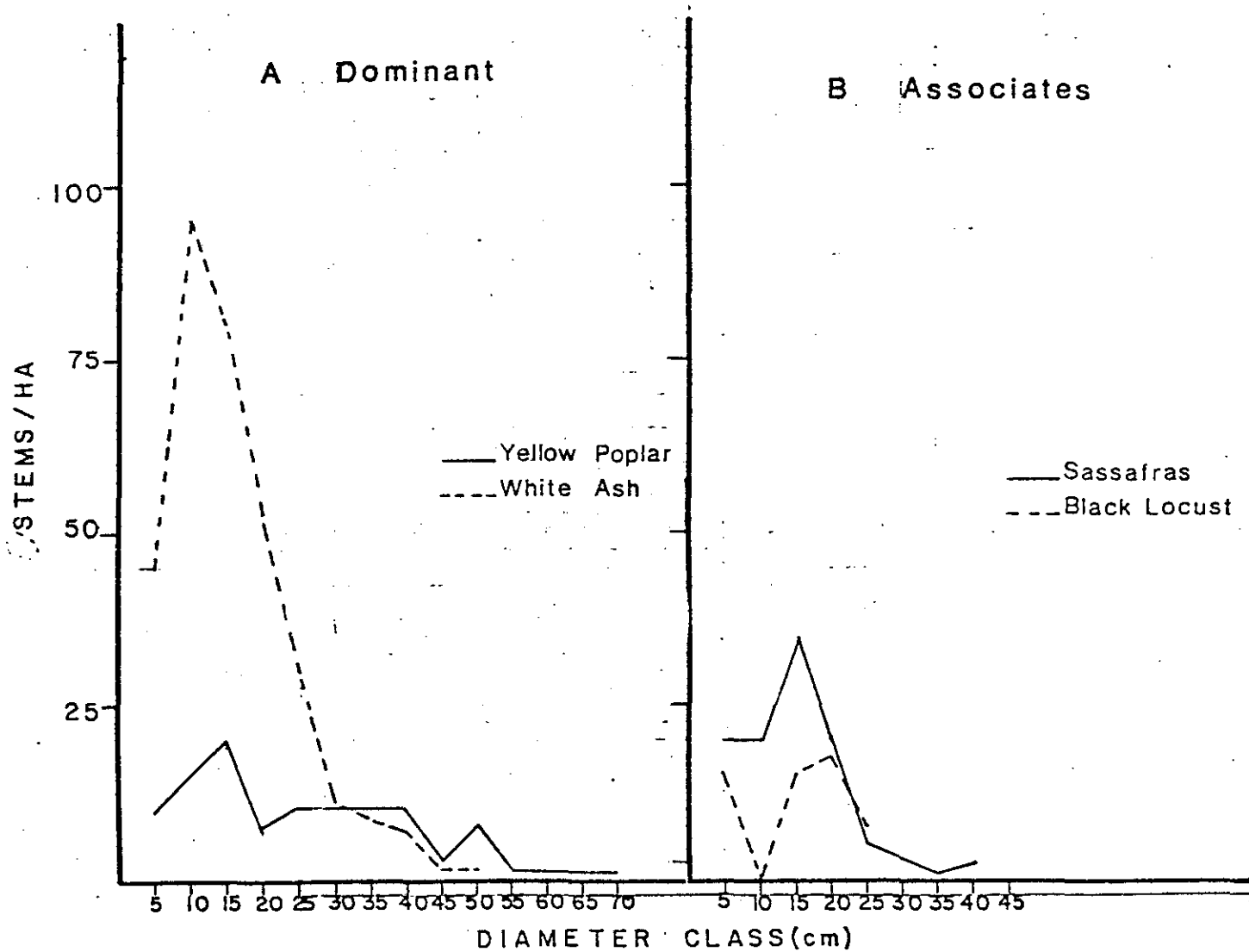


Fig. 6-8. Size-Class Distributions of Trees in the Successional Forest Community

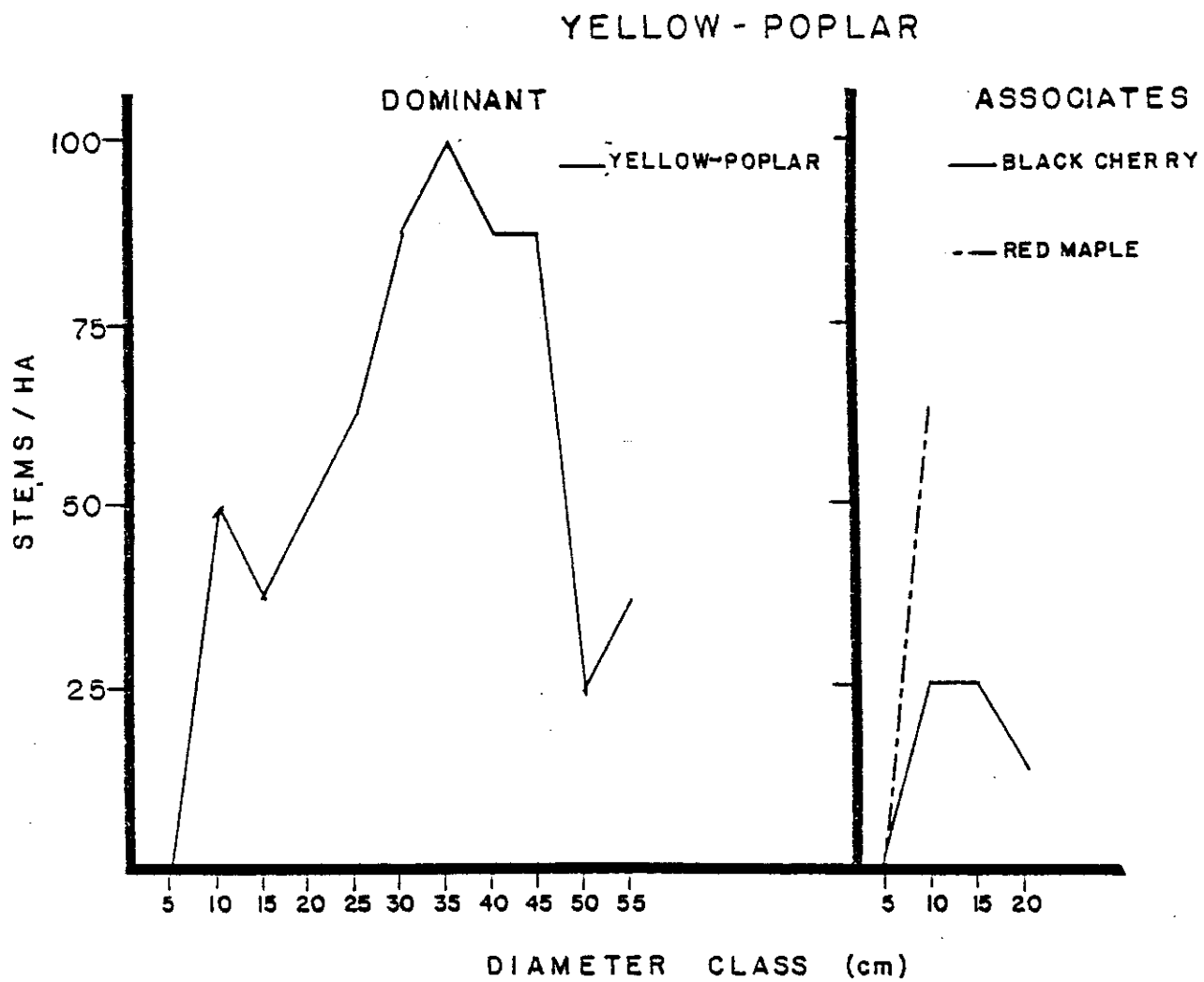


Fig. 6-9. Size-Class Distributions of Trees in the Yellow Poplar Community.

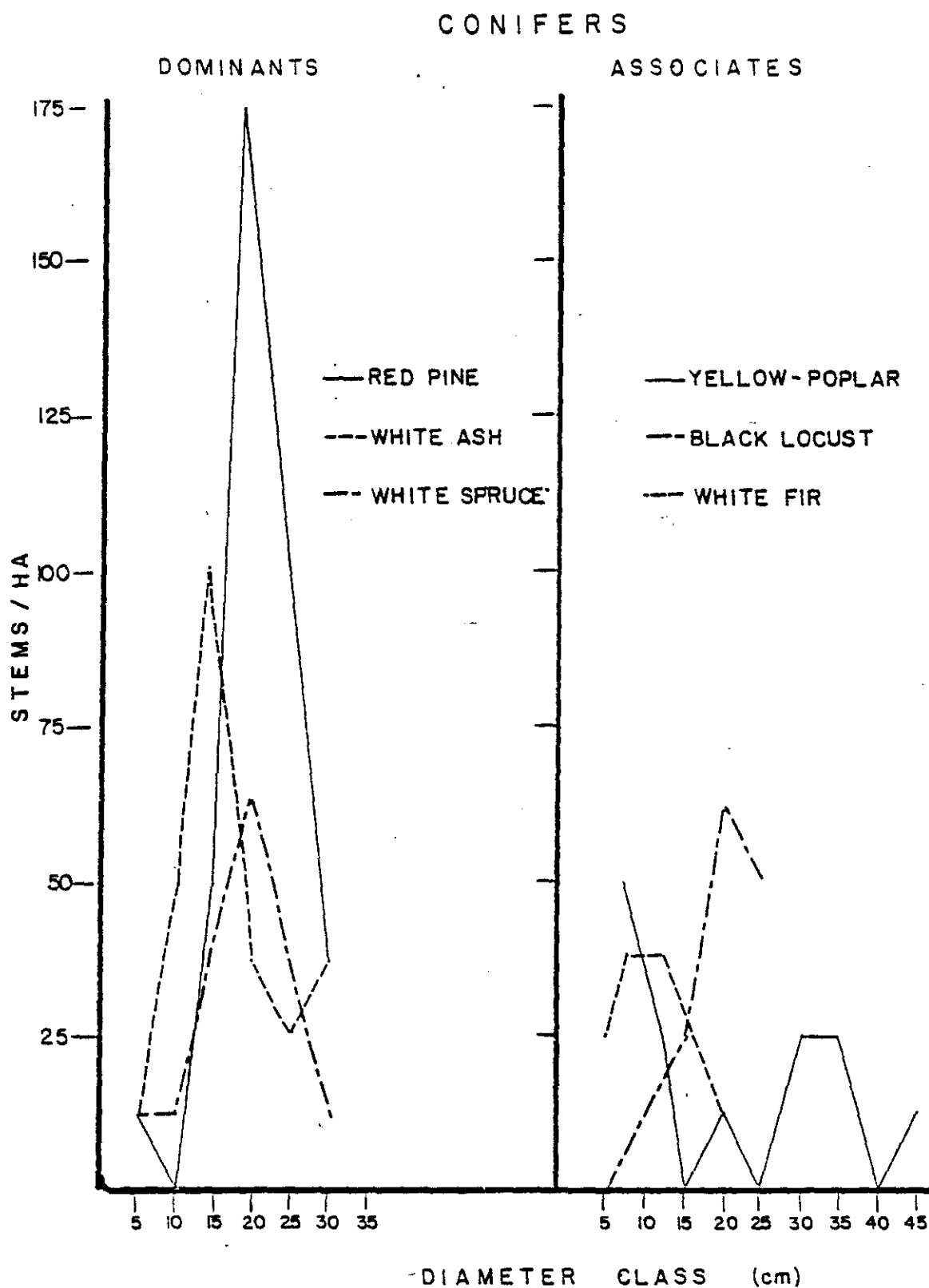


Fig. 6-10. Size-Class Distributions of Trees in the Conifer Community.

CHESTNUT OAK

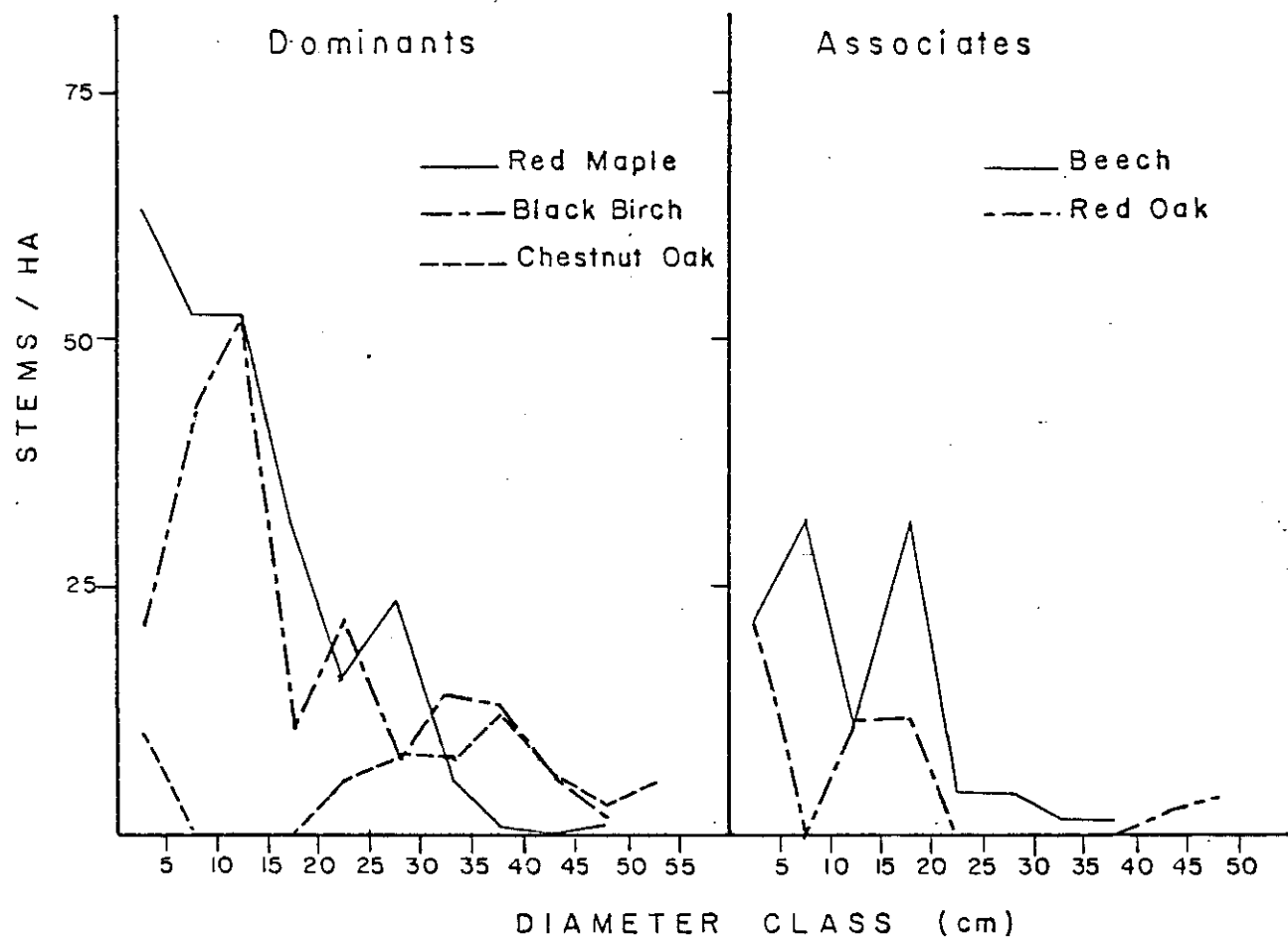


Fig. 6-11. Size-Class Distributions of Trees in the Chestnut Oak Community.

CHAPTER 7. INCREMENT BORINGS OF TREES IN JOCKEY HOLLOW

In this chapter, I present the results of the investigation of tree growth in the Park. The purpose of this segment of the project was to provide equations interrelating age, diameter breast height, and height of the tree, in order to both evaluate the quality of the site, and to provide methods for estimating age from more easily measured tree dimensions.

7.1 Methods

The sampling effort was concentrated on four species and species groups of trees that were clearly of central importance to the dynamics of much of the forest; these were beech, black birch, yellow poplar, and the mid-slope oaks (red, white, and black). Two transects were established along which sample trees were chosen for coring; the transects were placed at mid-slope position through the Mixed Oak - Yellow Poplar stand on the east-facing slope at Fort Hill, and through the Mixed Oak - Beech stand on the lower mid-slope portion of the west-facing slope of Mt. Kemble (Map #1). At sample points located at 40m intervals, the closest canopy-member tree (over 20cm DBH) of each species was cored at breast height and its height and diameter were recorded. Fifteen trees of each species were sampled. The transects were placed so as to reflect moderate site conditions in the Park, thus avoiding the drier slopes and wet valley bottoms. The results thus cannot be applied to trees in these more extreme habitats.

7.2 Results: Tree Growth in the Park

The trees cored spanned a range of ages from 50 to 145 years; the average values of age, height, and diameter for each species are given in Table 7-1. It should be noted that age at breast height may differ from the true age of the tree by 3-20 years (Cook and Good, 1972). This table also gives the site index and the mean annual increment for each species. The site index is the height of dominant and co-dominant trees at 50 years of age; it is a device for expressing the capacity of the site to support the growth of each species (Spurr and Barnes, 1973; Husch *et al.*, 1972). The sensitivity of site index to variations in stand structure and edaphic factors has been extensively studied (Spurr and Barnes, 1973); it has been found to be relatively insensitive to stand density, but quite sensitive to soil factors, the microclimatic factors associated with slope, aspect, and elevation, and species differences. It is most reliable when applied to even-aged stands; this should be borne in mind, insofar as the stands from which these data were taken are not simple even-aged stands. The mean annual increment is calculated as the diameter of the tree divided by the total age (no correction has been made here for bark thickness). Table 7-2 gives regression equations for height vs. age and height vs. diameter. The height-age curves, which are in the general relationship of $\log y = (m/x) + b$, are plotted on rectilinear coordinates in Figure 7-1.

The site indices are higher for oaks and yellow poplar than for beech and black birch, as might be expected in a mature community in which these species dominate. The site index of black birch may reflect its normal position in the lower parts of the overstory; it is typically a medium-size tree, 15-18m tall, and is not found as a dominant in the regional cover-types used by the Society of American Foresters (Fowells, 1965). Thus, the observed height growth here indicates that black birch is able to achieve good growth in these sites. Fowells (1965) reports that it is capable of living up to 200 years, and attaining diameters up to 60cm; thus, it is probable that these trees will persist and increase in diameter, with relatively little increase in height, during the next few decades. The prominence of black birch in the upper layers of the canopy in many of the stands in the Park (see Chapter 6), is thus attributable to the local absence of oaks or yellow poplar, rather than to a normal role as a dominant canopy tree.

Beech is also likely to attain good growth in these stands. The site index compares favorably with data published for the Lakes States area, and the height-age curve (Figure 7-1) approaches an asymptote less rapidly than some of the other species curves. According to Fowells (1965), typical growth of beech is for heights of 18-24m at maturity (at 150-200 years), and the data reported here suggest that beech will readily attain this growth. (Indeed, the maximum DBH of beech observed in the Park was 74cm (see Chapter 6-3). Beech is among the longest-lived of the tree species common to the Northeast, being exceeded only by white oak and sugar maple; it may frequently reach several hundred years of age. The populations in the Park are thus relatively young, and these trees will continue to make good growth of both diameter and height in the future.

The growth of yellow poplar is relatively poor. Although it attains greater heights than the other species studied and emerges above the rest of the canopy, its site index is low compared to values for more southern locations (Fowells, 1965). Its growth has been found to be strongly related to soil texture and moisture-holding capacity (Mowbray and Oosting, 1968; Fowells, 1965), and it may be that the soil characteristics in the Park are limiting to this species. However, both the average height and the slope of the height-age curve are greater for this species than for the others, and thus it can be expected to maintain its position in and above the top canopy layers of the forest.

The height growth of oak showed considerably less variation in relation to age than did that of the other species; this is reflected in the small slope of the regression line (Table 7-2, Fig. 7-1). Since it was possible that species differences among the oaks could account for this, the oak species were analyzed separately. The results for red and black oaks were similar to those for the grouped oaks, but the results for white oak were rather different, and have been reported separately. The height constancy of the oaks with age is also reflected in the similarity of the site index (height at age 50) to the average height of oaks at the current average age of 102. Thus, the oaks can

be expected to maintain a canopy at about 21m under these conditions of growth. According to Fowells (1965), average growth of black oak is 18-24m, and average growth of red and white oaks is 21-30m; thus the projected growth in Jockey Hollow is towards the lower end of the spectrum expected from a mixture of these three species.

The mean annual increment given in Table 7-1 is a rough guide to the growth rate of the trees. As mentioned above, no attempt was made to determine the contribution to diameter growth from bark; these figures, therefore, reflect the total change in diameter. Although the growth rates vary considerably among individuals, these figures, with the reported standard errors, can be used to estimate tree age from measured diameters.

7.3 Results: Old Trees

An attempt was made to locate trees dating from Revolutionary times, and to validate the ages of such trees by core analysis. To this end, a list of unusually large trees was compiled during the transect surveys made for the mapping work (Chapter 5). Subsequently, six of the largest were chosen for coring, the rest being considered unlikely to be 200 years old, either because of location or because of size.

The six trees that were cored are described in Table 7-3, and their locations are shown in Figure 7-2. Unfortunately, only one tree gave evidence of being very old, and this tree has substantial heart rot, which makes accurate dating impossible. It is significant that the tree, a sugar maple, is located near the reputed bake ovens at the Second Maryland Brigade site (Rutsch and Peters, 1976), and near the site of the Stroley house, in an area that has been farmed since Revolutionary times. It is possible that the proximity of the tree to the habitations was a major factor in its preservation; certainly, no trees of comparable age could be found in the mature forest areas maintained as woodlots through historic time. The extrapolated age of this tree is based on the very slow growth demonstrated over the past 70 years in the intact piece of core; if this growth rate is typical, the tree would be about 360 years old. This seems unlikely; it is much more probable that the tree grew more rapidly as a field-grown individual during its early life, and the natural slowing of growth with age coincided with the growth of the surrounding forest. However, the character of the surrounding forest is that of a mature community; this in turn suggests, as described in Chapters 8 and 9, that this tree has been growing within a forest for at least 100 years, and more probably, since shortly after the Revolutionary encampments. Rutsch and Peters (1976) were unfortunately able to uncover but little information about the Maryland Brigade sites, or the bake ovens, and therefore there is no historical material with which to support further speculation about this tree. The remaining large trees were all open-grown specimens, as could be seen in the large size of the annual rings. The large trees that were not cored were all located along old field lines, or within old fields, and therefore also almost certainly owe their size to open growing conditions during their early years.

Thus, it is possible that the sugar maple next to the bake ovens is over 200 years old, but it is unlikely that any other old trees exist in this forest.

Table 7-1. Characteristics of Cored Trees (n = 15 for all species except: white oak n = 5).

Species	Age (yr) $\bar{x} \pm \text{s.e.}$ (range)	DBH (cm) $\bar{x} \pm \text{s.e.}$ (range)	Hgt. (m) $\bar{x} \pm \text{s.e.}$ (range)	Site Index	Mean Ann. Incr. (cm/yr)
Beech	76.9+4.24 (43-91)	33.5+1.82 (20.6-47.0)	18.2+0.89 (10.9-23.0)	15.5	0.445
Black Birch	78.5+4.77 (53-112)	30.3+1.47 (23.9-43.2)	18.9+0.67 (14.8-23.0)	17.0	0.398
Yellow poplar	64.7+4.67 (33-100)	37.6+2.20 (21.8-53.3)	22.6+1.26 (20.0-32.4)	20.0	0.600
All Oaks	102.1+6.13 (51-142)	43.7+10.22 (31.0-60.0)	21.2+0.83 (16.4-28.5)	21.0	0.461
White Oak	112+11.07 (83-142)	40.7+3.94 (31.0-48.0)	21.1+1.70 (16.4-26.1)	18.0	0.330

Table 7-2. Regression Equations for height vs. age and vs. diameter for four species or species-groups.
All regression coefficients significantly different from zero at $P \leq 0.05$.

Species	Height (Y) vs. Age (X); (n)	Height (Y) vs. Diam. (X) (n = 15)
Beech	$\log Y = -10.455/x + 1396$ (14)	$Y = 3.565 x + 4.163$
Black Birch	$\log Y = -9.079/x + 1.404$ (15)	$Y = 2.448 x + 10.030$
Yellow poplar	$\log Y = -10.605/x + 1.526$ (8)	$Y = 1.604 x + 16.066$
All oak	$\log Y = -0.614/x + 1.328$ (15)	$Y = 1.198 x + 14.945$
White oak	$\log Y = -5.941/x + 1.375$ (5)	$Y = 3.052 x + 6.318$

Table 7-3. Large Trees Cored for Age Determination

Map Label	Species	DBH (cm)	Age (Yr.)
A	Sugar Maple	88.1	c. 360 ^a
B	Sugar Maple	83.3	150
C	Black Oak	93.2	107
D	White Oak ^c	99.8	145 ^b
E	White Oak	83.1	145
F	Elm ^c	60.2	137

^aTree has heart rot; this age estimated from 0.18 cm/yr. diameter growth rate measured in 10cm of good core obtained from tree; see text for discussion.

^bCorer unable to reach tree center; age estimated from growth rate.

^cSprout clump; largest stem measured and cored.

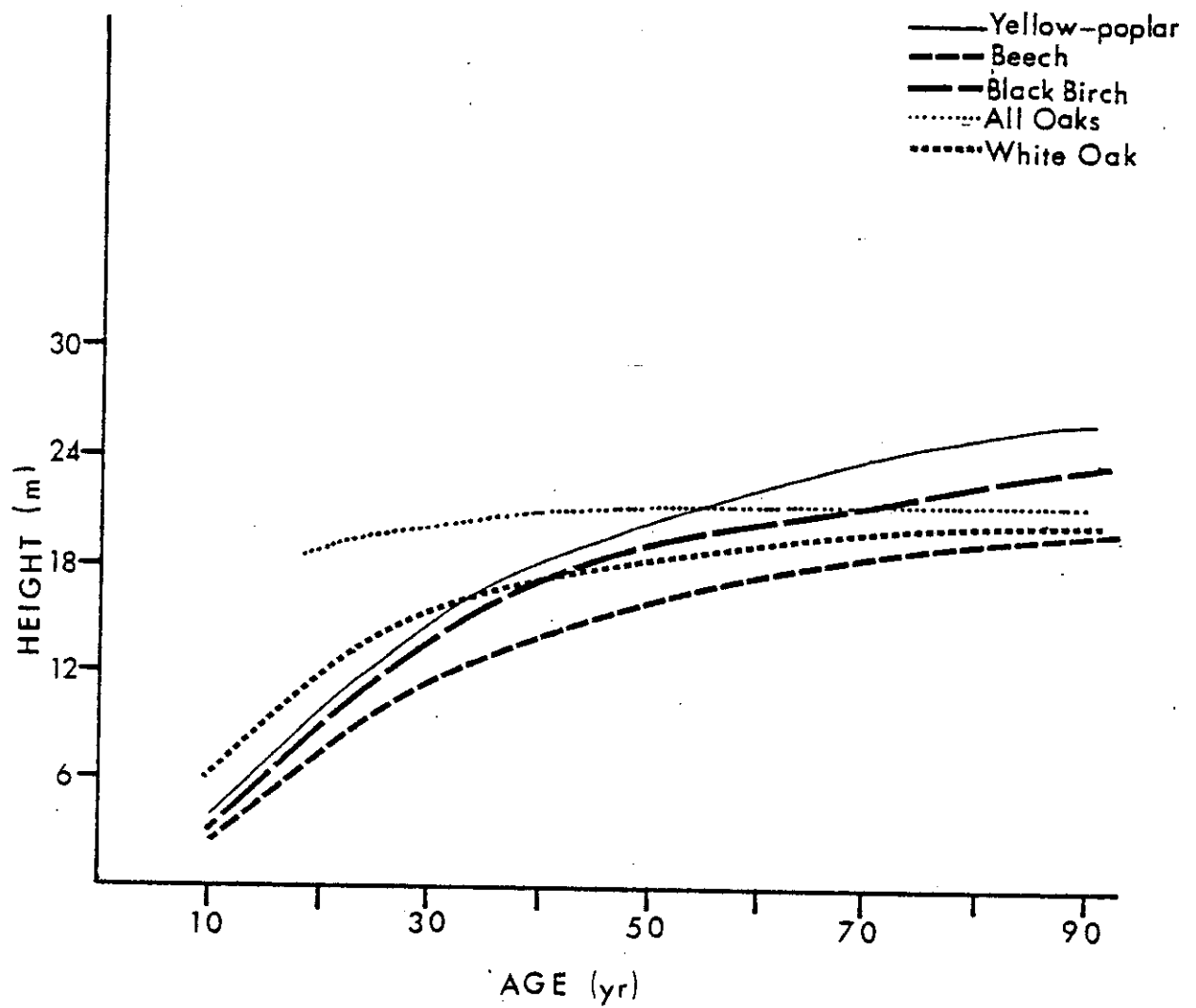
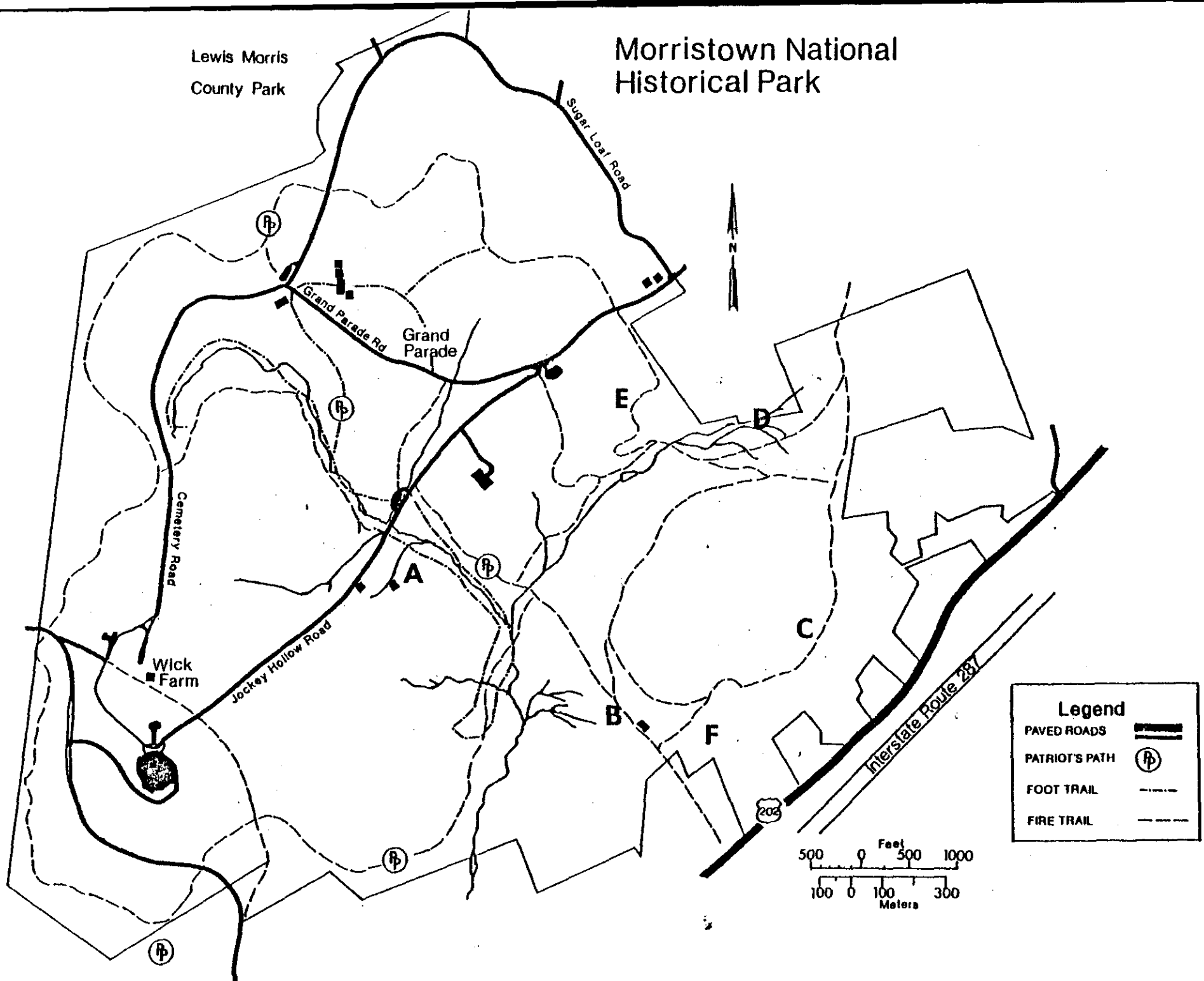


Fig. 7-1. Regression Curves for Tree Height as a Function of Age.

Fig. 7-2. Locations of Old Trees Cored for Age Determination.

Lewis Morris
County Park

Morristown National Historical Park



CHAPTER 8. HISTORICAL ASPECTS OF THE VEGETATION IN JOCKEY HOLLOW

In this chapter, the available information on the nature of the original forest and on the history of the use of land has been assembled. The analysis is based upon examination of all readily available sources; limitations of time did not permit the exhaustive historical investigation which would be necessary to establish these facts in detail. However, the information which has been obtained may be useful in the interpretation of historical features, providing that the limitations of inference are taken into account.

8.1 Review of Information in the Midyear Report

In Ehrenfeld (1977), the observations of colonial-era travelers were summarized and were correlated with contemporary studies of the past vegetation of northern New Jersey. These accounts uniformly listed oaks, chestnut, and hickory as the dominant species, and maples, walnut, yellow poplar, beech, elm, blackgum, locust, sassafras, and ash as the associated species; fruit trees, berry bushes, and grape vines were also common elements of the vegetation. The mesophytic species - beech, sugar maple, yellow birch, and hemlock were probably not abundant, insofar as they were rarely mentioned in journals or boundary surveys. On the contrary, early successional, or intolerant species, were frequently mentioned; these included walnut, sassafras, ash, and yellow poplar. Although much of the Highlands was heavily logged in support of the iron foundries, the initial evidence suggested that the forests in Jockey Hollow were distant from the centers of the iron industry and that logging never involved frequent clear-cutting, certainly not prior to the Revolutionary War. Therefore, it was concluded that the vegetation present at the time of the War was similar in species composition, if not in proportional representation of species, to much of the forest extant today.

With regard to the history of land-use in the Park, the documentary sources under scrutiny were listed in Ehrenfeld (1977), and the map presenting the information was described. Information from historical accounts, deeds, and related legal documents, Cobbett et al. (1938), and the maps listed in Table 1-1 were consulted.

8.2 Further Data on the Original Vegetation of the Park

In view of the uniformity of the travellers' accounts of the New Jersey forests, and the evident lack of floristically inclined travelers who actually passed through Morristown, I decided that the information obtained from deeds and surveys in the Jockey Hollow area would be more useful than further accounts written by colonists. Therefore, a concerted effort was made to examine the deed books on file at Park Headquarters, the surveys recorded in the deed books of the west Jersey Proprietors (on file at the New Jersey Room of the Alexander Library, Rutgers University), and miscellaneous deed and surveys of

the pre-War period in the New Jersey Room collection. This effort yielded disappointing results, in that most of the deeds for land in the Jockey Hollow area did not describe boundary trees, or other features of the land, and some of the early surveys in the area, notably those by Thomas Millege and John Lawrence, could not be located.

Table 8-1 lists the boundary trees that were obtained from this search and Table 8-2 lists the sources from which these were obtained. The data in the table include trees on boundaries not within the present Park, and thus not included in Land-Use History Map. A total of forty trees was located for the period c.1720-1840; taken together, they indicate that the forest varied between an oak-hickory association and an oak-chestnut association, the expected primary forest type for this part of the country (Braun, 1950). The distribution of the mapped trees (Land-Use History Map) suggests that the oak-chestnut association was better developed on the lower slopes surrounding the branches of Primrose Brook, whereas the oak-hickory association was more common on the higher slopes. This inference coincides both with the present distribution of abundant chestnut sprouts (Figure 4-1) and the general pattern of distribution of these community types, as described in Braun (1950) and Raup (1938). This inference is, however, based on scanty evidence. Unfortunately, virtually none of the deeds written in the early to mid-1800's incorporated boundary trees that covered the original Kemble estate and thus it is a matter of conjecture as to how the forest varied on the sides of Mt. Kemble.

Another detailed source of information about the regional forest was the survey, made by John Lawrence, of the division line between East and West Jersey, which ran within a few miles of the Park (Lawrence, 1743). I tabulated the survey trees, which were recorded at one-mile intervals, between "Chambers Brook", near Baskingridge, and the Muskonetcong River, twenty-two miles to the north. Of the twenty-one trees, 33% were white oak, 19% red oak, 14% black oak, 28% hickory, and 6% chestnut, a composition similar to the postulated oak-hickory association of the Park.

Several inferences concerning the nature of the original forest in comparison with that growing today can be made on the basis of these data. First, chestnut, in an oak-chestnut association, was an important part of the forest of the lower slopes, but probably was less important (although present), on the higher slopes. According to Braun (1950), the oak-chestnut association often had associated with it an ericaceous understory, which is almost entirely lacking in the forests today. The only suggestion of the typical heath understory is the abundance of low-bush blueberry on the higher slopes of Tea Hill and Mt. Kemble. It may be that the relief and elevation of the hills in Jockey Hollow have never been sufficient to support this kind of understory community. Second, the hickory species were clearly much more important in the original forest than they are today. Although they are locally abundant, they failed to emerge as a co-dominant of the oaks over an area large enough for mapping as a distinct community type (Chapter 5). Their decrease is possibly attributable to selective logging practiced over an extended time;

hickory would have been highly favored for fuelwood and sawtimber, and although it is capable of sprouting (Fowells, 1965), it evidently cannot compete with such trees as red maple and chestnut oak. Third, two groups of species have evidently increased in importance, compared to the original forest. One group, including red maple, black birch, and chestnut oak, has been favored by cutting and other disturbances, because they either sprout prolifically or are excellent at colonizing disturbed soil or rotting logs. The second group, including beech, yellow poplar, and perhaps red oak, is more mesic in ecological flavor than are the oak-chestnut or oak-hickory forest associations. Although the increase in yellow poplar is in part due to its ability to act as a pioneer species as well as a mature forest species, the general increase in mesic species suggests the long-term climatic trend toward cooler, moister climates, described by Raup (1937, 1938; see Chapter 3), may have been important in the development of the forest since pre-Revolutionary times. Fourth, it is clear from the species listed in Table 8-1 that the minor species present in the 1700's are paralleled by the minor species present today. Fifth, the sparse presence of naturally occurring conifers (hemlock, white pine, pitch pine), probably reflects the pre-colonial situation. The absence of any documentary evidence suggesting their presence; the geographical position of Jockey Hollow south of the optimal area for white pine (Braun, 1950), and the observation of Vermeule (1900) that conifers were sparse all suggest that the native conifers were present only in restricted localities, much as they are today.

Thus, the pre-Revolutionary forest was very similar to that found today, differing primarily in that chestnut was a major element of the forest community, and that some of the component species were present in altered proportions. A list of particular stands most likely to represent the old-growth community has been compiled in Chapter 2-9.

8.3 The History of Land Use in Jockey Hollow

The use of land in Jockey Hollow has been a function of the topography of the region and the changing economy of the surrounding population. Although it has been impossible in the time available for this study to completely reconstruct this history, some of the general outlines of the land-use patterns have emerged, together with enough specific information to lend credence to deduced patterns.

The information gathered has been plotted on the same base map of Jockey Hollow that was used for the maps of the vegetation (Land-Use History Map). Each item of information for a particular place is given with the date and the source of the information and the bibliographic information for each source is listed in the Literature Cited section of this report. Appendix 3 supplies information needed for use of the map.

The information available for the portion of the Park within the Wick Farm-Guerin Farm area was vastly greater than that available for the Kemble Estate, a consequence of the fact that many of the source

materials available were assembled prior to the acquisition of the lands comprising part of the Kemble Estate. Although some effort was made to locate information describing the Kemble lands, the readily available documents yielded no information, and time did not permit a search for the more obscure sources. Therefore, interpretation of the history of these lands is largely based on inference from the western portion of the Park.

The sources of information for the mapping of land-use history include accounts prepared by the inhabitants and visitors to the land, historical, and archeological studies done by Park personnel and others, and inferences based on characteristics of the present-day vegetation.

Frustratingly, most of those who lived in Jockey Hollow, as well as Army personnel present during the War, were not inclined to describe the landscapes in which they lived. For example, the diary kept by Peter Kemble during the early years of the Kemble estate mentions only the kind of fruit tree he had planted (no special location given), the beauty of the fall colors in the woods, and a fire in the meadows one summer; no other indication of the use of the land can be found (Kemble, 1780-1785). Again, Enos Reeves, a Lieutenant of the Pennsylvania Line, said that he had his men cut 2250 cords of wood in December, 1780, thus clearing the "remaining woodland belonging to Mr. Wicks" (Reeves, 1780). At the average stocking for oak woods of 20 cords/acre (Stout, pers. comm.), this would have meant 110 acres cleared; it is unclear where these acres were located. Reeves stated that 600 acres were cleared the previous winter; thus about 710 acres of the area's 1345 acres were cleared. Assuming that about 300 acres were under cultivation (as shown in the Ludlow map, 1787), about 300 acres would be left, enough to leave in doubt the locations of the cut-over areas.

The accounts left by those who lived on the land thus required a good imagination for their interpretation. Fortunately, one long-term inhabitant, Mrs. Elsie Weig, was an acute observer, and supplied a wealth of detailed information about the past seventy years of history. Rutsch and Peters (1976) have presented a detailed summary of the land ownership histories of the Wick and Guerin Farms; this information has not been included here. The general pattern of land-use history is apparent, however, from the assembled information. Although the land was first surveyed in 1715, settlement did not follow for several decades. Henry Wick and his father-in-law, Nathan Cooper, cleared it for agriculture after it was purchased in 1746 from Francis Rawles. This settlement was a part of the general influx of population into the Highlands of New Jersey which occurred around the same late date (Wacker, 1975). From the Ludlow map (1787) it can be seen that only the level and gently sloping land was thus cleared; woodland was retained on the steep slopes of Blatchley's Hill, and along the ridge running adjacent to Dr. Leddel's land on the western edge of the farm. Although the Ludlow map gives no indication of the use of the land near the main channel of the Primrose Brook West Branch, the present composition suggests that

this land, too, was retained as woodlot (see below). The Kemble estate was purchased in 1757, and was similarly largely cleared for agriculture (McClintock, 1894); that is, the lower eastern slopes of Tea Hill and Mt. Kemble, and the level and gently sloping land lying between the western boundary of the property and the road to Morristown (Rte. 202) were thus cleared, but the steeper slopes and the western sides of the two hills were evidently kept in woodland. The cleared lands were farmed by a sizeable population of slaves (Anon, 1882). The absence of boundary trees in the property deeds written during the early 1800's may be evidence for the clearing of these slopes during the tenure of the Kembles. No information was obtained concerning the Guerin farm; evidently, considerably less research has been devoted to this segment of the land (Rutsch and Peters, 1976), fewer sources have been assembled, and time did not permit independent search for such sources. Although the lands of the Guerin farm were virtually entirely used for farming at the inception of the Park, it remains to be determined when this clearing took place. From the description of the Guerin family in Rutsch and Peters (1976), it is evident that the original farm was a small affair, worked entirely by the family, without the help of slaves, and therefore it seems reasonable to suppose that like the Wick Farm, much of the land was kept in woodlot, and only the gentle slopes at the base of Sugar Loaf Hill were cleared for farming. Indeed, the woods on the hills were not thought valuable until after the turn of the nineteenth century (Anon., 1882). Therefore, it seems that actually a small proportion of the land now encompassed by the Park was cleared during the first wave of settlement, and that much of the land, occupying the steep slopes and dry ridges of the hills, was left alone.

There is also little evidence that the growing iron industry or the saw-timber industry had a great impact on the farm woodlots during the early years of settlement. According to Weig (1941), there was an iron forge (John Johnson's) present in 1779 near Leddell's Pond, for which wood was undoubtedly obtained in part from the forests around Jockey Hollow, but it seems unlikely that stands were completely cleared for it, at least prior to the War.

The best evidence that much of the land remained forested after settlement is, of course, the fact that the area was chosen for the encampment of the troops in part because there was "an abundance of oak and walnut" (Thatcher, 1779) that was "sufficient for the purpose of hutting and firing if it was used properly" (Greene, 1779). Lieutenant Reeves reported that 600 acres of forest were cleared by the Pennsylvania Brigade (and others) during the 1779-80 encampment, and yet 110 acres of woodland remained for these troops to cut the following year (Reeves, 1780). Again, Greene and Duportail (1780) felt that the standing wood between Fort Hill and the ridge just west of the Wick House, and between the ridge and the next hill west of it (see map of Rochfontaine, 1780, in Rutsch and Peters, 1976, Fig. 5), was sufficient to be used tactically in planning for British attacks.

It can fairly be presumed that the woodlands surrounding the brigade sites were completely cut for wood to construct and heat

the huts. It is unclear, however, how far from the encampments the soldiers went to obtain these supplies, and whether the suggestions of General Greene regarding the maintenance of wooded areas for tactical purposes were followed by the troops. Lieutenant Reeves (1780) said of Dr. Leddell's property, "We last winter destroyed six hundred acres of woodland for him and his step-father, and I suppose this winter will clear the plantation of every tree." From the geographical relations between Hand's Brigade, where his troops were renovating the huts of the prior year's encampment, and Dr. Leddell's property, it seems that the wood to which Reeves referred was that on the ridge on the western boundary of the Wick property, and possibly that on the hillsides between the Wick fields and Primrose Brook, but this is mere speculation. Unless more extensive documentary material from the period of the encampments is located to pinpoint the sources of the wood cut for the army, it will not be possible to ascertain which lands were entirely cleared by the soldiers, and which, if any, were logged but not entirely cleared. It can only be presumed that the slopes more distant from the brigade lines, such as the upper slopes of Tea Hill or Blatchley's Hill, and the northwestern parts of Mt. Kemble, were least used by the troops.

Land-use patterns after the war remain equally shrouded in mystery. However, some speculation can be based on the general patterns of agriculture that have been deduced for that time (Wacker, 1975). During the first half of the century, a greater proportion of land was cleared for agriculture than at any other time in American history (Vermeule, 1900; Spurr and Barnes, 1973). Concurrently with this agricultural activity, the iron industry in northern New Jersey reached its greatest development, with iron mines and forges scattered throughout the area around Morristown (as well as the rest of northern New Jersey; Boyer, 1931; Wacker, 1975; Anderson, 1932; Tuttle, 1850). At the same time, in Jockey Hollow, the Wick farm was divided into several homesteads, after the death of Mary Wick (Rutsch and Peters, 1976); dwellings were constructed, and tenant families moved in. Subsequent deaths and property divisions among heirs resulted in further splintering of the farms. It is probable, then, that the increase in number of homesteads and the social and economic climate favoring farming combined to keep open some of the area cleared by the soldiers. In Chapter 6-4, it was suggested that some of the present-day Mixed Hardwoods stands may occupy sites that were farmed after the soldiers left and the Wick Farm was fragmented.

It is clear, however, from the topography, from the vegetational evidence (discussed passim in Chapter 6, and see below), and from a few sources, that some of the cleared land was allowed to revert to forest immediately after the War. The eastern slope of Fort Hill, except for a couple of pastures maintained on the hillside (see Land-Use Map) is a case in point (see Chapter 6-2). The steep slopes of the ridge along the western border of the Wick Farm is another candidate for such history; its present vegetation of mature oak, combined with its topographic unsuitability for agriculture, suggests strongly that it is reverted to forest without an interim

period of fields. Other areas with suitable combinations of topography and vegetation are the Chestnut Oak - Black Birch stand lying south of the Aqueduct Trail and northeast of the Cemetary Road, the mature forests on Blatchley's Hill, and the west-facing slopes of Mt. Kemble and Tea Hill.

The evidence in the present vegetation that suggests these conclusions includes the following: a pronounced "pit-and-mound" microtopography, which indicates long-term persistence of forest on the site; extensive sprout-clump origin or present-day trees, which indicates at least one generation of trees prior to the 80 to 100-year-old trees growing on these sites today, and in some sites (see Chapter 4-3), extensive sprouts of the American chestnut, which indicates that vigorous, mature stands of this species were present c. 1910. In one place (at the base of Mt. Kemble, just east of the East Branch of the Primrose Brook), a stump was found which was from a sprout clump of chestnut; the two chestnut sprouts appeared, from their diameters, to have been about 70 years old when they died (1910-1920), and they had clearly originated from a large chestnut tree, of at least the same age when it was cut. By subtraction, the original chestnut must have been growing on the site before the soldiers arrived, and must have escaped their axes, in order to have given rise to the sprout clump whose base is still present. Finally, two of the deeds from the 1840's examined in the search for boundary trees described woodlots of mature trees which were to be managed for timber by the new owner (R.K. Tuttle to W. Tuttle, 1843, C-4-429; H. Baxter and wife to J.W. Blachley, 1852, Y-4-235; deeds on file at Park Headquarters); the presence of mature forest in 1840 indicates that no farming intervened on these sites between the time of the soldiers and the time of the deeds. Thus, much of the mature woodland present today is on land that has never been cleared for cultivation. (See Chapter 2-9 for specific discussion.)

By the middle of the nineteenth century, the amount of land in cultivation had reached its zenith, and lands were increasingly allowed to revert to forest (Vermeule, 1900; Robichaud and Buell, 1973). Although there is no available data indicating how this general trend affected the farms in Jockey Hollow, it may fairly be surmised that no new land was brought under cultivation at this time, and some previously cleared land may have been allowed to revert to forest. The mixed hardwood stands on the eastern slope of Mt. Kemble, along Jersey Brook, south of new Tempe Wick Road, and on the summit of Sugar Loaf Hill could represent such lands.

At the end of the nineteenth century, considerably more information about land-use was recorded. In 1871, the Reverend Joseph Tuttle visited the sites of the encampments with a former resident of the farm who had known Captain William Tuttle, husband of Tempe Wick. He published a detailed description of some of the land at that time (1871). McClintock published another description, considerably more detailed, in 1894, and Vermeule and Stock (1900) mapped the presence of forested lands, and described their general composition. Henry Pitney (1934) wrote down his observations of the land in the course of installing the Morristown Aqueduct System during the 1890's (see Rutsch

and Peters, 1976 for a detailed description of this event).

These accounts show little change in the distribution of fields and forest during the time period 1878-1900, and this pattern is preserved in the vegetation map prepared in 1937 for the Park. There was thus very little change in the arrangement or size of the farms from the second half of the nineteenth century until the inception of the Park in 1933. The few changes that took place were all in the form of fields reverting to forest: the land at the northeast corner of Jockey Hollow Road and old Tempe Wick Road was ploughed in 1870, and was forested by 1900, fields along Jockey Hollow Road between the Old Camp Road and the site of the New York Brigade came up in young woods, and the site of the first Maryland Brigade changed from ploughed field to woods. The remainder of the fields were kept in use for sheep, cattle, hay crops, and orchards by tenant farmers, until the 1920's to 1930's, when the land was acquired for the Park. Weig (1977) has given an admirably exact description of land-use in Jockey Hollow in the period 1900-1930; the reader is referred to this manuscript (Park files) for further information.

As was mentioned previously, most of the land-use information concerns the Wick and Guerin Farms, and little information has surfaced concerning the Kemble lands. Much of the eastern face of Mt. Kemble was owned during the late 1800's and early 1900's by William P. Jenks, who maintained goats and sheep on the land, and farmed most of the property. Rutsch and Peters (1976) found that much of the Stark's Brigade site had been ploughed. Today, much of the area on the east slope of Mt. Kemble supports successional forest; many of the stands are considerably younger than those on, for example, Sugar Loaf Hill, and probably have grown up in the last twenty years. Further indications of land-use history can be gleaned from the nature of the Mixed Oak - Yellow Poplar stand beneath the former orchard field on the summit of Mt. Kemble: although it is mapped by Eby (1976) as being on the same type of soil as the western slope of the mountain (that is, an extremely stony sandy loam), the ground today appears bare of stones, and the vegetation resembles more closely the forests on the non-stony Edneyville soils. This feature of the soils is probably the result of clearing and ploughing. The eastern slope of the hill is also covered with a dense network of old roads and trails. Many of these trails are bordered by open-grown trees, indicating that within the past 100 years the forest has grown up to surround these trees. In Ehrenfeld (1977), an association between the location of exotic species and this trail system was noted; this is further evidence of the role of human activity in shaping these forests. Some of these trails are bordered by the non-native conifer species associated with the plantations (Chapter 6-8). In summary, then, these disparate bits of evidence suggest that most of the eastern slope of Mt. Kemble, and perhaps also Tea Hill, were cleared for agriculture initially, that they reverted to forest more recently than the successional stands elsewhere in the Park, and that human disturbance of the natural vegetation has been much more pronounced than elsewhere in the Park. Considerably more research would be necessary, however, to accurately reconstruct the land-use history of the Kemble Estate.

The Report on Forests written by Vermeule in 1900 provides an excellent overview of the historical development of the forests growing on the permanent woodlot sites. In this work, virtually all forested regions of New Jersey were examined and mapped during the 1890's. As was noted earlier, the distribution of fields and forests shown for Jockey Hollow were accurate, and thus, it is likely that Vermeule and his coworkers actually passed through Jockey Hollow. They reported that in general, in the Highlands, coppice stands of oak and chestnut were the predominant forest type; black walnut, yellow poplar, beech, and conifers such as white pine and hemlock were scarce. Near Morristown, hickory, birch, white birch, (grey birch, *B. populifolia*) maple and elm were also common. Although the Highlands had been subjected to severe, frequent cutting during the earlier part of the nineteenth century, the lands south of Morristown were observed to have suffered less from excessive logging; the stands were somewhat older and better grown than the stands further to the north and west. Most of the timber at that time was 15-25 cm DBH, and about 40 years old, and advance regeneration (trees in the 5-10 cm DBH size class) was abundant. Although scattered trees attained diameters of 50 cm, none of the large trees (up to 76 cm DBH) recorded in the Highlands province were situated near Jockey Hollow. No evidence of soil erosion from deforestation was found on the hills southwest of Morristown (i.e., in the Jockey Hollow area). By 1900, cutting in Jockey Hollow area was minimal, because it had become residential, and so it is likely that cutting for fuelwood, and a small amount of cutting for a traveling sawmill on Primrose Brook, near the present Trail Center area (Weig, 1977) constituted all of the lumbering that occurred for fifty years prior to the establishment of the Park.

The general conclusion of this brief survey of land use history is that the pattern of fields and timber stands established before and shortly after the end of the Revolutionary War was little altered during the subsequent century. The fields on which successional forest is now growing were kept clear of forest growth from the time of initial clearing (by the settlers or the soldiers) until the early 1900's. The amount of land cleared for agriculture probably reached its peak in the mid-1800's and then remained stable until the beginning of the 1900's. Several waves of agricultural abandonment evidently occurred between the late 1800's and the inception of the Park in 1900 (Weig, 1977); however, these areas are now in forests of similar structure (if variable in species composition; see Chapters 5 and 6). From this stability in the location of fields, it is evident that where timber was permitted to regenerate after clearing or selective cutting by the soldiers, the forest has remained.

8.4 Possibilities for Further Research

This account of the land-use history of Jockey Hollow, and the nature of the original forest, is necessarily general and speculative, because limitations of time prevented adequate search for documents not readily available. It is probably that more extensive research could better document the history of the Kemble lands and the other outlying corners of the Park, and extend the detailed understanding

of the main portion of the Wick Farm area. However, two other methods are available which might shed considerable light on some of these questions:

1. Analysis of pollen or cores taken from the marshy area known as Cat Swamp, and perhaps from other marshy spots in the Park, might provide an accurate record of the changing importance of the dominant species in the Park (techniques are currently being developed for examining and dating pollen samples that reflect recent historical time (Russell, pers. comm.; 1974)).
2. Detailed dissection of small tracts of timber (about 0.5 ha in size), including tree initiation and growth studies, identification of all tree-fall mounds, wood fragments in the litter, charcoal or other evidence of fire or human management) has proved to be a powerful tool in understanding the dynamics and history of particular forest stands (Henry and Swam, 1974; Oliver and Stephens, 1977). Should a decision be made to clear the archeologically important sites in the Park, according to the recommendations of Rutsch and Peters (1976) (see Chapter 2-7), an opportunity to concurrently conduct such forest historical studies would arise without the necessity for cutting trees for the historical work alone.

Table 8-1. Boundary Trees Shown in Deeds and Surveys of the Jockey Hollow Area

Species	1700		1800		Total
	Mapped	Not Mapped*	Mapped	Not Mapped*	
Black Oak	1	2	1	0	4
White Oak	3	2	3	1	9
Red Oak	0	0	3	0	3
Pin Oak	0	1	0	0	1
Butternut	0	0	1	0	1
Black Walnut	0	0	0	1	1
Chestnut	1	1	5	1	8
Hickory	4	0	1	0	5
Yellow poplar	0	0	1	0	1
Black cherry	0	0	1	1	2
Maple	0	1	0	0	1
Elm	0	0	1	0	1
Red Cedar	0	0	1	0	1
Black Locust	0	0	1	0	1
Dogwood	0	0	1	0	1

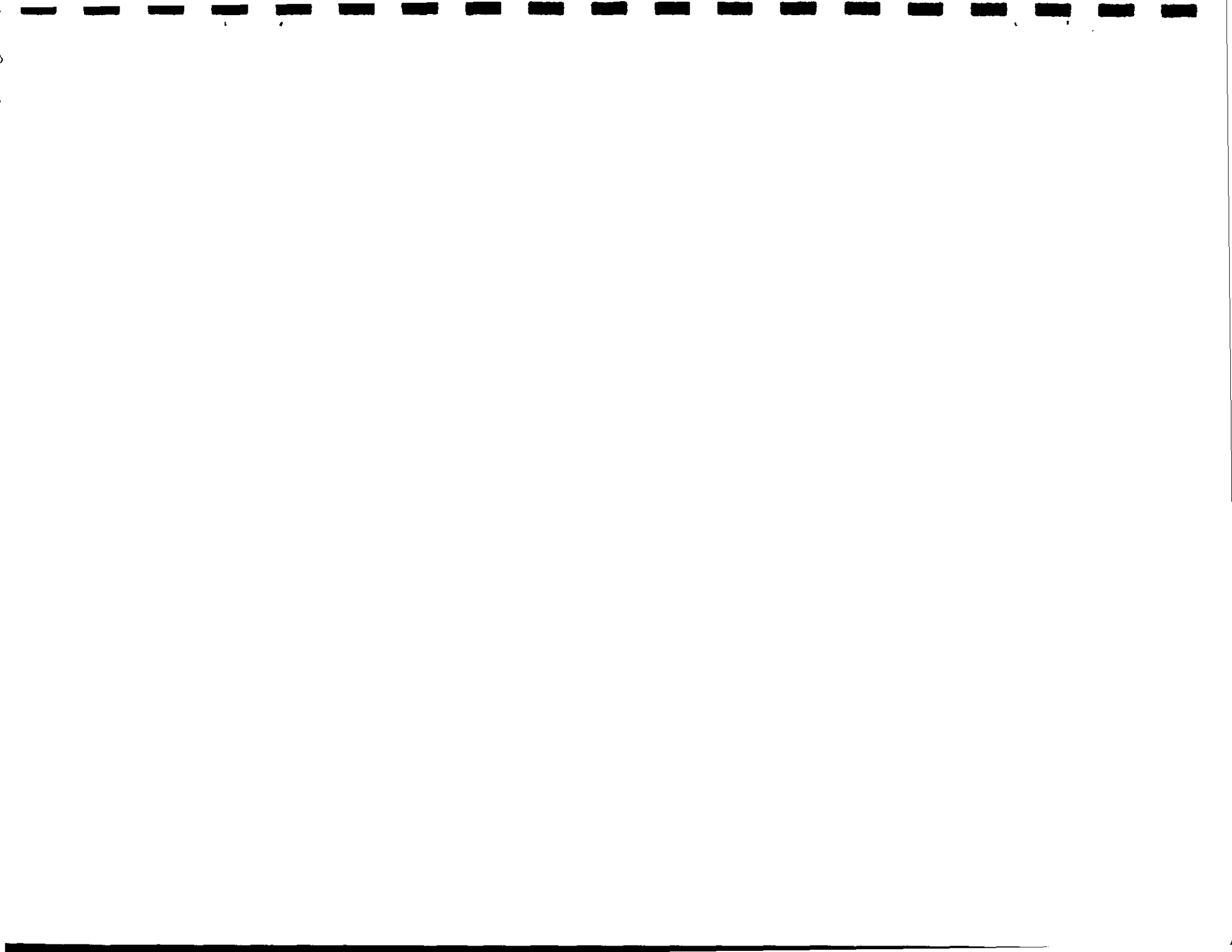
*These trees are located outside Park boundaries, in places adjacent to area shown on map.

Table 8-2. Surveys and Deeds Used in Compiling Boundary Tree Data.
 NJR = New Jersey Room, Rutgers University Library;
 MNHP = Park files, Morristown National Historical Park.

Date	Document	Source and Location
1714	Survey by John Reading for Amos Strettel	West Jersey Proprietors, Liber A folio 166; NJR
1715	Survey by Samuel Green for Francis Rawle	West Jersey Proprietors, Bulls Book, 1736, p. 37; NJR
1746	Deed, Bing and Rawle to Wick and Cooper	H-1802, p. 122, MNHP
1751	Deed, Amos Strettel to Peter Kemble	West Jersey Proprietors, Liber I-K, 11; NJR
1781	Survey by Wm. Gray of Wick Farm	Map; MNHP
1795	Deed, Ann Kemble to Robert Kemble	L-224; MNHP
1787	Map of Wick Farm by Israel Ludlow	Morris Township Public Library
1811	Deed, Moore and Halliday to Whithead and Hedges	V-444; MNHP
1828	Deed, E. Kemble to Nathan Mills	UV-306; MNHP
1839	Deed, R.F. Kemble to A.C. Logan	U-3, P. 421; MNHP
1840	Deed, R.F. Kemble to H. Baxter	V-3-456; MNHP
1840	Deed, R.F. Kemble to H. Baxter	V-3-458; MNHP
1840	Deed, R.F. Kemble to H.S. Hoyt	W-3-25; MNHP
1841	Deed, Mary Tuttle to Henry Tuttle	Y-3, p. 113, MNHP
1841	Deed, Mary Tuttle to R. Tuttle	B-4-319; MNHP

Table 8-2 Cont.

Date	Document	Source and Location
1841	Deed, Mary Tuttle to Phoebe and Nancy Tuttle	X-3-490; MNHP
1843	Deed, Robert Tuttle to W. Tuttle	C-4-429; MNHP
1852	Deed, H. Baxter, wife to J.W. Blachley	Y-4-235; MNHP
1867	Deed, H. Baxter, wife to H.S. Hoyt	W-3-25; MNHP
1899	Deed, T.H. Baxter, wife to D.H. McAlpin	B-16-97; MNHP



CHAPTER 9. SUCCESSIONAL TRENDS IN THE FORESTS AT JOCKEY HOLLOW

In this chapter, I review the findings of the intensive vegetation sampling, construct a general scheme of forest development in the Park, and discuss the factors influencing the predicted course of vegetation change.

9.1 A Brief Consideration of Climax Theory

In order to discuss forest succession at Jockey Hollow, it is necessary to establish a theoretical framework within which the available information can be arranged. Climax theory has been a fertile field for protracted argumentation, multiplication of terminology, and rarified conceptual distinctions, and therefore it is necessary to present the viewpoint from which the conclusions presented below have been drawn.

Concepts of successional change have been predicated upon the perceived interrelations among the component species of the communities, the relationships between the plants and the controlling environmental factors, and the geographic scale on which communities could be recognized. The traditional theory of Clements, Cowles, and others placed greatest emphasis on 1) the biotic interplay among species, giving rise to the "superorganism" conception of climax communities, and on 2) the controlling influence of regional climate on the development of vegetation types (Whittaker, 1953, 1974). According to this theory, a single "climatic climax" could be recognized for broad regions, toward which vegetation on most sites would develop if left to itself. This theory has been largely discredited, because it fails to account for the universal gradations found among "climax" communities, and the vegetational diversity engendered by variations in soil, physiography, microclimate, etc. A modern variant of this theory allows a greater subdivision of potential climax associations through regional variations in soil and climate; such concepts of the climax are termed the "polyclimax" theories (Whittaker, 1974). The critical features of the various schools comprising the polyclimax group are the following: 1) emphasis on the importance of associations among species, so that groupings of species (i.e., classifications of community types) have biological significance: although the precise composition of the community may vary, the association of species can easily be recognized in many places throughout the region in which it occurs. Species distributions are thought of as being keyed to the distribution of the community type, rather than being independently arrived at by each species. 2) Emphasis on the directionality of vegetation change on a given site; that is, seral communities replace each other in sequence, until the climatic climax, or edaphic climax, is reached. A corollary of this belief is that species modify the environment so as to favor the next stage of vegetation development, and discourage continuation of the current stage. 3) This corollary leads to the third postulate, namely that the climax community is that best suited to the environmental conditions prevailing at the site. It contains the most stable group of species, which is self-perpetuating, and possesses an array of characteristics such as high species diversity, stable population sizes, low productivity/respiration ratio, mature soil development, etc. (Odum, 1971; Margalef, 1963, Drury and Nisbet 1973).

Thus, this concept of succession to climax emphasizes the overall uniformity in space and time of the climax community, and incorporates minor variations as modifications of the climatic climax. Modern proponents of this conception include Daubenmire (1974; 1976) and Kuchler (1973), who champion the possibility of describing the "potential natural vegetation" of an area, and the use of this construct to interpret existing vegetation and to prescribe land-use practices in keeping with the land potential. Others, including Buell and his co-workers, have implicitly used such a concept in their interpretation of successional data.

The polyclimax idea has been criticized on a wide variety of grounds, some of which are as follows. Pioneering studies by Whittaker (1951), Gleason (1926), and the Wisconsin school (Curtis, 1959) showed that in many communities species are distributed along spatial environmental gradients irrespective of the distributions of other species (McIntosh, 1967). Thus, critical examination of the idea that species form integrated groups, or functional communities, led to a rejection of the concept of community, and a perception of vegetation as simply the end-product of many independently assorted species. Similarly, other studies accumulated which showed that vegetation development is often not a regular progression of communities proceeding towards a defined end-point; rather, species occur on gradients of time, from early to late stages of vegetation development, independently of each other, and with all conceivable patterns, and community types can follow each other in endlessly varying patterns, and not just in linear order. The variability in species occurrence through time has been championed by Egler (Egler and Foote, 1973), and Drury (Drury and Nisbet, 1973): among many others they have pointed out that many species characteristic of late successional stages are present at low abundance in early stages (for example dogwood), and vice versa with species characteristic of early stages. The lack of directionality in community change has been frequently described in communities on extreme or marginal habitats, such as bogs and peatland (Damman, 1975; Drury and Nisbet, 1973), but also has been found with certain groups of community types in moderate habitats (for example, shrub successions as described by Niering and Goodwin, 1974). Finally, the long-term stability of climax vegetation has been called into question as evidence is found for shifts of vegetation type over periods of time equal to life-spans of the component species (Botkin, pers. comm.), suggesting that communities with long-lived species are not necessarily relying on steady state conditions for perpetuation.

For some botanists, the upshot of these criticisms has been the rejection of the idea of "succession to climax" (e.g., Egler and Foote) (1973), who offer an award of \$10,000 to anyone who can prove that this occurs); these ecologists favor a view of vegetation change as simply a function of the ecological behavior of individual species. Others have attempted to synthesize the two viewpoints (Mueller-Dombois and Ellenberg, 1974). As this controversy has simmered in the journals, an appreciation of the importance of disturbance, both natural and man-made, has slowly been incorporated in the thinking of ecologists; the role of disturbance has been most eloquently described by Raup (1938) and Loucks (1970). Thus, community composition and community dynamics are thought to result from the interaction of history, local environmental factors,

the autecology of the component species, and the patterns of vegetation change that are evident in a given region (Keever, 1973; Peet and Loucks, 1977; Marks, 1974). As a corollary of this viewpoint, the variability in successional patterns has come to be stressed as one of the most salient features of the process (Whittaker, 1953, McIntosh, 1972; Drury and Nisbet, 1973). Thus, those ecologists espousing a middle view believe that climax groupings exist, and can be recognized on the basis of their similarity over an area and their functional properties (Whittaker, 1974). Furthermore, particular species groupings may be seral in one environment, and climax in another. Finally, the species groupings reflect environmental gradients as well as species interactions (Pickett, 1976; Drury and Nisbet, 1973). Thus, the climax vegetation of a region consists of a pattern of communities, with both the composition of the component communities and the scale of the pattern determined by the local history and local environment, and expressive of the total variation of the region.

In a study such as this investigation, the interpretation of successional trends and climax vegetation must be tempered by the uses to which the study will be put. Classification of community types inevitably involves arbitrary decisions about boundaries and defining elements, especially if the distribution of each species is believed to be independent of the distribution of others. Although community classification is thus rarely encountered in the work of "continuum" ecologists, it is a necessary tool in mapping vegetation for planning and management purposes. The approach taken here is that recurrent species groups can be recognized in the field, but that these groups primarily reflect individual species responses to the environment, compounded by the history of vegetation development and the history of disturbance for a given area; these responses are sufficiently similar over broad geographic regions, however, that species groups can be identified as characteristic of general habitat types. Thus, steep north-facing slopes and ravines usually contain some mixture of hemlock, beech, sugar maple and yellow birch throughout the Eastern Deciduous Forest, although the relative proportions and the associated species may vary considerably from place to place. From this general distribution, it is reasonable to suppose that some mixture of these dominants will eventually cover suitable habitats, given their presence in the young reproduction of the contemporary stand. No assumption is made that such a "climatic climax" will necessarily develop in all appropriate habitats, but the existence of such a widespread community type is used to interpret the data on stand composition. Succession towards a stable, steady-state community is a predictable phenomenon within limits, which are a function of the history of disturbance, the environmental characteristics, and the nature of the vegetation supplying the seeds for each stage of development. As McIntosh (1972) put it, "Changes in populations over time can be suggested (with some caveats) by examining the age structure of forests It does not follow that these can be taken as a guide to the unit potential of an entire region".

Thus, communities have been recognized by combining the observations on existing dominants with considerations of general, regional community associations described in the literature. A successional series has been constructed, also based in part on the observed differences in composition between the canopy and the understory, and in part on the patterns of

vegetation change recognized over the region. I have refrained from referring to the end-point of the series as a "climax" because it is not at all clear whether such a community can be meaningfully described for the northeast.

It is clear from many studies that frequent disturbance in the form of windstorms and fire were commonplace throughout the post-glacial history of the land, and were directly responsible for maintaining much of this part of the country in oak-dominated forest (cf, Henry and Swan, 1974; Oliver and Stephens, 1977; Loucks 1970). For example, the hurricane of 1950 blew down 299 trees in a "virgin" oak-hickory forest in New Jersey (Hutcheson Forest, Frei and Fairbrothers, 1963); this promoted the influx of many shade-intolerant tree species. Since the advent of Europeans, logging and introduced diseases and pests have replaced fire as the major sources of disturbance in addition to weather. The long-term effects of these changes in forest ecology can only be guessed at. For example, the removal of the American chestnut from the forests it dominated has caused variable changes in community composition (Keever, 1953; Mackey and Sivec, 1973; Woods and Shanks, 1959), and it is likely that another fifty or more years will pass before the forests reach a new equilibrium in species representation (Stout, pers. comm.).

Finally, in considering the nature of successional change, the time-scale of interest dictates the kind of conclusions that can be drawn. Predictions of species compositional changes over the next few years or decades can reliably be based on the observed size-class distributions of the component species. Predictions of community composition on the scale of a century or more are highly speculative; the expected occurrence of some kind of disturbance during this time, climatic fluctuations, and random events (for example, the advent of the chestnut blight), may well dwarf the significance of the present species composition of the reproductive strata. This difficulty is particularly pronounced in much of the forest at Jockey Hollow, where reproduction is evidently largely episodic, and little reproduction exists from which to forecast the future.

9.2 Successional Trends at Jockey Hollow

Figure 9-1 shows the successional trends among the recognized community types that have emerged from the community sampling, and perusal of relevant literature, and the considerations of succession and climax theory discussed above.

In the diagram, I suggest that the mature oak-dominated forests are converging on variants of the Mixed-Hardwood forest type, depending on the moisture regime of the site. In restricted areas, however, the Chestnut Oak type and the Mixed Oak type are perpetuating themselves; this is indicated in the diagram by the circular arrows. The arrangement follows the well-established observation that successional series are shorter on more xeric sites (e.g. ending in oak forest) and longer (oak forest to mixed hardwood or cove forest) on mesic sites (e.g. Peet and Loucks, 1977). Two of the oak types, namely the Mixed Oak - Beech type and the Mixed Oak - Black Birch type, are thought to be derived

through disturbance from the Mixed Oak type. The Mixed Hemlock-Hardwoods and the Stream Thicket communities are portrayed as self-perpetuating variants of the cove-type Mixed Hardwood forest. The pure stand of Red Maple is considered to be a self-perpetuating community, maintained by soil type and disjunct from the patterns of vegetation change evident in the rest of the Park. The successional forest types are shown as probably proceeding directly to the Mixed Hardwoods stage; their development is discussed more fully below.

The relations between the community types must be considered speculative, because 1) the absence of well-defined reproductive strata in most of the successional communities and many of the mature communities leaves little basis for prediction other than by analogy with other northern New Jersey stands and with the present composition of the mature stands in the Park; and 2) the indicated relationships between communities and environmental features would require a more detailed and extensive investigation to be substantiated.

With these caveats in mind, the general course of development of the forest types can be examined. The most striking feature of the forests is the paucity of oak reproduction everywhere except for the northwest-facing slope of Mt. Kemble, and the upper northwest slope of Tea Hill. Elsewhere, a mixture of hardwood species seems to be assuming dominance. This mixed hardwood forest includes beech, black birch, red maple, dogwood, and lesser amounts of sugar maple, hickory, yellow poplar, red oak, and ash. On the more xeric sites, beech loses prominence, hickory increases, white black, and chestnut oak may remain locally important, and serviceberry is prominent in the understory. In the moist coves and steep, north-facing slopes, beech, yellow birch, red maple and sugar maple, and in some localities, hemlock, may be the dominating species, with an understory of spicebush, witchhazel, and hornbeam. The chestnut oak-dominated stands on Mt. Kemble and Tea Hill appear to be reproducing themselves, whereas the chestnut oak-dominated stand above the Wick House appears to be giving way to an upland variety of mixed hardwood forest. Similarly, the mixed oak stands on Mt. kemble appear to be maintaining themselves although the proportion of non-oak species will probably rise over the current value.

The trend away from oak-dominated forests has been well documented in other New Jersey woods by Buell and his co-workers (Ohmann and Buell, 1968; McDonough and Buell, 1956; Monk 1961; Niering, 1953; Buell et al., 1966 Good, 1968; Forman and Elfstrom, 1975). Similar trends have also been documented in Connecticut (Stephens and Waggoner, 1970), New York (Raup, 1937), southern Wisconsin (Peet and Loucks, 1977) and elsewhere. In some parts of New Jersey, especially in the Piedmont province and on limestone soils, sugar maple is emerging as the successor to oaks (Buell et al., 1966). Elsewhere, red maple, black birch, white ash, and other hardwoods are preferentially replacing the oaks (McIntosh, 1972; Stephens and Waggoner, 1970; Good, 1968; Carvell and Tryon, 1961; Niering, 1953). The particular species which gain dominance appear to be determined in part by the history of disturbance, in part by the soil moisture characteristics of the site (Monk and Day, 1974; Keever, 1973), and in part by the ability of certain species to prosper on particular soil types (Stout, 1952). Studies of oak reproduction have repeatedly shown that dry sites and extensive disturbance

in the form of fire or logging are required for perpetuation of oak forests (Carvell and Tryon, 1961; Ward, 1966; Kuenzel and McGuire, 1942; Peet and Loucks 1977). Raup (1937, 1938), has related the decline of oak to long-term climatic changes favoring mesic, cove-type species. The occurrence of abundant oak reproduction solely on those portions of Mt. Kemble and Tea Hill with extremely stony, excessively drained soils supports these regional observations. Thus, the decline in importance of oaks appears to be a natural development in eastern deciduous forest during this century, and the forests at Jockey Hollow should not be viewed as atypical. However, this state of affairs also implies that in order to retain, in most of the Park, a mixed oak woods reminiscent of that which was probably encountered by the soldiers (Chapter 8), active management would be necessary and would have to include extensive cutting in order to open the canopy, scarify the forest floor and remove the competing hardwoods which are now excluding the oaks. The desirability of such a course of action depends on the goals of the Park management: if the goal is restoration of historically accurate conditions, then detailed plans for forest management should be developed, but if the goal is to let natural forces shape the environment of the Park, then clearly management is uncalled for.

The stands mapped as Mixed Oak-Beech and Mixed Oak - Black Birch are evidently the result of long-term selective logging in combination with the failure of oaks to dominate the reproduction; the logging removed the chestnut and some of the oak, and left the associate species growing space in which to achieve dominance of the forest. Beech assumed this role on lower slopes, and black birch (and red maple) assumed this role on upper slopes. This change in the relative abundance of species suggests that most or all of the logging in these woods has been selection cutting of valuable species with little or no clearcutting (except, of course, that done by the soldiers: see Chapter 8-3). The rise in importance of uneconomic, non-canopy species such as red maple and black birch also suggests that much of the logging was "high-grading," in which dominant trees were removed with no provision made for restocking with "desirable" species. This combination of harvest of the most valuable trees with absence of management for reproduction may explain the low importance of hickory in woods in which it should be a dominant.

Two other observations support this hypothesized role of logging in the forest history. 1) Observations made in the Highlands southwest of Morristown just prior to the turn of the century (Vermeule, 1900) showed that the forest throughout this region were better stocked and had trees of larger size than the more intensively worked forests to the north. 2) Both the observations of Vermeule (1900), and those of this study (Stout, pers. comm.). indicate that there has been no soil erosion even on the steepest slopes and along the old skid trails, indicating that the forests were neither frequently clearcut nor frequently worked on a selection cutting schedule. Thus, the logging in the Park has had the effect of simply accelerating the regional trend away from oak dominated forests by raising to co-dominant status the species that were subordinate to oak and chestnut at the time of logging.

Black birch and red maple have increased during this century in forests in the Catskills (McIntosh, 1972), Connecticut (Stephens and

Waggoner, 1970), New York Highlands (Raup, 1938), Wisconsin (Larsen, 1953), Massachusetts (Henry and Swan, 1974), Pennsylvania (Mackey & Sivec, 1973), and New Jersey (Ohmann and Buell, 1968; Good, 1968, Forman and Elfstrom 1975). Others have found that although these two species are not abundant in undisturbed portions of a stand, they are common in openings within the forest (Monk, 1961; McDonough and Buell, 1956). Black birch in particular has been associated with logging skid trails, wind-throw mounds and rotting tree stumps (Henry and Swan, 1974; Good, 1968; Marquis, 1965). The size distributions for these two species noted in Chapter 6 suggest that the rise occurred during the early part of the twentieth century, as in the other stands mentioned above, and that some of the increases can be attributed to the death of American chestnut trees (as in Good, 1968, and Mackey and Sivec, 1973). It may also be that the increases in these species has occurred in two stages: the first during the last part of the 1800's in response to logging, and the second during the early 1900's in the wake of the chestnut blight. It is interesting to note that in the Mixed Oak stands where logging was evidently less intense during this century and chestnut was not dominant, red maple and black birch are minor components. Because most of the established trees are young, these two species can be expected to at least maintain their role in the forest over the next few decades; it is not possible to predict whether they will remain as successful over a longer-term future. Good and Good (1972) found that in another Highlands forest black birch seedlings suffered a high rate of mortality and low rate of growth, but red maple seedlings survived and grew well. On the other hand, the approximately J-shaped distribution curves for these species suggest that in many of the stands, these species will continue to replace themselves.

Another factor important in the dynamics of these forests is the episodic nature of the regeneration in all but the open Chestnut Oak-Black Birch stands on Mt. Kemble and Tea Hill. Although episodic reproduction is characteristic of some kinds of mature stands (Oliver and Stephens, 1977), it is also characteristic of young even-aged stands in which intense root competition and dense canopy excludes reproduction (Peet and Loucks, 1977; Zeide, pers. comm., Stout, pers. comm.). The reconstruction of forest history presented in Chapter 8 is strongly reminiscent of the forest history deduced for the Harvard Forest by Oliver and Stephens (1977), in which series of major disturbances (hurricanes and intensive logging) and minor disturbances (fuelwood cuttings, small storms) had occurred. Pulses of tree reproduction had occurred only after major disturbances. Likewise, there was no evidence of extensive establishment of new tree seedlings (Ehrenfeld, 1977) in Jockey Hollow following the gypsy moth-caused mortality; the removal of 28% of the canopy trees corresponded in magnitude and effect to the "small" disturbances in the Harvard Forest. In the absence of major disturbances, decades or even centuries may elapse before the stands thin themselves enough to permit reproduction. The thinning, a result of natural tree mortality and the natural decrease in crown density, usually accompanies the pulse of maximum seed production of the remaining trees, and thus establishment of reproduction is promoted. The dense stocking of immature trees on the successional stands is almost certainly causing sufficiently intense root competition to exclude reproduction, and this situation is likely to prevail for the next several decades (Stout, pers. comm.).

A third factor, mentioned briefly above, is the important role of a catastrophic disturbance in these woods. There is little doubt that the oak forests of the northeast are as much the result of hurricanes and fires as the result of human management and exploitation. Loucks (1970) has shown that such disturbances are crucial to the maintenance of maximally diverse and productive forests, and has suggested that the species comprising these forests are specifically adapted to periodic, irregular environmental changes over a time-span of several decades to several centuries.

A fourth factor, related to the cocurrence of catastrophe and the establishment of reproduction, is the nature of the seed source in determining species composition. It was pointed out in Chapter 6, for example, that sugar maple is relatively uncommon in these forests, and that its observed distribution was correlated with the location of individual mature trees. Similarly, American linden (*Tilia americana*) is conspicuous in its absence in Jockey Hollow, and yet it is not uncommon only a mile away in the Scherman Wildlife Sanctuary. It is hard to state whether its absence in Jockey Hollow is attributable to a lack of seed source, but the circumstantial evidence strongly suggests this. Golley (1977) and Buell et al. (1971) have also commented on the crucial role of seed source in determining the course of successional change.

A fifth factor in the determination of successional trends in the Park is the local variation in soils and other aspects of site. As discussed above, the very stony soils on the west-facing slopes of Mt. Kemble and Tea Hill are correlated with abundant reproduction of oaks, and therefore with the projected stability of the present community. The east-facing slope of Mt. Kemble, although mapped by Eby (1976) as the same soil type as the western slope, has very few stones and boulders, and also lacks oak reproduction. Presumably, the absence of rocks is attributable to prior use of the land for farming (Rutsch and Peters, 1976) but the change in soil constitution has had a fundamental effect on the kind of forest which will persist on the site.

Finally, the allelopathic influences of several of the tree species may influence forest development. The chemical inhibition of other trees species described for sassafras (Gant & Clebach, 1975) may be responsible for the nature of the Sassafras stand (Map #2), and may delay the progression of this stand towards one of more diverse composition. The well-known allelopathic effects of black walnut (Brooks, 1951), however, do not seem to have had any effect on the Black Walnut stand, judging by the absence of black walnut reproduction, and the density of other species.

9.3 Successional Forests and the Rate of Forest Change

The stands mapped as successional forest types are diverse in species composition, age, and origin. The prior use of the fields for crops, pasture or orchard has had no effects on the subsequent succession that were discernible in this investigation. The length of time elapsed since abandonment is, however, correlated with some of the variations in communities, and is surprisingly unrelated to other aspects of community development. In order to evaluate the importance of stand age

in these early successional forests, comparison was made on a stand-by-stand basis of the information available from the Vermeule and Stock map (1900), the Vegetation Map (1937), and the maps prepared for this study. Table 9-1 and Fig. 9-2 give these data for selected stands of particular interest. In most cases, land that was open in 1900 was either still open, or in the forb and shrub stages of succession in 1937, and had proceeded to the successional forest stage now; these stands are not included in Table 9-1. In some cases, however, land that was open in 1900 had well-established tree growth in 1937, and the approximate species composition at that time could be compared with the species composition present today. In a few other cases, land that was forested in 1900, and was included in the "Yellow Poplar - White Oak - Red Oak" category in 1937, was currently supporting vegetation with a species composition comparable to the young successional forests, and not the mature oak forests. An example of this situation would be stand H (see Fig. 9-2 and Table 9-1): photographs of this stand taken in 1905 (see Chapter 8) showed a densely stocked young forest of small trees which had invaded after the field was last plowed c. 1870 (Tuttle, 1871), and yet today, a century after abandonment, the species present are yellow poplar, elm, red maple, white ash, black cherry, and vines which are the pioneer species elsewhere in the Park. In some places (e.g., stands B2, D, G and J of Table 9-1), there has evidently been little change in forest composition over the past 40 years, although other stands (e.g. A, C, and I) have experienced a diversification of the successional species present on the site. Finally, some series of stands (e.g. B1 and 2, and F1, 2 and 3) were evidently allowed to revert to forest at various times over a forty-year period, but today support forest not distinguishable from each other on the basis of species composition or physiognomy.

This variation in stand development with age suggests that during the first stages of forest growth, invasion of the site is by a constellation of species which can persist for a long time before succession produces a species group more typical of the mature oak forest. Figure 9-3 presents a hypothetical diagram showing how these successional forests appear to change with time. An initial rise in species richness ("A," Fig. 9-3) may occur, as a variety of successional species follow an initial invader in a field, or a single species may commandeer the growing space of the field from the start ("B"). In either case, the successional species common at Jockey Hollow are able to impose a pattern of episodic reproduction on the stand as discussed above, probably as a result of successful competition for soil resources. The species composition therefore remains stable until the trees begin to reach the end of their life-span ("C") whereupon reproduction leads to a change in species composition ("D"). This hypothesis would explain why stands of such diverse ages could have similar species compositions: once phase "C" is gained, the age of the stand will not be reflected in the composition. Persistent vine growth such as is seen in stand H (Fig. 9-2) could prolong the "C" phase, and thus keep a 100-year-old stand looking like a 50-year-old stand.

It must be emphasized that this interpretation is hypothetical, and would require much more extensive sampling of the successional communities to be validated. Succession is generally conceived to be a gradual process of replacement of one set of species by another (Horn, 1974; Stephens and Waggoner, 1970), especially in the earlier stages of the process; this

pattern has been termed the "autogenic" pattern of succession. However, the episodic pattern of reproduction discerned here corresponds well with the "allogenic" pattern found to predominate in several stands that have been exhaustively studied for their historical dynamics (Henry and Swan, 1974; Oliver and Stephens, 1977). Unfortunately, literature on succession and forest changes is concentrated on successional stages younger or older than these stands, and thus there are little data available to compare with my observations. Spurr (1956) has related vegetation of pioneer, transitional and mature forest types in the Harvard Forest to a well-described land-use history. He found that the three types formed a continuum, united primarily by the omnipresence of red oak, red maple, and black birch, and implied that the forests were gradually transforming from younger to older types, but he presented no data to show whether the transitions were slow or abrupt. Stephens and Waggoner (1970) found nearly constant "transition probabilities" among tree species over four decades in Connecticut forests, a remarkably steady rate of forest change indeed. The successional forests in Jockey Hollow may thus present an unusual opportunity to study the dynamics of mid-successional forest stages.

As was discussed in Chapter 6-6, the variations in species composition of the successional forests appears to be related to the kind of "wolf" trees growing in or near the stand, and to the kind of mature forest bordering the area. Some of the species most characteristic of these young forests, namely, ash, black birch, red maple, dogwood, and yellow poplar, are also important components of the mature forests, and this feature lends an aspect of continuity between the young and older forests similar to that discerned by Spurr (1956). However, the compositional continuum is apparently not paralleled by a temporal continuum of change, and thus the conclusion has been reached that the successional forests at Jockey Hollow will retain their present species composition for at least several decades, until the maturation of the stands or a natural catastrophe precipitates a change.

In Figure 9-1, the successional stands are portrayed as eventually proceeding to mixed hardwoods forest of either upland or lowland composition. The distinction in course was made in part on the observations of Keever (1973), who identified the common successional species in zone of the mature forest types of Braun (1950). Thus, white ash and black walnut were common in the Oak-Hickory zone, yellow poplar was more abundant in the mixed mesophytic zones, and red maple was abundant throughout. Therefore, stands in which yellow poplar was an important element were presumed to be as evolving toward a lowland mixed hardwood association, whereas stands in which yellow-poplar was uncommon or absent were presumed to be evolving toward the upland association.

In summary, the successional stands appear to be in a stage of arrested development, with intense competition precluding the growth of the tree seedlings from which future composition could be predicted. The dense growth of vines may in some places materially assist these stands in retaining their present aspect for long periods of time. However, the overlap in species present in both mature and successional stands permits the general trends in species composition observed in the mature stands to be extrapolated (with caution) to the successional stand; and thus,

in the long term of several decades to a century or more, the diversity in forest type in the Park can be expected to converge on a smaller number of types than is present today.

Table 9-1. Comparison of Vegetation in Selected Successional Stands, 1900-1977.

Stand	1900	1937	1977	Remarks
A	open	B2	*WA-YP	Change of Succ. forest type.
B	1 open 2 open	Cultivated BL(0-20)	WA-BL WA-BL	No difference in canopy composition despite difference in age.
C	open	BL(21-40)	Mix Succ.	Change of succ. type.
D	open	BL(21-40)	BL	No successional change.
E	forested	YP-RO-WO	YP	Persistence of pure YP as mature forest type.
F	1 open 2 open 3 forested	brush orcahrd B2(41-60)	WA-BL WA-BL WA-BL	Lands reverting to forest over 40-year period now with uniform successional forest.
G	open	GB-RM (21-40)	Mix	Little change in species composition.
H	forested	YP-RO-WO	Mix	Succ. forest composition retained in one patch.
I	open	BL	YP	Change of succ. type.
J	open	GB-RM (21-40)	RM	Persistence of pure RM as stable type.
K	open	Cultivated brush, BL(21-40)	Mix,WA- BL	Fields of various ages.

*Abbreviations: BL=Black Locust; RM=Red Maple; WA=White Ash, GB=Grey Birch; YP=Yellow Poplar; RO=Red Oak; WO=White Oak, Mix=Mixed successional species.

Fig. 9-1. Diagram of Successional Trends Among
The Forest Communities in Jockey Hollow.
Forest Type Abbreviations as in Table
6-1.

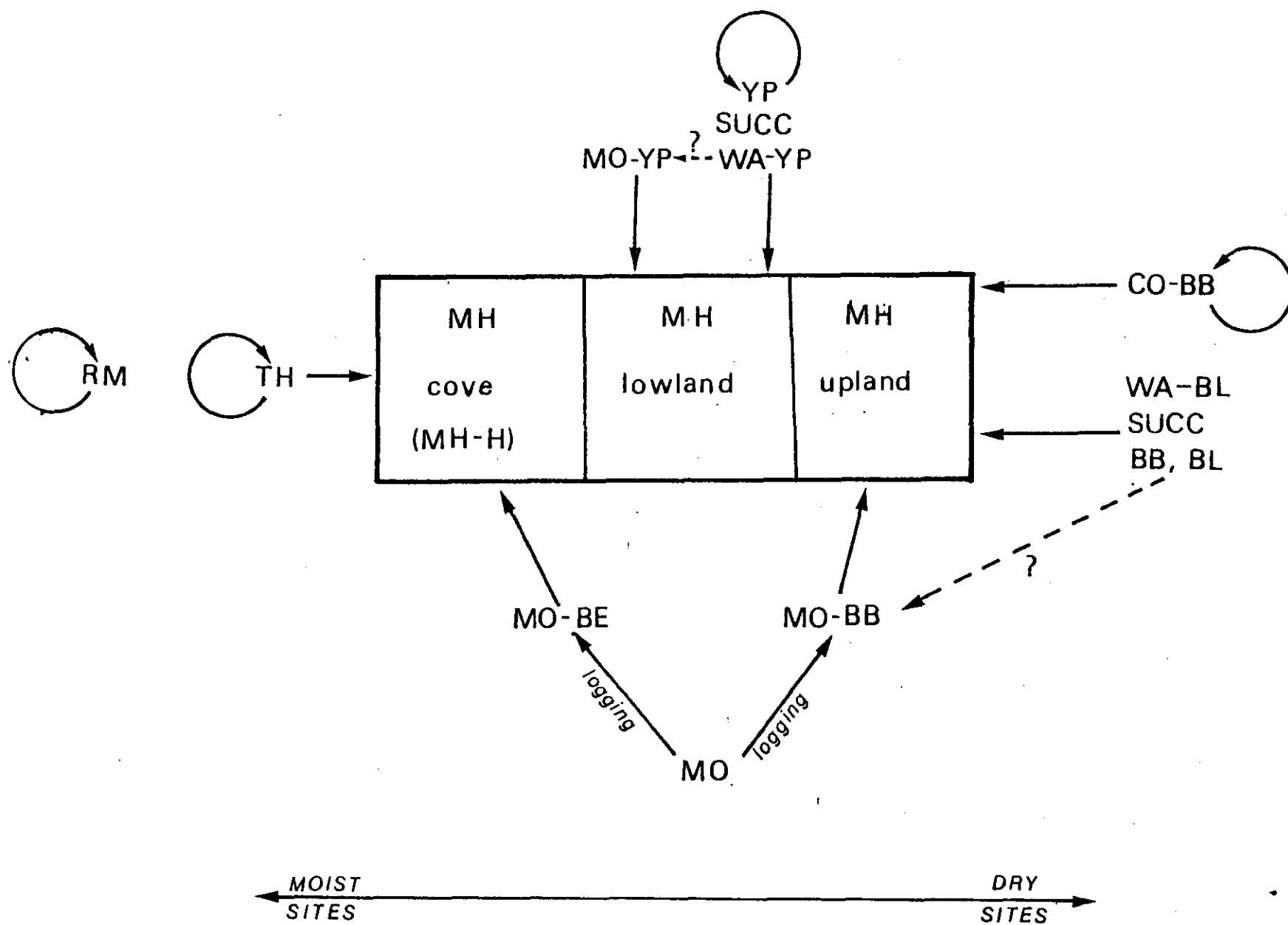
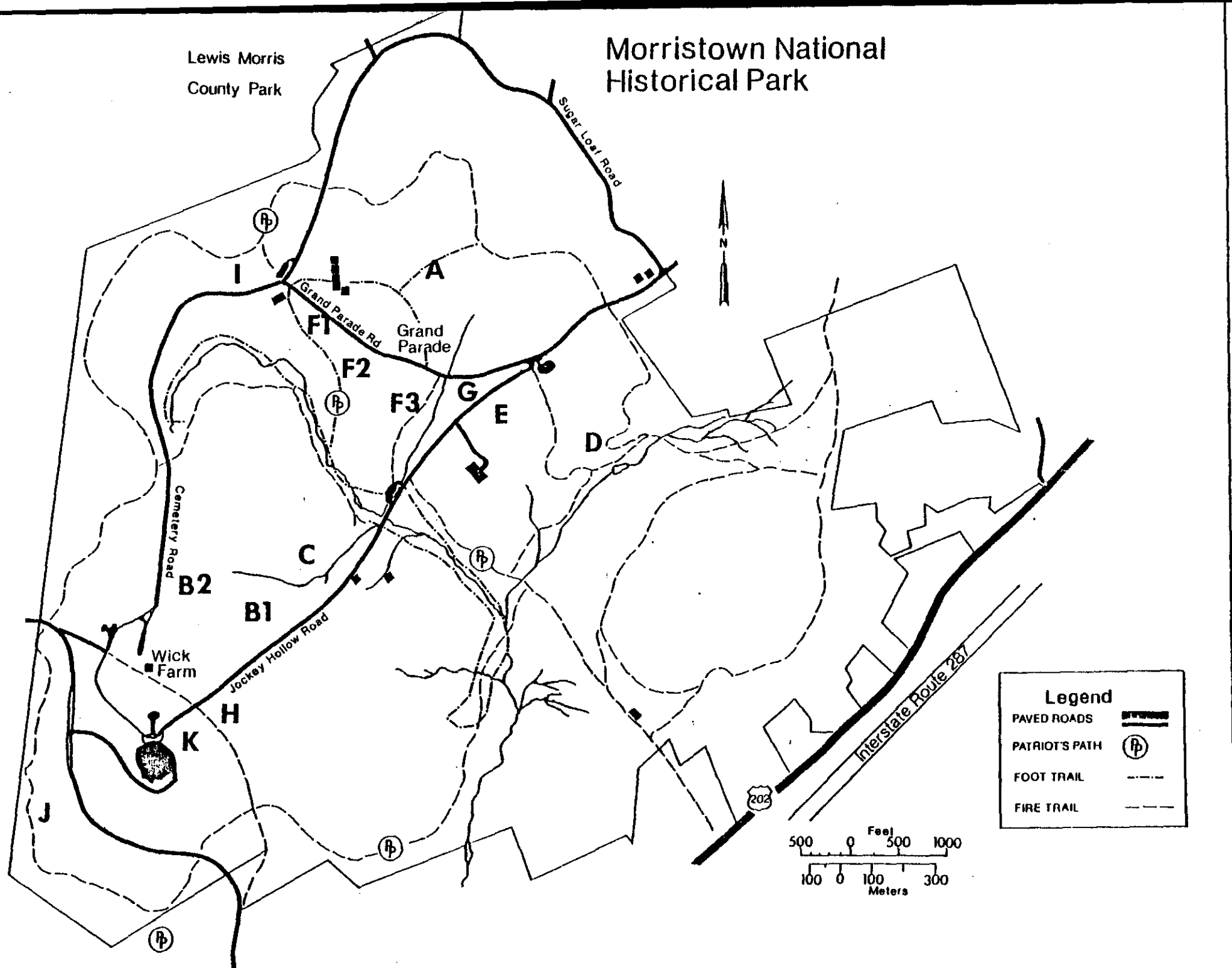


Fig. 9-2. Locations of Successional Forest
Stands Compared in Table 9-1.

Lewis Morris
County Park

Morristown National Historical Park



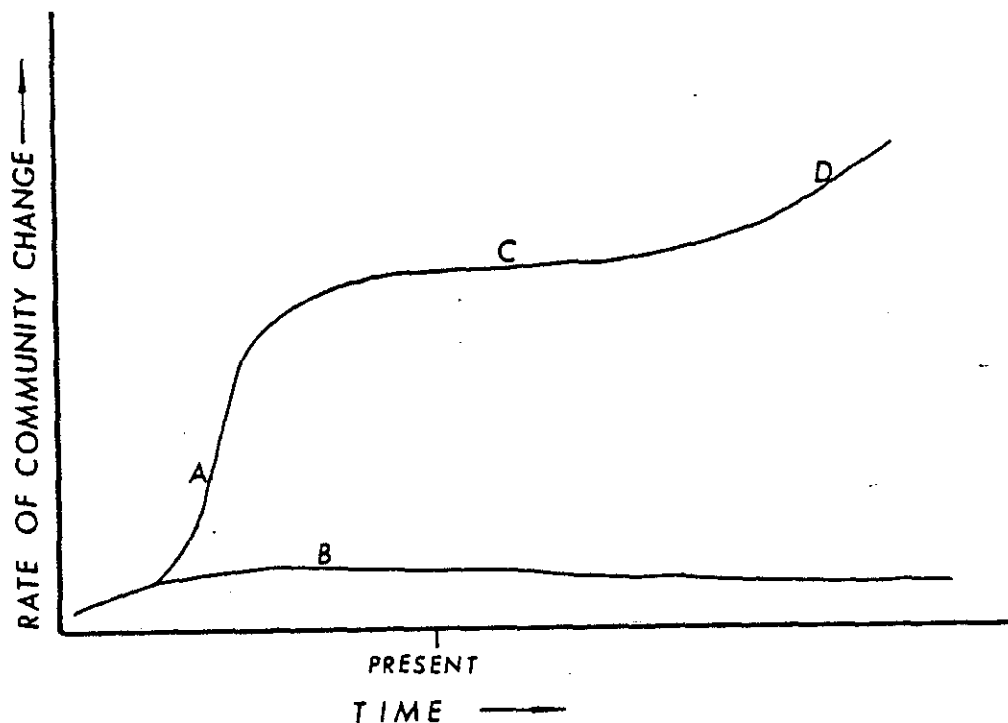


Fig. 9-3. Hypothetical Course of Early Forest Succession. A: Initial rise in species richness early in succession. B: Domination of growing space by one or a few species. C: Stable species composition during life-span of initial tree population. D: Change in species composition with establishment of new generation of trees.

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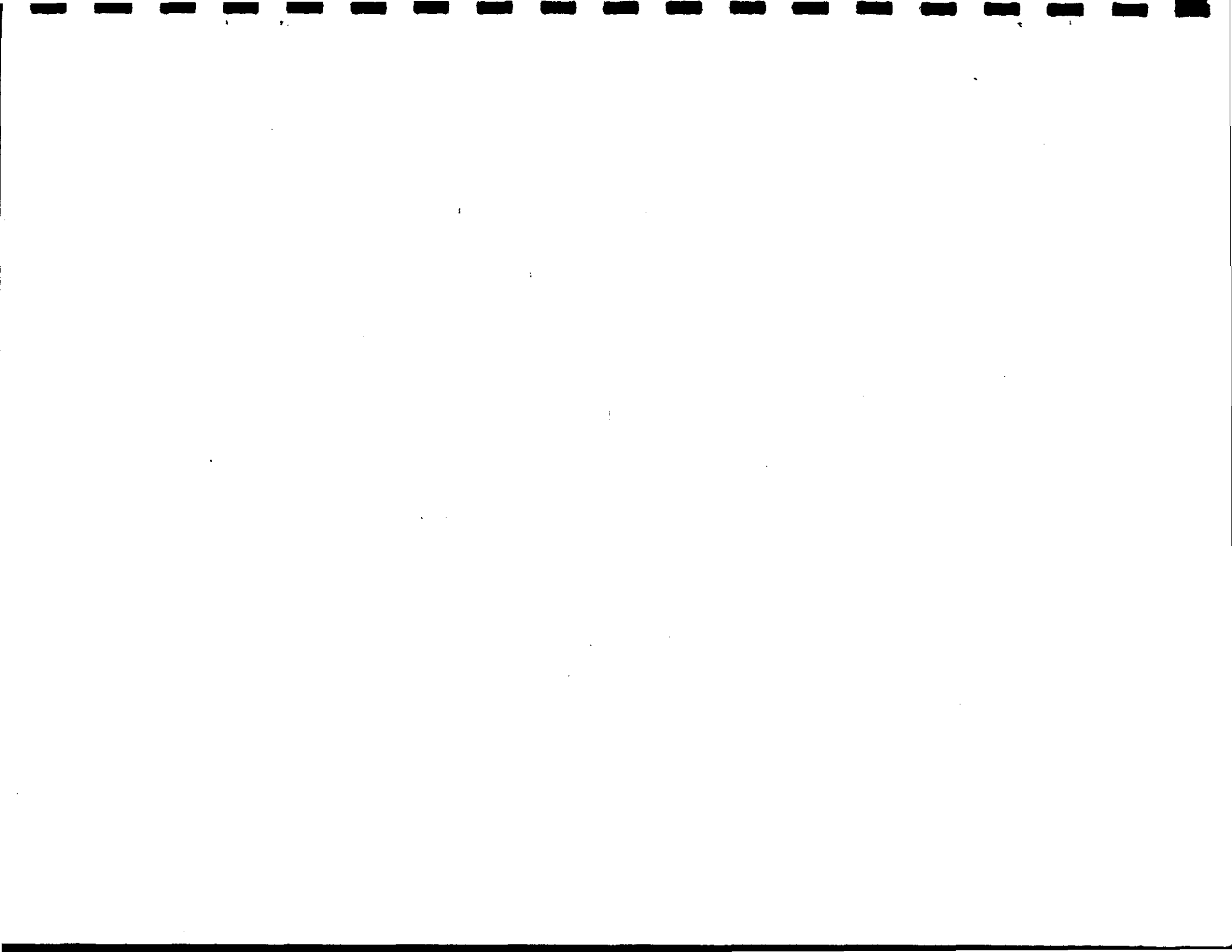
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APPENDIX 1. WOODY PLANTS OF THE JOCKEY HOLLOW AREA

Key to abundance and floristic codes: a = abundant; found frequently throughout the Park. c = common; abundant in some areas, absent or sparse in other areas. o = occasional; never a dominant species, but individuals scattered throughout the Park. u = uncommon; scattered clumps of individuals; r = rare; only a few individuals found; l = localized; a dominant component of the vegetation in a small number of sites. N = northern floristic affinity. S = southern floristic affinity. B = common to both northern and southern floristic regions.

PART 1. WOODY PLANTS NATIVE TO NEW JERSEY

TREES

- Acer rubrum L. Red maple (a), B
- Acer saccharum Marsh. Sugar Maple (c), B
- Amelanchier arborea (Michx. F.) Fern. Serviceberry (o), B
- Amelanchier laevis Weig. Serviceberry (o), B
- Betula lenta L. Black Birch (a), N
- Betula lutea Michx. f. Yellow Birch (c), N
- Betula populifolia Marxh, Gray Birch (o), B
- Carpinus caroliniana Walt, American hornbeam (o) S
- Carya glabra (Mill.) Pignut hickory (o), B
- Carya ovalis Sarg. Red hickory (o), B
- Carya ovata K. Koch. Shagbark hickory (c), B
- Carya tomentosa (Poir.) Nutt. Mockernut hickory (c), B
- Castanea dentata (Marsh.) Barkh. American chestnut (r), B
- Cornus florida L. Flowering dogwood (a), S
- Crataegus spp. L. Hawthorne (o)
- Fagus grandifolia Ehrh. Beech (o), B
- Fraxinus americana L. White ash (c), B
- Fraxinus nigra Marsh. Black ash (u), N
- Fraxinus pennsylvanica Marsh. Green ash (c), B

Juglans cinerea L. Butternut (r), N
Juglans nigra L. Black walnut (c), B
Juniperus virginiana L. Eastern red cedar (u), S
Liriodendron tulipifera L. Yellow poplar (a), B
Magnolia tripetala L. Umbrella magnolia (r), S
Nyssa sylvatica Marsh. Blackgum (c), S
Ostrya virginiana (Mill.) K. Koch Hophornbeam (c), B
Pinus rigida Mill. Pitch Pine (o), B
Pinus strobus L. White pine (o), N
Platanus occidentalis L. American sycamore (o), B
Populus grandidentata Michx. Bigtooth Aspen (o), B
Populus tremuloides Michx. Quaking Aspen (o), B
Prunus serotina Ehrh. Black cherry (c), B
Quercus alba L. White oak (c), B
Quercus borealis Michx. F. Red Oak (c), B
Quercus coccinea Muenchh. Scarlet oak (a), B
Quercus palustris Muenchh. Pin oak (c), B
Quercus velutina Lam. Black oak (c), B
Salix nigra L. Black willow (o), B
Sassafras albidum (Nutt.) Nees. Sassafras (c), B
Tilia americana L. Basswood (r), N
Tsuga canadensis (L.) Carr. Hemlock (o), N
Ulmus americana L. American elm (o), B
Ulmus rubra Muhl. Slippery elm (o), B

SHRUBS

Alnus rugosa (Du Roi) Spreng. Speckled alder (c), N
Alnus serrulata (Ait.) Willd. Smooth Alder (r), B

Corylus americana L. Hazelnut (u), B
Hamamelis virginiana L. Witch hazel (c), B
Ilex verticillata (L.) Grey Winterberry (c), B
Lindera benzoin (L.) Bl. Spicebush (a), B
Rhododendron nudiflorum (L.) Torr. Pinxterflower (o), S
Rhus glabra L. Smooth Sumac (o), B
Rosa virginiana Mill Rose (o), B
Rubus allegheniensis Porter Blackberry (c), B
Rubus occidentalis L. Black Raspberry (c), B
Rubus strigosus Michx. Raspberry (c), N
Sambucus canadensis L. Elderberry (c), N
Vaccinium corymbosum L. Highbush blueberry (c), B
Vaccinium vacillans Torr. Lowbush blueberry (c), B
Viburnum acerifolium L. Maple leaf viburnum (c), N
Viburnum dentatum L. Arrow wood (r), S
Viburnum prunifolium L. Black haw (c), S

VINES

Calastrus scandens L. American bittersweet (a), B
Parthenocissus quinquefolia L. Virginia creeper (a), B
Rhus radicans L. Poison ivy (o), B
Smilax glauca Walt. Catbriar (a), S
Vitis aestivalis Michx. Summer-grape (o), S
Vitis labrusca L. Fox-grape (a), B

PART 2. WOODY SPECIES EXOTIC TO THE U.S., INTRODUCED INTO JOCKEY HOLLOW.

TREES

Aesculus hippocastanum L. Horse-chestnut (1)
Acer palmatum Thunb. Japanese maple (r)

Ailanthus altissima (Mill.) Swingle Ailanthus (o)
Castanea mollissima Bl. Chinese chestnut (r)
Morus alba L. White mulberry (o)
Pawlonia tomentosa (Thunb.) Steud. Royal pawlonia (r)
Picea abies L. Norway spruce (u)
Prunus avium L. Sweet cherry (u)
Prunus persica (L.) Patsch. Peach (u)
Pyrus communis L. Pear (o)
Pyrus malus L. Apple (o)

SHRUBS

Berberis thunbergi DC. Barberry (o)
Berberis vulgaris L. Barberry (o)
Euonymus alatus (Thunb.) Sieb. Winged euonymus (o)
Ligustrum vulgare L. Privet (o)
Lonicera tartarica L. Tartarian honeysuckle (c)
Philadelphus coronarius L. Mock-orange (r)
Viburnum sieboldi Miq. Siebold's Viburnum (r)

VINES

Ampelopsis brevipedunculata (Maxim.) Trauta. Porcelain-
berry (r)

PART 3. WOODY SPECIES NATIVE TO THE U.S., BUT INTRODUCED INTO JOCKEY HOLLOW.

TREES

Abies balsamea (l.) Mill. White Fir (u)
Picea glauca (Noench) Voss White spruce (u)
Pinus resinosa Ait. Red Pine (u)
Pseudotsuga Menziessii (Mirb.) Franco Douglas-fir (u)
Robinia pseudo-acacia L. Black locust (c)
Thuja occidentalis L. Arborvitae (l)

APPENDIX 2. DESCRIPTION OF PLANT COMMUNITY TYPES DISPLAYED ON THE VEGETATION MAPS

MAP 1: BASE MAP OF VEGETATION TYPES

Successional Broadleaf Forest: Successional forests include those stands that have originated within the last forty to seventy years on land previously cleared for agriculture. The stands range widely in species composition (see below and Map 2), but are similar in structure. The canopy tree species are all intolerant or only moderately tolerant; they have open crowns, so that the ground is not heavily shaded (unless vines are present); their populations consist of numerous small stems. Beneath this canopy is usually found a dense growth of shrubs or understory trees; again, the species vary from site to site. Spicebush usually predominates on lower slopes and on moist sites, blackhaw viburnum is common on higher ground, and dogwood grows densely where it was present at the time of abandonment. In the few stands in which this shrub or understory tree layer is lacking, dense growths of herbaceous plants, especially snakeroot (*Eupatorium rugosum*) and bramble bushes (*Rubus* spp.) take their place. Many of the successional stands are moderately to densely overgrown with vines; in some places, these plants coat the canopy layer completely. A common feature of these stands is frequent openings in the canopy in which a fallen tree or broken limb has itself become completely covered with vines, rendering the canopy opening impenetrable. (This feature is common in, for example, the stands above the Wick Farm Orchard.) Although most of the stands included in this mapping unit arose on farmlands abandoned shortly before or at the time of establishment of the Park, and are therefore between forty and fifty years of age, some of the stands originated twenty to forty years prior to the early 1930's. These stands have changed little in the species composition given for them on the 1937 Vegetation Map, and because these species groupings are generally considered to be temporary community types, they have been included in the successional forest unit. The red maple stand below the Visitor Contract Station is an example of this kind of stand.

Mature Broadleaf Forest: The mature forests of the Park include those stands in which mature individuals are common, and in which oaks are a dominant or principal associate element; they thus represent variants of the Oak-Chestnut association recognized as "climax" for this area by Braun (1950). The relative importance of the non-oak species tends to vary more widely than that of the oaks, and has been used as the factor distinguishing a number of the types. The various kinds of mature forest recognized here were mapped in 1937 as "Red oak - White-oak- Yellow poplar" forests. These forests range in age and composition from those about 100 years old with an even-aged composition to those at least 150 years old with an all-aged composition. The variation in species composition and stand structure is described below.

Conifers: These stands are composed of mostly introduced species of conifers; they are the remnants of plantings and plantations established by the W.P.A. in the 1930's. The dominant species in the stands

near Old Camp Road are red pine and white spruce, and the associated coniferous species are Douglas-fir, white fir, white pine, Norway spruce, and hemlock. The small conifer stand at the northern edge of the field on Mt. Kemble is dominated by hemlock, but also contains Norway spruce, white spruce, and white pine. The stands are being invaded by successional species of hardwoods, mainly white ash, yellow poplar, and red maple, and display many of the features of the non-coniferous successional stands discussed above. Hemlocks, Norway spruce, Douglas-fir, white pine and other species border the trails near the conifer stands, and also border the old road running from the end of the Mt. Kemble field through the northern extension of the Park; these borders have not been mapped, inasmuch as they are isolated trees and not stands.

Open Areas: The regions mapped as "open" include all areas lacking forest cover. These are: the Grand Parade, the Wick Farm orchard, the orchard and field on the Stroley tract, the grass fields near the ranger residence, the Soldiers' Huts, and the entrances to trails from the roads, several old fields on Sugar Loaf Hill and Mt. Kemble, two marshes and a pond on the Primrose Brook, the parking areas at the Visitor Center, the trail center and the New York Brigade parking area and the lands surrounding the Guerin House and the former "field office." This mapping category thus includes both natural biotic communities (the marsh area and the old fields), managed biotic communities (the orchards and grassy fields near the historic sites and houses), and abiotic features (parking lots). The unmanaged old fields contain a considerable diversity of herbaceous plants (grasses, wildflowers and ferns), but in some cases are rapidly being invaded by successional tree species. The marshes include the region denoted as "Cat Swamp" on old maps of Jockey Hollow, and the site of a former holding pond of the Morristown Aqueduct Company, on the West Branch of Primrose Brook. Both marshes support a diverse group of sedges, rushes, grasses and ferns. The remaining holding pond of the Aqueduct Company, on the North Branch of the Primrose Brook, is connected to the Brook by only a single pipe, placed at a high level in the pond basin; it thus gets no inflow or outflow from the stream. This lack of drainage explains why this pond has not experienced the kind of hydric succession seen in the other pond area, and the pond can be expected to remain the way it is indefinitely. The managed fields in the vicinity of the visitor attractions are essentially lawns, containing grasses and little else.

Map 2: SUCCESSIONAL FOREST

Mixed Successional Forest: This mapping unit includes a wide variety of successional stands encountered in the Park. The tree species include white ash, yellow poplar, black locust, black walnut, red maple, black birch, elm, sassafras, black cherry, grey birch, red cedar, and bigtooth aspen. Each stand is dominated by two to four of these species; virtually all species combinations can be found. Within the stand, the species composition often changes over short distances, so that the stand as a whole is composed of small units in which one or more species predominates, and which is different from the surrounding units. Hickory saplings are frequently seen.

Dogwood, spicebush and blackhaw are found in various mixtures in the understory. The aspect of these stands is described under Successional Forest (Map 1).

White Ash - Yellow Poplar: In these stands white ash and yellow poplar are dominant, and the other successional species supply a small fraction of the stand. This variant of the successional forest occurs commonly throughout the Park, hence, its separation as a mapping unit. Most but not all of these stands have a dense understory of spicebush. See Stand Analyses (Chapter 6) for further detail.

White Ash - Black Locust: This combination of canopy species is analogous to the white ash - yellow poplar stand. It has a more open aspect, due to the lower foliage density of black locust in comparison with yellow poplar, and it is characterized by a smaller average size (again attributable to the difference in growth rate between yellow poplar, a fast-growing species, and black locust, a slower-growing species that rarely attains the mature size of the yellow poplar). These stands also frequently have an understory of spicebush, but may lack a well-developed shrub layer and have a dense growth of herbaceous plants instead.

Pure Stands: In this category fall stands whose canopy contains 75% to 100% of a single species.

Yellow Poplar: These stands constitute the largest percentage of the area mapped as pure stands. Some of the stands included in this category arose within the past forty years on lands previously mapped as old-fields; others occur in areas that were mapped as "yellow poplar - red oak - white oak" forest in 1933. Although the latter stands may thus not be truly "successional" in the sense of being a short-lived intermediate stage of vegetation development between the old field and the mature hardwood forest, they appear indistinguishable from the former kind of stand and therefore the two kinds of yellow poplar stands have been mapped together. This community is striking in appearance; the straight, tall boles of the yellow poplars rise above a well-developed shrub layer (composed almost entirely of spicebush), with a poorly developed understory layer intervening between the shrubs and the canopy. Ground layer vegetation is very sparse in the deep shade cast by the thick shrubs. Vines are often present in these stands, but they rarely form as dense a growth as in other types of successional forest. The older stands of pure or predominant yellow poplar usually fringe mature mixed oak - yellow poplar stands, suggesting that they are persistent remnants of the successional community, in which reproduction by yellow poplar has successfully maintained the type while oaks become co-dominant in the surrounding forest. Such areas can be seen, for example, on the southeast and northeast sides of Fort Hill.

White Ash: This type occurs primarily on the lower eastern slopes of Mt. Kemble. The stands are young (probably less than 20 years old) and consist of densely stocked small stems of pure white ash. The crowns of the small trees are open, so that sunlight readily penetrates to the ground. The older stands have a dense understory of spicebush;

the younger stands often lack a shrub layer and have instead a dense growth of herbaceous plants and brambles. The stands on Mt. Kemble are located near large, mature white ashes growing along the old roads and field lines that lace the area; these mature trees are clearly responsible for the high density of white ash in these successional stands.

Black Locust: This type occurs in several small patches on Sugar Loaf Mountain, the eastern slope of Mt. Kemble, and in the young forest areas east of Jockey Hollow Road. Each stand occupies a part of an open field shown on the 1937 map; clearly, this species seeded in heavily in these areas, and was able to exclude the other successional species which were growing along the perimeter of each area. The structure of these stands is similar to those of the white ash stands: the canopy is open and the trees are closely spaced and small, the understory is dominated either by spicebush or a mixture of herbaceous plants and brambles, and vine growth is common.

Black Birch: Like the preceding type, this type is represented by a few small areas, each found within the boundaries of an old field as shown on the 1937 map, and each surrounded by mixed successional type forest. The structure of the stands is similar to that described for Black Locust.

Sassafras: This type is represented by only one stand, found along Jockey Hollow Road near the northeastern boundary of the Park. It is mapped separately here because of the striking difference in species composition (i.e., the dominance of sassafras), compared with the other successional stands in the Park, and because the strong allelopathic effects of sassafras roots and litter (see Chapter 9) may perpetuate this community at this site for some time to come. The presence of this community can probably be attributed to the seeds derived from several large, old sassafras trees seen in the surrounding hedgerows. The structure of the stand is considerably different from the other successional types described above. The foliage of the canopy is more dense, so that the stand forest floor is well shaded; however, the trees are small in diameter and closely spaced, as in the other successional stands. The understory is dominated by blackhaw viburnum, with smaller amounts of spicebush present. The forest floor is virtually bare, except for sassafras seedlings. Vine cover is well-developed.

Black Walnut: This type is found only along the trail between the Grand Parade and the trail center. The black walnuts dominating the stand are all large and poorly formed; no reproduction of black walnut is evident. The soils in the Park are too acid, shallow, and stony to support optimal growth of black walnut; this may be the main factor contributing to the poor form and scant reproduction of this species in these stands. Surrounding these old trees is a typical mixed successional stand of younger trees, with some red-cedars still living and indicative of the formerly open nature of ground between the walnuts. According to Weig (1977), the black walnuts were probably retained when the surrounding forest was cleared for agriculture and orchard trees. The regular line of trees along the trail suggests,

however, that some of the walnuts may have been planted. In any case, the trees were clearly allowed to develop amidst the fields and orchards of the Thompson farm (see Rutsch and Peters 1976), and therefore date back to the latter part of the 19th century.

Red Maple: This type is found around the headwaters and springs feeding Jersey Brook, south of Tempe Wick Road. It is restricted to the area of Cokesbury soil, which is characterized by poor drainage and an underlying layer of impermeable material. The ground is typically mucky, with standing water or saturated soil present throughout the year. Red maple dominates both canopy and understory; associated species include yellow poplar, pin oak, sycamore, and white ash. The shrub layer is dominated by spicebush, with lesser amounts of blackhaw viburnum and high-bush blueberry. Vines are moderately dense. Although this type is mapped as a successional forest, the exclusive presence of red maple in the reproductive layers of the understory suggest that the type is likely to be self-perpetuating in the foreseeable future.

Ailanthus: This type is found in two locations: on the summit of Tea Hill, and along a portion of the Stark's Loop Trail on the easterly slope of Mt. Kemble. Although the area occupied by the type is small, it is mapped as a separate type because it is the only community dominated by an exotic species. The Tea Hill stand is bordered on the western side by Chestnut Oak forest, and on the eastern side by Mixed Hardwoods forest showing signs of disturbance (open canopy, dense vine growth, stumps of cut logs), and containing a mixture of yellow poplar, black and red oak, ash, beech hickory, black birch, and, near the bottom of the hill, several exotic shrubs (see Mid-year Report). The extreme stoniness of the soil at the summit of the hill may contribute to the success of the Ailanthus; however, its presence is clearly related to the history of disturbance and the neighboring houses. The stand bordering the Stark's Loop Trail grades into ash-locust successional forest on the downslope side, and disturbed Mixed Hardwoods forest containing yellow poplar, ash, and some oaks, on the upslope side. The Ailanthus stands are thus small, associated with highly disturbed areas and frequent human visitation, and are evidently being encroached upon by native hardwoods.

MAP 3: MATURE FOREST

The mature forests of the Park consist of five types in which oaks dominate, in association with a variety of other species, and three forest types in which oaks are present, but do not dominate the stand.

Mixed Oak - Black Birch: This is an upland forest type characterized by a high density of black birch, in addition to the dominating oaks. The stands are similar to the Chestnut Oak stand described in Chapter 6, except that black birch, black oak, and to a lesser extent red and white oak, share dominance with chestnut oak. Red maple is usually the third most important species. Hickory is locally abundant, and on ridge tops replaces black birch as the co-dominant species. Other associated species are beech, yellow poplar,

ash and yellow birch. Dogwood often forms a dense understory layer; where it casts a deep shade, there are few shrubs, and where some light penetrates, maple-leaf viburnum dominates the shrub layer. The canopy is relatively open, and the trees are sufficiently short that the red maple, not usually a canopy-member tree, does reach the top layer of foliage in these stands.

Mixed Oak - Yellow Poplar: This type is generally found on lower or middle slopes, on moist soils. Yellow poplar, red, white, chestnut and black oak contribute over 50% of the basal area. Beech, black birch, yellow birch and sugar maple are of secondary importance, and several other species, including hickory, white ash, and sassafras, contribute to the diversity of the community. This type is particularly well-developed on the lower slopes of Fort Hill. The understory is diverse in composition, but is notable for the absence of oak reproduction. The shrub layer is also diverse; although maple-leaf viburnum is the most common species, spicebush, witch-hazel, blackhaw viburnum and low-bush blueberry are present. The groundlayer contains low herbaceous plants characteristic of mature woods. The canopy is moderately dense, reflecting the abundance of yellow poplar and the multi-layered structure of the canopy and understory. In one stand (the region on the east slope of Mt. Kemble, between the Loop Trail and the large field covering the ridge-top), the typical structure of the type is modified by evident recent severe disturbance (probably grazing). Although large oaks and yellow poplars dominate the canopy of this stand, the understory resembles a mixed successional community, consisting principally of red maple, white ash, and black locusts, and being densely overgrown with vines.

Mixed Oak - Beech: These stands are found on lower slopes and bottomlands near streams. The canopy is composed almost entirely of oaks and mature beech trees, with small amounts of red maple and black birch completing the canopy. The understory is more diverse, with yellow birch, yellow poplar, and several understory species such as dogwood and serviceberry present; however, young beech and oak trees remain important elements of the understory. The beech is patchily distributed: it ranges from being common but mixed with the above-mentioned species, to being the sole occupant of a patch. The shrub and ground layers of vegetation are absent in the vicinity of these beech groves except for sprout clumps of beech saplings around each mature tree; maple-leaf viburnum and low-bush blueberry grow sparsely where the percentage of oaks and other species increases. The shrub layer is never as densely developed as in the oak communities described above. Herbaceous ground-level species are less abundant than in the Mixed Oak - Yellow Poplar communities. The canopy casts a dense shade, because of the abundance of beech; the sparse shrub layer makes the lower levels of this forest type more open than any of the other oak forests found in the Park.

Mixed Oak: In this forest type the oaks (red, white, black and chestnut) comprise 50% to 75% of the basal area. Red and white oak are common on the lower elevations in the stand, and chestnut oak increases in importance towards the higher elevations. On the gently

sloping upland sites (near the County Park, for example), red white and black oaks are approximately equally common, and chestnut oak is a minor constituent. Associated species include beech, yellow poplar, red maple, black birch, and white ash. There is usually a well-developed understory of dogwood. The shrub layer varies in density within each stand, ranging from a dense mixture of maple-leaved viburnum, low-bush blueberry, and canopy-tree seedlings and saplings, through patches containing only beech sprouts to patches devoid of ground layer or shrub layer plants. This variation appears to reflect small differences in topography and drainage, and small-scale disturbances such as tree-falls. This forest type is restricted to the moderate upland habitats of the Park, being found neither on ridges, in the bottom lands, or on lower mesic slopes. The stands all show signs of past logging; the stand on Mt. Kemble in particular is laced with old logging roads and trails.

Chestnut Oak: This forest type is restricted to steep slopes and dry ridge-tops. Chestnut oak is the dominant species of oak; black, white and red oaks may be present, but are not abundant. Red maple and black birch are as abundant as the chestnut oak, and black birch supplies a basal area equivalent to that of the chestnut oak. Beech, yellow poplar, hickory, ash, yellow birch are present, but not abundant. The canopy is open and the trees are relatively small in diameter and low in height. Dogwood is prominent in the understory; it ranges from dominating this stratum (with 65% of the stems, as in the stand above the Wick Farm described in the Mid-Year Report) to lower densities in which reproduction by the three principal species accounts for a large fraction of the understory (as in the stand on the west slope of Mt. Kemble). Maple-leaf viburnum and low-bush blueberry are abundant in the shrub layer. This forest type grades into the Mixed Oak - Black Birch type, as noted above.

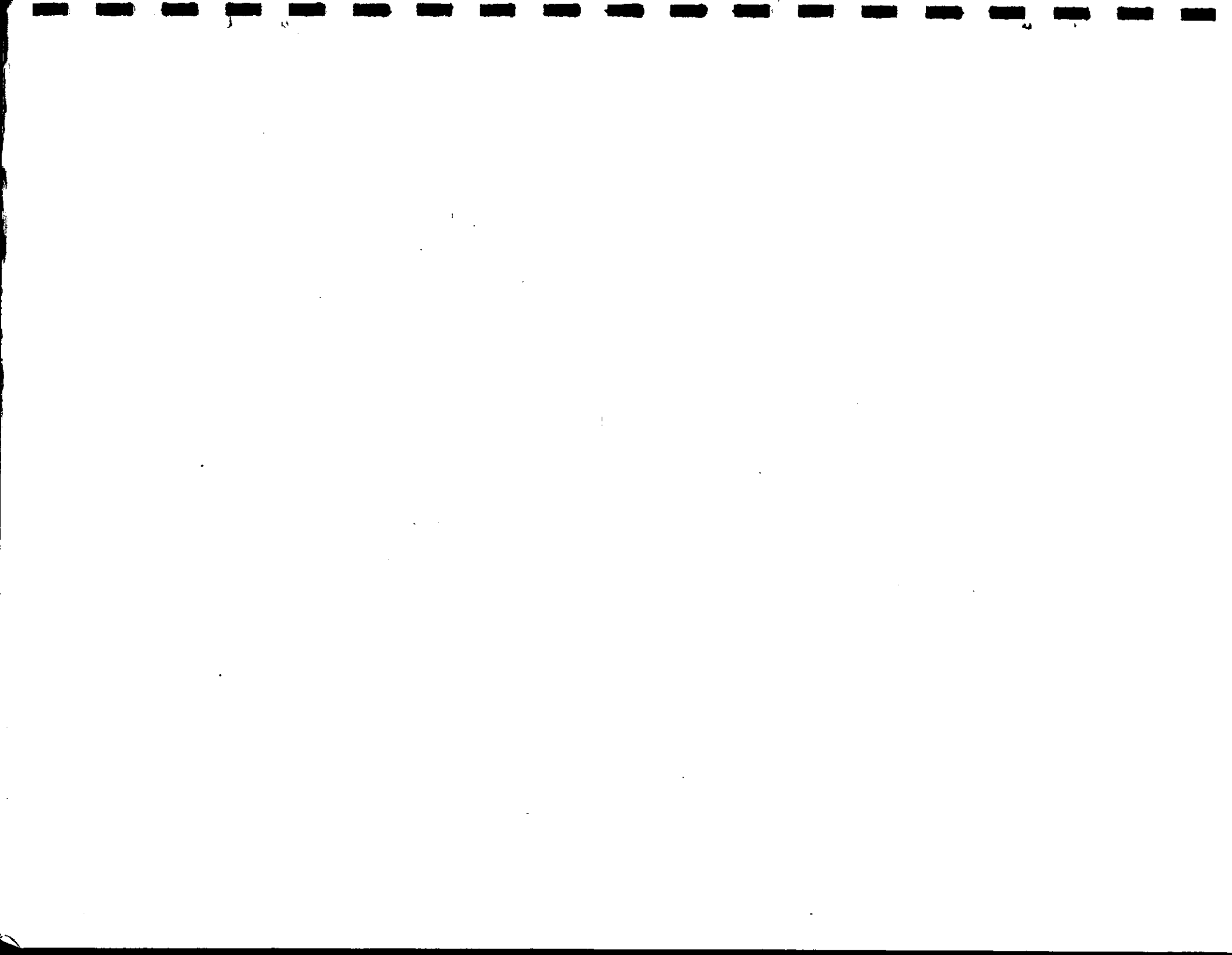
Mixed Hardwoods: This mapping unit has been used to include a diverse group of forest stands, sharing the characteristic that no species or pairs of species dominates the stand. A variety of oak species are mixed with red maple, black birch, hickory, white ash, yellow poplar, beech, yellow-birch, and sugar maple. These stands typically consist of small patches in which one or a few of the above species dominate, but the patch composition changes over short distances, so that no group of species predominate throughout the area. Oaks may be absent, or may be a minor component, in portions of these stands. In some of the stands, this structure is a result of recent disturbance; for example, the stand on the boundary of Lewis Morris County Park, in the northwest corner of the Park, should probably have been mapped as a Mixed Oak - Black Birch stand, had not the recent gypsy moth-caused mortality removed many of the canopy-member oaks. The stands on the east slopes of Tea Hill and Mt. Kemble also appear to reflect intense logging and other human interference; oaks, ash, yellow poplar and black birch are densely grown over with vines, brambles and herbaceous species characteristic of successional stands, exotic hardwood and coniferous trees are present along the boundaries, and cut stumps are abundant. However, some of the Mixed Hardwood stands, notably the area between the Aqueduct Trail and Grand Parade Road, appear to reflect natural forest development. In these

relatively undisturbed areas, the canopy species are more uniform in importance than in the other mature stands described above, and the understory contains a diverse assemblage of young individuals of canopy species and individuals of several non-canopy species (e.g., dogwood, serviceberry, azalea, ironwood, hop-hornbeam, and others; see Chapter 6). The ground-level vegetation contains reproduction of species from all forest strata. The canopy is dense, largely because of the complexity of the layering that results from the number of species in the overstory and understory.

Mixed Hemlock-Hardwoods: This is a small stand located in the northeast corner of the Park. It is situated on a steep slope which faces northeast. It is the sole representative in the Park of the typical forest community of cool, moist hillsides and ravines. The canopy consists of approximately 50% hemlock, and 50% mature hardwood species including red oak, black oak, beech, black birch, hickory, yellow poplar and red maple. Dogwood is present in the understory, and sapling-sized trees of both hemlock and hardwood species were seen. Shrub and herb layer vegetation is sparse, as is typical under the dense shade of the hemlocks. The stand has been heavily logged, and the openings have been filled by the hardwood species. Surrounding the stand is a narrow belt of successional forest (not mapped because of its small size), containing mostly yellow-poplar, red maple, dogwood, and vines; this successional community has invaded the borders of the hemlock-hardwoods stand. This type has been included in the "Mature Forest" Map, rather than being included in the Coniferous Forest type of the base map, because the mature status of both hemlocks and hardwoods, and the location of the stand in the expected type of habitat, strongly suggest that the stand composition is natural, and does not reflect planting by man, as does the hemlock stand found at the end of the Mt. Kemble field (see Coniferous Forest, above).

Stream Thicket: This forest type is restricted to the borders of the branches of Primrose Brook in the section of the Park east of Jockey Hollow Road. It closely follows the distribution of the Cokesbury soil (see Mid-Year Report), a moderately well-drained soil with an impermeable layer that restricts root growth, and supports a high water table. The soil in these stands is saturated for much of the year, and supports luxuriant growths of ferns and skunk-cabbage. The canopy layer is dominated by beech, red maple, and yellow-birch, which together comprise almost 80% of the large trees. The remainder includes white oak, white and black ash, black birch, yellow poplar, and occasional elms and sycamores. The understory is more dense and more rich in species than any other community mapped. In addition to abundant saplings and pole-size trees of the canopy-member species, witch-hazel, spicebush, dogwood, azalea, high-bush blueberry, elderberry, alder, serviceberry, ironwood, and saplings of sugar maple, red oak, black gum, and sassafras are present. Grape vines are present in the more open segments of the community. The salient feature of this forest type is the open canopy that prevails over much of the area. The trees are low, and the shrub layer of vegetation is very dense, so that the community often forms a thicket,

rather than a multitiered forest. It should be noted that this type of community occurs in small patches, albeit frequently, along the stream branches. Because the scale of the patch sizes was too small for accurate mapping, the entire region in which such patches occur was included in the representation of the type; it should thus be borne in mind that this community does not form a continuous, uniform belt along the streams. Small patches of this community type may also be found near the West Branch of Primrose Brook, where a thin tongue of mucky soils of the Califon type extends northward towards the Hospital site and Grand Parade Road. These patches were not mapped because of their small size and scarcity relative to their development along the East Branch of Primrose Brook.



APPENDIX 3. GUIDE TO THE LAND-USE HISTORY MAP

The purpose of this map is to portray the assembled information about the use of the land in the Jockey Hollow area during the past two and a half centuries. This Appendix describes the material that has been included on the map and explains the system of data presentation.

Documentary Sources: The descriptive material incorporated in the map includes accounts written during the nineteenth century (Tuttle, 1871 and McClintock, 1894), an account by Mrs. Elsie Weig of the farming activities in the area during the first part of the twentieth century, and a series of published (Sherman, 1905), and unpublished photographs of the area. The latter are in a collection maintained by Ms. Barbara Hoskins at the Morris Township Public Library in Morris Township Public Library in Morristown, and include photographs taken between 1865 and c. 1935.

The information in these sources was entered on the map in as much detail, and as accurately, as the description of the land usage permitted. Compass directions, landmarks, topographical information and vegetation descriptions were correlated with the present-day features of the area in the effort to accurately locate each piece of information. In the case of unclear descriptions of locations (especially in Tuttle (1871) and some of the miscellaneous photographs in the Morris Township Public Library), the information was compared with the other available historical information and with the current structure and composition of the vegetation, and an approximate location was assigned. Data from the miscellaneous photographs of Hoskins are listed by date, where the information was available.

Map Sources: The map of the Wick Farm drawn by Ludlow in 1787 contained a wealth of information concerning the location of fields, old woodlots, second growth timber, etc., and this information was rescaled and transcribed onto the Land-Use History Map as accurately as the original map would allow. (The copy of the map used was that on file at the Morris Township Public Library).

The map prepared by Vermeule and Stock in 1900 showed the distribution of forested and non-forested areas at that time, at the 1:24,000 scale of the topographic maps. The information on this map has been extrapolated to the current map, with consideration given to the limits in accuracy of such a small-scale map. Supplementary information from other sources was used in interpreting questionable areas on this map.

The land-use maps and vegetation maps prepared during the early years of the Park (see Table 1) provided very detailed information on field-forest distributions for the older (pre-1964) portion of the Park, and less detailed (and less accurate) information for the eastern addition to the Park. The information from the Road Map (1933), which shows the location of fields through the whole Jockey Hollow area, was transcribed in toto onto the Land-Use History Map in order to provide a reference point from which to examine the appearance and disappearance of fields during the two-and a half

centuries of the area's history; those areas shown as forest on the Road Map are shaded on the Land-Use History Map.

Boundary Trees: As described in Chapter 8, deeds to the properties in the Jockey Hollow area were examined in order to identify the locations of "boundary trees" (that is, those trees that were used by surveyors to delimit the boundaries of the properties). In addition, trees shown on the Ludlow map (1787) and on a map of the Wick Farm prepared by William Gray (1781) were located on the current map. The boundary trees were initially located on the deed map of Cobbett et al. (1938), and then transcribed onto the Land-Use History Map. The identification of the deeds from which the trees were taken is given in Table 8-2 of the text.

Data Presentation: Each item of information gleaned from the documentary and map sources described above was placed on the map as accurately as possible on the location to which it referred; thus, the work "orchard" shown on the map just west of the parking lot at the Soldiers' Huts shows the general location and character of the fields visible in the photographs in Sherman (1905). The sources of information are coded chronologically in the map key; thus, the sequence of letters in parentheses beneath each descriptive phrase indicates both the time at which the observation was made, and the length of time over which the condition obtained. For example, the entry "Mature Woods, 1856, (B,D,E,F)" shown on the east side of Fort Hill indicates that mature woods (oaks, beech, black birch, etc.) were observed in that region at least as early as 1856 (miscellaneous photograph of Hoskins), and also from 1871 to 1905. The boundary trees are shown by a letter code for the species and the date of the map or deed in which the tree was mentioned.

