

Recommendation for Land Management Jockey Hollow Area Morristown National Historical Park

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Recommendations for Land Management

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INTRODUCTION

The role of Morristown National Historical Park is to commemorate the encampments of George Washington and his troops, especially during the winter of 1779-1780. In 1779, Washington selected this site "lying behind Long Hill and the Watchung Mountains, protected from sudden attack by both those rugged heights and broad swamps.... From [the encampment site], with reasonable security he could keep an eye on the British wintering in and around Manhattan Island, guard the roads connecting New England with the Revolutionary capital at Philadelphia, and move swiftly to any threatened point." Washington decreed that his army should build a "Log-house city" from the 600 acres of forest in Jockey Hollow (Scheer, p. 8).

The park today includes both cultural artifacts from the times of the encampments, such as buildings and archeological remains, and extensive natural, or at least semi-natural,¹ forested areas, reminiscent of the 600 acres of forest to which Washington referred. It also includes some cleared fields which Historical records indicate were also part of the historic scene.

The Jockey Hollow area of this park includes 540 ha, 95% of which currently consists of unmanaged, primarily oak-dominated forest (Figure 1). These wooded areas include both mature forest, which was probably never completely cleared for agricultural purposes, and successional forest, which has regenerated on agricultural fields which were abandoned during the last century (Ehrenfeld 1977). Forest management has been essentially passive, based on the assumption that through natural succession and development all of the forested area would eventually resemble the pre-encampment forest.

It has become abundantly clear, however, that changes which are occurring in the forests are not tending simply to regenerate or perpetuate such a forest. The area supports a large population of white-tailed deer (about 60/km²) (Christie and Sayre 1989) and has large and increasing populations of non-native plants such as Japanese barberry,² oriental bittersweet and charcoal-hearth grass. Populations of many native plants, such as maple-leaf viburnum, have

¹"semi-natural" refers to landscapes which have undergone some human impacts but in which the flora and fauna are mostly developed spontaneously, without active human management, and in which the structure of the vegetation, e.g., forest or meadow, is the same as one would expect to exist there without human intervention (reference from Human Impact of Vegetation).

²Scientific names of plants mentioned in text, from Gleason and Cronquist 1991, are listed in Appendix 1.

Figure 1. Vegetational Cover, Jockey Hollow Area, MORR. Grid is 1000 m.



- ☐ no data
- ☒ mixed successional
- ☒ mature broadleaf
- ☒ conifers
- ☒ open
- ☒ road
- ☒ stagnated black locust successional forest

dwindled over the last decade.³ In some areas, older trees have been uprooted by storms, damaging archeological resources. There is also little evidence within the forests of canopy tree seedling or sapling regeneration (Russell 1989). Similar conditions exist in the New Jersey Brigade area.

It is thus appropriate at this time to reconsider the goals and policies for managing these natural areas, so that any action may be taken that is necessary to meet the goals for the areas as well as to minimize damage to undeveloped archeological sites.

This report has two aims: 1) to analyze the role of the forest in the context of preservation and interpretation; and 2) to make recommendations for managing the forest to play this role, within the larger context of overall National Park Management policies for cultural and natural resources. It specifically addresses 4 objectives:

- 1) Apportionment of the park into several zones or areas depending on the relative importance of cultural and natural resources. In those areas of primarily cultural importance, management will continue to focus on cultural goals.
- 2) Proposing management goals for those sites where there are known, undeveloped archeological remains, considering possible conflicts between management of the natural resources and protection of the archeological sites.
- 3) Proposing management goals for natural resources within those areas where there is little or no evidence of remains related to the winter encampments or little is known about any relationship to the encampments, other than as a source of natural resources.
- 4). Proposing and recommending management options, including research, based on the management goals.

This report will focus on the Jockey Hollow area, but results are applicable to the New Jersey Brigade area also. References to "the park" will therefore apply only to these two areas. They will not apply to the Fort Nonsense or Ford Mansion sections of the park.

Overall Issues Concerning Park Goals and Management

Any management decisions take place in the context of broader goals of the National Park Service as well as other contemporary cultural values. In this section, I will sketch changes over time in

³Personal observations; J. Ehrenfeld, personal communication, based on research at the Jockey Hollow and New Jersey Brigade sections of the park.

the philosophy of managing national parks, to place recommendations made in this report in a cultural context. Without some context, and an awareness that such contexts change with time, it is difficult to understand past decisions, which continue to affect the park, as well as to appreciate the complexity that is inherent in making such decisions.

According to the enabling legislation for the National Park Service, passed in 1916, the mission of the National Park System is to "conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (Hartzog 1988, pp. 5-6). The parks thus are to serve two purposes, first, protection of resources and second, provision for public enjoyment of these resources (Haskell 1994). The resources include historic as well as scenic landscapes. Establishing the parks implies that threats to the resources jeopardize the chance for the people of the nation to enjoy them and learn from them. Without a perceived threat, there would be no reason for preservation.

By the latter part of the 20th century, preservation has become even more critical as the direct threats to these resources loom even larger. In addition, the "enjoyment of the public" has itself become a threat, as more and more people visit the parks and technology makes possible more destructive means of enjoyment (Mitchell 1994). In addition, there is now recognition of the relationship of park management to more global concerns, such as extinction of species by destruction of their habitats. The parks can be seen in part as areas where biological diversity can be fostered.

In 1991, a major meeting in Vail, Colorado, resulted in a proposed revised statement of mission, which recommends that resource stewardship be at the top of the agenda for management of the parks, above enjoyment, in recognition of the ever greater threats to the integrity of the biosphere (Haskell 1994). The statement recognizes that parks are a storehouse of natural systems that are being threatened elsewhere, so that their preservation is critical, not only for national identity and enjoyment, but also for the global environment.

Among the national treasures that are threatened with loss are sites that commemorate historic events, such as Revolutionary and Civil War battlefields, that played a part in developing the national character. These are protected in national historical parks which both preserve historic scenes and instill an appreciation of our national history. They, too, have been managed both to protect (and, in many cases, to restore or rehabilitate) the historic resources and to foster public enjoyment and education. Many of these parks include lightly-managed, natural areas as part of the cultural landscapes to be preserved and interpreted as part of the historic scene. The specific role of this semi-natural part of the landscape for interpretation and for preservation of natural resources is currently under study in many parks such as Morristown NHP.

Establishment of Morristown National Historical Park

In 1933 the U.S. Senate approved legislation creating Morristown National Historical Park. The report that supported creation of the park emphasized its relevance under the section of the National Park Service Act that included preservation of sites of historic importance: "the purpose of the Congress has also been to preserve and utilize the inspirational and educational values growing out of the greatest scientific and historic interests of our national life.... The passage of this legislation will insure the perpetual preservation of these historic treasures and their most beneficial use not only by this generation but by all generations of Americans yet to come" (Barbour 1933). In recommending the establishment of this park, the Director of the National Park Service, Horace M. Albright, noted that there was an area along Jockey Hollow Road "so primitive and so beautiful as to excite the admiration of any lover of nature. A thousand acres of forest, dell, and hill. Through this forest and over these hills for 150 years, almost unmolested, the creatures of nature have roamed and flown. Providence has preserved this area by some miraculous deviation from the ravages of the developers and the builders. For 150 years it has lain dormant in its primitive state....

"[I]n December, 1779 ... [Washington] sought the healthful surroundings and the security offered in the hills of Morris County."

Mr. Albright continued with an explanation of why this site was of critical and unique historical value, both because of the arduous nature of the encampments there and because of its central location during the Revolutionary War. In addition, it was easily reached from major cities, making it an ideal park for attracting a large number of visitors. He concluded his discussion of the Jockey Hollow area with the observations that "[t]he countryside in every direction roundabout is rural with much of the aspect of Revolutionary days in the appearance of the farm buildings, fences, and other remains. It is believed therefore that the general environment of the proposed national historical park is advantageous for the developments which such a program should take," i.e., to provide the visitor with a view that would resemble that which Washington himself had 150 years earlier. The park should serve for the "development of a patriotic and vigilant American citizenship."

These statements from the legislative record indicate that not only the aspects of the built landscape, such as the farm and soldier huts, but also the general character of the countryside were critical to the purpose of the park, to evoke for visitors the nature of the experiences of the soldiers who camped there, especially the rigors that they had survived while contributing to founding the nation. In addition, the nature of the resources, especially the forest, were an important factor in locating the encampments here, since the

construction of the log huts for shelter and firewood for warmth and cooking required a "'good tract of woodland'" (MORR pamphlet, citing General Nathanael Greene on November 4th, 1779).

Because much of the land where huts were built was not subsequently plowed, the flattened hut platforms have remained in place, and can still be discerned within the forest. These hut platforms and the artifacts that are most likely preserved with them provide a unique archeological resource for understanding the conditions of such an encampment and activities that took place there.

Integrating Cultural and Natural Resource Goals

The semi-natural parts of the park thus serve several purposes within the overall goal of preserving the historic scene and contributing to understanding the nature of the historical events:

1. They provide a sense of the 18th century, pre-encampment landscape.
2. They indicate the kinds of resources that were necessary for such a large encampment.
3. They have, to this time, preserved archeological resources from which further interpretation of the historic events can be made.
4. They serve to buffer the built and interpreted sites from developed land that is encroaching on the park boundaries on several sides.

The entire complex of cultural and natural resources of the park can be thought of as a cultural landscape, where the "entire woodland [has] significance, so that preserving the ecological processes of the system rather than individual trees or animals [is] paramount" (NPS-28, 1993, p. 7:113). According to National Park Service Management Policies for cultural landscapes, "the management of cultural landscapes will recognize and protect significant historic, archeological, ethnographic, and design values. Treatment decisions will take into account both the natural and built features of the landscape and the dynamics inherent in natural processes and continued human and animal occupation. The perpetuation of significant vistas and historic parkway and park road landscape design features will receive special emphasis (NPS 1988, p. 5:6). Management policies for natural resources direct that in a cultural zone "[t]rees, other plants, and landscapes ... generally will be managed to reflect the historic designed landscape or *the scene that prevailed during the historic period*, except that soil erosion will be prevented wherever possible" (NPS-77 1988, p. 4:9) (*italics mine*). These management objectives are in agreement for the semi-natural areas of the park, in accordance with the legislative mandates for the park. The cultural

resource management policies also include "protection of archeological and other cultural resources, such as ... earthworks [and] subsurface features, except that any interference with the preservation of the unique archeological resources associated with the huts should be considered separately from preservation of the natural historic landscape.

In the rest of this report, I will elaborate on this theme: a major mission of the park is to evoke the sense of an 18th century forested landscape, to assist in recreating the historic scene, while a critical additional mission is to preserve the historic, archeological resources of the park. Other, more broad, goals of the park service, such as preservation of biodiversity, are probably not of primary importance, but are completely compatible with maintaining a forested landscape resembling that of the late 18th century. Assuming that the desired biodiversity is that which was present before the advent of European settlers, maintaining the 18th century landscape of necessity requires including as many of the species that made up that landscape as possible. Seeing wild flowers and shrubs in their previous diversity is as much a part of experiencing the historic scene as is the more obvious character of a mature forest. A forest devoid of native wild flowers and shrubs will not be "natural," even though the visitor may not recognize any of the species that are present.

I will first discuss some basic issues related to the dynamics of forest vegetation in a temporal and landscape context, and then turn to the historic and current landscape of the Jockey Hollow area of MORR. Based on the general concepts of forest ecology and the site-specific history and current vegetation and landscape of the park, I will then recommend a zonation scheme for the park and suggest management goals for each zone. This will be followed by a variety of options for management of these zones. This brief sketch of the concepts of forest ecology serves to indicate some of the complex issues that must be considered in deciding on management activities and provides a framework for recognizing the problems of predicting the consequences of actions that are taken.

THE FOREST AND HOW IT CHANGES

Both natural and cultural NPS management policies recognize that forests are dynamic; that they cannot be managed for one specific state which will remain constant over time. To understand the consequences of this characteristic of natural systems, it is useful to understand some of the patterns of change that have occurred in the forests at Jockey Hollow, and some of the forces that lead to change in forests.

Review of Forest Dynamics

Forests are dynamic aggregations of organisms, dominated in biomass and appearance by trees, ranging from almost monospecific stands of trees managed for production of timber to exceedingly diverse tropical rainforests with hundreds of species per hectare. None of these remains static over time. Changes contribute either to dynamic stability or to directional change. In the context of managing a forest as a resource, if the forest is currently in a state that approximates the one that is desired, dynamic stability is preferred for preservation. If it is not, then changes that lead to change in the direction of the desired state are preferable for rehabilitation. In neither case will an end point be reached when the forest no longer undergoes any change at all.

The two criteria that are most appropriate to consider for the appearance of an historic scene are structure and species composition. Structure refers to the physical characteristics of the forest: height of the canopy; closure of the canopy; and size, numbers and distribution of plants in the canopy, understory, shrub and herbaceous layers. Species composition refers to the identities and numbers of species present and their relative representation. Other ecological attributes of the forest, such as mineral cycling and productivity, are more subtle characteristics which will influence the long-term stability and dynamics, but are probably less amenable to manipulation, or appropriate to manipulate in the context of this forest. "Exact configurations and plant species can vary as long as the overall pattern is retained" (NPS-28 1993, p. 7:114).

The nature of a forest depends on the climate, geology, soils, hydrology, microclimate, species pool and history of the site. The climate determines which species might survive in the region. MORR lies in the north temperate zone, with cold winters and warm summers, and adequate precipitation distributed fairly regularly throughout the growing season. Occasional ice storms, hurricanes and other wind storms constitute the major meteorological disturbance events. There are very few natural fire ignitions. Geology affects soils, microclimate (through topography), and hydrology. In the case of MORR, a resistant, acidic bedrock has produced rugged topography with generally rocky soils of low fertility. The dendritic stream system has generally narrow valleys with little alluvial soil, and a few locally wet areas of springs.

The species pool derives from a rich Arcto-Tertiary flora and fauna that experienced successive depauperization through the Quaternary glaciations, at least one of which covered the area (Lewis and Kümmel 1950, Braun 1950). While lying just south of the Wisconsin terminal moraine, the area nevertheless was subjected to glacially cold climate in the last glacial advance, and the vegetation and fauna which exist here migrated into the region after the last retreat of

the glaciers 16,000 or so years ago. Oak-dominated vegetation with hickory was probably established by about 8-10,000 years ago (Webb 1988), but the other major forest dominant, chestnut, did not become well-established until several thousand years later (data from T. Webb). There is, unfortunately, little or no information on the arrival and distribution of less dominant taxa in the vegetation, such as shrubs and herbaceous plants, nor on the animals.

Climate change acting on these species over the last few thousand years included most likely a period around 6-8,000 years ago when July temperatures were warmer and January possibly cooler than today and a colder interval from about 400 to 100 years ago (the "Little Ice Age"). Since about 1850 the climate has generally warmed in this area (Webb 1992, Lamb 1966). In other words, the region has not experienced a long period of very stable climate over the last few thousand years, and thus one would not expect the forest structure and composition to have remained stable. In fact, the interpretation of changes in climate come mainly from evidence that the dominant species have changed in importance over this time period.

Species do not react directly and simply to changing climate. Some long-lived species, such as large trees, will persist long after the climate has become inappropriate for their reproduction, producing a lag of perhaps several hundred years in their adaptation to a change. The invasion of species that have newly migrated to an area, or for which the climate or microconditions have only recently become appropriate is usually slowed by competition with those already in possession of the sites and by the slow rate by which populations grow at first. The slow early increase may be followed by an exponential burst, however, apparently coming from nowhere, but actually being the natural outcome of a regularly increasing species.

Species populations do not, however, increase infinitely, as they are eventually limited by space, food, or other constraints. This maximum density of individuals in a habitat is referred to as "carrying capacity." This deceptively simple concept states that the number of individuals will increase until the habitat is saturated, at which time it will stabilize. To test whether long-lived species like many trees have stable populations is difficult, since the generation times are so long. In addition, because of high mortality in the early stages of growth, there need to be more young individuals than older to provide sufficient replacements as the older individuals die (Hett and Loucks 1971). A lack of regeneration of a canopy tree, such as oak, thus heralds a future decrease in its importance in the canopy. Currently, throughout most of the oak-dominated region of northeastern North America, and in England as well, there is an apparent dearth of oak regeneration (Lorimer 1989, Shaw 1974). The most commonly cited cause for the lack in North American forests is a change in disturbance regime, e.g., "the abundance of oak throughout the Eastern Deciduous Forest is an artifact of disturbance regimes that are no longer common (primarily due to fire suppression)" (Crow 1988). In some oak-dominated forests, however, there is reproduction of oaks, both as seedlings and as saplings (Keever 1973, Good and Good 1971), although experimental evidence indicates that they are only

moderately shade tolerant (e.g., McGee 1968). In England, oak seedlings found under an oak canopy are generally heavily browsed by insect pests falling from the canopy, accounting for much of the mortality of the seedlings (Shaw 1974). Openings, caused by the death of canopy trees, may release smaller oak saplings, though they face tough competition with the very fast-growing red maples and black birches which also flourish in the understory. Other, more shade-tolerant and fire-intolerant species, such as beech and sugar maple, often dominate the understory in oak-dominated forests on mesic sites, and may be expected to replace the oaks in the absence of further major disturbances such as fires or large blowdowns.

Herbivory by deer can also affect forest tree reproduction, as well as changing the understory of a browsed forest. In essence, the presence of a large herbivore, deer or moose for example, changes the carrying capacity for plant species, lowering it for those that the herbivores prefer to eat and raising it for those they do not eat (McLaren and Peterson 1994).

More specifically, for deer, early stages of succession, with ample understory supplying food and cover, favor high populations. As a few tree saplings become too tall for deer browsing, the canopy begins to close and shades out the lower dense understory. This removes both browse and cover for deer, so their populations again fall, supported mainly by the cover and food in small scattered blowdowns (Harlow 1984).

High deer populations within forest vegetation, however, can severely reduce sapling, shrub and herbaceous populations. In hemlock-dominated forests in northern Wisconsin, winter browse on hemlock and other evergreen species such as yew favors the deciduous sugar maple (Anderson and Loucks 1979). A comparison of photographs taken in 1942, 1952 and 1962 of plots in a hemlock-northern hardwood stand in western Pennsylvania showed a loss of hemlock and hobblebush, attributed to deer browse. Browsing favored beech and bigleaf holly (deciduous) although by 1962 the deer had begun to eat the beech. Rubbing of antlers on saplings also appeared to be a cause of tree mortality (Hough 1965). Populations of exotic species of deer have also affected tree reproduction, for example in northern Patagonia, where they have effectively eliminated tree regeneration in a beech/cedar forest area (Veblen et al. 1989). A point of comparison between this South American example and Jockey Hollow is the increase in a species of barberry, *Berberis darwinii*, in Patagonia under browse pressure even though it provided a large proportion of the deer diet. While one study documented deer browsing damage to barberry (Christie and Sayre 1989), it does not appear in general to be as heavily browsed as many other shrubs such as multiflora rose.

Two studies document the lack of height growth of seedlings under heavy browse pressure. In Pennsylvania, experimentally maintained populations of deer in enclosures reduced the height of tree seedlings significantly over five years, though there was no difference in the numbers of seedlings among the different deer densities (1, 10, 20, 40 and 80/259 ha). Black cherry did best under the highest deer density

(Tilghman 1989). An interesting interaction among species is that deer browse decreased the amounts of brambles (*Rubus* spp.), and favored ferns, especially hay-scented fern and New York fern. The ferns inhibited tree seedling growth and survival (Tilghman 1989). Thus deer stress tree seedlings two ways, directly by eating them and indirectly by increasing competition from species that thrive under browsing pressure. In New York State, at Saratoga NHP, deer exclosure studies suggest that a major impact of deer is to limit height growth of tree (and probably shrub as well) seedlings (Austin 1992).

Deer may also increase plant species diversity. In the studies at Saratoga NHP, the number of plant species present in the exclosures was greater than that outside after 4 years. Similarly, in northern Patagonia there were more herbs in gaps that were browsed by deer than in unbrowsed gaps (Veblen et al. 1989). This is actually not surprising if the most common species with the highest cover is favored by deer. Reduction of this species by deer would provide more space for a large variety of other species. These would, of course, be mainly limited to species less preferred by the deer.

Thus the concept of "carrying capacity" when applied to browsers such as deer is a complex one. In a more or less homogeneous landscape, perhaps dominated by forest vegetation (in itself heterogeneous), as the population of browsers approaches a limit determined by food supply and perhaps other factors such as disease or predation, it stabilizes, and fluctuates, around the maximum. There would undoubtedly be an impact on the producers, or plants, that the deer eat, in which the more conspicuous, palatable species would become rarer and the less palatable ones more common. If, however, the landscape is heterogeneous, so that areas of high food supply alternate with those with good cover, the number of deer that can be supported by the landscape, the "carrying capacity" of the entire landscape, may result in numbers too large to be accommodated by the areas of good cover without severe depredations of the food sources there, to an extent that would not occur if that were the only habitat available. The "carrying capacity" of the forest might be greatly overridden because of sources of food outside the forest.

Other factors outside a forest which may affect regeneration and diversity include the introduction of non-native species. Black locust planted as a hedgerow tree may quickly invade an adjacent abandoned field, and may inhibit or change the patterns of succession to a mature forest of native species. For example, in western North Carolina, a dense thicket of locust sprouts suppressed the height and diameter growth of tulip-tree (Beck and McGee 1974). Both species are native in North Carolina, but in northern New Jersey black locust has spread from planted trees, and is not part of the native successional sequence. In the lower midwest, planted stands of black locust are invaded by American elm, black cherry, boxelder and hackberry rather than the oak that replaces naturally reproducing sassafras/persimmon stands (Ashby 1987). Perennial alien plants often form thickets that preempt sites for the establishment of native species. There is much suggestive evidence that non-native herbivores expose new niches for non-native species, but the evidence is not conclusive (Crawley 1987).

It is difficult to determine whether a species that becomes very common in an environment that has been heavily browsed would have done so without the browsing, just as it is difficult to know whether the elimination of some native species in sites where non-native ones have spread is caused by the spread of the non-native species. It is at least clear that the species that become common under heavy browsing pressure are those that are less palatable to the browsers; they could not have spread abundantly if they had been a preferred food. Likewise, very palatable native species are significantly reduced by increased browsing (Anderson 1994).

This very brief introduction to the dynamics of a forest community may serve to focus attention on the complex forces that determine forest composition. The human role in forest dynamics is also complex. It may consist of changing the disturbance regime by introducing or preventing fires, introducing new species and eliminating others, as well as by removing the forest entirely, setting in motion a series of directional changes when the land is again allowed to revert to forest. These complex dynamics must be part of the consideration of potential management activities.

The Forest Resource at MORR

The historic forest at Jockey Hollow, which is the goal of management, resulted itself from a complex series of interactions of natural and human-initiated changes prior to 1779. Changes since 1779 have altered the forest and obscured the nature of the forest in 1779. The regional landscape of which this forest was a part has also been altered, affecting landscape structure, microclimate, air quality, and species pools. These must all be considered in deciding on management of the forest resource in the future.

The 18th Century Forest

Climate, biogeography, paleoecology and historical documents all indicate that the forests that existed here in the 18th century were dominated by oaks, with hickory and chestnut also important (Russell 1979, Ehrenfeld 1982). White oak was the most common oak species, but black oak was also common. The evidence for the differential distribution of the species on the landscape is scanty, as is evidence for different associations of species. The historical record for the region suggests that the forests were fairly open, with little understory in the uplands (Day 1953, Russell 1983), but the species composition of the understory or herbaceous growth is unknown. Possible impacts of the Lenni Lenape inhabitants would have included reduction of deer and other game populations by hunting, gathering plant products such as firewood, tubers (e.g., Indian cucumber) and

fruits, and possibly burning. There is, however, no evidence for local native American agricultural clearings.

By 1779, local farmers had cleared some forest for farmland. They used the remaining forest for firewood, game, and casual grazing of livestock such as pigs, cows and horses. The first law regulating deer harvest in the state was issued in 1722, establishing a season for killing deer, and in 1771 the General Assembly set the deer hunting season to September 1 to December 31. A regulation issued in 1772 prohibited deer hunting in the Township of Morris (immediately adjacent to Jockey Hollow) for the following five years (McDowell 1978). It thus appears that the deer population was not large at that time. It is also likely, however, that pigs, horses, and possibly cows and sheep had been substituted as herbivores in the local forests. State laws at the time regulated the height of fencing necessary around a field in order to collect damages if stray livestock damaged crops inside it (Schmidt 1973). In other words, because of livestock grazing at large, farmers had to use fences to protect their crops from these free-ranging animals.

The preencampment forest, then, had most likely undergone some changes due to local human activities. We have no evidence for the changed impact by substitution of domestic livestock for deer, but either would have contributed to keeping the understory fairly open. Harvest of wood for firewood, fencing, and other domestic needs would have had at least local impacts. Fires used for clearing fields may have burned into the forest. On the other hand, it is unlikely that any non-native plant species had spread far into the forests.

The encampments at Jockey Hollow led to greatly increased deforestation, as the soldiers used wood for construction, warmth and cooking. While some of the land where the trees were cut was subsequently plowed and kept clear for a century or more, much that was steep and rocky or otherwise not good for agriculture was allowed to reforest. These woods supplied timber, probably not only for farm use but also for a local iron furnace (Ehrenfeld 1982). As the land in the region became more intensively farmed, it is likely that grazing in the forest decreased, as it became ever more expensive to fence in the large plowed crop fields.

Changes to the Forest in the 19th to Early 20th Centuries

Changes in both extent and composition of forests between the Revolutionary Period and the present have affected perceptions of what a historic or old forest should look like and the extent and composition of the forests that are there today. While we have almost no direct evidence of changes to the forests in the 19th century except for extent (Ehrenfeld 1982, Rutsch and Peters 1976), we can assume that during that period land left forested was used heavily for forest products such as timber and charcoal. Near the end of the

century, the New Jersey Geological Survey conducted a survey of the forests of the state. The surveyors noted that in the vicinity of Morristown and Mendham

"either chestnut or oak predominates, but there is also a good deal of hickory, some [black?] birch, white [gray?] birch, maple, elm &c. There does not appear to be much cutting at present, but there has been a good deal 10 or 15 years ago, so that there is much timber only from 2 to 5 inches in diameter, but it runs from these sizes up to 20 inches. A fair average of the timber would be from 6 to 10 inches and 30 to 45 feet high. The steeper slopes are generally forested, and there is no evidence of washing from deforestation. On the easterly edge of the plateau, southwest from Morristown, the timber is of the same general character as that we have already described. As this is becoming a residence district there is a tendency to preserve the timber, and most of this is of fair size and age, and there is very little cutting. ... There is but little cutting, and what there is is mostly for fencing. It is mainly held either in connection with farms or the country places of people from the near-by cities, and there is a general tendency to cut the wood carefully and make the most of it." (Vermeule 1900, p. 74).

Maps made for the park in the 1930's showed very few forests older than 80 years, though some were indicated as "all aged" or "mixed ages (Morristown National Historical Park 1937)." Successional stands (dominated by gray birch and red maple or by black locust) ranged from 0 to 60 years suggesting a slow process of abandonment of agricultural fields starting in the 1870's (Ehrenfeld 1982). Some tulip-tree/red oak/white oak stands were also young in 1937 (21-40 or 41-60 years old) suggesting that these areas had been heavily logged in the preceding decades.

By 1900 other changes in the flora and fauna of the region were also evident. As early as 1862, the General Assembly of the State prohibited deer hunting for five years. The deer population of the state was at a nadir in 1900, even after several more years of closed seasons. The total (reported) deer harvest in the state in 1901 was 20 deer, and the season was closed from then until 1909. Between 1904 and 1913 the state restocked the deer herds from private reserves and other states, such as Pennsylvania and Michigan. By 1912 farmers were complaining about crop damage (McDowell 1978). Deer were thus most likely absent from the Jockey Hollow area during much of the 19th century, but were reappearing by 1940, when the park reported herds of from 3-16 deer, mainly does. In March of that year the Superintendent of the park reported that there were at least 20 deer in the park most of the time, as estimated from tracks in the snow, and at times there were as many as 40 (Superintendent's reports, Feb. 13, 1940; Mar. 9, 1940). [It is interesting that just 7 years earlier, the superintendent at Saratoga NHP north of Albany, NY also began to report the appearance of a few deer (Russell 1993).] Assuming that this number refers to the number in the approximately 500 ha area of

Jockey Hollow, 20 is already half the density recommended to allow tree regeneration and the development of a diverse understory in mixed hardwood stands, based on enclosure studies in Pennsylvania (Tilghman 1989).

At least one non-local tree species was also becoming common on the landscape by the early 20th century, black locust. Farmers had long planted black locusts in the vicinity of their farms, often in hedgerows, for use as fenceposts, firewood and other purposes (Little 1949, p. 763). In addition, John Wick may have planted black locusts on the grounds of the "cemetery", shortly after the beginning of the nineteenth century (McClintock 1894). Some other, native, species that were often favored and planted were black walnut for nuts and dye; sugar maple for sugar and landscaping; and red cedar for fence posts.

The only specific references to use of the forests of the park indicate that they were used for timber. One forested area was "criss-crossed with logging roads" and "frequented by a 'traveling sawmill,'" with logging continuing until the 1920's, according to a local resident, Mrs. Melvin Weig (Rutsch and Peters 1976, p. 44). In addition, 100 acres of the property had been used by the Morris Aqueduct Company to construct waterworks to carry water to Morristown, around the turn of the century. This involved extensive excavation, for holding ponds and canals, which undoubtedly altered drainage in several areas of the park.

This brief summary forms a backdrop for activities undertaken after designation of the park as a National Historical Park in 1933. The beautiful forest primeval described in the report accompanying the legislation in 1933 was primeval only in the mind of the beholder. Not only was there little evidence of the structure and composition of the forest as it existed in 1779, the forests of 1933 were heavily influenced by the activities of the intervening century and a half. The non-native black locust dominated many young forest stands and logging and other disturbances had most likely altered the species composition of the mature forests. Farming, farm abandonment and residential development had modified the surrounding landscape.

Land Management in the Early Years as a National Historical Park

The General Plan for MORR, dated July 1934, set out the general goals for management of the forest. It was proposed "to restore the area to that of the period when the cabins were just being completed and before too great a devastation had been effected on the woodland" (MORR 1934). This goal balanced the importance of the park as a historic site, thus including the cabins, with the aesthetic consideration of retaining the forests, both as a setting for the cabins and as a buffer from the surrounding residential areas. The program was to be a "pleasurable educational and scenic" one for the

visitor (p. 6). By 1934, about 55 acres had been reforested with native trees, and the expectation was to gradually remove the dying locust. They expected to extend this work to 30 to 60 more acres, as well as to improve the general appearance of the park by cleaning up dead and down limbs and brush in areas that would be frequented by visitors. In other parts of the forest, heavy debris and logs were to be flattened to the ground to reduce fire hazard (pp. 8-9). The contemporary perception of a proper primeval forest was one which did not include a tangle of litter and low vegetation.

The 1930's were an ideal time to begin such an ambitious project. The United States Civilian Conservation Corps (CCC) provided a generally untrained but energetic labor force. The Corps was dedicated to projects that led to conservation of the nation's forests (Murphy, ca. 1935). Between 1935 and 1939 the CCC carried out a wide range of forestry projects, including removing dead trees, planting, spraying trees for a variety of insect infestations and clearing brush to reduce fire hazard. The park management also prepared maps of the vegetation of the park, planting maps and lists of plants. Most of the species to be planted were native (Table 1), though two invasive vines, Oriental bittersweet and chinaberry were also included. The lists included trees, shrubs, vines, wild flowers and ferns. In addition, along Primrose Brook 200 specimens of local, native wild flowers were planted along a "wildflower trail," 0.7 mi of which was completed or partially completed by July 1936 (Atwood, 1936).

Black locust resisted both insect infestations and people's attempts to eradicate it. The CCC removed dead and dying locusts, infested with borers, in 1936 and 1937. In 1936 efforts to remove a 15 year-old stand of locusts on 11 acres near the Tempe Wick House included pulling up the roots. Chemical eradication was attempted to kill locust sprouts near the Thompson House in Oct. 1933 (Photograph, Park Series Group, 6531-3). Judging by the photographs of planting, the process involved clearing undergrowth from shrubby successional stands, probably mainly locust, and underplanting, often with ashes. Some deciduous trees were planted in open fields, as well. At least one plantation appears to be of white ash. Some of the forested areas may also have been coppiced (cut frequently to produce a profusion of quickly-growing sprouts); there is a series of pictures from the 1930's that show obvious stumps with coppice sprouts from them, and scattered standards (trees left to mature), perhaps tulip-tree.

Other trees than locusts suffered from disease, insects and other problems. The introduced chestnut blight had killed the very common chestnut trees by the 1920's. The CCC removed the last of them in 1936. Oaks seem to have been subject to a "wilt," leading to the removal of 4000 board feet of 2" planks at the lower end of the wildflower trail in February 1937 and 20-30 acres of wilted oak in March the same year. Other problems included Dutch elm disease, a variety of cankers, and scale insects on ashes and tulip-trees.

Table 1. Species shown to be planted in 1934, in vicinity of Wick House, 150' corridor near Wick House and along Jockey Hollow Road

Acer rubrum
Acer saccharum
Alnus incana
Amelanchier canadensis
*Ampelopsis quinquefolia
Azalea nudiflora
Benzoin aestivale [Lindera]
Betula lenta
Betula populifolia
*Celastrus orbiculata
Celastrus scandens
Comptonia asplenifolia [Myrica]
Cornus florida
Cornus paniculata
Cornus stolonifera
Corylus americana
Fagus americana [F. grandifolia]
Fraxinus americana
Hamamelis virginiana
Hickoria ovata [Carya]
Ilex verticillata
Juglans nigra
Juniperus virginiana
Lonicera halleana [?]
Oxydendron arboreum [a little far north]
Polystichum acrostichoides
Pteridium aquilinum
Quercus rubra
Rhus glabra
Rhus typhina
Rubus occidentalis
Sanguinaria canadensis
Staphylea trifolia
Ulmus americana
Vaccinium pennsylvanicum
*Veronica officinalis [seems odd] - could it be Vernonia sp.?
Viburnum acerifolium
Viburnum prunifolium
*Vinca minor
Vitis labrusca

*not native to the United States

Some efforts were also made to remove other undesirable plants. In September 1937 more than 60% of the sprouts and seed trees of Ailanthus were cleared out (Superintendent's Monthly Report, Sept. 20, 1937). Ailanthus still thrives in at least one stand at Jockey Hollow, on the east slope of Tea Hill. Twenty years later, the park participated in an experiment to remove Polygonum cuspidatum. An agent from the NJ. Agricultural Experiment Station treated the plants in several patches with various chemicals (Ilnicki 1958). No record was found at the park of the results of these experiments, but the species is not listed on the current park flora, so perhaps it was eliminated.

Finally, the largest concentrations of intentionally planted non-native trees were conifers used for reforestation. Many of these, such as red pine and Norway spruce still flourish in several plantations, though they do not appear to have successfully reproduced on their own (Ehrenfeld 1977). In 1940, the park ordered at least 50 each of red pine and Japanese larch from the New Jersey Department of Conservation and Development (Park records).

Thus, land management during these decades was most intense in the areas slated for regeneration of forests, both the few open fields and many young successional stands. Plantations included both deciduous and coniferous species, the coniferous mainly in areas away from those planned for active visitor use and the deciduous in fields and young black locust stands expected to develop more quickly into mature characteristic deciduous stands. The contemporary expectations for coniferous stands were similar; the conifers would provide protection for young, native deciduous trees, which would succeed the conifers when these were either harvested or died of old age.

Clearing of underbrush was probably most active in areas to be underplanted with desirable trees and near the roads. Other clearing of underbrush may have been more haphazard and incomplete. Planting of herbaceous species was limited to localized areas along roadways, near the cemetery, and along the Primrose Brook Trail. Spraying and treating for tree diseases was probably limited to areas along roads. Dead and dying chestnuts, oaks and locusts were probably scavenged throughout, reducing litter return to the soil.

Unfortunately, there are no maps of where most operations actually took place, and it is very difficult, if not impossible, to locate most management activities from photographs or evidence left in the forest. There is no estimate of how many chestnut trees were removed, but judging by the large numbers of chestnut sprouts in several areas, these trees had formed a major portion of the canopy in places, leaving a very much more open canopy when they died. Generally, after chestnut trees died, trees already in the canopy, expanded sideways to replace them in the canopy, but in many larger openings early successional trees such as red maple, black birch, and tulip-tree most likely became more common (Korstian and Stickel 1927, Good 1965). The more open canopy may have encouraged a more vigorous understory, both of shrubs and herbaceous plants (Dibeler and Ehrenfeld 1990).

After the 1940's the park engaged in less active management of the forests. Changes continued, however. Regional abandonment of farmland led to increased areas of brushy successional old fields. The encroachment of residential land-use in the surrounding area introduced large seed sources for non-native species used in landscaping, and decreased the area available for deer-hunting. The New Jersey Audubon Society, the Morris County Park Commission, and the Morris Area Council of the Girl Scouts prohibited deer hunting in large tracts of forested land adjacent to the park, which also did not allow deer hunting. Thus the increase of ideal habitat for deer coincided with a reduction in hunting pressure, encouraging population increases.

The increasing local human population began to use the park more as a nature preserve, for hiking, cross-country skiing, walking dogs, etc. rather than as a historic site. This apparent shift in the interests of many visitors may resemble that surveyed at the Roosevelt Campobello International Park (New Brunswick, Canada) where about 3/4 of visitors polled in 1989 indicated that they felt that the park management should concentrate equally on historical and natural resources, even though the park had been established primarily as a historical park (Manning and Smith 1992).

Thus, this historic site had developed through several stages after the American Revolution. In the first stage, much of the land was cleared for agriculture, though steep, rocky slopes were left in forest, to be used for the forest resources. The forest at that time, then, existed in a matrix of open, agricultural fields, subject to intense land management for crops. The forest was valued primarily for its products, primarily wood. By the early 20th century, farming was becoming less important in the local area, and fields were abandoned. Younger, successional forests began to replace the open fields adjacent to the older forest. While many such areas in the region were developed for residences, establishment of Jockey Hollow as a park, as part of Morristown NHP, led to management for maintaining an attractive forest, by treating diseased trees, planting primarily native trees, shrubs and herbaceous species around frequently visited roads and trails, and minimizing fire danger. Some old fields and successional stands were planted to hasten the change to mature forest. After the first few decades of activity, however, prevailing wisdom suggested that the best treatment of a "natural" forest was benign neglect, and active forest management essentially ceased at the park.

The 1970's to the 1990's

To evaluate the forest resources and suggest where problems might exist, a study in the mid- to late-1970's mapped the vegetation of the Jockey Hollow section of the park and noted management implications of the ecological analysis of the vegetation (Ehrenfeld 1977). This

report confirmed the commitment to a passive management strategy, noting that periodic catastrophic disturbances are part of the natural dynamic equilibrium of vegetation, and as such are not a concern. Treating outbreaks of insects, such as the gypsy moth, with chemical pesticides, for example, may not only distribute such chemicals widely in the forest, with unknown potential impacts, but also may be unnecessary because of the natural ability of forests to recover from such disturbances, though perhaps with changed composition. While there was little evidence for regeneration of oaks in the oak-dominated forests, or of development of some successional stands to later, more mature forests, Ehrenfeld did not view these lacks as causes for concern (Ehrenfeld 1977).

In her report Ehrenfeld also considered the encroachment of vines, especially in young successional forests, the impact of deer on the forest, diseases, and exotic plants. In all cases, she concluded that active intervention was unnecessary, though some limited management along edge sites might be advisable to inhibit the spread of some exotic species (Ehrenfeld 1977, pp. 3-11). She also recommended considering active management of archeological sites, particularly the possibility of clearing these to prevent further damage by treefalls, and as a side advantage, creating some small openings that would encourage a richer herbaceous flora. She did warn, however, that creating such openings might contribute to increasing the deer herd (Ehrenfeld 1977, p. 11). Her management recommendations included the establishment of permanent vegetation monitoring plots.

Less than ten years later, conditions had changed considerably. The regional and local deer herds had grown considerably, to where they were considered by many to be a problem, for road safety, maintaining residential plantings, and possibly even for their impact on unmanaged forest vegetation. A study of the vegetation of the New Jersey Brigade area of Morristown NHP, while generally echoing the recommendations of the previous study of the Jockey Hollow area, recommended that the growth of vines be carefully monitored and possibly curtailed (Dibeler and Ehrenfeld, n.d.). Two exotic shrub species, Japanese barberry and Euonymus were spreading. The report noted that "neither species is as aggressive as Japanese honeysuckle or multiflora rose. The spread of [both] can be readily controlled by cutting back the stems and then removing the roots using a grub hoe or pick" (p. 35). Again, clearing of archeological sites was recommended, with the caveat that such clearing might contribute to increasing the deer herd.

The increasing deer herd was the focus of other studies initiated at that time (Christie and Sayre 1989). Counting deer at dusk by use of spotlights and other studies began, to estimate the size and health of the herd. In one study, deer were tracked by radio-telemetry to assess their use of different habitat types. The amount of browse damage was also assessed in this study, in an attempt to quantify the possible impact of the deer on the vegetation of the park. While mowed fields in the summer made up only 7% of the home ranges of the deer monitored in this study, they accounted for 32% of the foraging

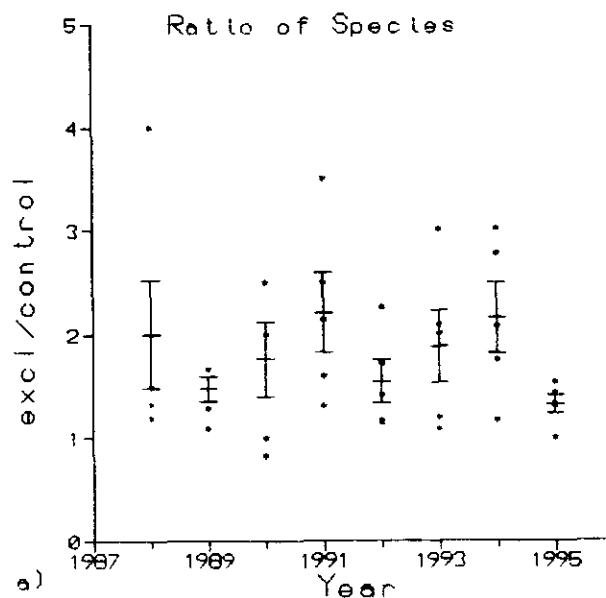
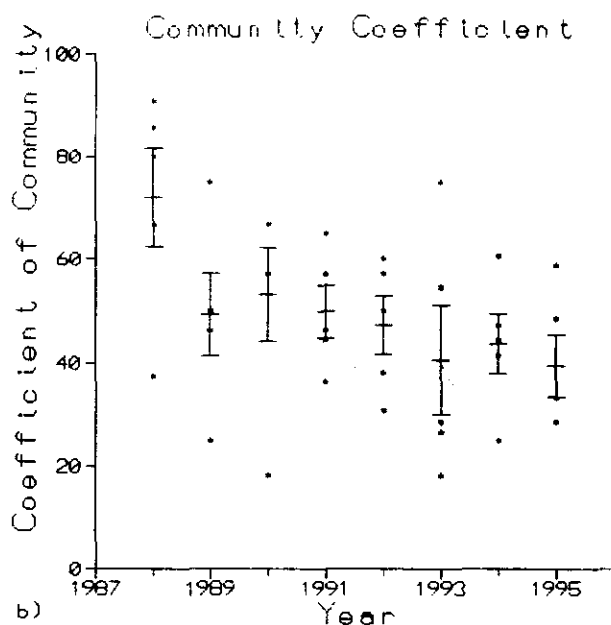
observations. On the other hand, mature oak-dominated forest stands made up 44% of the home ranges, but accounted for less than 10% of the foraging observations. Tulip-tree stands were also only lightly used in the summer. Similar results were obtained in the fall and winter, though the differences were not quite as great (Christie and Sayre 1989). The survey of the herbaceous vegetation suggested that the most common herbaceous species, white snakeroot was lightly used, while three species with much lower cover, hayscented fern, honeysuckle and wineberry, were very heavily utilized. The relationship between importance and use was much less clear for woody taxa, perhaps because of their highly variable size. For example, spicebush was both common and heavily used, but because it has much leaf area above deer browse height, and sprouts vigorously from the base, it can sustain heavy browse on the sprouts, while maintaining good cover. The very lightly browsed tulip-tree, on the other hand, was very common, but the plants were generally less than 5 cm tall, so were possibly overlooked by the deer.

These results suggested a deer impact on the vegetation, but without a control area, with no browsing, the importance of this impact could not be established. To compare vegetation being browsed by deer, with that in the absence of deer, 5 deer exclosure plots were constructed in 1986-1987. Annual monitoring of the species composition and cover of species in these plots over the next 7 years indicated little or no difference developing between the exclosures and the controls in terms of species presence (Figure 2), but major differences in the structure of the vegetation appeared in the plots in more open vegetation, an open field and a black locust/ash stand.

There have been many other changes in the last few decades, with unanticipated and often undetected effects on the vegetation. Air and light pollution may have subtle, but perhaps long-lasting impacts. Acidification of precipitation may have direct impacts on tree growth and indirect effects via soil changes. Increased input of nitrogen in the precipitation may over enrich the soil in nitrogen, leading to increased rates of litter decay, as seen along a gradient from urban to rural woodlots (McDonnell et al. 1993). These differences in litter decay are critical to the recycling of nutrients in forest ecosystems, so may be having as yet undetected impacts on the vegetation.

Increased park use most likely has contributed to spread of exotic species, which are often found first along roads and paths. Increased traffic in the park contributes to air pollution and to non-point source runoff of pollutants from road surfaces. Increased use also contributes to erosion on trails and to vandalism, especially of the archeological sites.

Figure 2. Comparison of species composition of deer exclosures and paired control plots; a) number of species in the exclosure divided by number in the control plot, b) community coefficient = $2 \times \text{number of species shared} / \text{sum of the number of species in exclosure and number in control plot}$. Data for each year include the mean and one standard deviation from the mean.



Brief Summary of Current Vegetation

The vegetation of the park can be divided into two major categories: actively managed and passively managed sites. The first includes mowed fields, orchards, and planted gardens. The second includes a variety of mainly forested stands, including successional and mature stands. Figure 1, adapted from Ehrenfeld's report (Ehrenfeld 1977), details the variation within this second major category, to which the rest of this discussion will be devoted.

Ehrenfeld (1977) described the different forest types in detail, and I will not repeat that discussion. I will instead focus on a few characteristics that are probably most important to consider in overall management goals and options. I will consider the successional forests in two categories, those which regenerated with mainly native species, such as red maple, black birch, and gray birch and those which regenerated mainly with the non-local species, black locust. The more mature forests will be lumped into one category because most are dominated more or less by oak species, with a diverse variety of associates of varying importance, such as beech and tulip-tree.

These descriptions are based on comparison of vegetation maps done for the park in the 1940's, Ehrenfeld's vegetation map of 1977, and observations I made from a reconnaissance of the vegetation in 1993 and 1994.

Successional Stands. - When the vegetation of the park was first surveyed in 1941, successional stands fell primarily into two major categories, black locust and mixed successional (gray birch/red maple). The black locust stands ranged from 70 down to 10 years old and the mixed successional were 10-30 years old. By 1993, most of the "mixed successional" stands had well developed canopies which included red maple, tulip-trees and black birch. In gross appearance, many are hard to differentiate from the stands mapped as older, mature stands in 1941, but the species composition still does not include large oaks. The black locust stands, on the other hand, are mainly still dominated by black locust, though now mixed with white ash, which was probably planted in the 1930's. These stands include dense patches of vines - primarily a mixture of native grapes and non-native bittersweet. They almost completely lack any indication of future succession to more typical mature forest trees, both where the vines are dense and elsewhere.

Most stands that were mapped in 1941 as grass or cultivated, which are now forested, consist of black locust-white ash forest, with very few saplings. For example, in 1989, a survey of 18 5m x 5m plots in the black locust/white ash stand north of the Tempe Wick farm found no saplings. A detailed survey of seedlings on 31 1m x 1m in the same stand found no tree seedlings in 24 of the quadrats, and 5 black

cherry seedlings, 8 black locust sprouts or seedlings, and 2 white ash seedlings distributed in the other 7 quadrats. The cover of charcoal hearth grass (non-native) was close to 100% in all of the quadrats (Russell 1989).

In 1977, understory shrubs and small trees included flowering dogwood, blackhaw, grapes, spicebush and others (Ehrenfeld 1977). In 1977 there was no description of the structure of these plants, but by 1989 most lacked leaves below about 1.5 meters. Spicebush had an especially distinctive structure, consisting of a thick brush of small low twigs at the base, with several tall stems. The small twigs leafed out in the spring, but were eaten back before they could develop into longer stems.

Older Forest Stands. - These stands, defined by both their existence and dominance by oaks and/or tulip-tree in 1941, and their dominance by oaks and/or beech in 1977 and 1989, most likely resemble more closely the 18th century forest than do the successional stands, in their dominance by oaks and by the size of the trees. They differ from them in several significant respects, however. There is little evidence for tulip-tree in the 18th century forests, though it is an obvious dominant in the forests of today. It and red maple are perhaps the most ubiquitous tree species at the park, though neither figured in the 18th century forest descriptions or local surveys. Hickory, which was important in the 18th century (4 of 16 trees tallied in the park in 1714-1800 surveys, Ehrenfeld 1982) contributed a maximum of 5% of the stems in 1977 surveys. Chestnut was also important in the 18th century forest, but had disappeared as a forest tree by the 1920's.

Red maple, black birch and beech dominate the understory of most of these stands, suggesting that their composition will change in the future (Ehrenfeld 1977). In 1977, the understory included a large variety of species, including small trees such as dogwood and shadbush and shrubs such as spicebush, witchhazel, pinxter flower, blueberry, elderberry and alder. By 1989, these shrubs were rare and/or stunted. The most obvious shrub by 1989 was Japanese barberry, which was most common along trails, field edges and in the younger successional stands, but was also found throughout the park. It is generally more common in cleared areas (Wohl 1994). Although Christie and Sayre (1989) had observed heavy browse on this barberry species, only the young new leaves appear to be eaten, and the shrub thrives even under the current heavy deer browse pressure. Other species that have spread widely in the last 20 years are the native white snakeroot, which poisonous to mammals (Gleason and Cronquist 1991, p. 601), and the non-native charcoal hearth grass, which is generally unpalatable. Tree seedlings appear sporadically in large numbers, though few survive more than one year.

These forests still support populations of native wild flowers, though in reduced numbers and changed structure. Jack-in-the-pulpit, for example, is widespread, but the colonies consist of many small

leaves, and flowers are rare. Partridge-berry is common and flowers abundantly, as does bird's foot violet. Some ferns thrive, such as, rattlesnake fern, Christmas fern and New York fern. Fewer fern species were found in a survey in 1992 than reported in 1971, but many of those that were missing had been rare in 1992 (Rasch 1992, Montgomery 1971), and may have been missed by the less exhaustive survey in 1992. It is of note, however, that the 1992 survey found the fern fronds to be significantly smaller than those collected in 1971. Similarly, jack-in-the-pulpit plants are most likely smaller. The factors contributing to this change in size are unknown, although it is possible that deer browsing on the leaves during the summer reduced the amount of photosynthate available for storage in the underground storage organs, which provide the energy source for spring-time leaf expansion.

Disturbance Factors. - Forests unaffected by humans still undergo changes brought about by disturbances. Lightning may ignite fires, which may spread in the understory of deciduous forests if the conditions are right. There was one lightning-ignited fire reported in Jockey Hollow, which burned only 0.01 acres (draft Wildland Fire Management Plan, Aug. 10, 1993). An undated photograph, probably from the 1930's, shows a surface fire within the forest (Photo L-81), and the 1937 vegetation map includes a burned area of several acres in oak-dominated forest (Forest Type Map 1937). Many of the dominant species in the older forests such as oaks and blueberries, are resistant to fire damage, and would flourish in the face of more frequent fires. Others, such as beech and red maple, are very fire-sensitive and would be eliminated by fire. The possible role of fire in affecting the forest in pre-encampment times is not known.

A more common disturbance in this region is a major blowdown, caused either by a major storm alone or a storm or heavy wind following a heavy ice storm. Trees heavily laden with vines are particularly susceptible to this kind of destruction (Siccama et al. 1971). Ice storms have been frequent in the park, mentioned especially in 1939, '40 and '41 (Superintendent's Annual Reports). The effects of these were not described nor are they evident on the ground today. Generally, the large gaps caused by such storms would be colonized by species that thrive in the open, such as black birch, red maple, and tulip-tree, though openings also favor the rapid growth of oaks, which may survive but do not flourish in the understory. Some non-native species such as *Ailanthus* also thrive in openings.

Windstorms may also topple some trees, leaving most of the forest intact. For example in one section of the old oak-dominated forest on Tea Hill there is a large number of old tree trunks on the ground all pointing northwest. The trunks are decaying, but still visible. The tip-up mounds made by their roots being pulled out of the soil still appear fresh, not colonized by plants or eroded completely away. The similarity in direction of fall and apparent age suggests that they were all blown down at once. Such disturbances generally create

niches for regeneration of trees and shrubs, both in exposing mineral soil and in making gaps in the canopy of leaves, so that more light reaches the forest floor. Such occurrences also, however, can cause severe damage to archeological structures in the forest floor, such as hut platforms.

Insect infestations and diseases are also part of natural disturbance regimes, but they have been exacerbated in the last century by introduced non-native insects and diseases, against which the plants have no natural defenses. Chestnut blight eliminated chestnut trees and Dutch elm disease has decimated these trees. Gypsy moths have killed many old or stressed oak trees, but most trees have so far survived the infestation. The death of many large trees, however, reduced the canopy leaf area in many areas, increasing light intensity in the understory. This led temporarily to a thicker understory than exists under a heavy forest canopy.

The forests of today have experienced new disturbances, caused by extensive clearing of forests for fields, later abandonment of many of these fields and frequent logging. These disturbances have differed from those in the prehistoric past in their extent, changes in seed sources by maintenance of hedgerows, loss of seed dispersers such as passenger pigeons, and the selective removal of species such as hickory and oak (Johnson et al. 1981, Dibeler and Ehrenfeld 1990). Grazing pressure has changed as well. Early settlers apparently removed deer from the forests by hunting, while most likely replacing them with domestic livestock such as pigs and cattle. These animals would have eaten mast of the oaks perhaps more effectively than deer, and have disturbed the soil more than the deer. Most recently, growing deer populations have increased browsing damage, apparently above that which can be tolerated by many species. Concurrently, some species, both native and non-native, which are less palatable to deer have spread in the forests, in part in response to past disturbances which have opened habitats and have provided migration corridors and in part because they have found niches emptied by the heavy browsing by deer. Other non-native species such as Japanese honeysuckle and multiflora rose have probably become less common because of browsing by deer.

Results from the deer exclosures discussed above suggest that removal of deer does not lead immediately to changes in the vegetation. One might posit two hypotheses: one, that over time the relative numbers of species in the exclosure and in the control outside it would diverge. Second, that the exclosure would begin to gain species that could not survive outside it, so that the species similarity would diverge over time. With the exception of one plot, these two hypotheses are not supported by the evidence. In that one plot, the similarity between species inside and outside the exclosure fence is diverging, with relatively more native species within the exclosure. However, non-native species also thrive within the exclosure. While charcoal hearth grass is disappearing within the exclosure, possibly because of increased shade, Japanese honeysuckle, multiflora rose, and garlic mustard are all increasing in biomass. Preventing deer browse has allowed the structure of the vegetation to

become much more dense in two of the plots, but in the other three, there is little evidence of change, with the exception of some leafing out of shrubs below the browse level. The spring and summer of 1994 were excellent ones for woody seedling germination, so the succeeding years will test the differential survival of seedlings in the presence and absence of deer browse.

RECOMMENDED GOALS FOR MANAGEMENT

In keeping with the two main missions of the park, protection of the historic (archeological) resources and interpretation, this report divides this area of the park into two zones for purposes of managing the natural resources: an archeological zone and a cultural landscape interpretive zone (Figure 3). This section of the report includes specific recommendations for management goals for these zones and subdivisions of the cultural landscape interpretive zone. These goals and options for attaining them are based on the mission of the park and the history, composition, structure, and dynamics of the forests.

Entire Park

1. Primary Goal

The primary goal for the entire park is to preserve the historic resources within the borders of the park in order to commemorate this important period in our national history. Specifically, the historic resources include the archeological remains dating from the time of the encampments, the Wick Farm, and the forest that served as a source of materials vital to the encampments. A second aspect of commemoration is to foster awareness by visitors of the historic events, especially by evoking the scene as it appeared at the historic period. To these ends, the entire park should be managed as a cultural landscape, which should be actively managed for the cultural resources. Where feasible, management should be coordinated throughout the park, since actions taken in one part will have impacts elsewhere. In addition, where feasible, management should be coordinated with management of adjacent open space, also because of reciprocal effects.

Figure 3. Proposed management zones, Jockey Hollow Area, WOPR Grid is 1000 m



- ☐ no data
- ☒ A. Archeological Zone including 10 m buffer
- ☐ B1. Historic Development Zone
- ☒ B2a. Historic and Scenic Corridors including 30 m buffer
- ☒ B2b. Mature Broadleaf Forest Interior
- ☒ B2b. Successional Forest Interior
- ☒ Open Fields and Conifer Plantations
- ☒ Roads and Trails

2. Secondary Goals

Secondary goals throughout are to prevent erosion, using natural materials and native species, to ensure the safety of those using the park, and to preserve and enhance the diversity of native species where this is compatible with the primary goal.

Specific Management Zones

A. Archeological zone

Management in this zone gives priority to archeological values. It includes the sites of the Pennsylvania Line, Connecticut Line/Hands Brigade (Fort Hill), Stark's Brigade, and the New Jersey Line.

B. Cultural landscape interpretive zone

Management in this zone gives priority to interpretive values and preservation of natural resources. It is divided into two areas, based on the relative importance of the built and the natural landscapes for interpretation.

1. Historic development areas

Active management for historical accuracy of structures and to maintain existing landscape, including plantings of appropriate species.

Wick House

Soldier Huts at the Pennsylvania Line

Grand Parade

2. Eighteenth century forest areas

Management for interpretation and protection of natural resources which evoke the historic period. This areas is further subdivided, based on relative importance for interpretation.

- a. Historic and scenic corridors. - Management for evocation of historic scene.
- b. Forest interior. - Management to protect corridors and to provide both visual and biological buffers for the corridors, as well as to preserve the natural resource

Figure 3 delineates these zones schematically. A corridor of 30m extends on each side of the tour road and all historic roads, as mapped by Ehrenfeld (1977) and identified as historic by James Kochan (Park Curator). The locations of the cantonment areas are derived from Ehrenfeld's map which was based on Rutsch and Peters (1976). The Maryland and New York Brigade areas and the area of the cook ovens have been deleted because it is not likely that any significant surface features have persisted through plowing in these areas (Jim Kochan, personal communication). A 10 m buffer area surrounds each of these because of the dangers of erosion starting outside the specific zone. The locations of vegetation and interpretive zones were derived from Ehrenfeld's vegetation maps.

This map is not designed to be used to locate specific locations on the ground by use of map coordinates. It serves, rather, to indicate the approximate locations of different management zones with reference to roads, trails, and different vegetation types. Decisions for the implementation of management activities should be made on the basis of ground surveys of the features indicated on this map and described in the following sections of this report.

MANAGEMENT OPTIONS

Because of the differing goals for different areas, management options are listed for each of three areas, the archeological zone, historic development areas, and the eighteenth century forest areas (including both historic and scenic corridors and forest interior). Recommended options are listed first, in order of priority, then some other alternatives. Areas in each are summarized in Table 2. Under each option, potential advantages and disadvantages of adopting it are

Table 2. Area of Jockey Hollow Area in each proposed management zone

<u>Zone</u>	<u>Area (ha)</u>	<u>%</u>
Archeological, including 10 m buffer	39	7
Historic Development	6	1
Historic and scenic corridors, including 30 m buffer	52	10
Mature broadleaf forest interior	236	44
Successional forest interior	160	29
Open fields and conifer plantations	23	4
Roads and Trails	27	5
TOTAL	543	100

described. The consequences of the various options include those that seem the most likely. Obviously, other, unanticipated consequences are possible. Recommended options are discussed in the comments section that follows options for each area.

The options for all areas include no change. This, as well as implementing some new action, is a decision that has consequences. Most potential advantages of this option are the same for all areas: management activities would not introduce new disturbances or unanticipated new problems; "natural" processes could proceed as they have in the recent past; it would take advantage of the local, native gene pool. The most serious disadvantage is that it does not offer the possibility of actively improving current conditions.

The options listed are not mutually exclusive, nor are they probably exhaustive, but are all reasonable in terms of cost and effort, i.e., they do not include such suggestions as replacing forest trees, massive planting over large areas, etc. Most are designed to help work with the natural processes that have been observed in the park, pushing them in a given direction. More active management is recommended for those areas most often seen by visitors, such as road corridors.

A. Archeological Zone

Problems. - The archeological resource is being damaged by surface erosion, especially along logs on the ground, and by subsurface disturbance from falling trees and probably also by decaying tree roots and burrowing animals.

RECOMMENDED OPTIONS

*1. Remove trees in danger of tip-ups

Advantages:

- a) Eliminate threat to the subsurface resource
- b) Reduce number of downed tree trunks that cause erosion by channelling water

Disadvantages:

- a) Difficulty of identifying trees in danger of tip-ups
- b) Soil disturbance by removal activities
- c) More open area would provide easier access and possibly more vandalism
- d) Continued subsurface disturbance by burrowing animals

*2. Remove vines

Advantages: a) Decrease threat of blow-downs
b) Increase light and thus shrub and herbaceous cover

Disadvantage: a) Damage to trees or soil during removal
b) Would require use of herbicides and continued surveillance

*3. Remove large down stems

Advantage: a) Reduce erosion

Disadvantages: a) Disturbance during removal
b) Expose bare soil under removed stems

Other Options

1. No change

Advantages: as discussed in introduction to this section

Disadvantages: a) Increasing threat of subsurface disturbance from tree falls
b) Continued soil erosion along downed logs
c) Continued soil erosion in areas of bare soil
d) Continued subsurface disturbance by burrowing animals

2. Remove all trees

Advantages: a) Same as under recommended option 1
b) Open area would encourage growth of shrubs and grasses which help prevent erosion

Disadvantages: a) Same as b) and c) under recommended option, only more severe

3. Enhance shrub growth by planting and fencing if necessary

Advantages: a) Fence to prevent browse damage of shrubs

- b) Rapid growth of shrubs to protect soil

Disadvantages: a) Enhance visibility of site by fence

- b) Subsurface disturbance by planting

4. Remove burrowing animals

Advantages: a) Reduce this problem

Disadvantages: a) Recolonization would require frequent removals

- b) Non-target animals may be harmed

Comments. - These sites are located in both secondary and mature forest stands. Growth of vines in the secondary stands, e.g., at Stark's Brigade site, can make trees more susceptible to blowdown. Vines could be removed from trees in these sites, with little damage to soils. This would, however, open the canopy. Judicious opening of the canopy at all of these sites would encourage shrub and herbaceous growth, which could be enhanced by seeding. Currently Japanese barberry and charcoal hearth grass are common on these sites. For purposes of protecting the soil and preventing vandalism, these species are functional. They do, however, detract from any interpretive value of the sites. Removing them would at least in the short term leave the sites open to erosion and vandalism.

The sites in the mature forest present other problems in relation to the options listed above. Again, vines should be removed from all trees. It is unlikely that a dense shrub and/or herbaceous cover will develop under the dense shade of the canopy, but the leaf and small branch litter helps protect from erosion. Large tree boles should probably be removed from the site, with as little disturbance as possible to the soil. Trees that stand well above the canopy ("emergents"), should also probably be removed, as these will be most susceptible to blowdowns.

These recommendations agree with recent recommendations for management of these sites. In 1989, Andropogon Associates noted that, while in general thinning of the forest was not advisable, "Occasionally the removal of a dead or dying tree may be required if an earthwork or other resource is jeopardized by the likelihood of a windthrow or drop of major limbs. Often, the root system may still be alive and may resprout, providing canopy replacement and limiting decomposition of the old root structure" (Andropogon Associates 1989, p. 5). Similarly, Seidel in 1990 recommended selective cutting of trees over archeological features to prevent damage by tip-up mounds (Seidel 1990). The problem with both of these recommendations is knowing which trees to cut. Neither they nor I would recommend large scale cutting of the forest in these sites.

Further research.

1. The patterns of erosion should be studied by a soil scientist and/or engineer, to make recommendations to slow erosion both in the successional and the mature stands.

2. An analysis of blowdowns in surrounding forest areas of similar slope and exposure should be made to assess the characteristics of trees that have blown down. Are particular species, sizes, locations, etc., more susceptible to blowing down? It is my preliminary observation that the trees that have come down in the black locust stands do not usually produce big tip-up mounds, while those in the mature forest do. This needs to be studied in greater depth to see if it is a generally valid observation, and thus would affect decisions of which trees to remove.

B. Cultural Landscape Interpretive Zone

B1. Historic development areas

Active management for historical accuracy of structures and to maintain existing landscape, including plantings of appropriate species. This zone includes:

Wick House

Soldier Huts at the Pennsylvania Line

Grand Parade

This report deals primarily with the semi-natural environments, and thus does not refer generally to these zones. However, because they all include semi-natural settings, a few recommendations might be made. The use of native species is probably not as important, or appropriate for these zones as for the forest zone. By the end of the 18th century many introduced European species were widespread in this region, including pasture species such as "Kentucky" blue grass, clovers and weeds such as plantains (Schmidt 1973). Other non-native species were planted in gardens and around houses. However, trees lining roads were generally probably native species, such as sugar maple and red cedar.

Problem. - Historic maps suggest that the woods surrounding the Visitor Center and between it and the Wick House were cultivated in

1780. Even if they formed a woodlot, it would have been heavily used, especially so near a farm house.

RECOMMENDED OPTIONS

*1. Protect and plant native tree species under locust and protect them from browse for the first few years

Advantages: a) Eventual replacement of non-local species with native ones

b) Maintains buffer

Disadvantages: a) Probably not the historic land use

b) Difficulty of establishing native species forest especially in black locust stand

c) Disturbance of the soil which may contain archeologically valuable artifacts

*2. Remove non-native vines and shrubs

Advantages: a) Could release native species

b) Would contribute to natural looking forest

c) Maintains buffer

Disadvantages: a) Would also require control of deer browse

b) Opening canopy would encourage perhaps non-native shrub growth

Other Options

1. No change

Advantages: a) Maintain buffer of forest between Wick House Area and modern parking lot, Visitor Center and roads

b) No period of disturbance in this highly visible woodlot

Disadvantage: a) Continuation of non-historic forest type

2. Clear forest and maintain the area as pasture or plowed farm

Advantage: a) Probably most accurate historically

Disadvantages: a) Logistically, would look unkempt for a few years

b) More open areas may support more deer

c) Would require constant upkeep

d) Would remove buffer

Comments. - Given the value of this woodlot as a buffer, it is probably best to maintain it as a forested area. However, it would seem feasible, in this fairly small area, to encourage native species. Planting is also possible, but would require disturbance of the soil.

B2. Eighteenth century forest areas

B2a. Historic and scenic corridors

Historic corridors include roads, such as Jockey Hollow Road, and trails, such as the Old Camp Road (part of Patriot's Path), that follow 18th century road traces. Scenic corridors include roads and trails that may not follow 18th century routes, but which serve today to connect different parts of the park, such as the tour road from the Wick House to the Soldier Huts. Both should provide the user with a feeling of being in an 18th century forest. It is probably necessary to manage at least a 60 m wide corridor for the visual impact, and more where the understory is most open.

Problems. - These corridors pass through both successional and mature forest. In much of the successional forest the view from the corridor is of trees being engulfed by vines, many of which are non-native, a shrub understory dominated by the non-native Japanese barberry, a herbaceous layer dominated by the non-native charcoal hearth grass, and in many areas non-local trees dominating the canopy. Native tree saplings and seedlings greater than 1 year old are very rare, so that there is little evidence of succession to a more mature, native forest, which would resemble the 18th century forest. There is very little native plant growth below the level of deer browse, except for a few highly resistant species such as white snakeroot and ferns.

The mature forest consists mainly of native tree species, but Japanese barberry is becoming increasingly important in the understory, as native shrubs become rarer. Charcoal hearth grass is spreading, as many native herbaceous plants become less common. There are few saplings providing advance reproduction to replace aging

canopy trees when they die. As in the successional forest, there is very little native plant growth of species that are palatable to deer within their reach. The forest thus lacks the structure and diversity which probably characterized the pre-encampment forest as well as apparently lacking regeneration to maintain it in the future. Perpetuation is probably a more serious problem than current structure, given the probable role of human disturbance in the pre-encampment forest.

B2b. Forest interior

Problems. - The interiors of both successional and mature forests have similar problems to those of forests along the corridors; there is no distinct line between the corridors and the forest interior. We may define an arbitrary line depending on how far into the forest one may see, but this will vary according to the season, the nature of the forest (e.g., successional or mature), and changes in thickness of cover from year to year. At all times, however, the interior of the forest serves as a reservoir of species to colonize near the edges. If one maintained or managed only a corridor wide enough to protect the view, the edges of this corridor would be susceptible to potential changes emanating from the forest interior. In addition, many native animal species that add to the quality of the experience reside only in the interior, but may be heard, and occasionally seen, from the corridor. Loss of native understory in these forests has most likely contributed to declining populations of species of songbirds, such as veery, wood thrush, black-throated blue warbler and Kentucky warbler, which require dense, low shrubs for feeding and/or nesting (Pough 1949). If these habitats are completely lost in the forest interior, the species cannot be sustained just in the corridor areas. The same is probably also true of interior forest plants, which must be maintained in a large enough area to provide for recolonization of temporarily locally extinct populations in the corridors.

On the other hand, species which are deleterious to maintaining the historic scene in the corridors and the resources in the archeological zones, which are embedded in the forest interior as well as in the corridors, are a concern in the forest interior for that reason. Deer populations are generally probably lower in the mature forest interior than in other areas of the park (Christie and Sayre 1989), but they are high in many successional forest interior regions, and most likely also find cover in the mature forests, as well as browse when the fields are covered with snow and ice.

RECOMMENDED OPTIONS

*1. Remove non-native vines, shrubs, and herbaceous plants

- Advantages:**
- a) Free habitat for native species
 - b) Remove distractions of seeing non-native species in corridors
 - c) Allow trees to grow unimpeded by non-native vines
 - d) Decrease competition with native species
 - e) Remove seed source for spread from interior to corridor

- Disadvantages:**
- a) Soil disturbance may lead to erosion and harm existing native species (plant and animal)
 - b) Herbicides may damage native species (Gardner and Smith 1992)
 - c) Mowing to remove charcoal hearth grass may damage native species. Pulling it would leave much bare soil.
 - d) Existing seed banks in soil will continue to germinate, requiring repeated removals over many years
 - e) Deer may still inhibit native species
 - f) There is no evidence that this will hasten succession in black locust/ash stands

*2. Protect naturally regenerating seedlings and/or saplings of native tree species from browse and other damage

- Advantages:**
- a) Encourage replacement of desired tree species
 - b) Does not disturb to soil
 - c) Uses local gene pool

- Disadvantages:**
- a) Difficult to predict all damage
 - b) May require pesticides
 - c) Other factors such as shade, air pollution, or soil may be preventing establishment of trees

- d) There is no way to predict how many individuals to protect or which species are best
- e) There are very few native tree species present in black locust stands

*3. Reduce deer herd

Advantages: a) Decreased deer browsing may allow native species preferred by deer to grow

Disadvantages: a) Decreased deer browsing will allow non-native species preferred by deer, such as Japanese honeysuckle and multiflora rose, to proliferate

- b) There is no evidence that this will hasten succession in black locust/ash stands
- c) Without changed habitat, removal would have to be repeated often. Repeated large-scale removal may be required to reduce rather than just to stabilize the herd (Wolgast and Kuser 1993)
- d) There is evidence that tree reproduction is not inhibited by deer alone
- e) Other factors such as litter depth and seed sources may be inhibiting understory regeneration

*4. Plant or seed in native species

Advantages: a) Can choose species most likely part of 18th century forest

- b) Encourage reproduction of trees of mature forest, e.g., oak and hickory

Disadvantages: a) Deer would eliminate these unless they were fenced

- b) Earlier efforts apparently did not succeed. Why would these?
- c) Vines and other existing species would outcompete these unless they were protected
- d) Changed soils and air quality may play a negative role

Other Options

1. No change

Advantages: as discussed in introduction to this section

- Disadvantages:**
- a) There is little evidence of natural succession to a more mature, native forest in most successional stands, especially those dominated by black locust, or of replacement of dominant tree species in mature forests
 - b) Non-native shrub, vine, and herbaceous species are currently spreading, not receding
 - c) Non-native vines, and perhaps other species, are most likely inhibiting reproduction of native trees and shrubs, and possibly herbs, especially in gaps
 - d) Deer are limiting the potential for growth of species which they will eat
 - e) Seed sources may be lacking for some desired species

2. In black locust stands, selectively remove black locusts and replace with oak or other desired species of mature forest

- Advantages:**
- a) Create appropriate openings for oak, etc. growth
 - b) Can choose appropriate species for forest
 - c) Gradually eliminate black locust

- Disadvantages:**
- a) Openings would be colonized by non-native shrubs and possibly trees as well
 - b) Difficult to kill black locust without herbicide and/or root removal
 - c) Soil disturbance by removing locusts or planting trees
 - d) Deer browse would kill planted trees
 - e) Soils may not be appropriate for tree growth

3. Remove unwanted native species such as grapevine

- Advantages:**
- a) Release tree saplings that are being smothered by grapevines
 - b) Contain spread of gaps caused by growth of vines over canopy trees and subsequent blowdowns or other death of the trees

- Disadvantages:**
- a) Some vine growth may mimic the 18th century, when vines were regularly described by travelers (and even earlier, in the 17th century).

- b) Loss of this food source for birds
- c) Would require soil disturbance, herbicides and/or repeated treatments

4. Burn undergrowth

- Advantages:**
- a) Remove fire-sensitive non-native species
 - b) May improve seed bed for native species such as oak

- Disadvantages:**
- a) Kill fire-sensitive native species
 - b) Given structure of forest, fire might spread to crown
 - c) Results highly unpredictable
 - d) Fire control would be difficult under local conditions of topography and vegetation
 - e) Would most likely eliminate beech, which is a major regenerating species in much of the mature forest

Comments. - While the "no change" alternative might at first glance seem most appropriate for regenerating a natural ecosystem, the degree of prior and continuing human disturbance on this landscape makes it unlikely that this will lead to the preferred results. The complex interactions of non-native species, disturbed habitats, and increased deer herd have derailed natural processes that would lead to development of a mature forest with the diversity of native species of the late 18th century forest. Controlling any one of these factors will also most likely only exacerbate the deleterious effects of the others. In addition, other, unanticipated changes are likely, though not predictable. Some management actions, such as changing the size of the deer herd, will have impacts on all others, and must be undertaken only in conjunction with attention to peripheral impacts. Experimental elimination of deer in the exclosures has not led to rapid rejuvenation of the native plant communities.

Removing non-native plant species along the corridors would have the most immediate visual impact, but would require constant surveillance and active management. The species would have to be replaced, probably by planting, and these plantings would have to be actively protected from deer to succeed, even if the deer herd is reduced, especially if they consist of species that are especially preferred by deer. The corridors, especially roads with mowed verges, will be attractive to deer, and will probably continue to suffer from heavy browse damage.

Removal of exotic species in the corridors would probably contribute to reductions in the interior, as the seed sources were

reduced, but whether that would increase or decrease the overall shrub cover is not known. Selective protection of some tree saplings and removal of vines and exotic tree species in gaps may improve the chances for native tree regeneration in the forest.

Further Research

Any management activities that are implemented should be regarded as experiments. They should thus be carefully planned and documented, including control areas with no management if feasible. Obviously, a control cannot be established in the park for the option of reducing the deer herd. Lack of a control means that changes cannot be unequivocally attributed to the experimental manipulations.

The following recommended research projects are aimed at understanding the causes of apparent changes currently underway, by studying various facets of the dynamics of the forest vegetation. While the manipulations may not be directly comparable to management options, they may reveal dynamic situations that will help predict the trajectory of change in the forests.

1. Establish a system of permanent vegetation sampling plots. These should be at least 20m by 20m (Russell 1989). Monitoring should continue for the foreseeable future. This would serve to evaluate the changes in the forest over a long time period, providing both baseline data for interpreting the consequences of area-wide phenomena, such as changes in the size of the deer herd, alterations in amounts and/or kinds of air pollution or climatic change. They should be located in all of the major kinds of vegetation at the park. While these plots alone cannot test for causes of changes, when compared with the large national set of such plots, the results can contribute to making correlations with factors that vary regionally. In addition, without baseline data, the direction and magnitude of changes cannot be assessed.

While requiring some time to set up, about 1/2 day per plot, and expertise in identifying the flora, subsequent monitoring is much quicker and requires less expert personnel. The return on effort and cost is very high, especially if the system is carefully planned at the outset.

2. Conduct a floristic survey of the park. Almost all references to changes in the flora of the park to date are anecdotal. It is difficult to know whether descriptions of the former profusion of wild flowers at the park refer primarily to the areas around the "wildflower trail." At the same time, some concrete evidence of change, such as the decrease in size of fern fronds and the unusual growth form of jack-in-the-pulpit, and the paucity of wild flowers in

general, suggest that there has been a loss. While I have found a diversity of wild flowers scattered throughout, they were generally small and scattered, or vegetative. For example, in several places I saw a single leaf of bloodroot or spring beauty, both plants that usually occur in large patches. The floristic survey should be carried out systematically throughout the park, with notations of associations and abundance of the species as well as presence. Herbarium specimens should be collected wherever feasible.

3. Continue to monitor the current deer exclosures, expanding the measurements to include some indication of structure of the vegetation. While very small and few, these exclosures serve as a baseline to indicate potential changes under the extreme case of no deer browse. The similarity of responses in terms of synthetic measures such as diversity and coefficient of community, among 5 plots in quite different habitats, suggests that the results are good indications of response to the treatment. Already, they have alerted the park to the probability that reduction of the deer herd will not have the desired effect of quick recovery of native species and decreases in non-native ones. The results from the one in a black locust/white ash stand indicate that eliminating deer browsing decrease the cover of charcoal hearth grass, probably by allowing shrubs to flourish.

4. Test the hypothesis that shading reduces charcoal hearth grass as suggested by the results in this exclosure. It is not possible from the exclosure data alone to know just why the grass cover is reduced, whether it is by shading, root competition with the rapidly growing shrubs, or by some other mechanism. Experimentation might provide suggestions of effective ways to control this grass.

5. Study the dynamics of tree seedlings in mature and successional forests. It is apparent that there are occasional years with abundant tree seed germination. In the first place, this shows that deer, even at their present density, are not eliminating mast in the forest; there are more than adequate seed supplies to replace forest trees. On the other hand, there have undoubtedly been good years for seed germination before 1994, and yet there are few seedlings over 1 yr old, and few saplings that would indicate success of seedlings over the past several decades (since before the deer herd became so large).

Because 1994 was such a banner year for seedlings, I set up 15 3m x 3m permanently marked plots, randomly arranged along a 500 m line north-northeast through the oak-dominated mature forest near the western edge of the park. I have counted woody seedlings in mid-June, mid-July, mid-September, and mid-October, 1994 and mid-May, 1995 and plan to continue this for the foreseeable future, about once a month whenever the ground is not snow- or ice-covered. I also estimate damage to the seedlings, in terms of the herbivore and the amount of damage. I have found that it is difficult to know in many cases whether a deer or insects have defoliated seedlings, but have assumed that deer are the herbivore if there is a large cluster of seedlings

all defoliated, and deer droppings or hoof prints in the area. Most seedlings are damaged in some way. Many tulip-tree seedlings appear, but they do not seem to get very large, and most just disappear with no evidence of damage. Some have turned yellow. The data are being recorded in DBaseIII, so that various comparisons can be made. A sample printout is included in Appendix 3.

In June of 1994, there were an average of 37 oak seedlings/plot in 15 9 m² plots, with a range from 1 to 234. There were seedlings of red maple, tulip-tree, ash, hickory and black birch, as well, almost all in their first year. Many were damaged by insects, and the many that persisted only as stems suggest deer browse, although some of these were also probably damaged by insects. The following May, only about 4 or these oak seedlings were still alive/plot, with a range of 0 to 14. All other species seen in 1994 were also still present. Follow-up studies will document the fate of these seedlings over the next few years.

6. Analyze the effects of various kinds of leaf litter on plant regeneration and growth. In much of the mature forest, leaf litter covers 100% of the surface. In late summer, the leaves from the previous autumn are still only very slightly decomposed. Several years' leaves accumulate and form a thick mat. This situation may interfere with growth of some of the ephemeral spring flowers, which overwinter as buried tubers or other underground organs as well as with the germination of smaller seeds. These leaves tie up nutrients that would otherwise be available for plant growth. McDonnell et al. found that litter closer to cities, and exposed to higher levels of nitrogen, decomposed by different processes than those in forests farther from cities, with bacteria predominating in near-city forests and fungi in those farther from the city. Comparative studies at Jockey Hollow and other forests in New Jersey both nearer and farther from New York City might help clarify the relationships between air pollution and other consequences of urbanization and litter decomposition. These would be relevant to the apparent decline of many herbaceous plants at the park, which are not recovering even in the deer exclosures.

7. Consider the hypothesis that barberry may serve as a nurse plant for regeneration of desirable trees. Thick stands of the shrub gray dogwood at Saratoga NHP appear to protect some seedlings from deer browse (Austin 1992). It seems quite possible that the same may happen at Jockey Hollow. I have found palatable shrubs and vines, such as multiflora rose and bittersweet growing well within clumps of barberry, as well as seedlings of several species of trees. (Ehrenfeld's current study may provide some evidence on this point.)

8. Any management activities should be treated as experiments, so fall under the rubric of research, and should be fully documented.

Conclusions

The current policy of passive management of the forest resource is itself an experiment. If the aim of the management is to create a forest that resembles the pre-encampment forest, several problems exist, such as the persistence of successional stands, the lack of reproduction of forest species, and the spread of non-native species. The potential for active management to correct these problems can be tested by experimental management of different zones. The one management activity that cannot be undertaken with an adequate control is reduction of the deer herd. The more adjoining properties that would participate in such a management activity, especially those with high concentrations of deer populations, the more effective it would be in reducing the herd. The impact of the herd with relation to other management activities may be tested by the expected management on the other properties. For example, at the New Jersey Audubon Society, passive management, including no reduction of deer herds, will continue to be the policy for the foreseeable future (Richard Kane, personal communication). On the other hand, at Lewis Morris County Park, the policy is expected to include not only deer herd reduction, but most likely removal of exotic plant species as well (Quentin Schlieder, Director, Morris County Park Commission, personal communication). If a policy of deer control were to be established, test plots set up on these parcels would allow comparison with the management activities at MORR, to test their effectiveness in restoring a forest with a greater abundance of diverse native species and reproducing forest trees.

Major landscape alterations to reduce the deer herd and the edges that foster non-native plant species have not been recommended as options because of the nature of the regional landscape and the importance of other objectives of land management at the park. While theoretically reducing the area of mowed fields could reduce habitat for the deer herd, other open areas in the area, such as golf courses, would continue to provide ample food for deer. The open fields were also an integral part of the 1779 landscape.

The forest as it existed in 1779 most likely had an open understory subjected to grazing/browsing by domestic livestock and harvesting of wood for domestic uses. The future of a forest with little or no reproduction of many species, as seen at Jockey Hollow today, is, however, in jeopardy. Efforts to assure the continuance of the forest should be undertaken while seed sources are still abundant. By setting up experimental management manipulations now, evidence can be gathered about the potential for encouraging reproduction of a diversity of species, while conditions are still favorable.

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Appendix 1. Scientific names of species and genera mentioned in text, arranged alphabetically by common and scientific names

alder	<u>Alnus</u>
American beech	<u>Fagus grandifolia</u>)
American chestnut	<u>Castanea dentata</u>
American elm	<u>Ulmus americana</u>
big-leaf holly	<u>Ilex montana</u> var. <u>montana</u>)
bird's foot violet	<u>Viola pedata</u>
black birch	<u>Betula lenta</u>
black cherry	<u>Prunus serotina</u>
black locust	<u>Robinia pseudoacacia</u>
black oak	<u>Q. velutina</u>
black walnut	<u>Juglans nigra</u>
blackhaw	<u>Viburnum prunifolium</u>
bloodroot	<u>Sanguinaria canadensis</u>
blueberry	<u>Vaccinium</u> spp.
boxelder	<u>Acer negundo</u>
charcoal hearth grass	<u>Microstegium vimineum</u>
chinaberry	<u>Ampelopsis brevipedunculata</u>
Christmas fern	<u>Polystichum acrostichoides</u>
clover	<u>Trifolium</u> spp.
eastern hemlock	<u>Tsuga canadensis</u>
elderberry	<u>Sambucus canadensis</u>
flowering dogwood	<u>Cornus florida</u>
garlic mustard	<u>Alliaria petiolata</u>
grape	<u>Vitis</u> spp
gray birch	<u>Betula populifolia</u>
hackberry	<u>Celtis occidentalis</u>
hay-scented fern	<u>Dennstaedtia punctilobula</u>
hickory	<u>Carya</u> spp.
hobblebush	<u>Viburnum alnifolium</u>
honeysuckle	<u>Lonicera</u>
Indian cucumber root	<u>Medeola virginiana</u>
jack-in-the-pulpit	<u>Arisaema triphyllum</u>
Japanese barberry	<u>Berberis thunbergii</u>
Kentucky bluegrass	<u>Poa pratensis</u>
Japanese larch	<u>Larix</u> sp.?
maple-leaved viburnum	<u>Viburnum acerifolium</u>
New York fern	<u>Thelypteris noveboracensis</u>
Norway spruce	<u>Picea abies</u>
oak	<u>Quercus</u> spp.
oriental bittersweet	<u>Celastrus orbiculatus</u>
partridge berry	<u>Mitchella repens</u>
persimmon	<u>Diospyros virginiana</u>
pinxter flower	<u>Rhododendron periclymenoides</u>
plantain	<u>Plantago lanceolata</u> and <u>P. major</u>
rattlesnake fern	<u>Botrychium virginianum</u>
red cedar	<u>Juniperus virginiana</u>
red maple	<u>Acer rubrum</u>
red pine	<u>Pinus resinosa</u>
sassafras	<u>Sassafras albidum</u>

shadbush
 spicebush
 spring beauty
 sugar maple
 white oak
 white snakeroot
 wineberry
 witchhazel
 tulip-tree
 yew

Amelanchier spp.
Lindera benzoin
Claytonia virginica
Acer saccharum
Q. alba
Eupatorium rugosum
Rubus phoenicolasius
Hamamelis virginiana
Liriodendron tulipifera
Taxus canadensis

Acer negundo
Acer rubrum
Acer saccharum
Alliaria petiolata
Alnus spp.
Amelanchier sp.
Ampelopsis brevipedunculata
Arisaema triphyllum
Berberis thunbergii
Betula lenta
Betula populifolia
Botrychium virginianum
Carya spp.
Castanea dentata
Celastrus orbiculatus
Celtis occidentalis
Claytonia virginica
Cornus florida
Dennstaedtia punctilobula
Diospyros virginiana
Eupatorium rugosum
Fagus grandifolia)
Hamamelis virginiana
Ilex montana var. montana)
Juglans nigra
Juniperus virginiana
Larix sp.?
Lindera benzoin
Liriodendron tulipifera
Lonicera spp.
Medeola virginiana
Microstegium vimineum
Mitchella repens
Picea abies
Pinus resinosa
Plantago lanceolata and P. major
Poa pratensis
Polystichum acrostichoides
Prunus serotina
Q. alba
Q. velutina

boxelder
 red maple
 sugar maple
 garlic mustard
 alder
 shadbush
 chinaberry
 jack-in-the-pulpit
 Japanese barberry
 black birch
 gray birch
 rattlesnake fern
 hickory
 American chestnut
 oriental bittersweet
 hackberry
 spring beauty
 flowering dogwood
 hay-scented fern
 persimmon
 white snakeroot
 American beech
 witchhazel
 big-leaf holly
 black walnut
 red cedar
 larch
 spicebush
 tulip-tree
 honeysuckle
 Indian cucumber root
 charcoal hearth grass
 partridge berry
 Norway spruce
 red pine
 plantain
 Kentucky bluegrass
 Christmas fern
 black cherry
 white oak
 black oak

<u>Quercus spp.</u>	oak
<u>Rhododendron periclymenoides</u>	pinxter flower
<u>Robinia pseudoacacia</u>	black locust
<u>Rubus phoenicolasius</u>	wineberry
<u>Sambucus canadensis</u>	elderberry
<u>Sanguinaria canadensis</u>	bloodroot
<u>Sassafras albidum</u>	sassafras
<u>Taxus canadensis</u>	yew
<u>Thelypteris noveboracensis</u>	New York fern
<u>Trifolium spp.</u>	clover
<u>Tsuga canadensis</u>	eastern hemlock
<u>Ulmus americana</u>	American elm
<u>Vaccinium spp.</u>	blueberry
<u>Viburnum acerifolium</u>	maple-leaved viburnum
<u>Viburnum alnifolium</u>	hobblebush
<u>Viburnum prunifolium</u>	blackhaw
<u>Viola pedata</u>	bird's foot violet
<u>Vitis spp</u>	grape

Appendix 2. Details of GIS map development

Figure 1. Forest types, 1977. This is a patch of the map layers "mature.forest" and "successional.forest" digitized by the NARO office from Ehrenfeld (1977)'s map layers of the same names, after the "successional forest" map layer was simplified by lumping those forest types with less than 2% of the area ("other successional") using the routine "reclass."

Figure 3. Recommended management zones. This is a composite of map layers from the NARO office's digitized map set from Ehrenfeld, modified as follows. The map layer "cantonments" was used for archeological areas. A buffer of 10 m around all of these was generated with the command "r.buffer." A map layer of historic corridors was generated by digitizing the tour road and fire roads with a line down the center of areas digitized on the NARO map layers, plus adding trails north of the Grand Parade as indicated on the park's trail map. These were the historic corridors and tour road as indicated by Jim Kochan at the park. A 30 m buffer was generated along all of these. This map layer was then patched into the cantonment map layer (= map layer #2). Interpretive zones were extracted from the "forest types" map layer as the open areas around the Wick House, Soldier Huts and Grand Parade. This map layer was patched onto map layer "#2" to give map layer #3.

The forest type maps were simplified by lumping all mature forest types into one class and all the successional types into a second. The two maps were then patched together, and the resulting patch map was patched into map "#3" to generate the management area map. This process gave priority to the archeological areas, historic development areas and historic and scenic corridors, in that order, i.e., where an archeological area fell within a forest area, it was mapped as archeological.

Appendix 3. Tree Seedling Study.
Jockey Hollow Area
Morristown National Historical Park

plot date	species	insect holes	insect edge	mammal damage	resprout	prev crowded?	age > 1 yr?	seedling number
** Next Plot 1								
1 06/13/94	UNK	0	4	0	.F.	.F.	.F.	1
1 06/13/94	QUEVEL	0	4	0	.F.	.F.	.F.	2
1 06/13/94	BETLEN	0	1	0	.F.	.F.	.F.	3
1 06/13/94	QUESP	0	0	0	.F.	.T.	.F.	4
1 06/13/94	QUEVEL	0	0	0	.F.	.F.	.F.	5
1 06/13/94	QUEVEL	0	1	0	.F.	.F.	.F.	6
1 06/13/94	QUEVEL	0	1	0	.F.	.F.	.F.	7
1 06/13/94	QUEVEL	0	0	0	.F.	.F.	.F.	8
1 06/13/94	QUEVEL	0	4	0	.F.	.F.	.F.	9
1 06/13/94	QUEVEL	0	4	0	.F.	.F.	.F.	10
1 06/13/94	QUEVEL	1	3	0	.F.	.F.	.F.	11
1 06/13/94	QUEVEL	0	0	0	.F.	.F.	.F.	12
1 06/13/94	QUEVEL	2	0	0	.F.	.F.	.F.	13
1 06/13/94	QUEVEL	0	3	0	.F.	.F.	.F.	14
1 06/13/94	QUEVEL	0	0	0	.F.	.F.	.F.	15
1 06/13/94	QUEVEL	0	3	0	.F.	.F.	.F.	16
1 06/13/94	QUEVEL	0	3	0	.F.	.F.	.F.	17
1 06/13/94	QUEVEL	0	2	0	.F.	.F.	.F.	18
1 06/13/94	QUEVEL	0	4	0	.F.	.F.	.F.	19
1 06/13/94	QUEVEL	0	4	0	.F.	.F.	.F.	20
1 06/13/94	QUEVEL	0	6	0	.F.	.F.	.F.	21
1 06/13/94	QUEVEL	0	2	0	.F.	.F.	.F.	22
1 06/13/94	ACERUB	0	2	0	.F.	.F.	.F.	23
1 06/13/94	QUEVEL	0	0	0	.F.	.F.	.F.	24
1 06/13/94	UNK	0	6	0	.F.	.F.	.F.	25
** Subtotal **		3	57	0				
** Next Plot 2								
2 06/13/94	CARSP	0	1	0	.F.	.F.	.F.	1
2 06/13/94	ACERUB	0	2	0	.F.	.F.	.F.	2
2 06/13/94	ACERUB	0	0	0	.F.	.F.	.F.	3
2 06/13/94	ACERUB	0	0	0	.F.	.F.	.F.	4
2 06/13/94	FRAAME	0	0	0	.F.	.F.	.F.	5
2 06/13/94	VIBACE	0	1	0	.F.	.F.	.F.	6
2 06/13/94	ACERUB	0	0	0	.F.	.F.	.F.	7
2 06/13/94	CARSP	0	0	0	.F.	.F.	.F.	8
2 06/13/94	ACERUB	0	0	0	.F.	.F.	.F.	9
2 06/13/94	ACERUB	0	0	0	.F.	.F.	.F.	10
2 06/13/94	ACERUB	0	2	0	.F.	.F.	.F.	11
2 06/13/94	LIRTUL	0	0	0	.F.	.F.	.F.	12
2 06/13/94	ACERUB	0	0	0	.F.	.F.	.F.	13
2 06/13/94	UNK	0	0	0	.F.	.F.	.F.	14
2 06/13/94	ACERUB	0	0	0	.F.	.F.	.F.	15
2 06/13/94	ACERUB	0	0	0	.F.	.F.	.F.	16



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