

Wawayanda Hemlock Ravine Natural Area Management Plan

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Division of Parks and Forestry
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Introduction

This management plan describes the natural resources, uses and other features of the Wawayanda Hemlock Ravine Natural Area and prescribes techniques, uses and practices that are consistent with or will aid in achieving the management objective of the natural area.

The Natural Areas System is established and administered pursuant to N.J.S.A. 13:1B-15.4 et seq. and N.J.S.A. 13:1B-15.12a et seq. A "Natural Area" is defined as "an area of land or water, owned in fee simple or as a conservation easement by the Department, which has retained its natural character, although not necessarily completely undisturbed, or having rare or vanishing species of plant or animal life, or having similar features of interest, which are worthy of preservation for present and future residents of the State" (N.J.A.C. 7:5A-1.3).

The 501-acre Wawayanda Hemlock Ravine Natural Area is part of Wawayanda State Park, located in Vernon Township, in northeastern Sussex County (Figure 1 and 2). The park was established in 1963 and encompasses approximately 13,422 acres. The park contains two other natural areas, Wawayanda Swamp Natural Area, less than a mile to the south and Bearfort Mountain Natural Area, about four miles to the southeast. The park is immediately surrounded by low density residential properties and agricultural land. There is very little industry in the immediate area. South of the park is the 35,000-acre Pequannock Watershed Municipal Area and to the southeast is the Wanaque Watershed Municipal Area. Other protected land in this region includes the 2,277-acre Wanaque Wildlife Management Area and 5,237-acre Ringwood State Park to the southeast, and Hainesville Wildlife Management Area (282 acres) to the southwest.

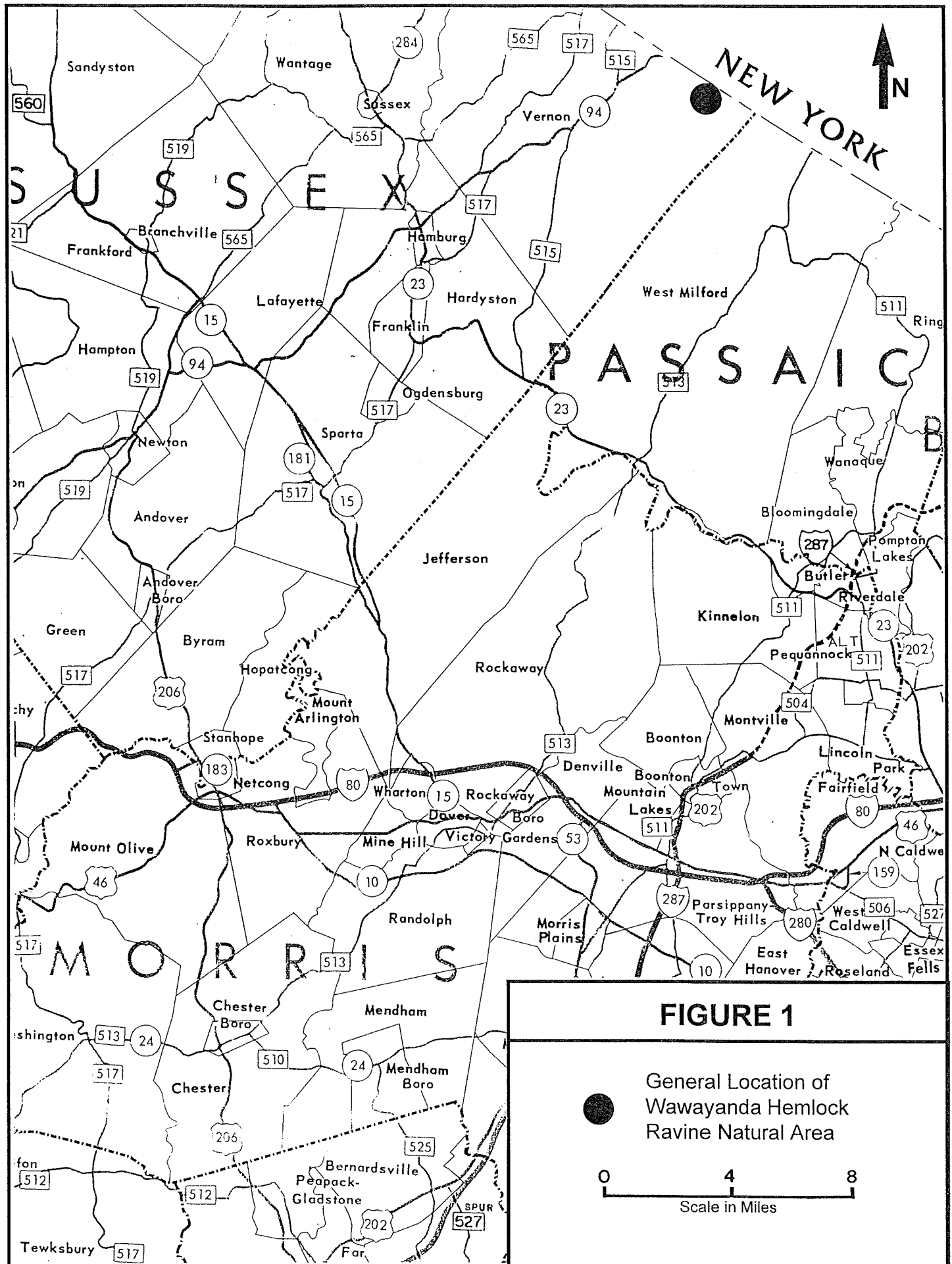
The tract containing the hemlock ravine was added to the park in separate parcels. A large parcel now comprising most of the natural area was purchased in 1977 from N. Kazmar. The natural area was added to the Natural Areas System in 1978 through promulgation of rules associated with the Natural Areas System Act of 1975. The management objective for the natural area under N.J.A.C. 7:5A-1.13(a)14ii is "preservation of hemlock/mixed hardwood forest and rare species habitat." N.J.A.C. 7:5A-1.8 also requires the preparation of this management plan.

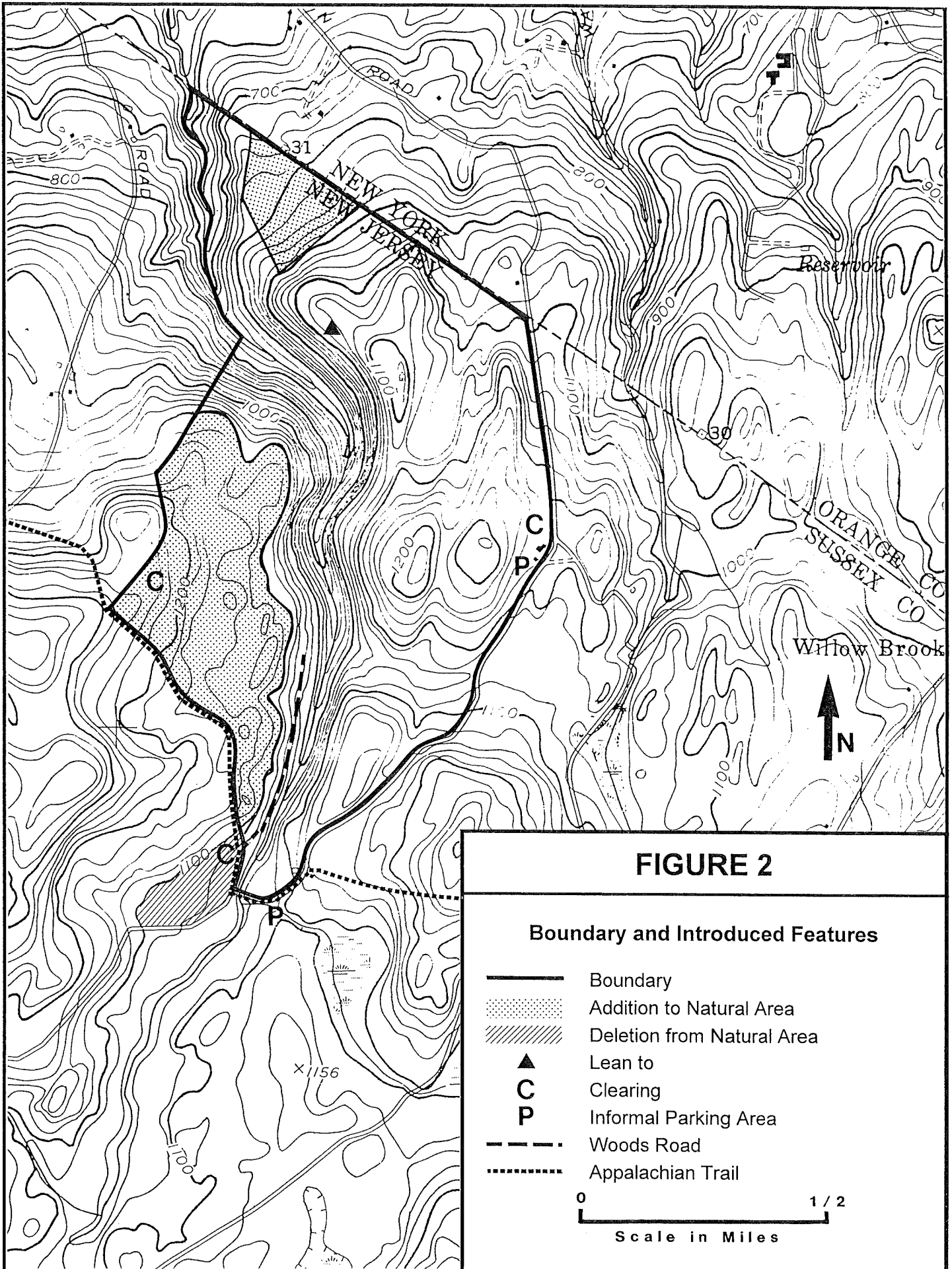
The Division of Parks and Forestry, through Wawayanda State Park, serves as the administering agency for the natural area, being responsible for implementing policy and, after consultation with other Divisions, organizations and individuals, making land management decisions affecting Wawayanda Hemlock Ravine. Wawayanda State Park implements the management policies necessary to achieve the objectives of this plan.

The Office of Natural Lands Management (ONLM) is responsible for overall administration of the Natural Area System, promulgation and revision of rules governing System lands, and preparation of management techniques outlined in management plans, and may propose amendments to plans as needed.

History

This area is known to have been used by the Lenne Lenape, or Delaware Indians. There is evidence of an Indian encampment on the north shore of what is now Wawayanda Lake (Apffel 1970). The early proprietors of the East Jersey land, which included the park, made treaties with the Lenne Lenape to control the land and other natural resources (Apffel 1970). Eventually all Indian claims to the land were relinquished





and the remainder of the tribe that had once lived there moved inland to distant territories (Apffel 1970).

In the late 1700s and early 1800s the Lenne Lenape Indians of the region were replaced by subsistence farmers. Also during this time period iron mining and smelting became an important industry in this area. In the 1840s the Ames family built a charcoal furnace at the outlet of Wawayanda Lake which was dammed to provide water power for the bellows of the furnace. Three mines were established; the Wawayanda Mine which was primarily an underground operation, the Green Mine which was mainly a surface mine and, later, the Layton Mine which had both pits and shafts (New Jersey Department of Labor 1982, Apffel 1970) (Figure 2). Mining supported a village near Wawayanda Lake until about 1890 when the operation was abandoned. Later, in 1918, the New Jersey Zinc Company purchased the Wawayanda tract to harvest timber to be used as supports for the Franklin and Ogdensburg Mines. Timber was harvested from the forest following a sustained yield timber management plan from 1925 until 1954 when the zinc was completely mined out (Apffel 1970). The 4,140-acre tract was purchased by the State through the Green Acres Program in 1963 and became a State park. Subsequent acquisitions and the inclusion of the Abram S. Hewitt State Forest has enlarged the park to approximately 13,900 acres.

The original Wawayanda tract did not contain the hemlock ravine. Most of the Wawayanda Hemlock Ravine Natural Area was purchased in 1977. An analysis of aerial photographs from 1940, 1951, 1957 and 1962 indicate that some of the uplands in the northeast portion of the natural area, adjacent to the New York State border, and portions of the southern tip of the natural area experienced small scale logging in the 1940s and early 1950s, although the hemlock ravine was left essentially undisturbed (New Jersey Department of Environmental Protection 1986). Aerial photographs indicate that the areas were revegetated by the late 1950s (NJDEP 1986).

Description and Management Concerns

Boundary

Development of this management plan revealed several inconsistencies between the natural area boundary and boundary requirements specified in the Natural Areas System Rules at N.J.A.C. 7:5A-1.12. The rules indicate that the natural area boundary must conform with physical features identifiable in the field or the extent of State ownership. These inconsistencies were particularly evident along the western boundary, which corresponded to the 1,100 foot contour interval, and the northern boundary, where newly acquired property had been added to Wawayanda State Park.

As a result, effective upon adoption of this management plan, the boundary of the natural area was revised to result in a net addition of 99 acres to the natural area, or a net increase of 24.6 percent. The resultant acreage of the Wawayanda Hemlock Ravine Natural Area is 501 acres. The revisions, indicated in Figure 2, include the addition of 94 acres of upland forest to the western portion of the natural area and 19 acres of upland forest in the vicinity of the Layton Mine in the northern portion of the natural area, and the exclusion of 14 acres of lowland forest south of the juncture of the Appalachian Trail and Iron Mountain Road.

Detail of the boundary in the vicinity of the Barrett Farm is indicated in Figure 3. The revised western boundary follows the Appalachian Trail (AT), heading northwest from Iron Mountain Road at the old iron

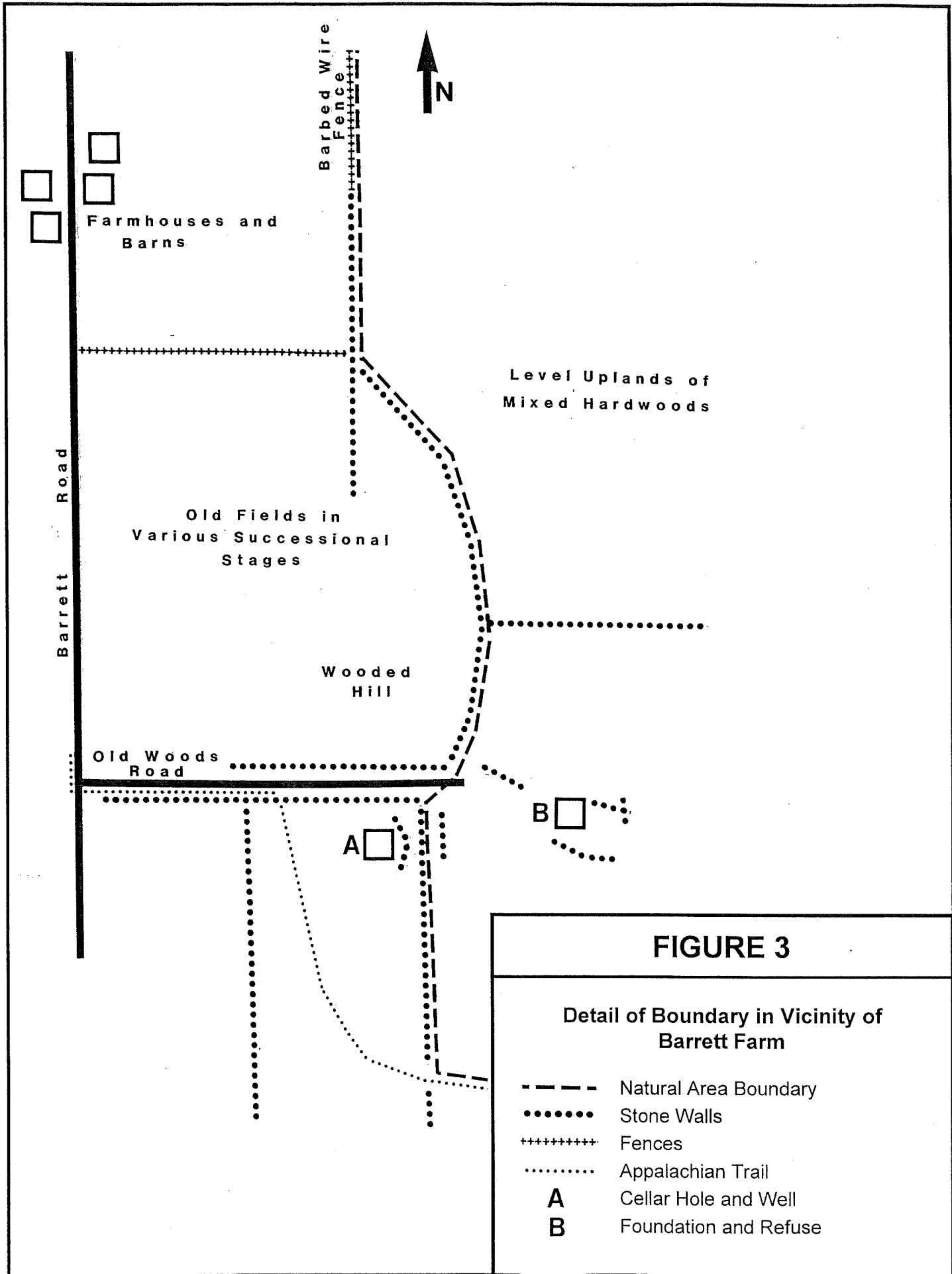


FIGURE 3

Detail of Boundary in Vicinity of Barrett Farm

- - - - - Natural Area Boundary
- Stone Walls
- +++++++ Fences
- Appalachian Trail
- A Cellar Hole and Well
- B Foundation and Refuse

bridge over the Doublekill Creek and then continues along a stone wall that intersects the AT near the old Barrett Farm. The stone wall and AT intersect in the uplands at a rock outcrop just south of the remains of an old clearing and two building foundations. The stone wall traverses the old clearing and then breaks at an old woods road that continues north-northeast through the woods. The stone wall reaches the eastern border of the Barrett Farm fields and then continues along the former property line as either a stone wall or an old barbed wire fence. This stone wall/fence creates a physical boundary extending from the old fields to the Doublekill and the New York-New Jersey state line.

Geology and Soils

Wawayanda State Park is located in the Highlands physiographic province which is part of the Reading Prong. A portion of the New England province, the Reading Prong extends northeastward from the Reading Hills in Pennsylvania, across northern New Jersey, and into Dutchess County, New York and then curves southward toward Manhattan Island (Wolfe 1977). It is the same province to which the Hudson Highlands, Berkshires and Housatonic Range belong (Tedrow 1986). The Highlands are composed of northeast-southwest trending broad ranges that are separated by deep, narrow valleys lying 400 to 600 feet below the ridge crests (Wolfe 1977). The broad ridges are made up of bedrock that is mostly Precambrian gneiss, schist, and metasediment with some marble or crystalline limestone and some intrusive metamorphosed igneous rock (Wolfe 1977). The intermontane valleys are composed of infolded and infaulted Paleozoic sedimentary strata (Wolfe 1977).

The landscapes of the Highlands were influenced by at least three stages of the Pleistocene glaciation. The Wisconsin glaciation left the most visible evidence of glaciofluvial processes such as the terminal moraine that crosses the Highlands, widespread glacial till deposits and stratified drift in the valleys (Wolfe 1977).

The soils of the natural area have been strongly influenced by the past glaciation. The descriptions of soils that follow are based on U.S. Department of Agriculture (1975) descriptions unless otherwise noted. The soils tend to be extremely stony with Rockaway soils, formed in coarse textured or moderately coarse textured glacial till, comprising 80 percent of the soil cover. They are well drained, gently sloping to very steep soils that have a fragipan in the lower part of the subsoil. These soils tend to be moderately to very acidic. Other soils mapped within the natural area are from the Whitman and Hibernia series and Carlisle Muck.

Soils of the Rockaway series that occur at the natural area are Rockaway-Rock outcrop association (sloping and moderately steep) and Rock outcrop-Rockaway association (steep), together covering about 69 percent of the area. Rockaway gravelly loam (3-8% slopes and 8-15% slopes) and Rockaway very stony loam (5-25% slopes) cover smaller areas.

The Rockaway-Rock outcrop association (sloping and moderately steep) is found in the natural area on most of the uplands. This association is 25 to 40 percent bedrock outcrop or soil material less than 10 inches thick over bedrock and 30 to 45 percent stony to extremely stony Rockaway soils. The Rock outcrop-Rockaway association (steep) is 70 to 90 percent bedrock outcrop, rock rubble, or soil material less than 10 inches thick and 5 to 20 percent extremely stony Rockaway soils. This association is found on the ravine slopes that range from 25 to 35 percent. The other Rockaway soils are found on adjoining uplands in the natural area.

Whitman extremely stony sandy loam is found in the natural area along Doublekill Creek where the

slope is relatively level and in low depressions within the uplands. This soil is poorly drained and is underlain by a fragipan 10 to 25 inches below the surface. Internal drainage of this soil type is slow with permeability moderate above the fragipan and slow within it. The reaction of this soil type is strongly acidic.

The Hibernia very stony loam (3-8% slopes) is located adjacent to a low lying area between Iron Mountain Road and Doublekill Creek and in a small level pocket west of Doublekill Creek in the southern tip of the natural area. Typical depth to bedrock for this series is greater than five feet. This soil is somewhat poorly drained with a fragipan in the lower part of the subsoil. This soil also tends to be acidic.

The Carlisle Muck, located in the low lying area between Iron Mountain Road and Doublekill Creek, is a hydric soil (U.S. Department of Agriculture 1990). It consists of deep, nearly level, very poorly drained organic soils. In a representative profile of this series, the surface layer is black, highly decomposed muck 12 inches thick. The next 36 inches is black, decomposed fibrous muck that contains partially decayed woody fragments, and the lower soil, to a depth of 60 inches is dark reddish-brown, fibrous and woody muck. The available water capacity of this soil is high and the permeability is moderately rapid to rapid. In poorly drained areas the water level is at or near the surface most of the time.

Topography and Surface Hydrology

The topography of the natural area is one of high relief with 300-foot increases in elevation from Doublekill Creek to the adjacent hills east and west of the stream. This rapid change in elevation results from the steep 25 to 65 percent slopes of the ravine between these uplands. The uplands to the east form several knobs that range between 1,140 and 1,220 feet while to the west the upland reaches 1,100 feet quickly but then climbs to elevations of 1,260 and 1,360 feet more gradually.

The surrounding topography is characteristic of this region with many small hills strewn between the northeast to southwest trending ridges. Bearfort Mountain, reaching 1,491 feet, is one of these ridges approximately five miles to the southeast, as is Wawayanda Mountain two miles to the west-southwest, reaching approximately 1,448 feet. These two mountains rise approximately 800 to 900 feet above the adjacent valley floors. The higher ridgetops throughout the Highlands are part of the Schooley peneplain.

The Doublekill Creek, which flows through the ravine, has headwaters within the park south of the natural area. Barry Lakes, Wawayanda Lake, Laurel Pond, Lookout Lake and Kazmar Pond are within the Doublekill drainage. The Doublekill Creek flows north into New York where it joins Wawayanda Creek. Wawayanda Creek flows southwest, around the northern terminus of Wawayanda Mountain and back into New Jersey where it joins Pochuck Creek in the valley between Wawayanda Mountain and Pochuck Mountain. This drainage is part of the larger Wallkill watershed that drains north and eventually joins Rondout Creek shortly before it enters the Hudson River at Kingston, New York.

The mile and a half portion of Doublekill Creek that flows through the natural area is mostly fast moving water that falls over boulders and outcrops of bedrock, and swirls in eroded pools. In the natural area, the stream drops 480 feet from an elevation of approximately 1,050 feet to an elevation of approximately 570 feet at the New York border. Other surficial hydrologic features at the natural area are small wetlands, seeps, and intermittent streams that run into the ravine or between adjacent uplands.

Biotic Communities

The descriptions of biotic communities within the natural area and Figure 4 are based on aerial photo interpretation of vegetation by the Office of Environmental Analysis (NJDEP 1986), the descriptions of community types by Breden (1989) and Robichaud and Buell (1973), descriptions of plant communities prepared by Brown (1986) and from site visits by staff of the Office of Natural Lands Management in 1993 and 1994.

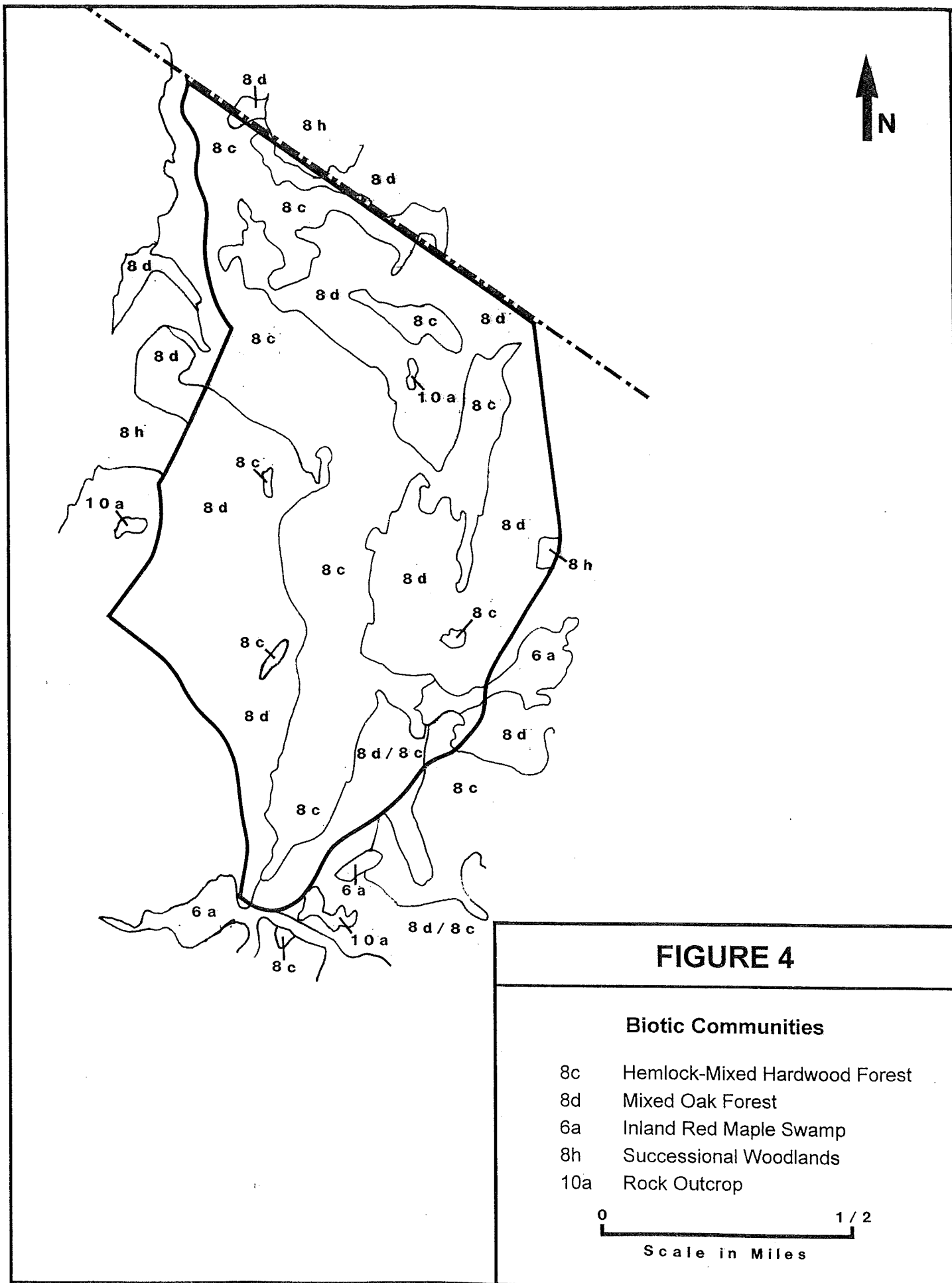
The species listed in the following community descriptions include those that are often found in that particular community as well as species observed at the site. The lists are not meant to be comprehensive.

Hemlock-Mixed Hardwood Forest

This community covers 40 percent of Wawayanda State Park (Robert Goodman pers. comm.) and is found within the natural area on the ravine slopes. The steep slopes, shading by the eastern hemlocks (*Tsuga canadensis*), and the rocky stream produces a cool, mesic microclimate in this community. Eastern hemlock is dominant and characterizes the community as a cool, shady conifer forest. Mixed hardwoods are also a part of this community, becoming more numerous toward the top of the slope. Hardwood canopy species include red oak (*Quercus rubra*), white oak (*Q. alba*), American beech (*Fagus grandifolia*), sugar maple (*Acer saccharinum*) and yellow birch (*Betula lutea*). Occasional pignut hickory (*Carya glabra*), black cherry (*Prunus serotina*) and basswood (*Tilia americana*) were also observed. The understory is extremely sparse with occasional beech saplings, witch hazel (*Hamamelis virginiana*) and rosebay rhododendron (*Rhododendron maxima*). The herbaceous layer is also sparse, possibly due to the dense shading of the canopy and the acidic litter of the hemlock needles. Species observed on the forest floor include mosses and ferns such as Christmas fern (*Polystichum acrostichoides*), marginal woodfern (*Dryopteris marginalis*), lady fern (*Athyrium filix-femina*) and common polypody fern (*Polypodium vulgare*). Additional species observed in the hemlock forest along the New York State border include the maiden hair fern (*Adiantum pedatum*), rattlesnake plantain (*Goodyera pubescens*) and round lobed hepatica (*Hepatica americana*). Indian pipe (*Monotropa uniflora*), partridgeberry (*Mitchella repens*), spotted wintergreen (*Chimaphila maculata*) and bedstraw (*Galium* sp.) were seen occasionally. On rock outcrops that were wet from seeps, mosses, shining club moss (*Lycopodium lucidulum*), common polypody fern and other ferns, bedstraw, goldenrod (*Solidago* sp.) and wild ginger (*Asarum canadense*) were observed.

This community is threatened by the hemlock woolly adelgid (*Adelges tsugae*), an aphid that feeds on the young branches and twigs of the hemlock. The woolly adelgid is a non-native species that was first reported in the eastern U.S. in 1953 from Richmond, Virginia (Watson 1992). The woolly adelgid was reported earlier on the west coast, however, its exact time and place of introduction on both coasts are unknown (Watson 1992). It is believed that range extension of the woolly adelgid has occurred by dispersal via wind, birds, deer and other mammals and human activity such as logging (McClure 1987, McClure 1990, Watson 1992).

Infestation of a hemlock with the woolly adelgid can result in death of the tree in four years. However, if the tree is already stressed, mortality can result within a year (McClure 1987, Watson 1992). Stresses that may increase morbidity and mortality include soil compaction, drought, and infestation by other insects or disease (Teague and Ohlsen no date). Evidence of infestation can be easily seen when the woolly adelgid lays small, white, cottony egg masses at the base of needles starting about the middle of February. When the woolly adelgid feeds in the late winter and early spring it retards the new growth of the hemlock and causes existing needles to discolor, desiccate and drop from the branches (McClure 1987).



It has been found that the woolly adelgid can be controlled by a number of sprayed pesticides including some petrochemical insecticides, insecticidal oils and insecticidal soaps (McClure 1987). This control, however, is currently only achieved via complete coverage of each tree which is exceedingly difficult in the field (McClure 1987). Aerial application of these agents is ineffective since complete foliar coverage cannot be attained by this method (Hayes 1992). Other research to find a means of woolly adelgid control is ongoing and includes study of systemic insecticides and biological controls such as a Japanese mite. Monitoring of the woolly adelgid is extremely important since populations can build rapidly due to the female's ability to produce offspring without the presence of males, the adaptation of two generations per year and few significant natural enemies (Watson 1992).

The woolly adelgid was first detected at Wawayanda State Park in 1993 and first observed in the natural area in 1994 (Robert Goodman pers. comm., Charles McCurry pers. comm.). Infestation may occur rapidly and be particularly devastating at this park since hemlock communities compose approximately 40 percent of the forest and the hemlocks may also be stressed by the fiorinia hemlock scale (*Fiorinia externa*) (Robert Goodman pers. comm., Robert Chianese pers. comm.). Light infestation by the fiorinia scale was noted at Wawayanda during a state-wide survey of hemlocks in 1988/89 and again in 1992. The scale was observed on hemlocks during a site visit in October 1993. It appears that the fiorinia scale does not kill the hemlocks alone, but may increase the rate of mortality of hemlocks that are also infested with the woolly adelgid. The fiorinia scale feeds on the needles of the hemlock, resulting in yellowing and premature dropping of the needles. The eventual result is slowed growth and thin weakened trees (Johnson and Lyon 1976).

Potential results of hemlock morbidity or mortality include uprooting of these shallow rooted trees and increased risk of fire due to decreased fluid content of the affected trees and an increase in dead timber. Erosion of the soil from the steep ravine slopes can occur due to increased impact of raindrops on the forest floor. Canter (1977) gives erosion rates for various land uses including forest and harvested forest. A representative erosion rate listed for forested land is 24 tons per square mile per year and 12,000 tons per square mile per year for harvested forest. Therefore, it is suspected that if hemlocks of a hemlock-dominated forest were to succumb to a pest such as the woolly adelgid, the rate of erosion would increase to a point somewhere between the rate for an intact forest and that of a harvested forest. This could result in an increased erosion rate ten to twenty times greater than the current rate.

Soil erosion can lead to turbidity and siltation within the water course affecting aquatic plants and animals at the natural area and down stream. Other potential impacts of hemlock morbidity or mortality are increased wind speed through the ravine, increased daytime ground temperature and increased stream temperature. These factors would also affect the moisture regime and the daily and seasonal temperature range of the ravine habitat. This could also influence the flora and fauna of the ravine, including rare species.

Dry-mesic Inland Mixed Oak Forest

The mixed oak forest is found in the uplands east and west of the hemlock ravine. The dominant species of this community type are white oak, red oak, and black oak (*Quercus velutina*) (Breden 1989). Other associated trees are the chestnut oak (*Quercus prinus*), hickories (*Carya* spp.), red maple (*Acer rubrum*), sugar maple, black birch (*Betula lenta*), American beech, white ash (*Fraxinus americana*) and tulip poplar (*Liriodendron tulipifera*) (Breden 1989). During a site visit in October 1986, Brown (1986) noted that the dominant trees of this community were red oak, shagbark hickory (*Carya ovata*), chestnut oak and white oak. Site visits in 1994 revealed that chestnut oak was dominant in dry, rocky areas at the higher elevations. Black cherry was observed around rock outcrops within this community. Also during site visits in 1994 it was noted that sugar maples were found to be abundant in the level areas of this community. One area in

particular was thick with even-aged sugar maples in the overstory and the ground was covered with sugar maple seedlings. This area, in the northwest corner of the natural area, was logged prior to 1950 and has since been subjected to a wild fire in the early 1980s. Species observed in the mixed oak forest where it fringes open areas include black cherry, white ash, grey birch (*Betula populifolia*) and quaking aspen (*Populus tremuloides*). The understory of this community typically includes flowering dogwood (*Cornus florida*) and maple leaf viburnum (*Viburnum acerifolium*) but, depending on the forest subtype, may also include ironwood (*Carpinus caroliniana*), hop hornbeam (*Ostrya virginiana*) and sassafras (*Sassafras albidum*) (Breden 1989). Understory species observed during field visits in August and October 1994 include witch hazel, mountain laurel (*Kalmia latifolia*), downy viburnum (*Viburnum rafinesquianum*) and lowbush blueberry (*Vaccinium pallidum*). In the mesic portion of the community are scattered hemlocks in the understory.

Inland Red Maple Swamp

This community is located in a small lowland area between Iron Mountain Road and Doublekill Creek over Carlisle Muck soil. The swamp grades from being more dry to more wet from Iron Mountain Road west to the Doublekill. The dominant tree species of this community is red maple. Typically, other tree species of this forested swamp community include sour gum (*Nyssa sylvatica*), white ash and yellow birch (Breden 1989). Typical shrubs include highbush blueberry (*Vaccinium corymbosum*), spicebush (*Lindera benzoin*) and winterberry (*Ilex verticillata*) (Breden 1989). Understory trees and shrubs observed at this swamp in October 1994 included winterberry, ironwood, nannyberry (*Viburnum lentago*), honeysuckle (*Lonicera* sp.) and highbush blueberry. Typical herbs and mosses include skunk cabbage (*Symplocarpus foetidus*), marsh fern (*Thelypteris palustris*), cinnamon fern (*Osmunda cinnamomea*), sensitive fern (*Onoclea sensibilis*) and *Sphagnum* species (Breden 1989). Additional herbaceous species observed include bedstraw, sedges (*Carex* sp.), horsetail (*Equisetum* sp.) and royal fern (*Osmunda regalis*) among others.

Successional Woodlands

Several old clearings exist as successional woodlands along edges of the natural area. These clearings surrounded old houses and barns and, in one case, an old mining operation. These sites were abandoned at least twenty years ago; the mine site was probably abandoned 80 to 90 years ago. Trees observed in the successional woodlands include oaks (*Quercus* spp.), red maple, hickories (*Carya* spp.), grey birch, quaking aspen and, in more open areas, sumac (*Rhus* spp.), eastern red cedar (*Juniperus virginiana*) and apple (*Pyrus malus*). Shrubs include southern arrow-wood (*Viburnum pubescens*), common buckthorn (*Rhamnus cathartica*) and multiflora rose (*Rosa multiflora*). Nannyberry, ironwood and red-osier dogwood (*Cornus sericea* ssp. *Sericea*) were observed at the streamside clearing near the old iron bridge. There are many vines in these areas including grape (*Vitis* sp.), poison ivy (*Toxicodendron radicans*), blackberries (*Rubus* sp.) and bittersweet (*Celastrus scandens*). The herbaceous layer is dense with early successional species at the old clearings near Crossover Road and northwest of the old iron bridge over Doublekill Creek (Figure 2).

Wildlife

The following description includes animal species that could possibly occur at the natural area based on general life history information available for the species. Sources include the New Jersey Natural Heritage Database (NJDEP 1994), DeGraaf and Rudis (1987) and other noted sources.

Mammals

Large mammals that inhabit the park and may use the natural area include white-tailed deer (*Odocoileus virginianus*), black bear (*Ursus americanus*) and the State endangered bobcat (*Lynx rufus*), discussed in the Rare Species section. The park is in deer management zone 3 which has an average of 22 deer per square mile of suitable habitat (Susan Predel pers. comm.). Black bear are numerous throughout this area. Tagging data from the late 1980s through the present indicate that this region has the largest bear population in the State estimated at approximately 200 bear (Pat McConnell pers. comm.). The high bear population is attributed to the high quality and quantity of habitat available, particularly the tremendous amount of wetlands in this part of the State that are used for cover and as food gathering areas. The natural area is probably used by both bear and deer that may follow the Doublekill Creek north into New York where agricultural fields serve as additional food sources for them (Pat McConnell pers. comm.).

Other mammals that may use the Doublekill stream corridor and associated wetland areas of the natural area include the water shrew (*Sorex palustris*), southern bog lemming (*Synaptomys cooperi*), otter (*Lutra canadensis*), mink (*Mustela vison*), long-tailed weasel (*M. frenata*), raccoon (*Procyon lotor*) and beaver (*Castor canadensis*). Beaver have been observed in the Doublekill south of the natural area in the past and have recently started building a dam north of the old iron bridge, within the natural area (Charles McCurry pers. comm.). Mammals that may specifically utilize the riparian forests of the natural area include those listed above as well as the grey fox (*Urocyon cinereoargenteus*), coyote (*Canis latrans*), opossum (*Didelphis virginiana*), masked shrew (*Sorex cinereus*), northern short-tailed shrew (*Blarina brevicauda*), smoky shrew (*Sorex fumeus*), least shrew (*Cryptotis parva*), white-footed mouse (*Peromyscus leucopus*), star-nosed mole (*Condylura cristata*) and grey squirrel (*Sciurus carolinensis*).

Mammals that may utilize the mixed oak forest are the woodland vole (*Microtus pinetorum*), white-footed mouse, smoky shrew, woodland jumping mouse (*Napaeozapus insignis*), grey squirrel, southern flying squirrel (*Glaucomys volans*), porcupine (*Erethizon dorsatum*) and grey fox. Bats that may find roosting sites under loose bark or in tree cavities are the big brown bat (*Eptesicus fuscus*), red bat (*Lasiurus borealis*), eastern pipistrelle (*Pipistrellus subflavus*), silver-haired bat (*Lasionycteris noctivagans*) and the little brown myotis (*Myotis lucifugus*). The mixed hemlock forest may serve as habitat for some species already mentioned as well as red squirrel (*Tamiasciurus hudsonicus*) and southern red-backed vole (*Clethrionomys gapperi*).

Mammals that may utilize open portions of the serial woodlands and trails include the eastern chipmunk (*Tamias striatus*), meadow vole (*Microtus pennsylvanicus*), opossum (*Didelphis marsupialis*), least shrew, striped skunk (*Mephitis mephitis*), eastern cottontail (*Sylvilagus subflavus*), red fox (*Vulpes vulpes*) and feeding bats. Many of the mammals of the natural area may den in tree cavities or rock crevices. If possible, suitable den sites should not be disturbed.

Birds

Avian species observed in the hemlock-mixed hardwood forest during field visits in October 1993 and 1994 include the downy woodpecker (*Picoides pubescens*), hairy woodpecker (*P. villosus*), black-capped chickadee (*Parus atricapillus*), tufted titmouse (*P. bicolor*), white-breasted nuthatch (*Sitta carolinensis*), blue jay (*Cyanocitta cristata*) and juncos (*Junco hyemalis*). Ruffed grouse (*Bonasa umbellus*) were observed in the mixed oak forest, in the lowlands of the red maple swamp, and near the Doublekill. The hermit thrush (*Catharus guttatus*) was also observed at the red maple swamp. The northern cardinal (*Cardinalis cardinalis*), American robin (*Turdus migratorius*), Carolina wren (*Thryothorus ludovicianus*),

Wilson's warbler (*Wilsonia pusilla*) and chipping sparrow (*Spizella passerina*) were observed in the serial woodland northwest of the old iron bridge during fall site visits. A pileated woodpecker (*Dryocopus pileatus*) was observed on a dead tree and a ruby-throated hummingbird (*Archilochus colubris*) was observed at flowers, both at the old clearing across from Crossover Road.

Other birds typical of hemlock-mixed hardwood and other forest types of the natural area include raptors such as barred owl (*Strix varia*), red-shouldered hawk (*Buteo lineatus*), and the northern goshawk (*Accipiter gentilis*) and game birds such as the ruffed grouse and turkey (*Meleagris gallopavo*). Red tailed hawk (*Buteo jamaicensis*), broad winged hawk (*B. platypterus*) and other hawks have been observed circling over the natural area during fall site visits in 1994. A broad winged hawk exhibiting breeding behavior was observed approximately one-half mile outside the western boundary of the natural area in 1995 (New Jersey Audubon Society 1996).

Reptiles

Reptiles that may be found in or near the Doublekill include the northern water snake (*Nerodia sipedon*), snapping turtle (*Chelydra serpentina*) and the State threatened wood turtle (*Clemmys insculpta*). Moist forests may be suitable habitat for the wood turtle, eastern box turtle (*Terrapin c. carolina*), observed during a fall site visit, five-lined skink (*Eumeces fasciatus*), eastern ribbon snake (*Thamnophis sauritus*) and the worm snake (*Carphophis amoenus*). Reptiles that may be found in the mixed oak or hemlock forests are the box turtle, eastern hognose snake (*Heterodon platirhinos*), eastern milk snake (*Lampropeltis triangulum*), copperhead (*Agkistrodon contortrix*) and the State endangered timber rattlesnake (*Crotalus horridus*). Other snakes that are found in a variety of habitats and that may be found at the natural area include the common garter snake (*Thamnophis sirtalis*), red-bellied snake (*Storeria occipitomaculata*), northern black racer (*Coluber constrictor*), rat snake (*Elaphe obsoleta*), brown snake (*Storeria dekayi*), ringneck snake (*Diadophis punctatus*) and the smooth green snake (*Opheodrys vernalis*).

Amphibians

Amphibians that may be found in the Doublekill or in the riparian area include the green frog (*Rana clamitans*), southern leopard frog (*R. utricularia*), pickerel frog (*Rana palustris*), gray tree frog (*Hyla versicolor*), wood frog (*Rana sylvatica*), northern spring peeper (*Hyla crucifer*), northern spring salamander (*Gyrinophilus porphyriticus*), four-toed salamander (*Hemidactylium scutatum*), two-lined salamander (*Eurycea bislineata*) and dusky salamander (*Desmognathus fuscus*). Additional species that may also be found in the ravine include the American toad (*Bufo americana*), Fowler's toad (*B. woodhousii*), eastern red-spotted newt (*Notophthalmus viridescens*), red-backed salamander (*Plethodon c. cinereus*), spotted salamander (*Ambystoma maculatum*), Jefferson salamander (*A. jeffersonianum*) and slimy salamander (*Plethodon glutinosus*). Species that may be found in the drier upland areas include the marbled salamander (*Ambystoma opacum*), American toad, Fowler's toad, and wood frog. A number of these amphibian species are listed as declining in New Jersey; these are the spotted salamander, marbled salamander, Jefferson salamander, northern spring salamander and four-toed salamander (NJDEP 1994). Amphibians observed during a site visit August 1994 are the slimy salamander, green frog and red-spotted newt.

Fish

Doublekill Creek was surveyed at the hemlock ravine in August of 1990 to determine fish species present, however, the high and very fast flow of the stream precluded a thorough sampling (Pat Hamilton pers. comm.). The species that were found to be present during the 1990 survey include creek chub (*Semotilus atromaculatus*), longnose dace (*Rhinichthys cataractae*), blacknose dace (*R. atratulus*) and one brown trout (*Salmo trutta*). Other species that may be present include fallfish (*Semotilus corporalis*) and minnows (*Cyprinid* spp.) (Pat Hamilton pers. comm.). Fish observed at the natural area by park personnel include blacknose dace, brown trout and brook trout (*Salvelinus fontinalis*) (Charles McCurry pers. comm.). Possible threats to the fish and other animals that inhabit the Doublekill is the potential loss of the riparian hemlock population. The hemlocks currently shade the stream helping to maintain the cool microclimate. If the hemlock population experienced high mortality stream sediment loads could increase due to higher erosion rates. Woolly adelgid control methods could also possibly affect the stream and should be carefully considered before implementation.

Endangered and Threatened Species

According to the New Jersey Natural Heritage Database (NJDEP 1994), there are six documented records of officially-listed endangered or threatened species at the natural area. Three of these records are for animal species and are recent records. The other three records, dating back to 1946 and 1924, are for plant species. The timber rattlesnake and great blue heron records are based on observations of these species outside the boundary of the natural area. However, the habitat for these species extends into and includes the natural area. The six species are listed below, accompanied by their state status, which is either State Threatened (ST) or State Endangered (SE):

<u>Animal Species</u>	<u>Status</u>	<u>Last Observed Date</u>
barred owl (<i>Strix varia</i>)	ST	April 1995
timber rattlesnake (<i>Crotalus horridus</i>)	SE	Summer 1986
great blue heron (<i>Ardea herodias</i>)	ST	April 1990
<u>Plant Species</u>		
Dewey's sedge (<i>Carex deweyana</i>)	SE	1946
white-grained mountain ricegrass (<i>Oryzopsis asperifolia</i>)	SE	June 1946
witch hobble (<i>Viburnum lantanoides</i>)	SE	June 1924

Barred Owl

The barred owl (*Strix varia*) is a large woodland owl that ranges across most of the eastern United States (Peterson 1980). In New Jersey it is not a common species but is locally distributed (Soucy 1982). This owl prefers large tracts of forest with limited disturbance, showing a strong avoidance of human activity, major roadways, and suburban housing developments (Valent 1985, Bosakowski *et al.* 1989). This species was observed in May 1986 approximately one-half mile east of the natural area. In April of 1995, barred owl was identified by its call in the southern portion of the natural area by C. Coritz and L. Torok. Because these birds have such a large home range and there is appropriate habitat within the natural area, the barred owl may be using the natural area for feeding or nesting.

Favored habitat of the barred owl is woodland that borders lakes, swamps, streams, or marshes (Soucy 1982). The breeding habitat of the owl is low, wet deep woods or wooded swamps (DeGraaf and Rudis 1987). It frequently uses mixed or coniferous woods for nesting and roosting, particularly wetland areas associated with mature stands of hemlock, white pine, and northern hardwoods (Bosakowski *et al.* 1989). Barred owls prefer nesting in large trees with cavities, though they will utilize old bird nests or squirrel nests (DeGraaf and Rudis 1987). Soucy (1982) states that the barred owl almost always nests in hollow trees. Suitable nesting trees have a minimum diameter at breast height (dbh) of 20 inches and are dead soft wood (DeGraaf and Shigo 1985).

The threatened status of the barred owl is due to their specialized habitat requirements (Soucy 1982). Destruction of suitable habitat is a likely cause of their decline as is the lack of proper nest sites even when habitat is otherwise adequate (Soucy 1982, Valent 1985). Soucy (1982) cites the removal of large, dead standing trees either for fire wood or to reduce public hazard as part of the reason that nest sites are limited.

Barred owls will often stay in the same area throughout the year rather than migrate (Sutton and Sutton 1985) and tend to show high fidelity to a successful nest site (Soucy 1982). Barred owls are known to have used and are likely continuing to use Wawayanda State Park near the natural area. Maintenance of suitable habitat for the owls, particularly nest sites, is recommended. Standing dead or injured trees of 20 inches or more dbh are considered potential nest sites and should be left in place if possible. In the event that such trees require removal due to hazardous proximity to trails, consideration should be given to installing owl nest boxes in suitable nesting habitat (Soucy 1982).

Timber Rattlesnake

The timber rattlesnake (*Crotalus horridus*) is State Endangered and, in New Jersey, is decreasing or stable at low numbers within its range. A timber rattlesnake den is not known to occur within the natural area. However, based on the size of their home range and habitat preferences, timber rattlesnakes may be utilizing the western portion of the natural area.

The current geographic range of the timber rattlesnake encompasses an area bounded by New Hampshire and Minnesota to the north, the eastern coastal plain to northern Florida, and Texas and southeast Nebraska to the west (Brown 1991). The highest densities of the snake occur in the Appalachian Mountains from northern Alabama to Pennsylvania (Brown 1991). Toward the northern and western portions of the snake's range, habitat modifications have led to its decline, and in some areas extirpation, resulting in isolation of some populations (Brown 1991).

Loss of suitable habitat is one reason for the timber rattlesnake's decline. Other causes include hunting of the snakes, collection, mortality due to automobiles and the reproductive biology of the snake. The timber rattlesnake is a species that has a pattern of low-frequency birthing and delayed age of reproduction (Brown 1991). Some data indicate a biennial pattern of birthing for females and a first reproduction at four to six years of age (Brown 1991). However, other data from northeast New York indicate that the majority of marked females had reproductive cycles of three years with some as long as six years and the age of first reproduction from seven to eleven years of age (Brown 1991). These data indicate that the timber rattlesnake is a slow reproducer and that recovery of populations will also be slow. Also, it has been noted that the data concerning reproductive rate indicates a possible correlation with climate; the southern U.S. populations possibly growing faster and reproducing at a higher rate than northern populations. A reason for this is that the frequency of reproduction is affected by the female snake's ability to store body fat, which is influenced by environmental factors such as climate and food supply (Peterson 1990).

The primary food item of timber rattlesnakes is small mammals, particularly mice (DeGraaf and Rudis 1987). Oak mast is a primary food of small mammals, including white-footed mice (Peterson 1990), which appear to be one of the primary food items of timber rattlesnakes in New Jersey (NJDEP 1994). Peterson (1990), in a study of timber rattlesnakes in south central New York, found that there was a positive correlation between annual mast production and the small mammal trapping success rate in the denning area. Since repeated defoliation of oaks due to gypsy moths can cause mast failure, there may be a correlation between gypsy moth defoliation, small mammal populations and, ultimately, the number of timber rattlesnakes in a given area (Peterson 1990). Peterson (1990) concludes that gypsy moth defoliation should be considered an undesirable component of rattlesnake denning ecology.

Other important considerations for rattlesnake management include locating den sites since these are important areas for hibernation, birthing and basking (Brown 1991, Peterson 1990, DeGraaf and Rudis 1987). Since natural succession sometimes makes denning areas unfit for the snakes when the canopy blocks the sun, clearing the den area is recommended (Peterson 1990, NJDEP 1983). Also, anthropogenic disturbance to the denning areas should be minimized and mortality caused directly or indirectly by humans should be monitored (Peterson 1990).

Great Blue Heron

Great blue heron (*Ardea herodias*) rookeries are protected elements due to the rarity of suitable rookery sites in New Jersey used by these herons. The natural area does not contain a heron rookery but one exists approximately .3 miles south of the natural area along Doublekill Creek. Robert J. Cartica and C. Coritz observed a great blue heron flying above Doublekill Creek near the Iron Mountain Road bridge on August 8, 1995. It appears that breeding herons may use portions of Doublekill Creek within the natural area for food gathering. Great blue herons feed on aquatic and terrestrial insects, fish, amphibians, reptiles, crustaceans and, occasionally, small birds and mammals.

The great blue heron is a colonial nester that prefers to nest in tall trees centrally located near foraging wetlands (Gibbs 1991). Nest sites are often located on islands or in wooded swamps that discourage disturbance and predation (Butler 1992). Great blue herons are sensitive to disturbance and may abandon rookeries if disturbed by human activity (Galli 1982). Most studies indicate a 300 meter buffer zone around a rookery in which no human activity should take place during the courting and nesting period (Butler 1992).

Great blue herons breed in April and typically lay four eggs between mid April to the beginning of June, with an incubation period of about 28 days (DeGraaf and Rudis 1987). Brood size is usually two to three young that fledge at two months. These birds reach sexual maturity at two years (DeGraaf and Rudis 1987).

The great blue heron has been affected by a number of factors that have resulted in decreased population sizes. The heron was extensively hunted at the turn of the century for the millinery trade. The Migratory Bird Treaty of 1916 helped to protect them after much of their population had dwindled. Other factors affecting heron populations have included loss of habitat due to decreases in beaver populations and the wetlands that they create, loss of wetlands to draining and development, and a decrease in hatching success rates due to pesticides such as DDT. The now long-term protection of the heron, restocking of beaver populations, wetland protection measures, and the ban on pesticides such as DDT have contributed to increases in heron populations.

Dewey's Sedge

Dewey's sedge (*Carex deweyana*) inhabits moist or dry woods from Labrador and Newfoundland to British Columbia and south to Pennsylvania, Michigan, Iowa and Colorado (Gleason 1952). It is known from four sites in New Jersey, only one of these being a recent documented observation. The fruiting period is from late May into June.

Dewey's sedge reaches the southern limit of its range in New Jersey (NJDEP 1994). This species was last documented from the natural area in 1946, however a recent observation, made in 1990, was from a nearby location, at Wawayanda Mountain. This species is likely to still occur at the natural area, although this site has not been recently surveyed to determine its presence (David Snyder pers. comm.).

White-grained Mountain Ricegrass

White-grained mountain ricegrass (*Oryzopsis asperifolia*) is a grass of moist or dry upland woods from Newfoundland and Quebec to British Columbia and south to Pennsylvania, northern Indiana, and in the Rocky Mountains to New Mexico (Gleason 1952). In New Jersey, it is near the southeast limit of its range. It is one of three species of this genus that occurs in the State (NJDEP 1994). The white-grained mountain ricegrass flowers late April to early May and fruits are mature by late May, dropping by mid June.

This species is known from six sites in Sussex and Warren counties. It was last documented at the natural area in 1946. Although not surveyed recently, it is likely that the species still exists here (David Snyder pers. comm.).

Witch Hobble

Witch hobble (*Viburnum lantanoides*) is a shrub of moist, cool woods from Nova Scotia to Michigan and south in mountains to North Carolina and Tennessee (Gleason 1952, Schuyler 1990). Witch hobble flowers from April to June with sessile, branched, nearly flat-topped clusters of flowers up to 15 cm wide. It fruits from June to October, its drupe turning from red to nearly black. Witch hobble is readily distinguished from other *Viburnum* species by the nearly round, cordate based leaf blades, naked winter buds and sessile inflorescence (Schuyler 1990). In New Jersey, it is known from four sites, all in the northern part of the State and all over 1,000 feet in elevation. At three of the four known New Jersey sites it was associated with eastern hemlock. This species has not been documented from the natural area since 1924, but it is likely that the plant is still extant there (David Snyder pers. comm.). Threats to this species include browse by deer in the winter and any activity that would open the canopy and change its preferred microclimate. Such activities include logging and hemlock morbidity and mortality caused by pests such as the woolly adelgid.

Potential Species

Other State listed species of New Jersey that have been documented in the Natural Heritage Database from locations near the natural area, and that may also find suitable habitat at the natural area, include the northern goshawk (State Threatened), red-shouldered hawk (State Endangered), wood turtle (State Threatened) and bobcat (State Endangered) which was reintroduced to New Jersey in 1978. In addition, the New Jersey Breeding Bird Atlas (New Jersey Audubon Society 1996), contains recent records for the barred

owl, Cooper's hawk (State Endangered) and bobolink (State Threatened) in lands adjacent to but in the vicinity of the natural area along Barrett Road.

A northern goshawk (*Accipiter gentilis*) is documented within Wawayanda State Park approximately two miles south of the Wawayanda Hemlock Ravine Natural Area. The northern goshawk prefers remote, heavily wooded coniferous and mixed forest and nests in large trees, particularly American beech and black birch (*Betula lenta*) (Speiser and Bosakowski 1984, Peterson 1980). The northern goshawk is a species that has expanded its breeding range southward to include New Jersey. The first strong evidence of possible nesting was noted in 1954 and the first nest site in New Jersey was discovered in 1964 (Speiser and Bosakowski 1984). Speiser and Bosakowski (1984) found that of 20 goshawk nests observed in New Jersey, most were located in mature northern hardwood-hemlock forests. Possible threats to goshawks is loss of chicks to falconers collecting legally and illegally, particularly during years of low reproductive success, and disturbance caused by hikers, campers and ATVs near nest sites (Speiser and Bosakowski 1984).

A red-shouldered hawk (*Buteo lineatus*) has been documented approximately .5 miles southeast of the natural area near the Park office. The red-shouldered hawk prefers habitat of moist hardwood or mixed woodlands, wooded streams, swamps, or other lowlands (Peterson 1980). Bosakowski *et al.* (1991) found that analysis of habitat data for red-shouldered hawks resulted in trends of habitat factor preference and avoidance. Preference factors were wilderness area, abundance and proximity of wetlands, moderate forest openings due to wetlands, little open water, stream bottomlands, and coniferous and mixed forest areas. Avoidance factors were suburbia, steep uplands, too few or too many forest openings, open water, dry upper slopes, and areas with too few conifers. These factors indicate that the natural area may provide suitable habitat for this species, and Bosakowski *et al.* (1991) identify Wawayanda State Park and the northern half of the Pequannock Watershed as the breeding stronghold for the red-shouldered hawk within the northern Highlands region. Also, Speiser and Bosakowski (1984) found that red-shouldered hawks, northern goshawks and barred owls showed similar habitat preferences and often occurred with overlapping territories. Additional threats to the red-shouldered hawk include predation by great horned owls (*Bubo virginianus*), competition with red-tailed hawks and disturbance by hikers, bicyclists and ATVs (Bosakowski *et al.* 1991).

The wood turtle (*Clemmys insculpta*) has been documented in reaches of Wawayanda Creek, approximately .5 miles upstream of the confluence with Doublekill Creek, and may also find suitable habitat in the low gradient portion of Doublekill Creek at the southern tip of the natural area. The wood turtle ranges from Nova Scotia, west through the Great Lakes region to eastern Minnesota and, in the east, ranges south to northern Virginia (Conant 1975). Wood turtles may be found far from water but prefer riparian habitats, favoring slow moving streams with sandy bottoms (Cross 1992). This turtle has declined throughout its range due to loss of suitable habitat and other human disturbance including collection and water pollution (Zappalorti and Johnson 1982, Cross 1992). In New Jersey, Zappalorti *et al.* (1984) report that the wood turtle is restricted to hardwood forests of northern and central parts of the State and that its distribution is spotty and discontinuous. Wood turtle populations in northern New Jersey normally occupy an area of 40 to 120 hectares (Harding and Bloomer 1979). Quinn and Tate (1991) found that half of the wood turtles that they studied in Ontario had widely separated seasonal ranges. Home ranges, or activity areas, averaged 24.3 hectares and ranged from less than one to 115 hectares. Quinn and Tate (1991) compared their study results with other studies that indicated wood turtles have small home ranges of several acres, or that the home ranges were 200-700 meter long strips associated with creeks. The results of these studies indicate that the size of wood turtles' home ranges vary greatly between individuals and different populations and that the turtles may regularly use different habitats on a seasonal basis. Wood turtles mate in April and lay eggs in June in an open area with good drainage and few or no trees. The turtles disperse from streams into adjacent forests in the summer and return in the fall to hibernate, becoming active again in March (DeGraaf and Rudis 1987). They are omnivorous, feeding on algae, grasses, berries and other fruit, insects, snails, slugs, worms,

crayfish, fish, tadpoles and carrion (Zappalorti and Johnson 1982, Cross 1992). Young hatch late summer or early fall (Cross 1992).

The bobcat (*Lynx rufus*) has not been documented from the natural area but may use this area. Bobcat have been observed several times over the last few years crossing the main road within the park (Charles McCurry pers. comm.). A number of bobcat were released in the Bearfort Mountain area from 1978 to 1982 during a reintroduction program of the N.J. Division of Fish, Game and Wildlife, Nongame and Endangered Species Program (Jim Sciascia pers. comm.). The bobcat inhabits mixed deciduous-coniferous forests, hardwood forests and swamps (DeGraaf and Rudis 1987, Burt and Grossenheider 1976). Bobcats favor brushy and rocky woodlands broken by fields, old roads and farmland (DeGraaf and Rudis 1987). This cat dens in rock crevices, hollow logs and beneath downfalls. Bobcats have large home ranges; the home range being larger for males than females, and larger during the winter (DeGraaf and Rudis 1987). Bobcats prey upon small mammals, birds and eggs, snakes, fish, crustaceans, insects as well as carrion and weakened deer in winter (DeGraaf and Rudis 1987). In the mid-1980s four bobcat kittens were found shot along the edge of a road within the park (Charles McCurry pers. comm.). This poaching appears to be an isolated incident.

A Cooper's hawk (*Accipiter cooperii*) was observed in 1995 within one-half mile of the western boundary of the natural area near Barrett Road (New Jersey Audubon Society 1996). Because the bird exhibited agitated behavior when sighted, it is probable that the bird was breeding. The following information was obtained from Rosenfield and Bielefeldt (1995). The Cooper's hawk is a medium-sized woodland raptor that breeds throughout the United States. It may be found in deciduous, evergreen or mixed forest types and is tolerant of both human disturbance and habitat fragmentation. Its diet includes various prey, such as medium-sized birds (jays, robins) and mammals (chipmunks). There is little recommended management for this species, as it is known to thrive in a diversity of habitats, including suburban areas and plantations.

In 1995, a bobolink (*Dolichonyx oryzivorus*) was observed feeding its young between the western boundary of the natural area and Barrett Road (New Jersey Audubon Society 1996). This activity confirms that the bird was a breeder. Northern New Jersey falls just within the breeding range of this passerine species, which winters in South America (Martin and Gavin 1995). The bobolink is a medium-sized bird that prefers tall grass, hayfields and meadow habitats. Its food source includes adult and larval insects and weed and grain seeds. In New Jersey the species is considered threatened.

Public Use

The area surrounding the park is one of relatively low population density compared with areas to the south and east in Morris, Passaic and Bergen counties. Based on 1990 census records Sussex County has a population of approximately 131,000 people with a density of 251 people per square mile. Passaic, Morris and Bergen counties to the south and east have densities of 2,449, 898, and 3,525 people per square mile, respectively. Due to the high population densities in this region, Wawayanda State Park and the other protected areas of the region are important open spaces for the nearly two million people of these North Jersey counties.

The natural area is used for nature interpretation and study, hiking, cross-country skiing, snowshoeing, bird watching and botanizing. Fishing, hunting and trapping are permitted in the natural area, but in recent years hunting has been most popular (Robert Goodman pers. comm.). Stocking Doublekill Creek with trout has not occurred for 30 years or more, but may be proposed in the future (Robert Goodman pers. comm.).

Access to the natural area is obtained via the Appalachian Trail, that borders the natural area to the west, and Iron Mountain Road, a one lane dirt road, which runs along the eastern boundary of the natural area. Parking at the natural area is limited to places where one can pull off Iron Mountain Road, including a spot east of the road next to the bridge over Doublekill Creek and at the clearing west of the road just south of Crossover Road (Figure 2). Although there are no marked and maintained trails through the natural area, there are old woods roads that appear to be used by hunters and hikers.

Research at Wawayanda State Park has included historical studies of the iron mining era of northern New Jersey. One such study (Apffel 1970) focussed on Wawayanda and included information about the early mining operations and village near Wawayanda Lake. Currently, there is no known ongoing research at the natural area.

Management issues concerning public use of the natural area include maintenance of Iron Mountain Road, posting natural area boundaries, and illegal uses such as riding ATVs throughout the natural area, overnight camping and fires. According to Park Superintendent Robert Goodman, ATVs are a problem throughout the entire park. ATV's are accessing the park from the new housing development along Barrett Road and are causing damage to trails as well as posing a safety problem for other trail users. Another management issue is the Layton Mine that includes test pits and an open shaft. Orange plastic snow fence has been erected around one open shaft and appropriate signs indicating that the shaft is dangerous have been posted.

Introduced Features

The Appalachian Trail and Iron Mountain Road form the boundary of much of the natural area. These trails are outside the natural area and there are no other maintained trails located within the natural area. Old woods roads can be followed along the western portion of the ravine and in the hemlock woods near the old Layton Mine. Iron Mountain Road, which was once used as an access road to house lots, is open for public use. Vehicles are allowed on Iron Mountain Road south of Crossover Road, however, no vehicles are allowed on the road north of Crossover Road. Telephone poles and wires remain along this dirt road.

Clearings are represented on the 1935 revised New Jersey Atlas Maps and the 1954 Wawayanda quadrangle U.S.G.S. topographic map. These clearings, surrounding the hemlock ravine, are located along Iron Mountain Road, in the vicinity of the old Layton Mine, near the old iron bridge and southeast of the old Barrett Farm. Three of these clearings are still apparent. They are located at the old homesite on Iron Mountain Road across from Crossover Road, northwest of the old iron bridge, and in the uplands southeast of the old Barrett Farm (Figure 2). The 1954 U.S.G.S. topographic map also shows several buildings along Iron Mountain Road. These buildings have since been demolished.

The old clearing in the uplands southeast of the Barrett Farm is a site where two buildings once stood. The revised natural area boundary follows one of the stone walls through the site. A cellar hole constructed of stone and a well that is capped with a large flat stone fall outside of the natural area boundary. A poured cement foundation is within the addition to the natural area. These remains are at the end of an old woods road that serves as part of the Appalachian Trail west of this site.

The Layton Mine site appears to have been abandoned at least 80 years ago, based on a 1910 report (New Jersey Department of Labor 1982), and the area is now revegetated with birch and hemlock (Figure 2). Several abandoned vehicles can be found along old woods roads in this area near the New York State border. The mine site is south of a woods road that runs parallel to a low stone wall. At least four pits are located in

this area and there are an additional four pits that may be filled shafts. There is one shaft that was found to be open and filled with water 15 feet below the surface. Mounds of dirt are also found here next to the pits or shafts. Adjacent to the open shaft there is an old foundation or platform of stone, brick and iron. This may have been a pulley operation next to what appears to have been a small spillway. Southwest of the open shaft are flat stones on the ground that form three sides of a low rectangle. There may be other artifacts of the mining period at this location.

The mine was first opened in 1878 and was explored by shafts and pits on a line 550 feet long (New Jersey Department of Labor 1982). A 1910 report describing this site indicated that there were three old and three comparatively new shafts and a number of shallow pits, some of recent origin (New Jersey Department of Labor 1982). Work done at the site by personnel of Wawayanda State Park during the fall of 1994 included erecting a snow fence around the open shaft to alert people to this hazard. It is thought that this may be the main shaft which has been described as 128 feet deep (New Jersey Department of Labor 1982). The Bureau of Mine Safety has also been contacted about the location of the open mine shaft and inspected the site in February 1995.

In addition to the three clearings themselves, there are other introduced features at these sites. The clearing site off Iron Mountain Road, west of Crossover Road, is an old driveway and house lot that is currently used to park off the road (Figure 2). There are two stone pillars along the road next to the current access way to the clearing. West of the clearing there is a path that leads to a small pile containing broken bottles, and metal refuse.

There are a number of introduced features in the natural area that have been left by those that use the area for hunting or for overnight outings. At an outcrop area immediately west of one of the small falls of the Doublekill Creek is a camp fire site. Also, above the western slope of the ravine, along one of the old woods roads, there is another camp fire site with a ring of stones, refuse such as old pans and bottles, cut logs and cut saplings tied together in a crisscross pattern forming a four foot by five foot support. Throughout the natural area small wooden hunting platforms were seen in trees along old woods roads. On an outcrop east of Doublekill Creek there is a lean-to made from logs and sticks. There is also a campfire site here (Figure 2). This spot was known to have been used by a hunter for many years.

The use of insecticide to control gypsy moths can also be considered an introduced feature. A portion of the natural area south of the ravine and a portion of the upland east of the ravine were sprayed with Sevin in 1970, and the larvacide B.t.i. (*Bacillus thuringensis* var. *israeliensis*) was sprayed along the north shore of Wawayanda Lake, south of the natural area in 1991 (George Koeck pers. comm.). Gypsy moth induced defoliation first appeared in this region in 1979; extensive defoliation occurred from 1980 through 1982 and 1990 through 1992 (George Koeck pers. comm.).

Management Techniques

Natural Areas System Rules

Relevant sections of the rules and regulations concerning Natural Areas and the Natural Areas System (N.J.A.C. 7:5A-1.1 et seq.) appear in Appendix A. An important function of these rules is to provide general interim management guidelines for all natural areas for which management plans have not been prepared.

Upon preparation of a management plan, interim management guidelines may continue or may be superseded by management techniques more appropriate to fulfill the management objective of the natural area. Should an issue arise that is not addressed in the management techniques below, the interim management techniques at N.J.A.C. 7:5A-1.9 (Appendix A) will apply and should be consulted. The following analysis will outline management and uses contrary or supplemental to existing rules.

Management Objective And Classification

The management objective for Wawayanda Hemlock Ravine Natural Area is "preservation of hemlock-mixed hardwood forest and rare species habitat." The following management techniques are derived from issues discussed in previous sections of this plan and the interim management guidelines found in Appendix A. Techniques are based, in part, on consultation with appropriate agencies, individuals and the Natural Areas Council, and are designed to protect the features of the natural area and further its management objective. An explanation of the basis for each technique is also provided below each management technique. Appendix B includes a summary and implementation schedule of the management techniques described below.

Throughout this section, administering agency refers to the Division of Parks and Forestry, through Wawayanda State Park. It is recognized that the State Park Service is severely understaffed and, as a result, some management activities may need to be extended beyond the implementation dates indicated.

A. Endangered and Threatened Species

1. The Office of Natural Lands Management (ONLM) will, within the limits of available staff and funding, perform periodic surveys for rare species and historically known rare plant species.

This technique is included to help ensure the preservation of these species and to ensure consideration of these species in future planning in the natural area.

2. The ONLM will provide the administering agency with a map indicating known and possible locations of all species within the natural area tracked by the Natural Heritage Database and, if possible, an illustration of any rare plant species in the natural area by December 31, 1996. These materials will be updated by the ONLM should locations for any additional species be discovered.

This management requirement is included so that the administering agency can more effectively manage the natural area for rare species and their habitats, and to ensure consideration of these species in future planning in the natural area.

3. Should a timber rattlesnake den be found to exist in the natural area where canopy cover exceeds 75 percent, State Forestry Services, in cooperation with the ONLM, may perform selective cutting to increase the amount of sunlight in the vicinity of the den. The cutting should take place in winter while the snakes are in hibernation. However, selective cutting should not be performed if a gypsy moth infestation is imminent. The size of the clearing will depend on the extent of the snake population and will be determined through consultation with the Division of Fish, Game and Wildlife. Cutting should begin at or near the den and radiate in the direction of the least public use to minimize human-snake conflicts. Care should be taken to avoid damage to standing trees, and slash may be removed or placed around the perimeter of the cut area to provide habitat for prey species and other wildlife.

This management technique is included to prevent canopy closure from causing den sites to become unsuitable for snakes should a den be found within the natural area. This technique furthers the management objective of this natural area by helping to manage rare species habitat.

4. Standing dead or injured trees of 20 inch or greater diameter at breast height (dbh) should be preserved by the administering agency as potential nest sites for the barred owl. If such trees have been removed in the past for reasons of public health and safety, or if removal becomes necessary for this purpose (e.g., proximity to trails, etc.), consideration should be given, within the limits of available staff and funding, to installing owl nest boxes in suitable owl nesting habitat.

Because dead trees of the size indicated provide potentially suitable nesting sites for the state threatened barred owl, efforts should be made to maintain or enhance suitability of the natural areas as habitat for this species. This is consistent with the management objective for the natural area. Mitigation methods are provided in the event that tree removal is required to protect public health and safety.

B. Boundary

1. The natural area boundary is hereby revised to include 19 acres along the New York-New Jersey state boundary (Layton Mine) and 94 acres along the Appalachian Trail near Barrett's Farm while removing 14 acres south of the juncture of the Appalachian Trail and Iron Mountain Road (refer to Figure 2). This will result in a net addition of approximately 99 acres to the natural area. The resulting acreage of the Wawayanda Hemlock Ravine Natural Area is 501 acres.

Revising the natural area boundary in accordance with the Natural Areas System Rules at N.J.A.C. 7:5A-1.12 will create a boundary that conforms with physical features identifiable in the field as well as with the extent of State ownership. This boundary change also furthers the management objective by adding habitat that may be suitable for rare species such as the barred owl. In accordance with N.J.A.C. 7:5A-1.12, revisions to the boundary of a natural area that result in a net change of not more than 25 percent of the total acreage of the natural area may be made, upon public notice, if the boundary change conforms with physical features identifiable in the field or the extent of State ownership and serves to protect the natural area or further its management objective. The revision will make the boundary more distinct, thus, more enforceable and will further the management objective by increasing protection of suitable habitat for State endangered and threatened species documented at the natural area. The net addition of 99 acres equates to a 24.6% net increase in size of the natural area.

2. The administering agency, in cooperation with the ONLM, will post State Natural Area boundary signs along the boundary, where practicable, at a maximum of ten per mile by May 1, 1997. Posting of that portion of the boundary that forms the New Jersey-New York state line is not necessary. Signs will be replaced as needed. The ONLM will provide the administering agency with boundary signs.

The boundary of the natural area should be clearly posted for the public and to reduce inadvertent impacts to natural area features. The ONLM, which is responsible for overall administration of the Natural Areas System, designs and distributes paper boundary signs for posting of all State Natural Areas.

C. Biotic Communities

1. Infestation of the natural area by the hemlock woolly adelgid could result in the complete loss of hemlock forest canopy and would likely render the ravine unsuitable as habitat for many of the associated plant and animal species of this ecosystem, including endangered and threatened species. Long-term damage to soils could also occur through increased exposure and erosion with resultant sedimentation of streams. Because no preventative measures or control techniques within interior forest environments are currently known, specific techniques cannot be prescribed to control the adelgid. Should such control techniques become available, their application may be allowed upon Natural Areas Council review and Commissioner approval. The Bureau of Forest Management and the ONLM will conduct periodic monitoring for hemlock woolly adelgid and forward results to the Division's Forest Health program. Should monitoring indicate that a significant infestation has occurred, experimental techniques to control the infestation may be proposed by staff of the ONLM and the Bureau of Forest Management and may be applied upon Natural Areas Council review and Commissioner approval. Potential infestation control techniques could include, but are not limited to, use of systemic insecticides and aerial application of pesticides. Should loss of hemlock canopy occur as a result of infestation, means to preserve the habitat and discourage erosion of the slopes will continue to be pursued.

These techniques are included to address the significant threat that hemlock woolly adelgid poses to the integrity of hemlock stands and all associated biota within the natural area, and the need to closely monitor the natural area for infestation by this introduced pest. However, there is currently no proven technique for treatment of hemlock under interior forest conditions.

2. The Division of Parks and Forestry may perform gypsy moth control activities in the natural area if the following three criteria are met: counts of at least 400 egg masses/acre are recorded; the previous year defoliation occurred during or immediately preceded a severe drought; and a significant amount of tree mortality (not defoliation) will be expected if control activities are not performed. If these criteria are met, the Division should submit a gypsy moth control plan, including a spraying program environmental impact statement (EIS), with data that substantiates the above criteria, to the ONLM. The EIS should contain methods to avoid impacts on lepidoptera, rare and endangered species and other non-target species. If spraying is conducted, the following spraying guidelines must be followed: one application of B.t. is permitted per year; and spraying will be conducted from mid to late May; Should a more environmentally sound method of gypsy moth control become available in the future, this new gypsy moth control method will be allowed upon Natural Areas Council review and Commissioner approval.

The Commissioner hereby approves of gypsy moth control activities at Wawayanda Hemlock Ravine Natural Area. Performing gypsy moth control will further the management objective by helping to maintain suitable habitat for State endangered and threatened species documented at Wawayanda Hemlock Ravine Natural Area such as barred owl. High egg mass counts and defoliation during or preceding a drought are known to increase the susceptibility of the forest to mortality from gypsy moth defoliation (Schweitzer 1988). Drought places an additional stress on already defoliated trees which increases the chance of mortality from a second defoliation.

D. Public Use

1. Current uses of the natural area, which include nature interpretation and study, hiking, cross-country skiing, snowshoeing, bird watching, botanizing, horseback riding on designated trails, hunting, fishing and trapping, are allowed to continue in the natural area.

The above uses are compatible with preservation of the species and natural communities that occur within the natural area and should continue to be allowed. Should monitoring indicate that continuation of the above uses is contradictory to achievement of the management objective of the natural area, modification or discontinuation of the use will be considered.

2. The administering agency will obtain all applications to conduct research or collect specimens, forward a copy to the ONLM, and provide a response within a reasonable date of application submittal. The administering agency shall coordinate a response with the ONLM.

This requirement is included in accordance with procedures for conducting research and collecting specimens in natural areas as outlined at N.J.A.C. 7:5A-1.10, and to ensure thorough review of all proposals.

E. Introduced Features

1. The administering agency will remove refuse located near the clearing west of Crossover Road.

Rubbish or any other waste material must be removed from the natural area according to Natural Areas System Rules at N.J.A.C. 7:5A-1.9(e)7.

2. The administering agency may perform activities at the location of the abandoned Layton Mine, as well as any other abandoned mine shafts found within the natural area, that will insure protection of the health and safety of the public. The administering agency will notify the ONLM and the Historic Preservation Office in advance of any actions taken to secure mine safety.

Because abandoned mine shafts pose a significant threat to public safety, the administering agency is provided with the flexibility to quickly implement actions necessary to secure their safety.

3. The administering agency will forward any plans that include ground disturbance or any activity that may disturb historical features of the natural area to the New Jersey Historic Preservation Office for review. Should erosion or other factors result in the exposure of cultural remains within the natural area, the administering agency will contact the New Jersey Historic Preservation Office.

This requirement is included to help ensure preservation of any historical or cultural features within the natural area.

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Appendix A

INTERIM MANAGEMENT PRACTICES FOR NATURAL AREAS

From Natural Areas System Rules
(N.J.A.C. 7:5A-1.1 et seq.)

7:5A-1.9 INTERIM MANAGEMENT PRACTICES

- (a) Interim management practices shall be implemented by the administering agency, provided that:
 - 1. The practice will have no direct or indirect adverse impact on natural features of concern;
 - 2. The administering agency notifies the secretary of the Council, in writing, no later than 30 days after initiating the practice;
 - 3. Approval of the Commissioner is not required by provision elsewhere in this subchapter; and
 - 4. The practice is consistent with terms of any conservation easement held by the Department.
- (b) Interim management practices listed at (e) or (f) below which require the approval of the Commissioner shall first be submitted to the Council for its review and recommendation.
- (c) Upon finding that an interim management practice listed below at (e) or (f) would be detrimental to achieving a specific management objective, the Council shall recommend to the Commissioner the substitution of a more appropriate interim management practice. Should the Commissioner concur with the recommendation of the Council, the Commissioner may approve substitution by a more appropriate interim management practice.
- (d) Where there are conflicts between general practices described below at (e) and practices specific to a natural area classification described below at (f), the latter shall apply.
- (e) The following interim management practices apply generally to all natural areas upon designation to the System and until and unless superseded by the provisions of an adopted management plan:
 - 1. Natural area boundaries shall be made clearly evident by posting signs at a maximum density of ten signs per mile; entrance points shall be posted to indicate to users that they are entering a natural area; boundary signs shall be of a standard size and format as approved by the Commissioner and provided by the Division;
 - 2. Boundary fences that are needed to protect the natural area may be installed provided the fence shall not have a detrimental effect on movement of wildlife, air circulation, or other natural conditions;

3. Vehicular access lanes may be maintained within a natural area but may not be enlarged in any manner except upon approval of the Commissioner.
4. Existing firebreaks within a natural area may be maintained for safety purposes; temporary firebreaks made by mowing, raking, plowing or wetting, may be used in conjunction with prescribed burning for habitat management;
5. Existing structures may be maintained in a natural area; new structures and enlargement of existing structures may be undertaken upon approval by the Commissioner, provided the structures directly or indirectly contribute to the management objective; new structures, of a temporary nature, may be constructed for research purposes in accordance with N.J.A.C. 7:5A-1.10;
6. No measures, such as cutting of grass, brush, or other vegetation, thinning of trees, opening of scenic vistas, or planting, shall be taken to alter natural processes or features for the purpose of enhancing the beauty or neatness of a natural area;
7. Except as otherwise provided in this section, there shall be no introduction, removal or consumptive use of any material, product, or object to or from a natural area; prohibited activities include grazing by domestic animals, farming, gathering of plants or parts thereof, mining or quarrying, and dumping, burying, or spreading of garbage, trash, or other materials; structures or materials may be removed as follows:
 - i. Old interior fences may be removed, giving consideration to leaving posts to mark boundaries between former land uses;
 - ii. Rubbish or any other waste material may be removed; and
 - iii. Structures having no historic, scientific or habitat value may be demolished and removed unless such structures are deemed essential for administrative purposes;
8. Water levels within a natural area shall not be altered except to restore water levels which have been altered due to a sudden natural phenomena or man-induced conditions off-site; routine repairs to existing water control structures may be undertaken but the structures may not be enlarged;
9. All wildfires shall be brought under control as quickly as possible; after a fire within a natural area, there shall be no cleanup or replanting except as approved by the Commissioner to achieve the management objective or for reasons of health and safety;
10. Prescribed burning, to eliminate safety hazards and to manage habitat, may be conducted upon review of a proposal for prescribed burning by the Council and approval by the Commissioner; use of vehicles and equipment shall be specified in the proposal for prescribed burning;
11. Erosion control within a natural area shall not be undertaken except to restore existing grades which have been altered due to a sudden natural phenomena or man-induced conditions within or beyond the natural area;

12. Habitat manipulation may be undertaken if preservation of a particular habitat type or species of native flora or fauna is included in the management objective of the natural area and upon approval by the Commissioner of a specific habitat manipulation plan prepared by the Department.
13. Gypsy moth control activities may be implemented as an interim management practice after approval of a gypsy moth control plan by the Commissioner; the Commissioner shall review a gypsy moth control plan only after the State Forester has determined that egg mass counts and prior year defoliation indicates that tree mortality will be severe without intervention; to the extent practicable, biological controls, rather than chemical means, shall be used to control gypsy moths;
14. There shall be no physical manipulation of a natural area or application of chemicals known as adulticides for the purpose of controlling mosquitoes; the application of larvicides may be permitted in salt marshes only and only as follows:
 - i. The application of *Bacillus thuringensis* var. *israeliensis* (B.t.i.) may be initiated by a mosquito control agency at any time; and
 - ii. The application of other larvicides may be initiated upon approval by the Commissioner of a specific mosquito control plan submitted by a mosquito control agency; the plan shall identify the specific area where a larvicide application will be made, the types and amount of larvicide to be applied, the need for the application, and the reason why B.t.i. cannot be used for this application;
15. Research activities and the collection of specimens may only be conducted in accordance with N.J.A.C. 7:5A-1.10 and upon approval of the administering agency; and
16. Public use of natural areas shall be allowed only to the extent and in a manner that will not impair natural features; the administering agency may restrict access and use as necessary to protect the natural area; the following are permissible public uses of natural areas:
 - i. Hunting, trapping, and fishing are permitted in accordance with N.J.A.C. 7:25-5 and 7:25-6; except for the stocking of fish and game, habitats may not be manipulated for the purpose of enhancing hunting, trapping, or fishing;
 - ii. Occasional camping along trails, boating, and swimming may be permitted in specified locations of natural areas in accordance with N.J.A.C. 7:2-2, 7:2-5, 7:2-7, 7:2-8, and 7:25-2, and are further limited as follows:
 - (1) No permanent structures may be erected;
 - (2) No motorized methods of boating or camping are permitted;
 - (3) Trailside shelters of the type called lean-tos are permitted, but there may not be two such shelters within three miles of each other; and
 - iii. Existing trails may be maintained, but not enlarged in any manner, by the administering agency to allow public use and prevent erosion, trampling of vegetation beyond the trails, and other deterioration as follows:

- (1) New trails or enlargement of existing trails for interpretive purposes may be initiated subsequent to review of a plan by the Council and approval of that plan by the Commissioner;
 - (2) Rare plants may not be removed for the purpose of maintaining existing or constructing new trails; and
 - (3) To the extent possible, natural materials shall be used on and along trails; and
 - iv. All pets shall be kept caged or leashed and under immediate control of the owner except that dogs used while legally hunting shall be exempt from the leashing requirement.
- (f) The following interim management practices, unless superseded by an adopted management plan, apply to the appropriate specified natural area classifications:
1. Location markers identifying interpretation points of interest may be installed except within ecological reserves;
 2. Trail blazes may be used within any natural area;
 3. Existing vehicular access lanes may not be enlarged in any manner within an ecological reserve;
 4. New vehicular access lanes may be constructed only within buffer areas and upon approval by the Commissioner;
 5. The alteration of natural processes or features for the purpose of enhancing public use of the natural area may be conducted by the administering agency only within buffer areas; and
 6. The following management practices shall not be permitted within ecological reserves:
 - i. New, existing, or temporary firebreaks;
 - ii. Construction of new trails;
 - iii. Alteration or restoration of water levels;
 - iv. Prescribed burning;
 - v. Erosion control measures;
 - vi. Gypsy moth control activities; and
 - vii. Manipulation of vegetation and wildlife habitats.

Appendix B

Wayayanda Hemlock Ravine Natural Area Management Plan Summary of Management Techniques and Implementation Schedule				
Technique	Description	Responsible Agency	Accomplishment Date	Comments
A1	Conduct rare species surveys	ONLM	Periodic	
A2	Create rare species map	ONLM	December 31, 1996	
A3	Selective cut to manage rattlesnake den	State Forestry Services; ONLM		May be performed if den is discovered; consult with Division of Fish, Game and Wildlife
A4	Preserve standing dead trees for barred owl management	Wayayanda State Park	Periodic	Should be performed to preserve nesting habitat
B1	Revise boundary to include 501 acres	ONLM	Effective upon adoption of management plan	
B2	Post boundary signs	Wayayanda State Park; ONLM	May 1, 1997	Replace signs as needed
C1	Monitor/propose control for hemlock woolly adelgid	Bureau of Forest Management; ONLM	Periodic	Natural Areas Council review and Commissioner approval required prior to application of control

Technique	Description	Responsible Agency	Accomplishment Date	Comments
C2	Monitor/control for gypsy moth	Division of Parks and Forestry	Periodic	Criteria for control are provided; Natural Areas Council review and Commissioner approval required prior to application of control
D1	Allow current uses to continue	Wayayanda State Park		Monitor uses to determine compatibility with management objective
D2	Review and approve applications for research/collection	Wayayanda State Park; ONLM	Periodic	Coordinate response to request with ONLM
E1	Remove refuse along Crossover Road	Wayayanda State Park	Periodic	
E2	Secure safety of abandoned Layton Mine	Wayayanda State Park	Periodic	Notify ONLM and Historic Preservation Office prior to action
E3	Seek review of Historic Preservation Office prior to ground disturbance	Wayayanda State Park	Periodic	Report exposure of cultural remains to Historic Preservation Office