10/30/2013

WHITING WILDLIFE MANAGEMENT AREA
NATURAL RESOURCE STEWARDSHIP PLAN

Manchester Township, Ocean County, New Jersey
Block 75.01, Lot 26
Block 81, Lot 1

MANAGEMENT PERIOD 2013 - 2022

1,163 Total Acreage of Property
(1,154 Woodland Acres, 9 Lake Acres)

Plan Date: October 30, 2013

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I. OVERVIEW

This document is a comprehensive natural resource stewardship plan for the Whiting Wildlife Management Area (WWMA) that addresses many conservation issues and will serve as a guide for resource management activities important to forest stewardship. This plan was developed by a committee of representatives from several agencies within the NJ Department of Environmental Protection (DEP) Natural and Historic Resources (NHR) Group, including NJ Forest Fire Service, NJ State Forestry Services, NJ Division of Fish and Wildlife, and NJ Office of Natural Lands Management, as well as representatives from other outside agencies. Inventory and planning efforts were supported by a third party contractor, Land Dimensions Engineering (LDE).

The focus of the committee was to provide insight and assistance, formulate management direction, and establish priorities and prescriptions in the development of a comprehensive resource management plan that incorporated both an ecological and stewardship approach to management of the habitat resources. This management philosophy integrates human values and needs while sustaining a diverse ecosystem across the landscape. The WWMA plan is a part of a wider planning effort across a broad landscape involving many diverse stakeholders known as the Berkeley Triangle Project. Although not really triangular in shape, the Berkeley Triangle consists of lands roughly centered around Berkeley Township, Ocean County, NJ held by three major landowners, the NJ Division of Fish and Wildlife, the NJ Division of Parks and Forestry, and the NJ Audubon Society. Stakeholders include state, private, and not-for-profit individuals and organizations.

Plan development efforts required various resource managers, each with diverse backgrounds and technical expertise from different agencies and organizations to cooperatively work together and integrate a broad range of management tools and strategies. The end result was the development of a natural resource stewardship plan which sustains a desired level of diversity, ecological communities and habitats, forest health, and wildfire protection through a carefully planned and coordinated effort.

Undoubtedly all forest and public lands owned by the NJ DEP are today faced with many challenges and circumstances that require the preparation of comprehensive forest stewardship resource plans. Environmental pressures, changing population trends, climate changes, air and water quality, occurrence of forest pests and diseases, changing habitats, and recreational pressures can negatively affect these forest resources. As a result, more attention must be given to monitoring, sustainability, and management of healthy forests.

Under the jurisdiction of the New Jersey Division of Fish and Wildlife the 1,163 acre property known as the WWMA is located in Manchester Township, Ocean County. The Central Railroad of New Jersey lies to the west, with Wrangle Brook Road and Schoolhouse Road to the south. Major developments occur to the south and east of the property. WWMA is located east of state Route 70 and north of county Route 530. All property acquisitions for location have been through the Division of Fish and Wildlife. The land area is a mix of upland and wetland forest types with pitch pine as the dominant tree cover. The forest has mostly been unmanaged for the last forty years. Prescribed fire has been utilized within buffer strips adjacent to developed areas.

The forest is comprised of a plethora of forest types and ecological communities that offer an excellent representation of the vegetation commonly occurring throughout much of southern New Jersey and the Pinelands. From xeric dry upland sites to pitch pine lowlands, to Atlantic white-cedar swamps, WWMA offers a wide variety of habitat for the highly diverse fauna and flora which occur there. Forest management goals for WWMA include identifying ecologically significant communities, reducing wildfire risk, improving habitat value for species of interest, strengthening forest health, and developing management strategies that will provide the recommended level of diversity. Establishment of concerns for endangered and threatened plant and animal species will be incorporated into planning, and whenever possible activities will be designed to enhance the habitats necessary for their survival.

Implementation of the plan, since it is under the jurisdiction of the Division of Fish and Wildlife, is primarily the duty of the Director of the Division of Fish and Wildlife. However, all natural resource agencies involved with the development of the plan share in the responsibility of its implementation. This ultimately places the task for the plan's action upon the Assistant Commissioner of NHR since it addresses all disciplines of the DEP's Natural and Historic Resources group.

II. GOALS AND OBJECTIVES

Goal 1: Protect public health and safety through forest management actions that reduce fuel loads and wildfire hazards.

Objective 1.1: Thin approximately 240 acres across 7 different stands located in the Wildland Urban Interface (WUI) low and from below in order to disrupt ladder fuels in the 10-year planning cycle.

Objective 1.2: Use prescribed burning to reduce fuel loads in the WUI by establishing a regular burning regimen in the 7 different thinned stands.

Goal 2: Manage forest stands to conserve native vegetation types and patterns, rare ecological communities, critical habitats, and the diversity of rare and common native species associated with these various habitats.

Objective 2.1: Establish 296 acres of High Conservation Value Forest (HCVF) in this plan according to Forest Stewardship Council guidelines (Forest Stewardship Council 2010).

Objective 2.2: Treat approximately 245 acres across 2 different sub-stands with a combination of variable density thinning, single tree selection, and group selection harvesting in order to increase horizontal and vertical structural diversity during the planning cycle.

Objective 2.3: Treat approximately 80 acres with Stoddard-Neel variable density thinning to encourage wildlife populations inward to the new basking and habitat areas developed in Objective 2.2.

Goal 3: Utilize ecological forestry approaches to conserve the above components and patterns of biodiversity and mimic the natural and historic fire regimes which created this biodiversity.

Objective 3.1: Re-introduce fire into roughly 280 acres of fire-dependant HCVF using aerial ignition in a fashion more similar to conditions provided by natural fire during the planning cycle.

Goal 4: Improve growth, vigor, health, and function of retention post treatment.

Objective 4.1: Tree retention in thinnings associated with objectives 2.2 and 1.1 will consist of the healthiest trees in each size class desired according to the objectives.

Goal 5: Manage for the range of natural variability of habitat and species found in this area of the Pinelands region.

Objective 5.1: Establish 73 acres of Representative Sample Area (RSA) according to Forest Stewardship Council guidelines (Forest Stewardship Council 2010) of untouched pitch pine-shrub-tree-oak (PPSTO) for comparison to adjacent treated areas of the same forest type.

Objective 5.2: Utilize treatments in the HCVF (see goal 2) during the planning cycle that enhance natural variability by promoting a broad range of tree retention sizes and species.

Objective 5.3: In contrast to the overall matrix of surrounding forest, manage 40 acres of grass fields (including disturbed/regeneration types 1 and 2) and establish a 13-acre field strip for maintenance and establishment of beneficial herbaceous cover.

Objective 5.4: Control invasive species throughout the WMA, particularly where these have become established.

Goal 6: Provide an example of active land, forest, and wildlife management that allows for the conservation of biodiversity; while at the same time mitigating concerns of uncontrolled wildland fires to demonstrate that each goal is not mutually exclusive, but dependent upon one another.

Objective 6.1: Provide a template for NJ state lands planning through the outline and collaborative process established by this plan.

Objective 6.2: Use the WWMA plan to promote and encourage "Fire Adapted" communities though the Firewise program. Incorporate Manchester Township into the planning process through a Community Wildfire Protection Plan (CWPP).

Goal 7: Support local forestry economies.

Objective 7.1: Provide forestry work to be accomplished by local contractors on 579 acres of state-owned land during the planning cycle.

Objective 7.2: Make approximately 3,702.5 cords of wood available for harvest over the 10-year planning cycle.

III. SOILS DESCRIPTION

Nine soil types are present at WWMA (refer to the soil map in Appendix C for details) with different drainage conditions and physical and chemical properties that influence forest structure, species composition, and management. Site index is a standard measure of the productivity of soils defined as the average height of dominant or codominant trees at a reference age of 50 years. Thus, a soil with a site index of 80 will generally have dominant trees 80 feet tall at 50 years of age. Brief descriptions of soil properties and site indices follow, derived from the USDA Natural Resources Conservation Service (2009). Best Management Practices, such as seasonal logging and evaluating specific types of equipment for certain areas should ensure problems with soil productivity and erosion will not occur during management activities.

AtsA - Atsion sand, 0 to 2 percent slope

The Atsion series consists of poorly drained hydric soils, with a depth to seasonal high water table of 0 – 12 inches. Atsion-Lakehurst intermediate sites have a seasonal high water table depth of 12 - 18 inches. This soil is not flooded and it is not ponded. Slopes range from 0 to 2 percent. The Atsion series is found on flats at the edges of swampy wetlands, in headwater swales, or natural depressions. Typically these soils have a dark gray sand surface layer over 10 inches of light gray sand. The subsoil from 18 to 24 inches is very dark brown sand, and from 24 to 36 inches is very dark gray sand. The substratum from 36 to 60 inches is brown loose sand. Native vegetation on Atsion sands is usually pitch pine with a minor component of red maple and blackgum, while highbush blueberry, huckleberries, and sheep laurel often create thickets in the understory. The site index for pitch pine is 65.

Note: This soil occurs in forest types such as PPlo, and even PPSTO or PMC.

BerAr – Berryland sand, 0 to 2 percent slopes, rarely flooded

The Berryland series consists of deep, very poorly drained hydric soils with a depth to seasonal high water table of 0 – 6 inches. This soil is rarely flooded and rarely ponded. Slopes range from 0 to 2 percent. The Berryland series is found in flats, depressions, and drainageways of swampy wetlands. Typically these soils have a black sand surface layer 10 inches thick over 2 inches of gray sand. The subsoil from 12 to 20 inches is firm and weakly cemented dark reddish brown loamy sand. From 20 to 30 inches the subsoil is dark gray loose sand. The substratum from 30 to 72 inches is grayish brown stratified loose sand. Native vegetation on Berryland series is pitch pine, red maple, black gum, and sometimes Atlantic white-cedar. The site index for pitch pine is 60.

Note: This soil occurs in forest types such as CED and PPlo.

LakB - Lakehurst sand, 0 to 5 percent slopes

The Lakehurst series consists of very deep, moderately well drained soil with a depth to seasonal high water table of 18 - 42 inches. This soil is typically not flooded and not ponded. Slopes range from 0 to 5 percent. The Lakehurst series is found on flats and paleodunes in uplands frequently adjacent to wetlands with Atsion soils. Typically in woodland areas these soils have a dark gray sand surface 3 inches thick and a light gray sand layer from 3 to 15 inches. The subsoil between 15 to 18 inches is dark brown loamy sand. The lower part of the subsoil from 18 to 36 inches is yellowish brown sand. The substratum from 36 to 60 inches is pale brown loose sand. Native vegetation on Lakehurst series is pitch pine and oaks or where wildfires have been severe, pitch pine, scrub, and black jack oaks. The site index for pitch pine is 60.

Note: This soil occurs in forest types such as PPSTO.

LakkB - Lakehurst sand, clayey substratum, 0 to 5 percent slopes

The Lakehurst series consist of deep, moderately well drained or somewhat poorly drained soils with a depth to seasonal high water table of 18 - 42 inches. This soil is not flooded and not ponded. Slopes range from 0 to 5 percent. The Lakehurst series is found on flats and paleodunes in uplands frequently adjacent to wetlands with Atsion soils. Typically in woodland areas these soils have a dark gray sand surface 3 inches thick and a light gray sand layer from 3 to 15 inches. The subsoil between 15 to 18 inches is dark brown loamy sand. The lower part of the subsoil from 18 to 40 inches is yellowish brown sand. The substratum from 40 to 60 inches is brownish yellow sandy clay loam and light gray sandy clay. Native vegetation on Lakehurst series is pitch pine and tree-oaks or where wildfires have been severe, pitch pine, scrub and black jack oaks. The site index for pitch pine, black oak, and white oak is 60.

LasB - Lakewood sand, 0 to 5 percent slope

The Lakewood series consist of deep, excessively drained soils with a depth to seasonal high water table of more than 80 inches. This soil is not flooded and not ponded. Slopes range from 0 to 25 percent. The Lakewood series is found on flats and knolls in uplands. Typically in woodland areas these soils have a black loose sand surface layer 1 inch thick and a light brownish gray loose sand layer from 1 to 10 inches. The subsoil between 10 and 14 inches is yellowish brown loose sand. The lower part of the subsoil is yellowish brown loose sand. The substratum from 36 to 60 inches is brownish yellow loose sand. Native vegetation on Lakehurst series is pitch pine, shortleaf pine, and tree-oaks or where wildfires have been severe, pitch pine, scrub oak and black jack oaks. The site index for pitch pine is 60.

Note: This soil series occurs in forest types such as PPSTO and PPop.

LasC - Lakewood sand, 5 to 10 percent slope

The Lakewood series consist of deep, excessively drained soils with a depth to seasonal high water table of about 48 to 122 inches. This soil is not flooded and not ponded. Slopes range from 0 to 25 percent. The Lakewood series is found on fluviomarine terraces in uplands. Typically in woodland areas these soils have a black loose sand surface layer 1 inch thick and a light brownish gray loose sand layer from 1 to 10 inches. The subsoil between 10 and 14 inches is yellowish brown loose sand. The lower part of the subsoil is yellowish brown loose sand. The substratum from 36 to 60 inches is brownish yellow loose sand. Native vegetation on Lakehurst series is pitch pine, shortleaf pine, virginia pine, and tree-oaks or where wildfires have been severe, pitch pine, scrub oak, and black jack oaks. The site index for pitch pine and shortleaf pine is 50, and for Virginia pine is 60.

Note: This soil series occurs in forest types such as PPSTO and PPSTOb.

MakAt - Manahawkin muck, 0 to 2 percent slope, frequently flooded

The Manahawkin series consists of very deep, very poorly drained hydric soils formed in organic muck deposits, over sand and gravel alluvium, with a depth to seasonal high water table of 0 – 6 inches. This soil is frequently flooded and frequently ponded. Slopes range from 0 to 2 percent. The Manahawkin series is found in wetland swamps and flood plains, as well as in low positions in lake basins and along fresh water channels as they open to tide water. Typically they have a black surface and subsurface layer of highly decomposed organic material 39 inches thick. The substratum to a depth of 60 inches is gray sand. Native vegetation on Manahawkin series is Atlantic white-cedar, red maple, and sometimes black gum. The site index for Atlantic white-cedar is 50 and for red maple is 75.

Note: This soil series occurs in forest type CED.

WobB - Woodmansie sand, 0 to 5 percent slope
WobC - Woodmansie sand, 5 to 10 percent slope

The Woodmansie series consists of deep, well drained soils with a depth to seasonal high water table of about 48 to 122 inches. This soil is not flooded and not ponded. Slopes range from 0 to 25 percent. The Woodmansie series is found on hilltops, ridges, and slopes in uplands. Typically these soils in wooded areas have a dark gray sand surface layer 2 inches thick; from 2 to 8 inches is gray sand and from 8 to 17 inches is light yellowish brown sand. The subsoil between 17 to 30 inches is yellowish brown sandy loam. The substratum from 30 to 60 inches is stratified yellow sand and reddish yellow sandy loam. Native vegetation on the Woodmansie series is pitch pine, scrub oak and black jack oaks, and sometimes shortleaf pine and tree-oaks. The site index for pitch pine is 60.

> ***Note: These soils occur in forest types such as PPSTO, PPSTOb, PPO, and PPop.***

IV. FORESTRY CONCERNS

A. Rare, Threatened, and Endangered Species

The species described below are those that have been identified as either "threatened and endangered" or "species of concern," by the Office of Natural Lands Management Natural Heritage Program using the Natural Heritage Database and the Landscape Project. The descriptions following the tables identify rare species that also may be of concern in regards to planned management objectives.

Table 1: Rare plant species documented at WWMA by the Natural Heritage Database

Common Name	Scientific Name	Federal/Regional Status	State Status	Global Elements Rank	State Elements Rank
Knieskern's beaked-rush	*Rhynchospora knieskernii*	LT / LP, HL	E	G2	S2
Pale beaked-rush	*Rhynchospora pallida*	HL	-	G3	S3
Purple bladderwort	*Utricularia purpurea*	LP, HL	-	G5	S3

Table 2: Rare animal species or their habitats documented at WWMA by the Landscape Project (Version 3.1).

Common Name	Scientific Name	Federal/Regional Status	State Status
Pine Barrens treefrog	*Hyla andersonii*	N/A	State Threatened
Northern pine snake	*Pituophis melanoleucus melanoleucus*	N/A	State Threatened
Barred owl	*Strix varia*	N/A	State Threatened
Corn snake	*Pantherophis guttatus*	N/A	State Endangered
Dotted skipper	*Hesperia attalus slossonae*	N/A	Special Concern
Great blue heron	*Ardea herodias*	N/A	Special Concern

Table 3: Rare animal species or their habitats documented within ¼ mile of WWMA by the Landscape Project (Version 3.1).

Common Name	Scientific Name	Federal/Regional Status	State Status
Cooper's Hawk	*Accipiter cooperii*	N/A	Special Concern

Table 4: Other Rare or Declining Species with Critical Habitats on Site, which are tracked by NatureServe, Natural Heritage Database, or Pinelands.

Common Name	Scientific Name	Federal/Regional Status	State Status	Global Elements Rank	State Elements Rank
PLANTS					
Pine Barrens reedgrass	*Calamovilfa brevipilis*	LP		G4	S4
Pine Barrens gentian	*Gentiana autumnalis*	LP		G3	S3

Explanation of Federal/Regional Status Codes:

LT – Taxa formally listed as threatened

LP – Indicates taxa listed by the Pinelands Commission as endangered or threatened within their legal jurisdiction. Not all species currently tracked by the Pinelands Commission are tracked by the Natural Heritage Program.

Explanation of State Status Codes:

HL – Indicates taxa or ecological communities protected by the Highlands Water Protection and Planning Act within the jurisdiction of the Highlands Preservation Area.

E – Native New Jersey plant species whose survival in the State or nation is in jeopardy.

Explanation of Global and State Element Ranks:

G2 – Imperiled globally because of rarity (6-20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.

G3 – Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single western state, a physiographic region in the East) or because of other factors making it vulnerable to extinction throughout its range; with the number of occurrences in the range of 21-100.

G4 – Apparently secure globally; although it may be quite rare in parts of its range, especially at the periphery.

G5 – Demonstrably secure globally; although it may be quite rare in parts of its range, especially at the periphery.

S2 – Imperiled in New Jersey because of rarity (6-20 occurrences). Historically many of these elements

may have been more frequent but are now known from very few extant occurrences, primarily because of habitat destruction. Diligent searching may yield additional occurrences.

S3 – Rare in state with 21-100 occurrences (plant species and ecological communities in this category have only 21-50 occurrences). Includes elements which are widely distributed in the state but with small populations/acreage or elements with restricted distribution, but locally abundant. Not yet imperiled in state but may soon be if current trends continue. Searching often yields additional occurrences.

S4 – Apparently secure in state, with many occurrences.

State Threatened & Endangered Wildlife Species

Barred owl: The Barred Owl's habitat is characterized as heavy mature woods with nearby open country for foraging. These vary from upland woods to lowland swamps usually near creeks, lakes, or river valleys. The area should include densely foliated trees for daytime roosts, conifers or deciduous trees with year round leaves for winter roosts, and the presence of large trees (at least 20 in. in breast-height diameter) with suitable cavities for nesting. For southern New Jersey, mature, low density, closed canopy swamps with Atlantic white-cedar, hardwoods, and sometimes pine provide the primary forest interior habitats used by barred owl in this subregion of the Pinelands. Larger diameter hardwood trees are suitable for critical nesting habitat. The Barred Owl is almost always resident year round except during exceptionally harsh winter conditions or depending on prey availability.

> **Management Implications:** Mature, closed canopy swamps with Atlantic white cedar, hardwoods and sometimes pine provide the primary forest interior habitats used by barred owl in this subregion of the Pinelands. The primary potential nesting habitat of swamps are to be protected during this management period. The thinning of overstocked pitch pine lowlands adjacent to swamps will not impact the required older, larger diameter hardwood trees suitable for critical nesting habitat. Burned, thinned or cleared openings in pitch pine lowlands create habitat heterogeneity that benefits barred owl when adjacent to mature swamp habitats.

Cooper's hawk: Cooper's Hawks are forest and woodland birds but our tree covered suburbs appear equally sufficient. These hawks are a regular sight in parks, quiet neighborhoods, over fields, at backyard feeders, and even along busy streets if there are trees around. Hardwood and cedar swamps are also suitable for nesting habitat for this species and some mature pine stands are suitable for both nesting and foraging, including some pitch pine lowlands and pine-oak uplands in wetland buffers. Although more adaptable in habitat than the Sharp-shinned Hawk, this species still prefers sizeable tracts of woodland for breeding and migrating to fragmented and developed areas. Cooper's Hawks build nests in pine, oak, Douglas-fir, beech, spruce, and other tree species; often on flat ground rather than hillsides; and in dense woods. Nests are typically 25-50 feet high, often about two-thirds of the way up trees in a crotch or on a horizontal branch.

> **Management Implications:** The loss of large, contiguous forests and desirable breeding habitat remains a threat to this species and warrants the continued protection of Cooper's hawk nesting habitats. Maintaining a variety of forested habitats along with field edge benefits Cooper's hawks. During forestry operations, areas will be surveyed for potential stick nests and if suitable nests are located they would be provided a 300 foot "no activity" protected buffer.

Corn snake: The red cornsnake, corn snake, or red rat snake, is a North American species of rat snake that subdues its small prey by constriction. Corn snakes are found throughout the southeastern and central United States. Open sandy pine-oak and early successional upland habitats are preferred by this species. Corn snakes prefer habitats such as overgrown fields, forest openings, trees, palmetto flatwoods, and abandoned or seldom-used buildings and farms from sea level to as high as 6,000 feet. Typically, these snakes remain on the ground until the age of four months old but can ascend trees, cliffs, and other elevated surfaces. They can be found in the southeastern United States ranging from New Jersey to the Florida Keys and as far west as Texas. In colder regions, snakes hibernate during winter. However, in the more temperate climate along the coast they shelter in rock crevices and logs during cold weather and come out on warm days to soak up the heat of the sun, a process known as thermoregulation. During cold weather,

snakes are less active and therefore hunt less. A highly fossorial (burrowing) species, the corn snake seeks cover within subterranean burrows, stump holes, or old, rotten, and hollowed railroad ties. These snakes also tunnel beneath sand mounds, boards, logs, rubbish, or concrete slabs. Abandoned buildings or foundations may be used for nesting or hibernating. The New Jersey Natural Heritage Program considers the corn snake to be "demonstrably secure globally," yet "critically imperiled in New Jersey because of extreme rarity" (NJ Division of Fish and Wildlife and Conserve Wildlife Foundation of NJ, 2012). Documented corn snake sites are currently protected through the Pinelands Protection Act and environmental reviews of proposed development.

Management Implications:

The thinning, scarification, and prescribed burning treatments being proposed are expected to greatly enhance the open pine-shrub oak and early successional habitats preferred by the corn snake.

To avoid any impacts to this species during management activities in forested upland habitats, the following best management practices will be applied: a) low pressure harvesting equipment/vehicles (< 2 pounds per square inch) can be used during any season; b) if heavy equipment/vehicles are utilized, no harvesting shall occur during the dormant season October 1 through April 30 inclusive to avoid impacting hibernating snakes in dens; c) surface scarification using low pressure equipment/vehicles can be done during any season; d) if heavy equipment/vehicles are utilized, no surface scarification shall occur during the dormant season October 1 through April 30; e) no deep drum-chopping (with a filled drum) shall be applied during the dormant season October 1 through April 30 inclusive; f) shallow drum-chopping (with an unfilled drum) used with low pressure equipment/vehicles can be applied during any season; g) deep drum-chopping, root-raking or bulldozer scrapes in isolated patches of under 1 acre in size per 50 acres of forest can be applied during the active season, May 1 through September 30 inclusive.

To avoid impacts to this species in or within 50 feet of critical habitats (i.e. documented or potential egg laying/basking sites with open sandy early successional habitats, or documented hibernacula sites), the following best management practices will be applied: a) harvesting using hand tool clearing and removal can be applied during any season; b) surface scarification using hand tool clearing and removal can be applied during any season; c) low pressure harvesting equipment can be used during the dormant season, October 1 through April 30 inclusive, with oversight by ENSP; d) no harvesting equipment/vehicles, regardless of pressure, shall be used in the active season, May 1 through September 30 inclusive; e) no drum chopping, root-raking, bulldozer scrapes or surface scarification using equipment/vehicles, regardless of pressure, shall be applied in any season.

Dotted skipper*:* Sunny open pine stands, broomsedge fields, and frequently burned areas where the grass is not mowed are favorable habitats. They also prefer dry, sandy areas such as old or active railroad beds, power lines, and airport runways (NJ Division of Fish and Wildlife and Conserve Wildlife Foundation of NJ, 2012).

Management Implications: Critical habitats for this butterfly species (and several other rare Lepidoptera species) include open grassy successional uplands. Due to decades of fire exclusion and lack of severe disturbance, early successional habitats are currently rare on the landscape. The thinning, scarification and prescribed burning treatments being proposed are expected to eventually restore more of this habitat to the landscape, but this will take time. To avoid impacts to this species from loss of critical habitats and local extirpation, extant patches of this habitat will be preserved as population refugia during management. Surface scarification and more severe soil and root disturbing site prep methods will be avoided within these habitats, and initial prescribed burning will be done in the dormant season.

Great blue heron: This species is the largest of the North American herons. The Great Blue heron is found throughout most of North America, as far north as Alaska and the southern Canadian provinces. The range extends from the southern U.S. through Florida, to Mexico, the Caribbean, and South America. Birds east of the Rocky Mountains in the northern part of their range are migratory and winter in Central America or northern South America. In the southern United States southwards and on the Pacific coast these birds are year-round residents. However, their hardiness is such that individuals often remain through cold northern winters. The Great Blue Heron can adapt to almost any wetland habitat in its range. They may be found in significant numbers in fresh and saltwater marshes, mangrove swamps, flooded meadows, lake edges, and/or shorelines. They are quite adaptable and may be seen in heavily developed areas as long as they hold bodies of water bearing fish. Great Blue Herons rarely venture far from water bodies but are occasionally seen flying over upland sites. They generally nest in trees or bushes near water's edge often on islands (which minimizes the potential for predation), or partially isolated locations.

> **Management Implications:** No activities proposed in swamps or within 100 feet of a pond (Bauer Pond).

Northern pine snake: The northern pine snake is a relatively large (48-68 inch or 122-172 cm) black and dull white, to yellowish or light gray snake. These snakes have blotches that are dark towards the front of the body, but may fade to brown near and on the tail. Known for their noisy hiss, pine snakes are typically ground dwellers and rarely climb vegetation. Since this species is both secretive and fossorial, meaning it burrows underground, it can easily go undetected even in locations where it is known to be common (NJ Division of Fish and Wildlife and Conserve Wildlife Foundation of NJ, 2012). Pine snakes in New Jersey require dry pine-oak forest types growing on very infertile sandy soils such as Lakehurst or Lakewood sands (Burger & Zappalorti 1988, Burger & Zappalorti1989). Both human-caused and natural disturbances (e.g. agriculture, forestry, and fire) create the types of openings important for snake nesting

and basking areas. Sandy infertile soil not only provides for persistent openings in disturbed sites but is also important since pine snakes are among the few types known to dig hibernacula and summer dens. The secretive nature of this snake has lead to a degree of uncertainty about its overall status in the northeastern United States. However, all indications seem to suggest that pine snake abundance has decreased throughout its northeastern range. It is also believed that pine snakes have been extirpated from West Virginia and Maryland. The New Jersey Pinelands may hold some of the largest populations of pine snake in the Northeast, but even in the Pinelands this species is at risk.

> **Management Implications:** Management implications for the Corn snake will also apply to the Northern pine snake. See the section headed, "Management Implications" for the Corn snake, above.

Pine Barrens treefrog: Vibrant green and boldly marked, the Pine Barrens treefrog is arguably one of New Jersey's most beautiful amphibians. A purple stripe with a yellowish-white border extends from the snout through the eye, down each side of the body. Although the under parts are white, there is a vibrant orange patch beneath each hind leg that shows a flash of color when the frog jumps. Its throat has a purplish tinge which is particularly visible on the male. Adults measure 2.8 to 4.4 cm (1.13 to 1.75 in.) in length (Conant and Collins 1991). The call of the Pine Barrens treefrog is a rapid and nasal quonk-quonk-quonk, which is repeated frequently. The series may be reiterated faster on warm evenings and slower on cool nights.

The Pine Barrens treefrog requires specialized acidic habitats such as Atlantic white-cedar swamps, and pitch pine lowlands that are carpeted with dense mats of sphagnum moss. Plant species found at breeding sites include highbush blueberry, greenbrier, red maple, swamp azalea, swamp magnolia, viburnum, inkberry, mountain laurel, sheep laurel, black jack oak, scrub oak, sundew, pitcher plant, sweet pepperbush, and various orchids. Structural characteristics of preferred habitats include an open canopy, a dense shrub layer, and heavy ground cover. Typical soil types include sands and mucks.

Temporary woodland ponds, Atlantic white-cedar or cranberry bogs, and seepage areas along tributaries of major rivers and streams serve as breeding ponds for the Pine Barrens treefrog. Occasionally, disturbed areas such as borrow pits, roadside ditches, vehicle ruts, or pools found along power line corridors may be used as breeding sites provided that appropriate shrubby and herbaceous vegetation is present. Treefrogs prefer ponds which support sphagnum moss, sedges, grasses, and/or various aquatic plants and are surrounded by dense woody vegetation. Breeding ponds which may dry up by mid-summer contain shallow water with depths often less than 60 cm (23.6 in.) and in some cases less than 10cm (3.9 in.). The water is clean, yet acidic with pH values ranging from 3.38 to 5.9 (NJ Division of Fish and Wildlife and Conserve Wildlife Foundation of NJ, 2012).

The preference for acidic water serves to reduce competition by other frog species that cannot tolerate the lower pH. In 1979 the Pine Barrens treefrog was listed as an endangered species in New Jersey due to its restricted range and declining population, habitat loss, and pollution of breeding ponds. The New Jersey Natural Heritage Program considers this species to be "apparently secure globally," yet "rare in New Jersey," (NJ Division of Fish and Wildlife and Conserve Wildlife Foundation of NJ, 2012). Although endangered, the Pine Barrens treefrog is currently considered stable in New Jersey. Large expanses of protected habitat within the Pinelands National Reserve of southern New Jersey allows the state to serve as a stronghold for this species throughout its entire range. In areas of suitable habitat particularly on public land, Pine Barrens treefrogs may seem abundant. However, protection of this species is warranted as suitable habitat is limited to specialized Pine Barrens ecosystems that are patchily distributed throughout the southeastern U.S.

> **Management Implications:** No activity should be proposed within 100 feet of any potential breeding pond (or within 100 feet of Bauer Pond). An inner buffer of at least 100-feet surrounding a water body can prevent direct physical disturbance of breeding habitat. Continuity between adjacent forest and breeding habitat should be maintained by leaving portions of outer buffers (100 – 300 feet)

uncut, as treefrogs spend time within the forest during the non-breeding period. No major soil disturbance, such as drumchopping should occur in the outer buffer. Creation of slash piles causes no major concern and may even be beneficial by providing protection against desiccation and predators. Applications of chemicals should be avoided entirely. The impact to treefrogs from harvesting within the outer buffer and beyond is minimal.

Two-spotted skipper: This species prefers herbaceous wetland habitat such as bogs, sedge meadows, marshes, and openings along streams and swamps (NJ Division of Fish and Wildlife and Conserve Wildlife Foundation of NJ, 2012).

Management Implications: None in particular at this time.

Rare, Threatened, and Endangered Plant Species

Knieskern's beaked-rush: Knieskern's beaked-rush was federally listed as a threatened species in 1991. A semi-perennial member of the sedge family, Knieskern's beaked-rush is a grass-like plant that grows 0.6 to 24 inches tall and is distinguished from other species by its fruit (achene) which typically appears from July to September. Knieskern's beaked-rush is found only in (endemic to) New Jersey. An obligate wetland species, Knieskern's beaked-rush occurs in early successional wetland habitats often on bog-iron substrates adjacent to slow-moving streams in the Pinelands region. In the past, fire may have played an important role in creating and maintaining suitable habitat for Knieskern's beaked-rush. This species is also found in human-disturbed wetland areas that exhibit similar early successional stages due to water fluctuation or periodic disturbance from vehicles, mowing, or fire. These human-influenced habitats include abandoned borrow pits, clay pits, ditches, rights-of-way, and unimproved roads. Knieskern's beaked-rush is often associated with other sedge and grass species. However, it is intolerant of shade and competition (especially from woody species) and is sometimes found on relatively bare substrates. Threats to Knieskern's beaked-rush include habitat loss from

development, agriculture, hydrologic modification, and other wetland alterations; excessive disturbance from vehicle-use, trash dumping, and other activities; and natural vegetative succession of the open, sparsely-vegetated substrate preferred by this species. The dense pitch pine lowland stands in the WWMA do not contain suitable habitat for the species at this time.

> **Management Implications:** No management activities will be planned in the open wetlands and buffers (near Bauer Pond where this species is currently found).

Pale Beaked-rush: This species is currently found at a specific pitch pine lowland and roadside habitats.

> **Management Implications:** No management activities are planned in this pitch pine lowland or the roadside habitats located at the upland ecotone where this species is currently is found. The dense pitch pine lowlands which are planned for management at other stands do not contain suitable habitat for this plant species, although management activities may create new habitat.

Pine Barrens gentian: The Pine Barrens gentian is native to the Atlantic coast from New Jersey southward to Georgia. Historically, fires caused by lightning were common in these wet Pine Barrens and coastal bogs where this rare species grows. These fires maintained this unique plant community by preventing succession to hardwood forest, in addition to recycling organic matter to the sandy, acidic, and nutrient-poor soil. Development, fire suppression, invasive weeds, and the alteration of natural water flows all pose threats to remaining Pine Barrens gentian populations. Preferred habitats include moist open sandy areas, roadsides, pitch pine lowlands, and streambanks. The Pine

Barrens gentian may also occur in relatively dry habitats, at the base of slopes, or in the vicinity of clay lenses. Old field locations provide suitable habitat for this species as well. Areas too dense with trees, woody understories, and shading cannot support this species adequately.

Management Implications: None in particular at this time.

Purple bladderwort: This is a submerged or aquatic wildflower species growing in swamps and marshes (found in Bauer Pond). It is found in wet, poorly-drained to permanently inundated calcareous and/or organic soils. The purple bladderwort has high nutritional requirements, requiring rich organic soils for optimal growth. This plant species has a low tolerance to flooding by salt or brackish water and does not tolerate long periods of drought, but requires full sun for best growth.

Management Implications: No management activities will occur at or within 100 feet of a pond site (Bauer Pond).

B. Cultural Resources

No ground penetrating disturbances are planned within 300 feet of any wetland areas. The planned forest management activities will not result in any adverse impact to any potential cultural resources. The NJ Historic Preservation Office will be notified if any artifacts are discovered during the process of conducting any forest management operations.

C. Aesthetics

Although the aesthetic values of a forest can vary from person to person, the uniqueness of the NJ Pinelands draws many to the surrounding area. The WWMA is being managed for its ecological values to protect and improve fish and wildlife habitats. As such,

management will conserve the integrity of native pinelands vegetation types to maintain and develop wildlife-associated recreational activities. All activities being conducted in the WWMA will take aesthetic values into account to the greatest extent practical while managing to meet the goals and objectives set for this planning cycle. Informing the public about activities that are going to occur in the WWMA plays a critical role in how these activities are perceived. The public will be kept informed via NJ DEP public information policies. These polices provide outlets for information and processes for public comment.

D. Recreation

As a Wildlife Management Area (WMA), the primary focus for this property is on wildlife habitat management to provide the public opportunities to enjoy wildlife. The management recommendations detailed in this document are the product of a collaborative effort to improve habitat for valuable wildlife species. Hunting, fishing and trapping are the most common activities that occur on New Jersey's WMAs, but recreational pursuits such as birding, wildlife viewing, photography, cross country skiing, and hiking also occur at WWMA. Several open canopy fields are maintained in the WMA to attract game species and song birds, and similar early-successional areas will be established by this plan to benefit those same species. The habitat diversity created by the medley of activities in this plan is expected to benefit game species and the recreational activities that they support. Further, throughout the planning cycle, common recreational routes should be monitored for hazard trees.

E. Carbon

Collectively, forest ecosystems represent the largest terrestrial carbon sink on earth. The accumulation of carbon in forests through sequestration helps to mitigate emissions of carbon dioxide to the atmosphere from sources such as forest fires and the burning of

fossil fuels. Early in stand development most forest ecosystem carbon is in the soil organic matter and belowground tree components. Statewide analysis in 2011 of data collected by the US Forest Service Forest Inventory and Analysis program in 2008 shows that as forest stands mature, the ratio of above-to-belowground carbon shifts and by age 61 to 80 years the aboveground components represent the bulk of ecosystem carbon. This trend continues well into stand development as carbon accumulates in live and dead aboveground components (Crocker, et. al. 2011).

Part of the strategy of this plan is to mitigate wildfire by creating conditions less favorable to producing crown fires. With carbon shifting from belowground to aboveground components in NJ, it is assumed that these activities could be of benefit by preventing the rapid release of aboveground carbon associated with crown fires. Retention policies associated with the activities proposed for this planning cycle also encourage maintenance of forested cover, albeit at lower densities, to protect the integrity of native pinelands vegetation types which sequesters carbon.

F. Economics

Although the production of wood products is ancillary to wildfire mitigation and the ecological objectives for WWMA, the value of these products cannot be ignored. The economics of land management decisions must be considered as a part of the practicality of implementing the activities proposed in the plan. The wood produced from activities during this planning cycle is largely considered a "byproduct" of management for other amenities and may not readily fit into traditional timber markets. It is our hope to provide support for the development of niche markets that can make use of this material. By providing a plan with measurable objectives, it is possible to provide a rough outline of the amount and type of wood that would be available for use as a result of management activities during the planning cycle.

G. Invasive Species

Present observations indicate that invasive species are not a major concern on the WWMA. Due to the overall droughty, sandy, low fertile characteristics of the property's soils and unique fire ecology, invasive species are generally unable to get a strong foothold. However, weeping lovegrass (*Eragrostis curvula*), now considered invasive, was planted in the fields under earlier management regimes. Similarly, 'Blackwell' switchgrass, a genotype of *Panicum virgatum* non-native to New Jersey, was also planted in the fields and requires management. There has been no indication of spread of weeping lovegrass or other invasive species within the forested areas. With the proper implementation of responsible forest resource management practices and an active monitoring program that utilizes adaptive management strategies it is not anticipated that invasive species will be an ongoing or future concern. However, special measures will be practiced in order to prevent the potential spread of invasive species during harvesting and management operations, including the implementation of appropriate best management practices (BMPs). Invasive species found in the future within the WMA will be eliminated using appropriate techniques (targeted herbicide applications), if necessary.

H. Fire

Historically, fire has shaped much of the landscape within the pinelands region and the WWMA. Fires occurred primarily through natural disturbances such as lightning strikes, and by Native American land management practices. Prior to development of the area, fire was able to spread at various intensities and frequencies across the forest creating a very complex structure as well as distinct fire regime. During more recent times the WWMA has experienced little influence from fire, although a 49,000 acre wildfire burned much of the upland areas in WWMA on May 4-5, 1930. With the exception of smaller wildfires in 1952 and 1971, fire has largely been excluded from the ecology of the forest, with the exception of the Wildland-Urban Interface zone managed by the NJ Forest Fire Service. With the suppression of fire, fuel conditions become increasingly

dangerous, escalating the likelihood of a major wildfire. The WUI has been intensely managed with prescribed fire in an effort to reduce hazard fuel loads, increase public safety, and reduce the risk of harm or damage due to wildfire. Through the active fire management strategies outlined in this plan such efforts will be accomplished and persist long through the extent of the planning cycle.

Wildfire

The WWMA is critically at risk to wildfire conditions, and as such poses an even greater threat to the ecological integrity as well as human life and infrastructure of the surrounding locations. In addition to smaller developments, Holiday City to the East of WWMA remains severely threatened if wildfire were to occur. This is especially evident if forestland to the northwest of the WWMA were ignited since winds predominate from the northwest. Due to fire suppression on private lands as well as state-owned lands (Berkeley Triangle) fuel loads have increased. These conditions can lead to rapid fire spread, making control and containment of wildfire difficult and treacherous.

Prescribed Fire

Prescribed burning is a complex tool utilized in forest and natural resources management. The process involves the deliberate use of fire in a controlled manner to reduce fuel loads and mitigate wildfire hazards, ensure public health and safety, control understory conditions and structure, manipulate wildlife habitat, reduce insect and disease issues, and encourage fire-adapted species composition within the forest. The techniques used by the NJ Forest Fire Service can perpetuate many of the native Pinelands forest types and the unique forest structure reminiscent of historical fire conditions. The implementation of prescribed fire however, depends on numerous conditions including weather, proximity to infrastructure, forest fuels, and most importantly safety. The primary goal of prescribed fire utilization in the WWMA is hazard fuel reduction which ensures public health and safety through reduction of surface and ladder fuels in the Wildland Urban Interface (WUI). Refer to the management recommendations section for details on the planned use of prescribed fire.

I. Forest Health

A forest in good health exhibits an overwhelming capacity for resilience, resistance, and recovery from an array of disturbances. Major threats to forest health in the WWMA include southern pine beetle, sirex woodwasp, gypsy moth, pine looper, bacterial leaf scorch, sudden oak death, extreme weather conditions, and wildfire. Efforts to improve forest health within the WWMA (aside from the outlined management recommendations) include surveying and monitoring of forest conditions throughout the planning period. An adaptive management approach will also serve to establish prevention mechanisms should disturbances become adverse to overall forest health conditions during the planning cycle.

J. Wetlands

Within the WWMA unique freshwater wetland sites exist in which special precautions must be taken in order to maintain and protect their function and integrity including water quality. During treatment implementation the guidelines and recommendations according to the New Jersey Forestry and Wetlands Best Management Practices (BMP) Manual, and the FSC US Forest Management Standards will be adhered to. This includes careful placement of harvest landings in and around locations defined as wetlands (refer to Appendix F), protection of streamside management zones (SMZ's) through proper buffer size and placement, adapting harvest schedules for poor weather conditions, as well as logging debris management. Streamside management zones were determined using the 0 – 10% slope category in the NJ BMP manual and the 1 – 10% slope category in the FSC US Forest Management Standards requirements for the Appalachia region, since the terrain across the WMA is fairly flat. For perennial streams the stricter SMZ requirements defined in the FSC guidelines were adhered to, consisting of a 25' inner zone and a 55' outer zone, for an 80' total SMZ width around perennial streams at a minimum. Any treatment activities proposed through the WWMA plan should not adversely impact threatened or endangered species, modify the flow or hydrology of wetland sites, or manipulate the extent of freshwater wetland habitat. Management

treatments on the WWMA as outlined in this document should also be in compliance with the Freshwater Wetlands Protection Act (FWPA).

V. FOREST TYPE DESCRIPTIONS

The 1,154 acres of woodland in the WWMA was divided into 11 forest types according to overstory and midstory composition, density, and major recent disturbance history during the inventory in 2009 by Land Dimensions Engineering. The overstory consists of the tree component that grows 20+ feet and forms the canopy. The midstory is the tree and shrub component that grows from 5 - 20 feet tall and forms a sub-canopy level. The understory is composed of all ground cover less than 5 feet. The woodland forest types developed are Pitch Pine-Shrub Tree Oak (PPSTO), Pitch Pine-Shrub Tree Oak prescribed burned (PPSTOb), Pitch Pine open (PPop), Pitch Pine lowland (PPlo), Pitch Pine lowland burned (PPlob), Pitch Pine-Red Maple-Atlantic White-Cedar (PMC), Atlantic White-Cedar (CED), fields (FIELD), Disturbed/Regeneration (DIS), Pitch Pine-Tree Oak (PPO), and Disturbed pitch pine lowland (DISlo).

LDE Forest Type One - PPSTO

(Pitch Pine/Shrub-Tree Oak) 652.90 Acres

This is an upland forest type where pitch pine dominates the overstory and shrub tree oaks such as blackjack oak and post oak dominate the midstory. Sassafras and tree oaks like scarlet oak, white oak or chestnut oak are occasionally found in the overstory. The shrub tree oaks periodically grow taller than 20 feet and enter the overstory. This type exhibits characteristics typical of the upland pine-shrub oak native Pinelands forest type. PPSTO is the most common forest type in the WWMA occurring on 652.90 acres in 8 stands (referred to as PPSTO – 1 through 8, see stand map).

The canopy consists of 95 - 100 percent pitch pine, with white oak, scarlet oak, chestnut oak, sassafras, blackjack oak, and post oak comprising the other 0 - 5 percent. The canopy is mostly open with closure being between 50 - 70 percent. Some thicker and thinner patches are also scattered throughout the type. The pines are mostly 6 - 12 inches in diameter at breast height (DBH) with heights mainly ranging between 20 and 40 feet tall. Some larger pines are scattered throughout the type, the largest measured being 16 inches in diameter and 50 feet tall. The tree oaks range from 4 - 6 inches in DBH and 20 - 30 feet in height. The shrub tree oaks are 2 - 4 inches in DBH and 10 - 20 feet tall. Most trees are in the 60 - 70 year old range, with some older stands and specimens scattered throughout the forest type.

The midstory or shrub layer contains 50 - 60 percent shrub tree oaks, 20 - 30 percent scrub oak, 10 - 20 percent advanced pitch pine regeneration, and the remaining midstory consists of inkberry and mountain laurel. The midstory is 30 - 50 percent closed. The understory is comprised of 60 - 70 percent lowbush blueberry/huckleberry and 10 - 30 percent bare ground, with inkberry, fern, sheep laurel, partridgeberry, heather, and greenbrier making up the remainder. There is little new regeneration currently occurring within stands found in this type located in Whiting.

This forest type is found in eight (8) separate stands distributed across the Whiting forest. Stands comprising this type exhibit high forest fuels at this time. Fire exclusion and lack of disturbance has allowed for overstocking of overstory and understory plant communities.

Volume Estimation and Stock Table (LDE)

Forest Type: PPSTO – 652.9 Acres

Pitch Pine

	Per Acre			*Total Across Forest Type*	
DBH	**Trees**	**Basal Area (ft^2)**	**Cords**	**Trees**	**Cords**
4	126	11	0.82	82,301	533.01
6	1523	30	4.41	99,759	2,881.74
8	66	23	3.67	43,021	2,397.55
10	31	17	2.81	20,351	1,831.60
12	12	9	1.56	7,482	1,021.48
14	2	2	0.29	1,222	187.36
Total	**389**	**92**	**13.56**	**254,136**	**8,852.74**

LDE Forest Type Two - PPSTOb

(Pitch Pine-Scrub Oak Prescribed Burned) 93.40 Acres

This forest type is the same as PPSTO, but was burned with prescribed fire within the last ten years for fire safety. It is basically a 450 foot buffer along the southeastern and western management area boundaries that borders residential development. The burning removed most of the midstory which, in the event of a wildfire, would have provided ladder fuels to the canopy. The midstory is now 20 percent or less closed due to the effects of prescribed burning. Stands in this type have received more recent prescribed burn treatments over the last five years. Overstory canopy cover ranges from 50-70% with an average of approximately 56% cover. PPSTOb is also characterized as the Pinelands upland native forest type of pine-dominated forest.

Volume Estimation and Stock Table (LDE)

Forest Type: PPSTOb – 93.4 Acres

Pitch Pine

	Per Acre			*Total Across Forest Type*	
DBH	**Trees**	**Basal Area (ft^2)**	**Cords**	**Trees**	**Cords**
4	57	5	0.30	5,352	28.31
6	76	15	2.22	7,135	207.39
8	57	20	3.12	5,352	291.43
10	46	25	4.12	4,281	384.54
12	26	20	3.25	2,378	304.01
14	19	20	3.16	1,747	294.78
Total	**281**	**105**	**16.17**	**26,245**	**1,510.46**

LDE Forest Type Three - PPop

(Pitch Pine Open) 95.70 Acres

This is also an upland forest type located on the Whiting property. Pitch pine dominates the overstory but both the canopy and midstory are more open with less shrubs and barer ground occurring. PPop occurs on 95.70 acres in five stands (referred to as PPop – 1 through 5, see stand map). This type is categorized as a pine-shrub oak native Pinelands forest type.

The canopy consists of 100 percent pitch pine. Rarely do the blackjack oak and post oak attain 20 feet in height. The canopy is very open with closure being between 20 - 30 percent. Thicker patches are scattered throughout the forest type as well, reaching 40 percent canopy closure. The pines are more variable in size within this forest type, they are mostly 6 - 10 inches in DBH with heights between 20 and 40 feet tall. In some areas pines 4 - 8 inches in diameter are typical, while in other areas pines 8 - 12 inches in diameter and 40 feet in height are the norm. The largest tree measured in this forest type was 12 inches in diameter and 30 feet tall. The shrub tree oaks are 2 - 4 inches in DBH

and mostly attain 10 feet or less in height. Most of the trees in this forest type are 50 - 60 years old, and a few scattered older specimens are in the 80 - 100 year old range.

The midstory or shrub layer is mostly comprised of 70 - 80 percent shrub tree oaks, 0 - 10 percent scrub oaks, and the remaining midstory consists of pitch pine regeneration and inkberry. The midstory is 30 - 40 percent closed. The understory is composed of 30 - 50 percent bare ground and 30 percent lowbush blueberry/huckleberry with grass. Fern, sheep laurel, heather, and greenbrier make up the remainder of the understory. There is little regeneration currently occurring in this forest type.

Volume Estimation and Stock Table (LDE)

Forest Type: PPop – 95.7 Acres

Pitch Pine

	Per Acre			*Total Across Forest Type*	
DBH	**Trees**	**Basal Area (ft^2)**	**Cords**	**Trees**	**Cords**
4	229	20	1.21	21,933	116.03
6	204	40	4.83	19,496	462.65
8	29	10	1.56	2,742	149.30
12	13	10	1.48	1,219	142.10
Total	**474**	**80**	**9.08**	**45,390**	**870.08**

LDE Forest Type Four - PPlo

(Pitch Pine Lowland) 131.60 Acres

This forest type is located in poorly drained sites adjacent to red maple and Atlantic white-cedar types. Pitch pine dominates the overstory, but both the canopy and midstory are thicker than those of other forest types. Red maple and blackgum also occur in this type but are very minor components. The overstory is relatively short, rarely over 30 feet tall. The trees are also significantly smaller in this forest type with 12 inches in DBH being the largest. PPlo occurs on 131.60 acres, is comprised of ten stands in the WWMA (referred to as PPlo – 1 through 10, see stand map), and corresponds with the Pinelands CMP classification of Pitch Pine lowland.

The canopy consists of 90 - 100 percent pitch pine. Occasionally, red maple and blackgum will be present in the overstory. The canopy is very closed, with closure being between 70 - 90 percent. Some more open patches are scattered throughout the forest type reaching 60 percent canopy closure. The pines are only 4 - 8 inches in DBH with

heights mainly between 20 and 40 feet tall. The largest tree measured in this type was 12 inches in diameter and 40 feet tall. Most of the trees in this forest type are between 50 - 60 years of age and a few scattered older pockets are in the 70 - 80 year old range.

The midstory or shrub layer consists of 40 - 50 percent highbush blueberry and 25 percent greenbrier, while the remainder of the midstory consists of pitch pine regeneration, red maple regeneration, sweet pepperbush, dangleberry, blackjack oak, and inkberry. The midstory is 50 - 60 percent closed. The understory is composed of 50 - 60 percent lowbush blueberry/huckleberry, and 20 percent greenbrier and grass, while Fern and sheep laurel make up the remainder. There is little regeneration currently occurring in this forest type. In some areas the greenbrier is draped over the shrub layer, forming an almost impassable wall.

Volume Estimation and Stock Table (LDE)

Forest Type: PPlo – 131.6 Acres

Pitch Pine

	Per Acre			*Total Across Forest Type*	
DBH	**Trees**	**Basal Area (ft^2)**	**Cords**	**Trees**	**Cords**
4	229	20	1.46	30,161	192.35
6	115	23	3.19	15,081	420.44
8	57	20	3.12	7,540	410.62
10	23	13	1.99	3,016	261.59
12	16	13	2.21	2,095	291.17
16	2	3	0.42	236	55.15
Total	**442**	**90**	**12.39**	**58,129**	**1,631.32**

Hardwoods (Red maple, Blackgum, Sassafras)

	Per Acre			*Total Across Forest Type*	
DBH	**Trees**	**Basal Area (ft^2)**	**Cords**	**Trees**	**Cords**
4	115	10	0.67	15,081	87.98
6	38	8	1.11	5,027	146.11
8	7	3	0.46	943	60.53
10	5	3	0.38	603	50.45
12	3	3	0.44	419	58.23
Total	**168**	**25**	**3.06**	**22,073**	**403.30**

Summary

	Per Acre			*Total Across Forest Type*	
Species	**Trees**	**Basal Area (ft^2)**	**Cords**	**Trees**	**Cords**
Pitch Pine	442	90	12.39	58,128	1,631
Hardwood	168	25	3.06	22,082	403
Total	**610**	**115**	**15.45**	**80,210**	**2,033**

LDE Forest Type Four "A" – PPlob

(Pitch Pine Lowland Burned) 2.40 Acres

Within this Forest type there was one stand of pitch pine lowland consisting only of two acres (referred to as PPlob, see stand map), and located within the 450 foot burning buffer strip. This forest type is the same as PPlo, only the midstory is more open due to fire induced mortality of the shrubs and other vegetation in the midstory and understory.

LDE Forest Type Five - PMC

(Pitch Pine-Maple-Cedar) 81.20 Acres

This forest type is located along streams, drainages, and some isolated poorly drained depressions. This type is mostly a result of red maple and pitch pine reclamation of open patches located within Atlantic white-cedar stands. These openings are created from cedar mortality due to causes such as fire, water salinity, poor forest management practices, or changes in hydrology due to beaver and/or residential development. Pitch pine and red maple dominate the overstory but some white-cedar persists. Blackgum also dominates in some areas. The midstory of this forest type is denser than in pitch pine lowlands or pure cedar stands. PMC occurs on 81.20 acres of the WWMA and is comprised of three stands (referred to as PMC- 1 through 3, see stand map).

The proportion of the canopy components is highly variable throughout this forest type with areas of pitch pine being more prevalent than hardwoods and vice versa. One constant is that cedar is consistently the lesser component. The canopy is significantly

closed—with closure being between 70 - 90 percent. Some more open patches are scattered throughout the type reaching 60 percent canopy closure. The pines and cedars are 6 - 10 inches in DBH with heights mainly between 30 and 50 feet. The maples and gums are 2 - 8 inches in DBH with heights mainly between 20 and 30 feet, with a few reaching 40 feet tall. The largest tree measured in this forest type was a pitch pine 14 inches in diameter and 40 feet tall. Most of the trees in this forest type are in the 80 - 100 year old range with the youngest trees occurring around stand fringes. The age of the trees in the stand fringe corresponds with time since the intense wildfire of 1930; that fire burned much of the property's upland areas, but was either stopped by or reduced in intensity at the drainages, re-starting the establishment of cedar on the edges of the stand.

The midstory or shrub layer is dominated by highbush blueberry, sweet pepperbush, inkberry, and in some areas, mountain laurel. The remaining midstory consists of pitch pine regeneration, red maple regeneration, swamp azalea, dangleberry, and inkberry. The midstory is 80 - 90 percent closed. The understory is patchy in most places due to flowing and standing water. Slight hummocks are present in some areas, while in other areas there is 30 percent bare soil. The remainder of the ground cover is composed of moss, greenbrier, grass, fern, and sheep laurel. There is little regeneration currently occurring in this forest type.

Volume Estimation and Stock Table (LDE)

Forest Type (PMC) – 81.2 Acres

Pitch Pine

	Per Acre			*Total Across Forest Type*	
DBH	**Trees**	**Basal Area (ft^2)**	**Cords**	**Trees**	**Cords**
6	102	20	2.96	8,271	540.40
8	57	20	3.68	4,653	298.77
10	73	40	7.27	5,955	590.09
12	51	40	7.08	4,136	574.91
14	9	10	1.72	760	139.77
Total	**293**	**130**	**22.71**	**23,775**	**1,843.94**

Hardwood

	Per Acre			*Total Across Forest Type*	
DBH	**Trees**	**Basal Area (ft^2)**	**Cords**	**Trees**	**Cords**
4	344	30	2.57	27,915	208.39
Total	**344**	**30**	**2.57**	**27,915**	**208.39**

Summary

	Per Acre			*Total Across Forest Type*	
Species	**Trees**	**Basal Area (ft^2)**	**Cords**	**Trees**	**Cords**
Pitch Pine	293	130	22.71	23,775	1,844
Hardwood	344	30	2.57	27,915	208
Total	**637**	**160**	**25.28**	**51,692**	**2,053**

LDE Forest Type Six - CED

(Atlantic White-Cedar) 16.60 Acres

This forest type is located along the major streams and drainages throughout the WWMA. There are two stands in this forest type referred to as CED- 1 and CED- 2, see stand map. Atlantic white-cedar dominates the overstory, and the canopy is almost 100 percent closed. Red maple, blackgum, and pitch pine occur but are a very minor component. The overstory is taller compared to other forest types, sometimes reaching 60 feet in height. Cedar stands are very dense; densities typically range from between 1,000 and 3,000 stems per acre. CED occurs on 16.60 acres of the WWMA.

The canopy consists of 90 - 100 percent Atlantic white-cedar. Occasionally pitch pine will be present in the overstory, while red maple and blackgum form a sub-canopy rarely reaching 40 feet tall. The canopy is very closed, with closure being between 80 - 100 percent. Some more open patches are scattered throughout the forest type reaching 70 percent canopy closure. The cedars are 6 - 10 inches in DBH with heights mainly

between 50 and 60 feet tall. The largest tree measured in this forest type was 10 inches in diameter and 50 feet tall. The edges of the stands appear to have been harvested about 50 - 60 years ago, but the trees toward the center of the stands are in the 80 - 100 year old range.

The midstory or shrub layer consists of highbush blueberry, sweet pepperbush, and in some areas, mountain laurel. The remaining midstory is comprised of red maple, blackgum, sweetbay magnolia, swamp azalea, dangleberry, and inkberry. Due to the closed nature of the canopy, the midstory tends to be rather sparse, in contrast to the edges where the midstory is 50 - 60 percent closed. The understory is also sparse, not only because of the closed canopy, but because of stream-flow. Where there is ground to grow, the understory is mostly composed of sphagnum moss, pitcherplants, and skunk cabbage. There is little regeneration currently occurring in this forest type.

LDE Forest Type Seven – PPO

(Pitch Pine-Tree Oak) 24.70 Acres

This is another upland forest type located on the WWMA, characterized as the Pinelands pine-dominated native forest type. Just like PPop, pitch pine dominates the overstory in this type, but the canopy also contains tree oaks such as white oak, scarlet oak, and chestnut oak. This type occurs in one small stand (referred to as PPO, see stand map) on 24.70 acres north of the lake, along the east boundary of WWMA. The trees in this forest type are in the 70 - 80 year old age class.

The canopy consists of 80 - 90 percent pitch pine, with the remainder being large post oaks. The canopy is about 70 - 80 percent closed. The pines are mostly 8 - 12 inches in DBH, with tree heights mainly between 30 and 40 feet tall, and some larger specimens scattered throughout. The post oaks range from 4 - 8 inches in diameter and 20 - 30 feet in height. There are shrub tree oaks scattered throughout the forest type, but they only range between 2 - 4 inches in DBH and 10 feet or less in height.

The midstory or shrub layer consists mostly of shrub tree oaks, scrub oak, pitch pine regeneration, and some sassafras. The midstory is 20 - 30 percent closed. The understory is composed of 10 - 20 percent bare ground and 90 percent lowbush blueberry/huckleberry. There is little regeneration currently occurring in this forest type.

Volume Estimation and Stock Table (LDE)

Forest Type: PPO – 24.7 Acres

Pitch Pine

	Per Acre			*Total Across Forest Type*	
DBH	**Trees**	**Basal Area (ft^2)**	**Cords**	**Trees**	**Cords**
6	102	20	2.96	2,516	73.13
8	57	20	3.12	1,415	77.07
10	73	40	7.27	1,812	179.50
12	26	20	3.54	629	87.44
14	19	20	3.44	462	85.03
16	7	10	1.68	177	41.40
Total	**284**	**130**	**22.01**	**7,011**	**543.57**

White Oak

	Per Acre			*Total Across Forest Type*	
DBH	**Trees**	**Basal Area (ft^2)**	**Cords**	**Trees**	**Cords**
6	51	10	1.48	1,258	36.56
Total	**51**	**10**	**1.48**	**1,258**	**36.56**

Summary

	Per Acre			*Total Across Forest Type*	
Species	**Trees**	**Basal Area (ft^2)**	**Cords**	**Trees**	**Cords**
Pitch Pine	284	130	22.01	7,011	544
Tree Oak	51	10	1.48	1,258	37
Total	**335**	**140**	**23.49**	**8,269**	**580**

LDE Forest Type Eight - FIELD, DIS, DISlo

(Fields 32.00 Acres, Disturbed/Regeneration 19.00 Acres, Disturbed lowland 4.50 Acres)

The fields are 4 - 5 acre square patches that were cleared of trees and planted with warm and cold season grasses for wildlife foraging. There are seven fields scattered throughout the WWMA. The Disturbed/Regeneration areas are basically failed or abandoned fields. For whatever reason, the grasses did not establish well and are now being replaced by pitch pine regeneration, bearberry patches, scrub oak, bare soil, and prickly pear cacti. There are four of these plots scattered throughout the WWMA. There is no overstory in both the fields and Disturbed/Regeneration areas. They were separated into two groups depending on the condition of the grasses growing in them, which may also dictate how these plots will be managed in the future. One of these failed fields is mostly located in a lowland area and was designated as Disturbed lowland (DISlo).

VI. HIGH CONSERVATION VALUE FORESTS (HCVF)

High Conservation Value Forests (HCVF) are managed to protect and maintain their identified high conservation value attributes. HCVF are defined in the Forest Stewardship Council (FSC), US Forest Management Standards as those that possess one or more of the following high conservation values (HCV) (Forest Stewardship Council 2010):

1. HCV forest areas containing globally, regionally, or nationally significant concentrations of biodiversity values (e.g., endemism, endangered species refugia), including rare, threatened and endangered species and their habitats;
2. HCV forest areas containing globally, regionally, or nationally significant large landscape level forests, contained within, or containing the management unit, where viable populations of most if not all naturally occurring species exist in natural patterns of distribution and abundance;
3. HCV forest areas that are in or contain rare, threatened, or endangered ecosystems;
4. HCV forest areas that provide basic services of nature in critical situations (e.g. watershed protection, erosion control);
5. HCV forest areas fundamental to meeting basic needs of local communities (e.g. subsistence, health); or,
6. HCV forest areas critical to local communities' traditional cultural identity (areas of cultural, ecological, economic or religious significance identified in cooperation with such local communities).

Specific HCVF in WWMA

Atlantic White-cedar

Atlantic white-cedar (*Chamaecyparis thyoides*) ranges along the Atlantic and Gulf coasts in the US from southern Maine to central Florida and as far west as Mississippi, generally

within a narrow coastal belt 50 to 100 miles wide (Harlow and Harrar 1937). It is found in swampy areas with acidic soils consisting of organic peat overlaying sandy subsoil (Little 1950). In New Jersey cedar forms dense stands of trees. The trees in these stands are dense enough to suppress movement of air and modify the climate in which they grow. Cedar swamps are cooler than the surrounding forest in the spring and summer and warmer in the winter (Harshberger 1916). Atlantic white-cedar (AWC) forest acreage has declined from an estimated 500,000 acres throughout its range at the time of European settlement to approximately 115,000 acres range wide (Kuser and Zimmerman 1995). It has been in decline in New Jersey since European settlement for a variety of reasons including pressure from white-tailed deer (*Odocoileus virginianus*), wildfire, improper logging, development (including building of roads and man-made lakes), hydrologic change, excessive flooding from beaver (*Castor canadensis*) dams, theft, salt water intrusion, and succession (Mylecraine and Zimmermann 2000).

Atlantic white-cedar decline merits special concern from the New Jersey State Forestry Services, environmental groups, and landowners interested in forest stewardship not only because of the species' social and historic economic value, but also because of the important ecological value of cedar swamps in New Jersey. Cedar swamps serve to filter and purify water by absorbing and filtering pollutants and sediment, stabilize stream flows by storing floodwaters and mitigating the effects of drought, benefit a wide variety of plant and animal species including several threatened and endangered species (Mylecraine and Zimmermann 2000) and may act as natural firebreaks (Little 1964). Throughout the past several decades the New Jersey State Forestry Services have experimented with a variety of methods for restoring Atlantic white-cedar in the New Jersey Pinelands and assisted in the development of *Atlantic white-cedar: Ecology and Best Management Practices Manual* (BMP's).

Stands CED-1 (10.1 acres) and CED-2 (6.5 acres) are the only pure AWC stands occurring in the WWMA. Since AWC is such a small component of the WWMA, all stands in this forest type will be retained during this planning period barring unforeseen circumstances such as insect outbreaks, fire damage, disease, etc. In the case of such

events, restoration techniques would be applied according to the Atlantic white-cedar BMP manual by Zimmerman and Mylecraine (2000). Although no activity is scheduled to occur in these stands during this planning cycle, the surrounding uplands will be managed in order to mitigate the risk of wildfire entering the stands, killing standing cedar, and possibly "turfing" and killing off the established seed bank. Stand CED-1 is particularly susceptible to wildfire, being nearly surrounded by highly flammable upland pitch pine forest types on almost all sides.

Fire Dependant Pitch Pine-shrub oak habitats for rare species such as Pine Snakes

The vegetation found within the WWMA is dominated by several globally rare ecological communities including pitch pine-shrub oak barrens and pine-oak-shrub oak woodlands in uplands; pitch pine lowlands in marginal wetlands; with smaller amounts of other wetland types in swampy stream corridors that contain a mixture of pitch pine, swamp hardwoods, and/or Atlantic white-cedar. The pitch pine-dominated, fire-dependent forest types of the WWMA are typical of the most fire-prone firesheds in the "plains-barrens subregion" located in the core of the Pinelands, which historically had an open-canopy structure in most areas due to frequent fires (Windisch 1999).

The predominant features of the existing forests at this time are the result of long-term exclusion of both fire and disturbance including high canopy cover and excessive fuel load build up. These features are having a profound impact on habitats present and thus the diversity of plant and animal species. Stands PPSTO-4a through PPSTO-4g (roughly 406 acres broken into seven stands) represent some of these upland types and could provide valuable habitat for northern pine snakes. Two portions of stand PPSTO-4 will be managed for reduced density and the reintroduction of fire: PPSTO-4b (roughly 153 acres) and PPSTO-4e (roughly 93 acres) (see Management Recommendations). Stands PPlo-3 (roughly 13 acres), PPlo-4 (roughly 7 acres), and PPlo-7 (roughly 14 acres) are pitch pine lowlands directly adjacent to stands PPSTO-4b and PPSTO-4e that could have fire re-introduced during the planning cycle and as such will also be considered as part of the WWMA HCVF.

VII. REPRESENTATIVE SAMPLE AREAS

Representative Sample Areas (RSA) are ecologically viable representatives designated to serve one or more of three purposes:

1. To establish and/or maintain an ecological reference condition; or
2. To create or maintain an under-represented ecological condition (i.e. includes samples of successional phases, forest types, ecosystems, and/or ecological communities); or
3. To serve as a set of protected areas or refugia for species, communities and community types not captured in other areas of the Forest Stewardship Council Standards (e.g. to prevent common ecosystems or components from becoming rare).

The purpose of having RSA under the FSC standards is to provide a mechanism for protecting ecosystems in their natural state that might not qualify for other protections under the standards such as HCVF (Forest Stewardship Council 2010).

Specific RSA in WWMA

Forested types needing protection in WWMA are covered as HCVF; however the RSA category can serve a valuable purpose by establishing reference areas for evaluating treatments used to enhance fire dependant pitch pine-shrub oak communities. Stand PPSTO-4 has been divided into seven sub-stands for the practicality of re-introducing fire into two of the sub-stands (PPSTO-4b and PPSTO-4e) that are a part of the WWMA HCVF. Sub-stand PPSTO-4g comprises the southeastern portion of stand PPSTO-4. Conditions of this sub-stand are comparable to portions of PPSTO-4 located in the HCVF. PPSTO-4g shares a common boundary with Crossley Preserve, complicating the re-introduction of fire and consequently no activity will take place in this sub-stand during this planning cycle. This sub-stand can serve as a reference for comparison to the portions of PPSTO-4 that will be managed as part of the HCVF.

VIII. MANAGEMENT RECOMMENDATIONS

The intent of the overall habitat management plan for WWMA is to enhance wildlife habitat, particularly for endangered and threatened species, decrease the incidence of interactions between humans and rare wildlife species, reduce wildfire risk, and improve forest resiliency.

The current forest structure along the edge of WWMA encourages the emigration of corn and pine snakes from the WMA into the adjacent housing development. This not only reduces the value of otherwise safe habitat to endangered and threatened species, but it increases the likelihood of negative interactions with humans. Stand structure changes are needed in this boundary strip to reduce the appeal of the wildland-urban interface for these rare reptiles and facilitate their movement towards the safer interior forest.

Additionally, to improve the desirability of the property's interior to snakes, as well as to encourage rare ecological communities, management is needed. Treatments for the interior forest that incorporate variable density thinning coupled with prescribed burning will create the habitat structure needed to achieve both of these goals. However, the application of intense fire in the interior forest requires considerations for public safety to mitigate risk to the development adjacent to WWMA. Through multi-disciplinary discussions, a two-pronged approach at landscape-scale management was developed.

Treatments along the western and southern boundaries of the property will reduce the risk of wildfire impacts to the neighboring community, allowing the use of variable burning in the forest interior, and simultaneously discouraging rare reptiles from utilizing the habitat along the property's edge. In conjunction with the treatments on the interior of the forest, a safer, more beneficial outcome will result for both targeted wildlife species as well as for the local residential community.

Wildfire Mitigation

Wildland-Urban Interface

These treatments were developed in close conjunction with fire wardens in the NJ Forest

Fire Service specifically for providing low maintenance fuel breaks near wildland-urban interfaces (WUI) located in the western end of WWMA. Treatment of these stands involves disrupting the fuel ladder from the ground to the forest canopy while maintaining enough canopy cover to prevent the germination of tree seedlings followed up with prescribed burning. Maintenance will be lessened by limiting tree regeneration in this fashion.

The fuel ladder can be broken while retaining substantial forest canopy cover by thinning "low and from below" (removing the shortest and smallest trees as a priority) to an average density of roughly 80 square feet per acre and 45 % canopy cover. Retention will primarily consist of the largest and tallest trees in the stand which will create a distinct gap between the understory and the overstory, disrupting the ladder fuels while maintaining some canopy cover. Thinning can then be followed up with periodic (5 – 7 year intervals) prescribed burning. An average density of 60 square feet per acre and 34% canopy cover is ultimately desired. However, thinning to a target basal area level above that desired, and then using repeated prescribed fire to further reduce the density over time for a "soft landing" at the desired basal area target had greater long lasting effects in simulation. Stands targeted for this treatment are located mostly in the western end of the WWMA near residential development and the WMA's border. This will facilitate containment of prescribed fire in the more variable burning conditions that will be promoted in Whiting's interior where most of the area's fire-adapted high conservation value forests are located in order to meet biodiversity objectives for the overall management unit. These treatments should be completed early in the planning period.

Stands to receive the above treatments include a safety strip that is currently regularly burned in order to protect a WUI (stands PPSTOb-1, PPSTOb-2, and PPlob-1), in addition to stands PPSTO-2, PPSTO-3, PPop-1, and PPlo-1. The total area to receive treatment is 240 acres (approximately 21 % of the total WMA) with 95 acres in the PPSTOb forest type, 96 acres in the PPSTO type, 34 acres in the PPop type, 14 acres in the PPlo type, and 1.6 acres in the PPlob type. Removal estimates are highly variable but average about 5 cords per acre throughout the planning cycle (1,379 cords total). Much

of this material is unlikely to be commercially salable and therefore may be slashed and left on site, or mowed using a forestry mower. Thinning activities will not take place from April 15 – July 31 (inclusive) out of consideration for nesting birds. The NJ Division of Fish and Wildlife may adjust this timing restriction based upon which birds are actually found to be present on a stand by stand basis.

An approximately 35 acre subset of the stands receiving this treatment will undergo a transitioned thinning to create a more variable edge, creating a wider transition area between forest types. Just inside the interior of the WUI treatment area in stands PPop-1, PPSTO-2, PPSTO-3, and PPlo-1, an arbitrary line will be used to transition from low-and-from-below thinning to variable density thinning towards the untreated lowland areas to the east. The line will tie-in to the northernmost corner of stand FIELD-1, head northeast and run parallel to the property boundary until the line reaches stand PMC-1. From the starting corner at the northern end of stand FIELD-1, the line will run along the stand's northeastern boundary, and then proceed from the easternmost corner of stand FIELD-1 directly to the northernmost corner of stand FIELD-2, and along the eastern edge of this stand to its southeastern corner. From this line, the WUI treatment of thinning low and from below will be feathered in so that as distance from the line increases, the remaining trees will be dispersed less evenly. Put another way, the trees cut will be more clustered. The treatment will extend from the abovementioned line to the nearest stand boundary opposite the full WUI treatment. Access would be provided to these treatment areas through existing roads which will be maintained in order to provide access for forest fire staff. Maintenance activities will likely include practices such as brushing back road edges using a side-arm mower or forestry mower, grading, and crowning. A new plowline will be installed along the southern edge of stand PPSTO-2 in order to facilitate prescribed burning in this stand.

Over the next ten to forty years stands PPSTOb – 1, PPlob – 1, and PPSTOb - 2 will continue to exhibit an even-aged structure dominated by pitch pine with relatively low canopy cover. As growth continues, basal area, diameter, and subsequently volume will gradually increase across all stands. Stand health will also increase, as the largest and

most vigorous trees are retained. A distinct gap between the overstory and understory will be more evident due to continuous prescribed burning treatments and removal of the midstory fuel ladder. The midstory will remain quite open due to fire-induced tree mortality as well, from the periodic prescribed fire regime for maintenance of the WUI. The understory density of greenbrier, huckleberry, and sheep laurel, etc. will perpetuate depending on the frequency of prescribed burning regimes. The stands will appear open aesthetically, possibly increasing the opportunities for recreation and wildlife viewing. The canopy will begin to gradually fill, eventually increasing the amount of canopy cover in each stand overall. Regeneration will remain very low, yet understory species adapted to frequent fire conditions will persist vigorously. These stands will demonstrate the effectiveness of fire and forest management as a wildfire prevention mechanism through adaptive management as well as continued monitoring of the stands during that time. PPop - 1 will have a reduced midstory pine-shrub oak layer over the next ten to forty years from the recommended management scheme which also seeks to reduce the fuel ladder. Thinning operations will increase the overall health of the stand by removing the weaker, lower quality trees, while at the same time reducing density and competition for limited site resources. The overstory will remain open with possible patches of advanced pine regeneration reaching the upper canopy. Depending on the frequency of prescribed fire an increase of exposed ground surface could create possible snake habitat over time. Stands PPSTO – 2, PPSTO – 3, PPop – 1, and PPlo – 1 will also exhibit future conditions similar to that of the previously stated stands, however the midstory may remain slightly higher in density even after the thinning and prescribed burning treatments due to current structural differences in comparison to the previously fire managed stands.

The portions of stands PPop-1, PPSTO-2, PPSTO-3, and PPlo-1 where the low-and-from-below thinning will transition to more variable density thinning will allow for patchy regeneration in an uneven-aged fashion. Not only will this improve the light environment for future canopy regeneration, but it will create growing space for understory shrub species that are important for rare *Lepidoptera* species, and create small patchy openings (≤ 0.25 acres) favorable for reptile basking (particularly Northern pine snakes). Ultimately, an average density of 60 square feet per acre and variable canopy cover

between 25-70% across the treated area is desired, down from 50-70% canopy cover for the PPSTO portions, with lower canopy cover already present in some of the stands. Retained trees will span across all diameter classes and height ranges. Overstory tree species composition will not vary significantly from what is currently present in the stand to what is ultimately retained.

Fire-Dependent Pitch Pine-Shrub Oak

In order to restore and maintain globally rare pitch pine-shrub oak habitats a roughly 246-acre portion of the 406-acre stand PPSTO-4 (which is a part of WWMA's High Conservation Value Forest) and stand PPlo-2 will receive treatments to reduce forest density and return fire to this ecosystem. This stand will be managed as seven separate sub-stands (PPSTO-4a, PPSTO-4b, PPSTO-4c, PPSTO-4d, PPSTO-4e, PPSTO-4f, PPSTO-4g) mainly due to road and drainage transects which will be utilized for containing prescribed fire. After the completion of the wildfire mitigation treatments in the WUI treatment areas of WWMA, three portions of PPSTO-4 (PPSTO-4a, PPSTO-4b, PPSTO-4e) will be thinned using separate variable density thinning treatments similar to the Stoddard-Neel approach (McIntyre et al. 2008). The purpose of these treatments is to open the canopy further, allowing the safe reintroduction of fire into open canopy fire adapted pitch pine communities. Not only are these plant communities important to several rare, threatened, and endangered species, but these treatments will encourage particular species of interest, such as Northern pine snakes, into the interior for better habitat and more attractive basking conditions. The staggered implementation of the variable-density treatments will further aid in the migration of species of interest. Actions along the boundaries of the property in conjunction with these activities in the interior are needed to improve the wildlife habitat value of the entire WMA.

Thinning activities will not take place from April 15 – July 31 (inclusive) out of consideration for nesting birds. The NJ Division Fish and Wildlife may adjust this timing restriction based upon which birds are actually found to be present on a stand by stand basis. Furthermore, the sites will be evaluated by the NJ Division of Fish and Wildlife

Endangered and Nongame Species Program (ENSP) for the possibility of the presence of pine snake hibernacula. Although these activities will most likely be of benefit to overall populations of pine snakes, hibernacula will be identified and avoided if heavy equipment is to be used during thinning operations. If the location of the hibernacula is unclear, thinning activities involving heavy equipment may be further restricted from November 1 to April 1 at ENSP's discretion. If thinning is deemed necessary by ENSP within the immediate vicinity of a hibernacula to improve habitat for pine snakes, this activity will be conducted by hand.

Prior to beginning the larger habitat improvement activities in stands PPSTO4-b and PPSTO4-g; PPlo-3, PPlo-4, and PPlo-7 will not be thinned, only burned using aerial ignition. A less extensive but similar prescription will be done in stands PPlo-2 (23.6 acres) and PPSTO4-a (21.6 acres). This area will be thinned across age classes until an average of 30% of canopy cover remains. The open canopy cover will be demonstrated here using variable density thinning similar to the Stoddard-Neel approach, meaning residual trees and trees removed will vary in diameter, age, and height. No aerial ignition fires will be applied to these areas, but their thinning will create habitat connectivity between the WUI area, the feathered transition portion of the WUI, and the more intensely disturbed interior of the forest, providing a valuable corridor for mobile species seeking improved habitat.

The increased light environment will also encourage the ingrowth of broadleaf deciduous shrub species and their associated ecological community. Timing restrictions (April 15-July 31) for nesting birds will be followed when thinning these stands also.

Subsequent to the mechanical treatment in stands PPSTO – 4a and PPlo-2, prescribed burning will take place. Applied prescribed burning is ideally beneficial to the globally rare plant communities found within the WWMA. However, stands PPSTO-4a and PPlo-2 will not be included in the aerial ignition burn planned as part of the management of the stands to the east Instead, PPSTO-4a and PPlo-2 will be burned in once within the ten year plan (roughly 5-7 year intervals).

PPSTO-4e is a 93-acre portion of stand PPSTO-4 located south of Schoolhouse Road and North of Michaels Branch. A combination of variable density thinning, single tree selection, and group selection harvesting will be used to allow for patchy regeneration in an uneven-aged fashion. The purpose of this treatment is to enhance vertical structure of the canopy, create growing space for understory shrub species that are important for rare *Lepidoptera* species, and create small patchy openings (≤ 0.25 acres) favorable for reptile basking (particularly northern pine snakes). Canopy cover of retained trees will range from 25 – 40% on average, down from the 50 – 70% cover currently present in the stand. The variable density harvest would take place after completion of the WUI fuel hazard mitigation treatments. Residual basal area would average approximately 45 square feet per acre after initial treatment, but vary greatly throughout the stand. Approximately 11 cords per acre would be removed during the ten year planning cycle (1,023 cords total). Retained trees will span across all diameter classes and height ranges. Overstory tree species composition will not vary significantly from what is currently present in the stand to what is ultimately retained.

After variable density cutting treatments are completed, stand PPSTO-4e (93 acres) and stand PPlo-7 (14 acres) will be treated with prescribed fire. In order to limit the use of plowlines that could create problems with unauthorized access into sensitive habitats, Schoolhouse road and the woods road to FIELD-6 that form the boundaries of stand PPSTO-4e would be lit from the ground and allowed to burn into the stand. Once a buffer has "burned in" from the roads, the north side of Michaels Branch would be lit using aerial ignition. This would "meet up" with the prescribed fire started from the roads and would also burn into stand PPlo-7. The exact conditions of the prescribed burning regimen will be determined by the NJ Forest Fire Service. Evaluation of the effects of fire frequency and ecosystem response will be accomplished by the NJ Office of Natural Lands Management and the NJ Division of Fish and Wildlife.

PPSTO-4b is a 153-acre portion of PPSTO-4 located north of Schoolhouse Road and east of portions of Wrangle Brook. The management prescription for this stand is very similar to that of PPSTO-4e with the exception that a slightly higher average density will

be retained with a greater degree of variability. This will create conditions particularly favorable for globally rare pitch pine-shrub oak communities and several rare *Lepidoptera* species. A combination of variable density thinning, single tree selection, and group selection harvesting will be used to allow for patchy regeneration in an uneven-aged fashion following treatment of PPSTO-4e. Residual canopy cover would be more variable than that left in PPSTO-4e ranging from 25% - 70% cover retained after treatment from the current 50% - 70% cover. Residual basal area would average approximately 60 square feet per acre after initial treatment, but would vary greatly throughout the stand. An estimated 8.5 cords per acre (1300.5 cords total) would be removed during the ten year planning cycle of a total 19 cords per acre estimated standing after 5 years into the planning cycle. Species composition of overstory retention will not vary significantly from what is currently present in the stand. Trees across varied diameter classes will be retained much like the distribution of those retained in the prescription for PPSTO-4e.

After variable density cutting treatments are completed, stand PPSTO-4b (153 acres) along with stands PPlo-3 (13.4 acres) and PPlo-4 (7.3 acres) will be treated with prescribed fire. In order to limit the use of plowlines that could create problems with unauthorized access into sensitive habitats, Schoolhouse road and the woods road running north from PPop-2 to field 3 and eventually along the WMA's northern boundary (skirting the south side of PPlo-5) forming the southern (Schoolhouse road) and western (woods road) boundaries of stand PPSTO-4b would be lit from the ground and allowed to burn into the stand. Once a buffer has "burned in" from the roads, the east side of Wrangle Brook which forms the western boundary of the stand would be lit using aerial ignition. This would be allowed to "meet up" with the prescribed fire ignited from the roads and would also burn into stands PPlo-3 and PPlo-4 along the Wrangle Brook. The exact conditions of the prescribed burning regimen will again be determined by the NJ Forest Fire Service. Evaluation of the effects of fire frequency and ecosystem response will be accomplished by the NJ Office of Natural Lands Management and the NJ Division of Fish and Wildlife.

Over the next ten to forty years stands PPlo – 3, PPlo – 4, and PPlo – 7 will continue to exhibit even-aged overstory's dominated by pitch pine. The midstory and understory will be highly variable in density, species composition, and forest structure, due to unique prescribe burning regimes instituting aerial ignition treatments. Stands PPSTO – 4a, PPSTO – 4b, PPSTO – 4e, and PPlo-2 will appear uneven-aged in structure over the next ten to forty years as a result of the variable density and selection thinning treatments. This will create a forest with unique horizontal and vertical structural components, increase health and vigor through residual tree selection, and provide differential habitats for numerous plant and wildlife species.

Fields/Disturbed Management

Fields

In an effort to maintain the already established fields existing in the WWMA for wildlife forage in addition to Lepidoptera and snake habitat during the ten year planning cycle, a combination of prescribed burning and mowing will be implemented. The prescribed burning treatment activity will occur throughout the planning cycle in conjunction with the NJ Forest Fire Service, of which the exact conditions and regimen will be determined. Mowing and other implementation activities other than prescribed burning will be performed at the discretion of the NJ Division of Fish and Wildlife. This activity will occur on approximately 32 acres of the FIELD type (1-7). Management of the fields will retain both native warm and cool season grasses which numerous wildlife species are dependent upon, and will also remove any non-native invasive species and varieties such as love grass (*Eragrostis curvula*) and 'Blackwell' switchgrass.

Disturbed/Regeneration

In order to support structural as well as biological diversity in the WWMA the disturbed/regeneration types DIS-1 and DIS-2 will be maintained as early successional habitat; disturbed/regeneration types 3 and 4 will be left to grow naturally within this planning cycle. When the next planning cycle convenes, DIS 3 and 4 will be considered for the same thin from below treatment currently prescribed for PPSTOb stands.

Treatment activities for DIS 1 and 2 will consist primarily of periodic prescribed burning and/or mowing to control non-native plant species (such as love grass) and to promote natural fire-adapted and early successional plant communities. The exact conditions and scheduling of prescribed burning activities will be determined by the NJ Forest Fire Service. Mowing and other implementation activities other than prescribed burning will be performed at the discretion of the NJ Division of Fish and Wildlife.

Field Strip

For the purpose of providing habitat connectivity between the fields on the property, a narrow corridor of early-successional habitat will be established. This will take the form of a 100 foot wide strip to the east of stands PPop-1, PPSTOb-1, and PPSTOb-2, and will facilitate the movement of and habitat utilization by wildlife throughout the fields.

IX. ACTIVITY SCHEDULE (10-YEAR)

STAND ID	ACRES	TREATMENT	TIMING (Planning Year)	GOAL AND OBJECTIVE ASSOCIATIONS
PPSTOb-1	17.2	• Thin low and from below • Prescribe burn (normal)	• 1-7 • 1-10 (5 to 7 year intervals), after thin	**G3**, *O3.1, O3.2*; **G4**, *O4.1*; **G6**, *O6.1*; **G7**, *O7.1, O7.2*
PPSTOb-2	78.0	• Thin low and from below • Prescribe burn (normal)	• 1-7 1-10 (5 to 7 year intervals), after thin	**G3**, *O3.1, O3.2*; **G4**, *O4.1*; **G6**, *O6.1*; **G7**, *O7.1, O7.2*
PPlob-1	1.6	• Thin low and from below • Prescribe burn (normal)	• 1-7 • 1-10 (5 to 7 year intervals), after thin	**G3**, *O3.1, O3.2*; **G4**, *O4.1*; **G6**, *O6.1*; **G7**, *O7.1, O7.2*
PPSTO-2	106.0	• Thin low and from below • Prescribe burn (normal) • Variable density thin (portions)	• 1-7 • 1-10 (5 to 7 year intervals), after thin	**G1**, *O1.1; O1.3;* **G3**, *O3.1, O3.2*; **G4**, *O4.1*; **G6**, *O6.1*; **G7**, *O7.1, O7.2*
PPSTO-3	8.7	• Thin low and from below • Prescribe burn (normal) • Variable density thin (portions)	• 1-7 • 1-10 (5 to 7 year intervals), after thin	**G1**, *O1.1; O1.3;* **G3**, *O3.1, O3.2*; **G4**, *O4.1*; **G6**, *O6.1*; **G7**, *O7.1, O7.2*
PPop-1	42.8	• Thin low and from below • Prescribe burn (normal) • Variable density thin (portions)	• 1-7 • 1-10 (5 to 7 year intervals), after thin	**G1**, *O1.1; O1.3;* **G3**, *O3.1, O3.2*; **G4**, *O4.1*; **G6**, *O6.1*; **G7**, *O7.1, O7.2*
PPlo-1	21.8	• Thin low and from below • Prescribe burn (normal) • Variable density thin (portions)	• 1-7 • 1-10 (5 to 7 year intervals), after thin	**G1**, *O1.1; O1.3;* **G3**, *O3.1, O3.2*; **G4**, *O4.1*; **G6**, *O6.1*; **G7**, *O7.1, O7.2*
PPSTO-4e	92.7	• Variable thinning • Prescribe burn (normal) • Aerial ignition burn	• 5-10 • 5-10 (single treatment), after thin • 5-10 (single treatment), after thin	**G1**, *O1.1, O1.2*; **G2**, *O2.1*; **G4**, *O4.1*; **G5**, *O5.2*; **G6**, *O6.1*; **G7**, *O7.1, O7.2*

STAND ID	ACRES	TREATMENT	TIMING (Planning Year)	GOAL AND OBJECTIVE ASSOCIATIONS
PPlo-2	23.6	• Variable thinning • Prescribe burn (normal)	• 5-10 • 1-10 (5 to 7 year intervals), after thin	**G1,** *O1.1***;** *O1.3;* **G7,** *O7.1*
PPlo-3	13.4	• Prescribe burn (normal) • Aerial ignition burn	• 5-10 (single treatment), after thin • 5-10 (single treatment), after thin	**G1**, *O1.1*; **G2**, *O2.1*; **G6**, *O6.1*
PPlo-4	7.3	• Prescribe burn (normal) • Aerial ignition burn	• 5-10 (single treatment), after thin • 5-10 (single treatment), after thin	**G1**, *O1.1*; *O1.3;* **G2**, *O2.1*; **G6**, *O6.1*
PPlo-7	14.0	• Prescribe burn (normal) • Aerial ignition burn	• 5-10 (single treatment), after thin • 5-10 (single treatment), after thin	**G1**, *O1.1*; **G2**, *O2.1*; **G6**, *O6.1*
PPSTO-4a	21.6	• Variable thinning • Prescribe burn (normal)	• 5-10 • 1-10 (5 to 7 year intervals), after thin	**G1,** *O1.1***;** *O1.3;***; G7,** *O7.1*
PPSTO-4b	152.6	• Variable thinning • Prescribe burn (normal) • Aerial ignition burn	• 5-10 (after PPSTO-4e thin) • 5-10 (single treatment), after thin • 5-10 (single treatment), after thin	**G1**, *O1.1, O1.2*; **G2**, *O3.1*; **G5**, *O5.2*; **G6**, *O6.1*; **G7**, *O7.1, O7.2*
FIELD (1-7)	31.3	• Prescribe burn (normal) • Mowing • Invasive Control	• 1-10 • 1-10 • 1-10	**G5**, *O5.3*; **G5,** *O5.4;* **G6**, *O6.1*
DIS (1&2)	8.9	• Prescribe burn (normal) • Invasive Control	• 1-10 • 1-10	**G5**, *O5.3*; **G5,** *O5.4;* **G6**, *O6.1*
DIS (3&4)	9.3	• Natural Regeneration	• 1-10	**G5**, *O5.3*; **G6**, *O6.1*
FIELD STRIP	13.3	• Clearing • Mowing for wooded grassland	• 1-20	**G5**, *O5.3*; **G6**, *O6.1*; **G7**, *O7.1, O7.2*

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XI. APPENDIX

A. Location Map
B. USGS Quadrangle Map
C. Soil Survey Map
D. Forest Type Map
E. Forest Stand Map
F. Freshwater Wetlands Map
G. Whiting WMA Streams Requiring Streamside Management Zones
H. High Conservation Value Forests Map
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M. Classification Crosswalk of Berkeley Triangle Vegetation Types,
N. ONLM Vegetation Map
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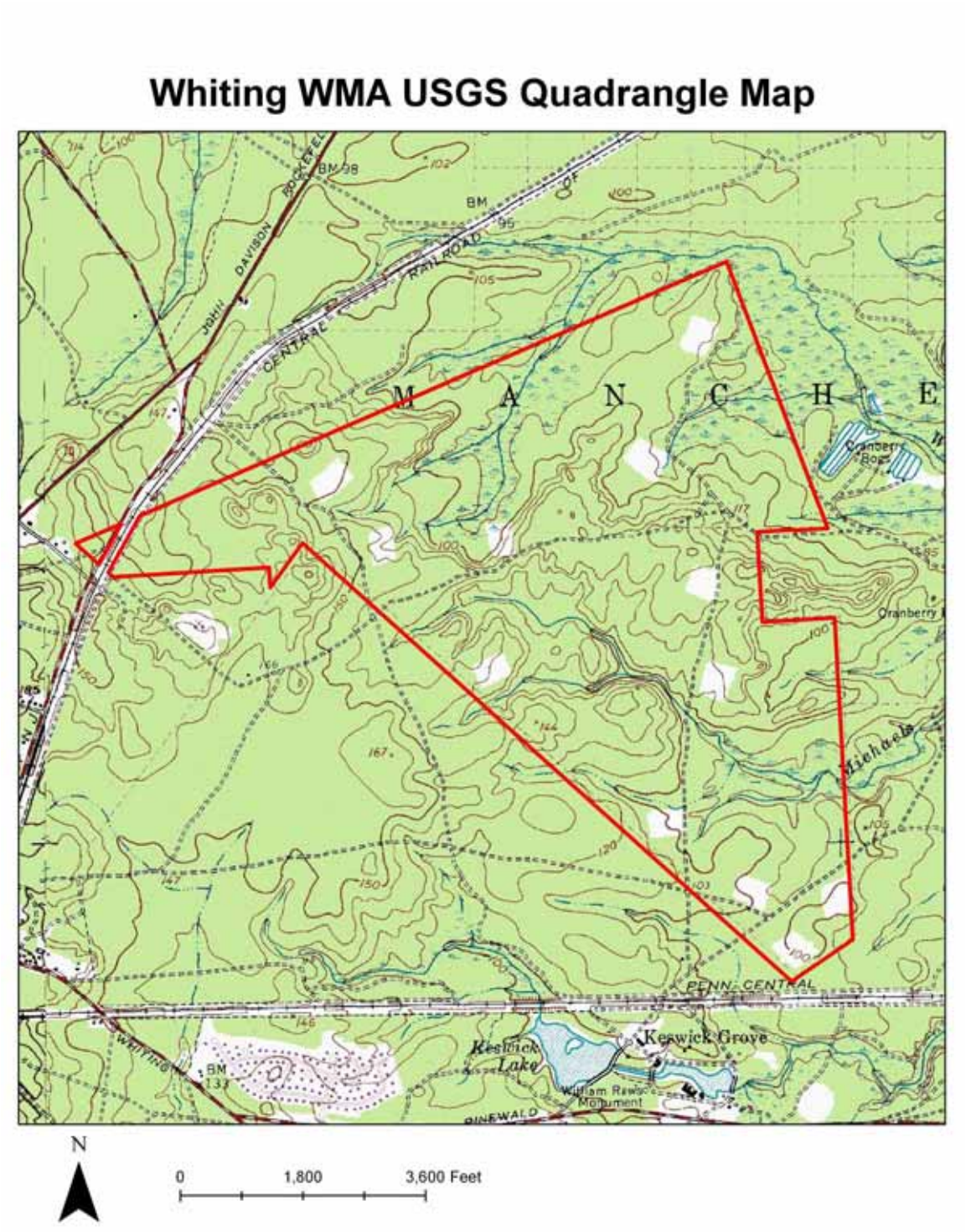
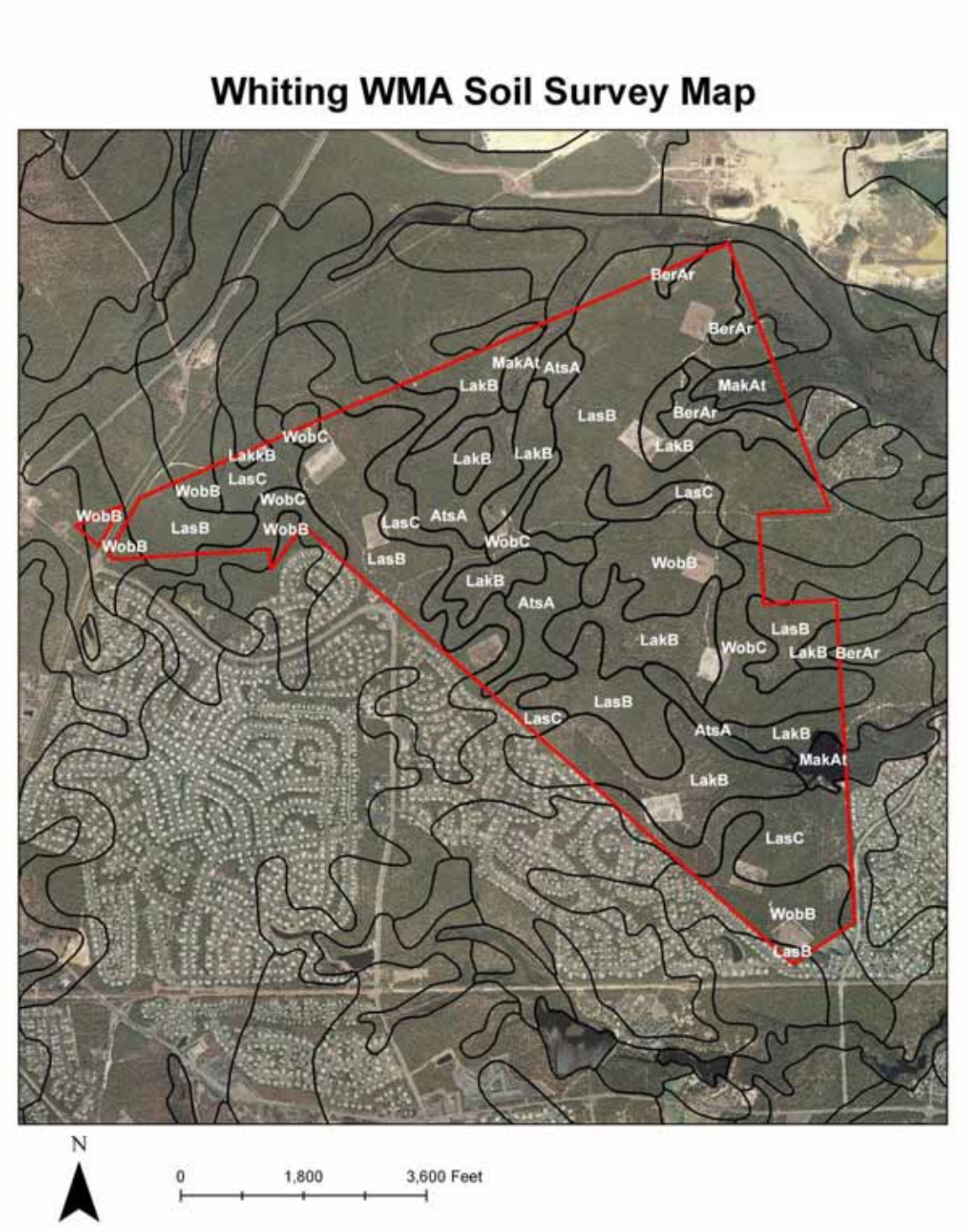
A. Location Map

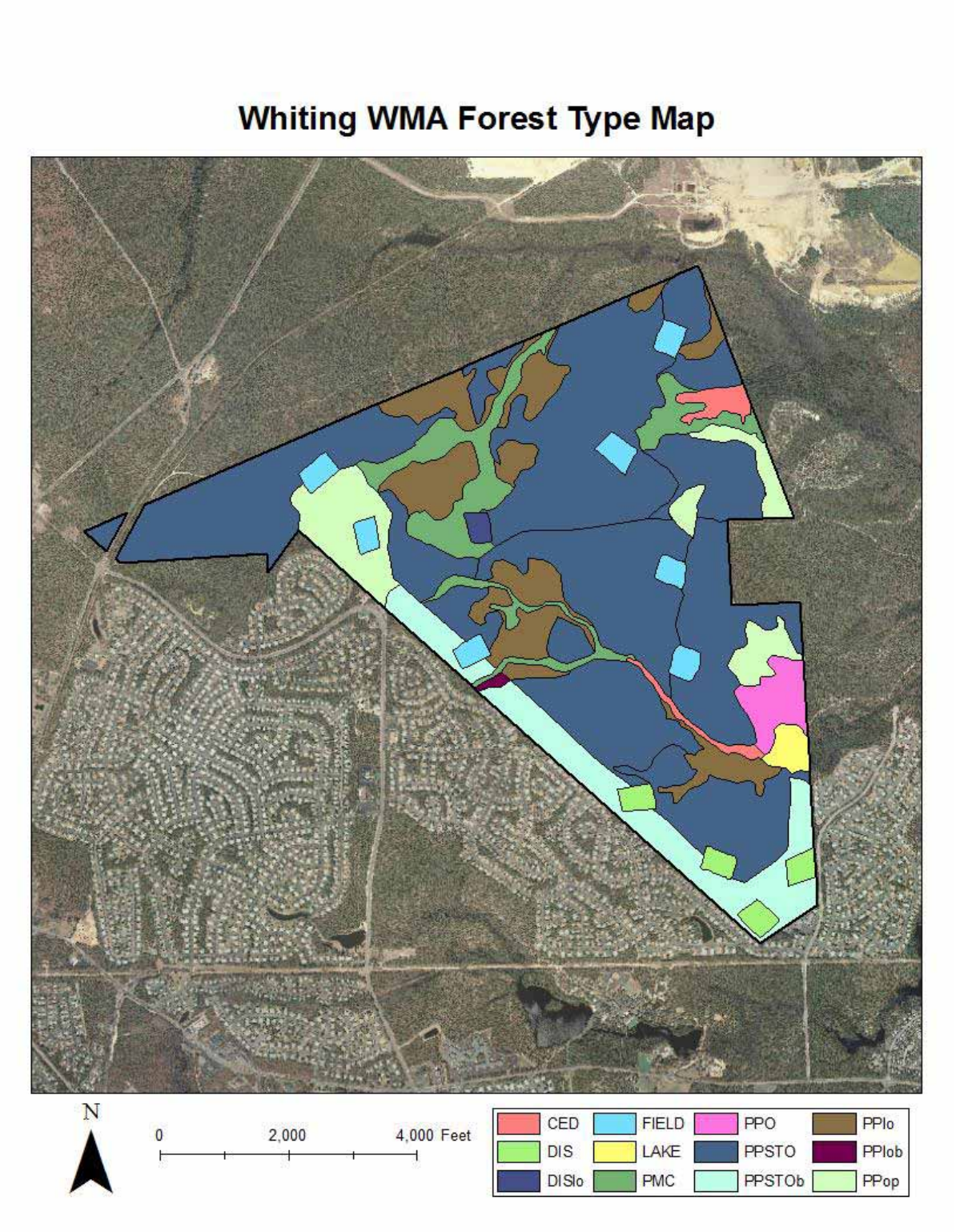
B. USGS Quadrangle Map



C. Soil Survey Map

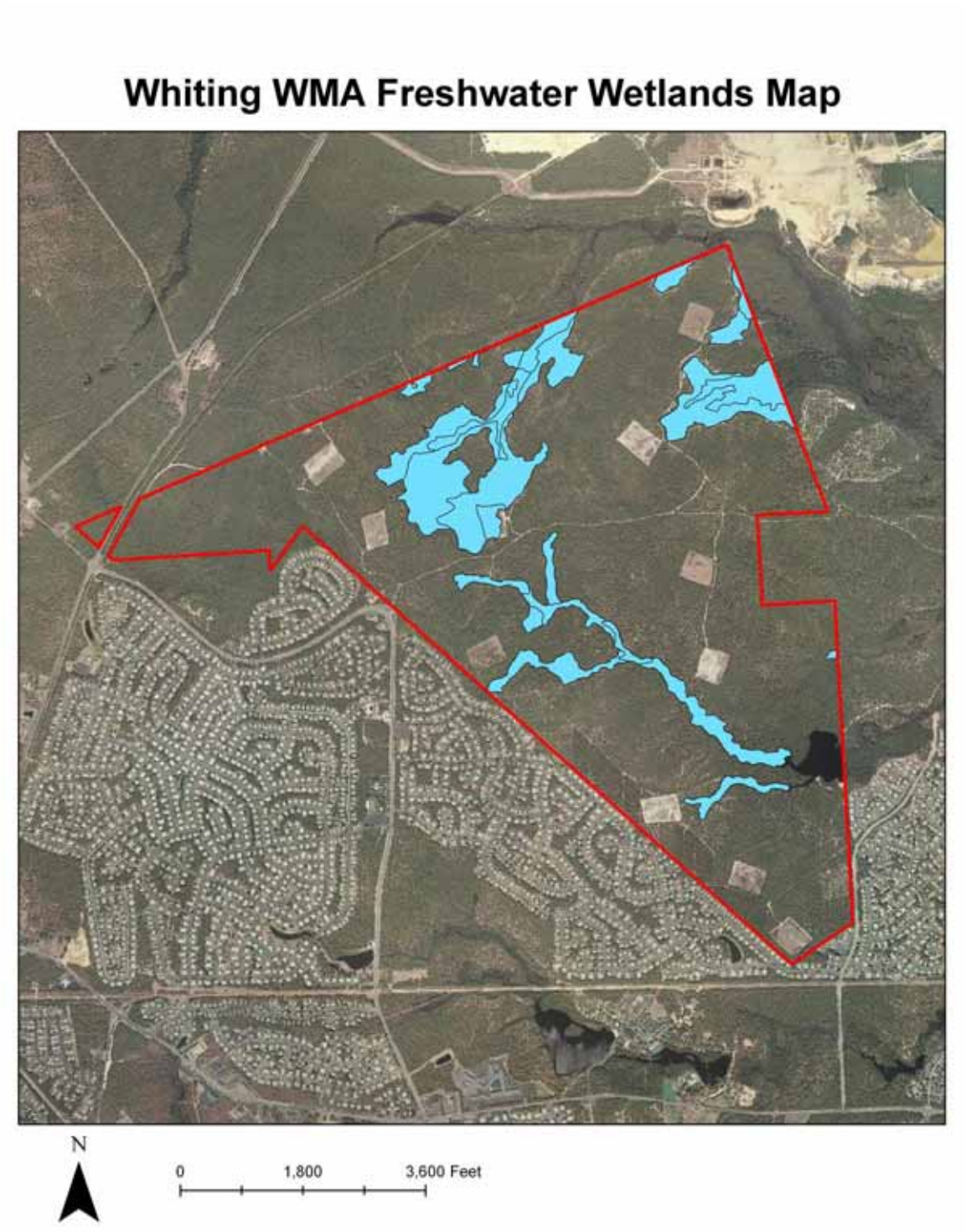


D. Forest Type Map



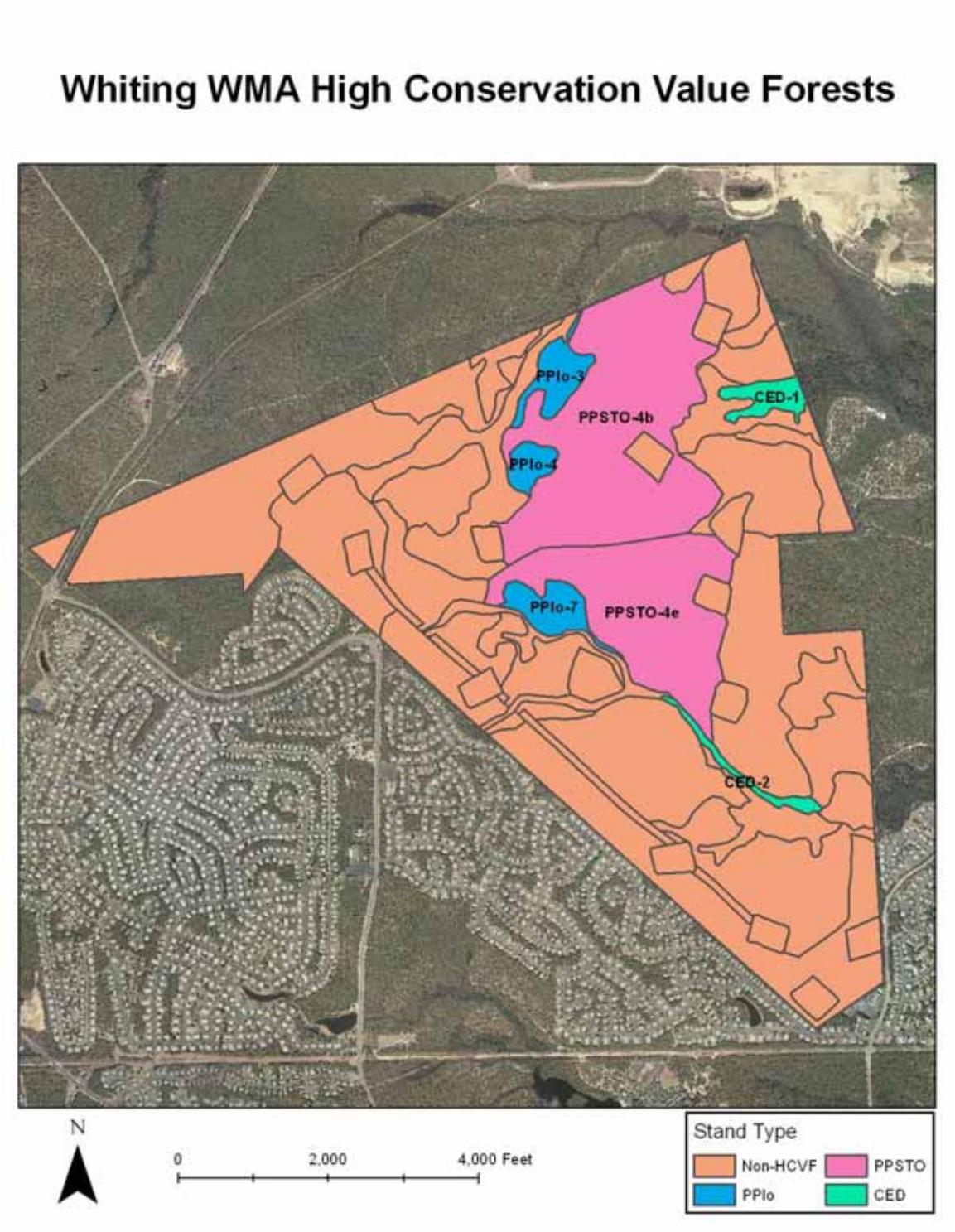
E. Forest Stand Map

F. Freshwater Wetlands Map

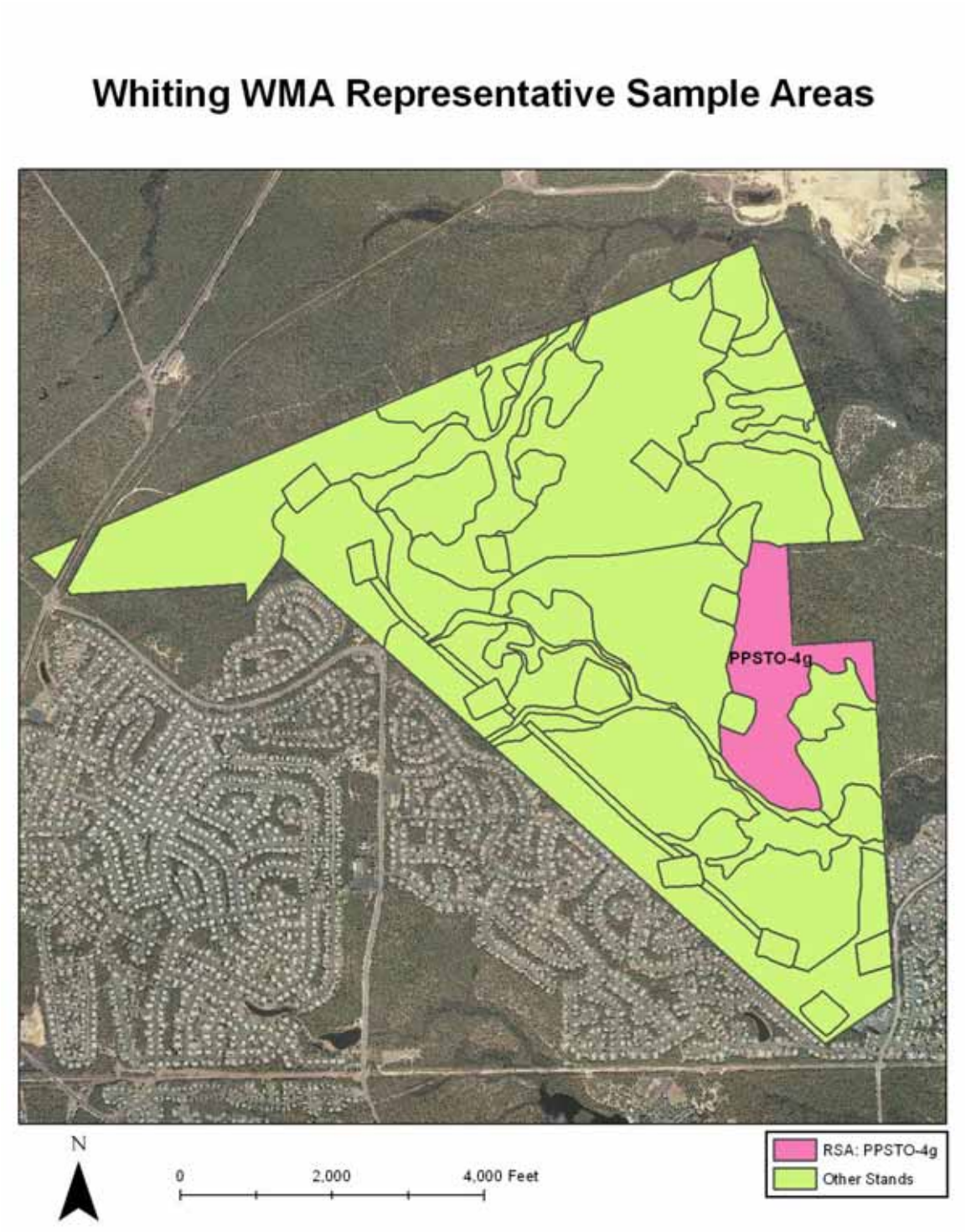


G. Whiting WMA Streams Requiring Streamside Management Zones

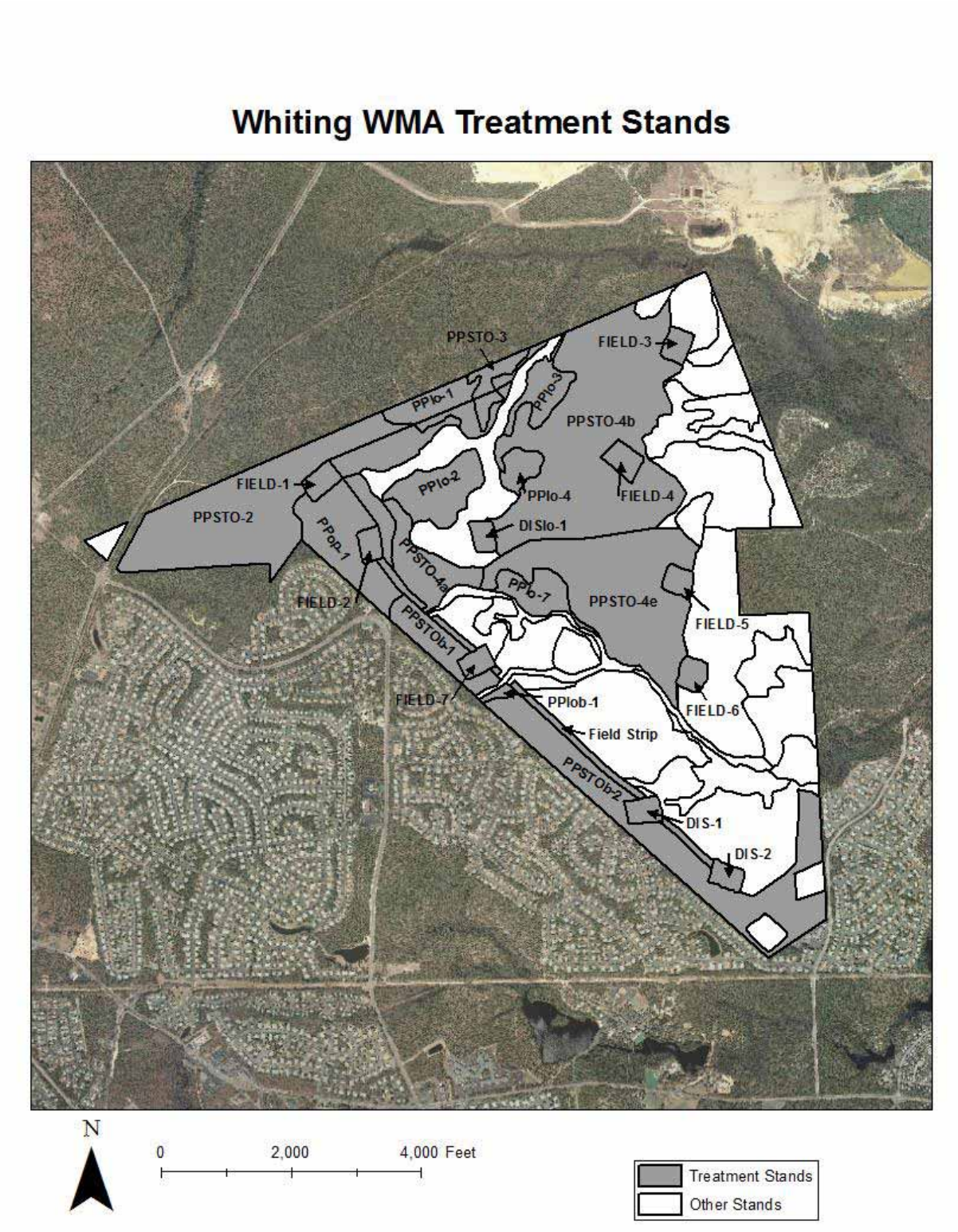
H. High Conservation Value Forests Map



I. Representative Sample Area Map



J. Treatment Map



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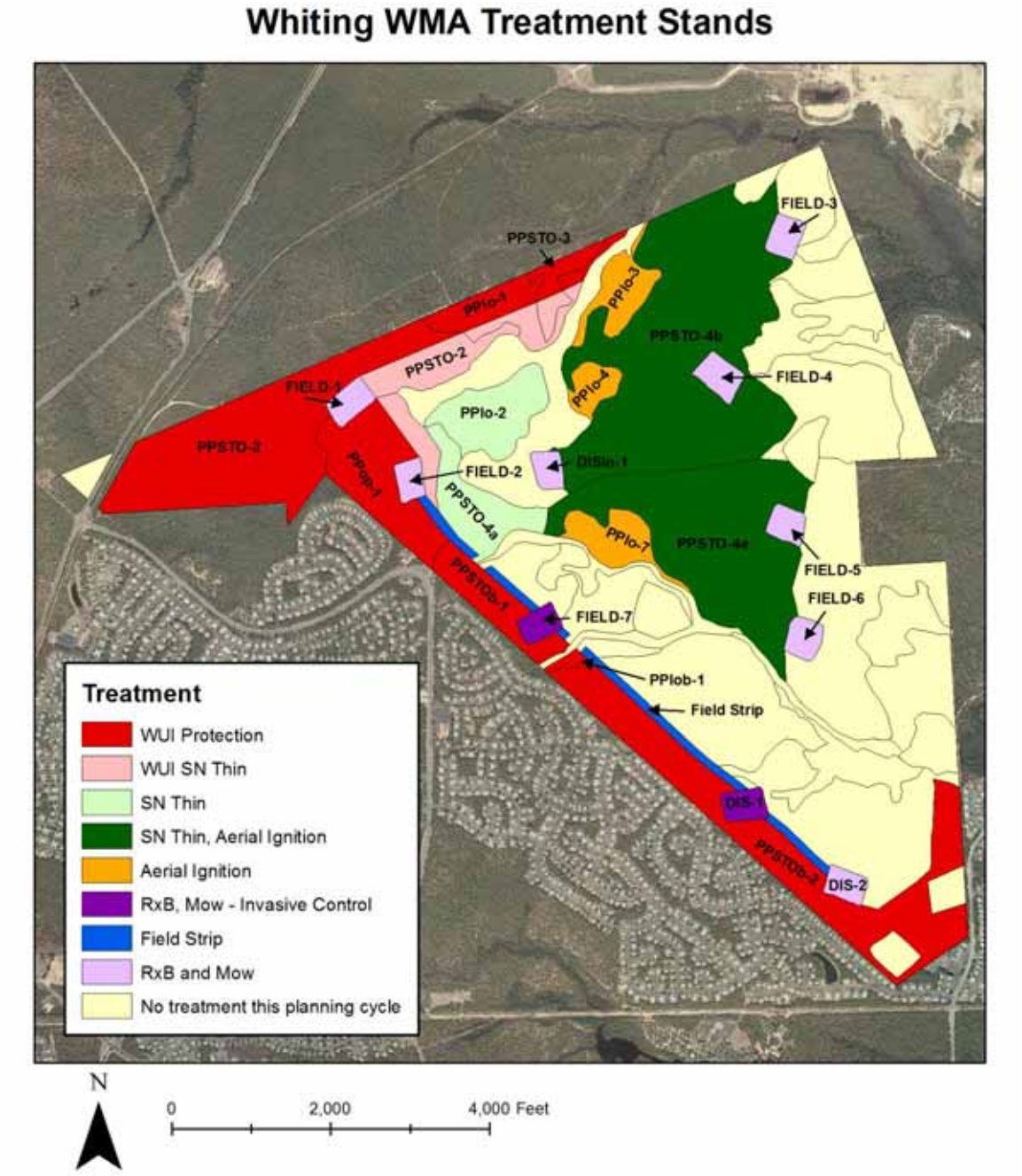


L. ONLM Vegetation Types: Diagnostic Traits of Berkeley Triangle

Upland Vegetation Types (part 1)

ONLM - Upland Vegetation Types (map code)	Diagnostic Traits	Rarity Ranks
pitch pine-shrub oak barrens (**Pb4/5**)	• **shrub oak stratum** with >5% cover of shrubform blackjack oak (<5m tall) and scrub oak; cover often 25-75% (providing critical habitat for rare Leps (Lepidoptera) feeding & birds nesting on shrub oaks), but cover < 25% with closed canopy • Pb5 variant with only scrub oak (often 50-100% cover) found in lower elevation frost pockets • Pb4 variant with only blackjack oak (often 10-25% cover) found on frost-free hill tops • tree-oaks absent or < 5% cover • pitch pine dominates an open canopy (closed canopy w/ fire exclusion) • herbs can include pyxie moss, bearberry, hudsonia, little bluestem, Pennsylvania sedge, panic grasses, bracken fern & lichens, providing critical habitat for rare Leps	**G2 S2
pitch pine-shrub oak barrens – open variant (**Pb4/5-o or Pb-o**)	• **shrub oak stratum** as in Pb4/5 • tree-oaks absent or < 5% cover • a structural variant of Pb4/5 where pitch pine dominates a very open canopy of about **25-40% cover** • some sites with increased cover of exposed sand and herbs of Pb4/5 enhancing critical habitat for rare Leps and pine snake nesting/basking	**G2 S2
pitch pine-shrub oak mesic barrens (**Pb2**)	• **shrub oak stratum** as in Pb4/5 • mesic species such as inkberry, sheep laurel, sand myrtle, turkey beard providing critical habitat for rare Leps • tree-oaks absent or < 5% cover • pitch pine dominates an open canopy (closed canopy w/ fire exclusion)	**G1 S1
pitch pine-shrub oak-sedge paleodune barrens (**Pb7**)	• **shrub oak stratum** as in Pb4/5 present but more sparse • ≤ 5% tree-oak species or sassafras • pitch pine dominates an open canopy, with some sites joined by shortleaf pine • herbs include Pennsylvania sedge, little bluestem, switchgrass, sandwort, lichens, rarely pickerings morning glory • found on xeric paleodunes with exposed sand & open herb cover, providing critical habitat for rare Leps and pine snake nesting/basking	**G1 S1
successional pitch pine-shrub oak barrens (**SPb**)	• **shrub oak stratum** as in Pb4/5 • tree-oaks absent or < 5% cover • a successional variant of Pb4/5 where pitch pine dominates a very open canopy with **< 25% canopy cover**, existing for several years after severe fire, cutting or disturbance • increased cover of exposed sand and herbs such as hudsonia, pyxie moss, bearberry, Pennsylvania sedge, little bluestem, panic grasses, enhancing critical habitats for rare Leps, plants and pine snake nesting/basking	**G2G3 S2S3

Upland Vegetation Types (part 2)

ONLM - Upland Vegetation Types (map code)	Diagnostic Traits	Rarity Ranks
pine-oak-shrub oak woodland (**POw**) (several types)	• **shrub oak stratum** as in Pb4/5 • 5-25% cover tree-oak species, e.g. black, post, scarlet and chestnut oak • pitch pine dominates an open canopy (closed canopy w/ fire exclusion) • some types joined by shortleaf pine	**G3 S3
pitch pine-treeform blackjack oak-shrub oak woodland (**POw8**)	• **shrub oak stratum** as in Pb4/5 • 5-25% cover of treeform (>5m) blackjack oak, on clay-rich hilltops • pitch pine dominates an open canopy (closed canopy w/ fire exclusion) • shortleaf pine joins pitch pine in POw8-1 variant	**G1 S1
pitch pine-heath upland (**PU1**)	• no shrub oak stratum, dense heath stratum • tree-oaks absent or < 5% cover • pitch pine dominates an often closed canopy	G4 G5 S4
pitch pine-sedge upland (**PU7**)	• no shrub oak stratum, little or no heath stratum • tree-oaks absent or < 5% cover • pitch pine dominates an open or partially closed canopy • Pennsylvania sedge and bare sand dominates ground cover, providing critical habitat for rare Leps and pine snake nesting/basking	GNR S2 S3*
pine-oak upland (**POU**)	• no shrub oak stratum, dense heath stratum • 5-25% tree-oak cover, e.g. black, post, scarlet, white and chestnut oak • pitch or shortleaf pine dominate a typically closed canopy	G4 S4
successional uplands - treeless (**SU1**)	• early successional herbs, grasses and bare sand as dominant ground cover, providing critical habitat for rare Leps and pine snake nesting/basking • <5% cover of trees and shrubs • forming in <u>severe</u> disturbances, total clearings, locally severe turf fires • mosaic of open areas with bare sand, herblands with lichen, hudsonia, bearberry, etc.; grasslands with Pennsylvania sedge, little bluestem, broomsedge, or switchgrass, • mixed with scattered heaths and pitch pine with up to 5% cover	**G3 S3
successional grassland (**SG**)	• successional or planted native grasses dominate after total clearing, e.g. little bluestem, broomsedge, switchgrass, panic grass, wiregrass • up to 5% tree and shrub cover if not mowed or burned every few yr	G5 S3 S4
successional pine upland (**SPU**)	• no shrub oak or heath strata • tree-oaks absent or < 5% cover • pitch pine or shortleaf pine dominates a **very open canopy** with < 25% canopy cover • often follows total clearing / severe disturbance • much exposed sand, providing critical habitat for pine snake nesting/basking • herbs include lichens, hudsonia, bearberry, Pennsylvania sedge, little bluestem, broomsedge, panic grasses, & switchgrass providing critical habitat for rare Leps	**G3 S3
non-native vegetation (**NNV**)	• Non-native vegetation dominates, often in disturbed sites • At Whiting WMA: tree-of-heaven, African lovegrass, Blackwells switchgrass	GNR SNR

Wetland Vegetation Types (part 1)

ONLM - Wetland Vegetation Types (map code)	Diagnostic Traits	Rarity Ranks
pitch pine lowland - undifferentiated (**PL**) (an alliance with several types)	• pitch pine dominates in a closed canopy after fire exclusion, in an open canopy after regular crown fires, and in a very open canopy (<25% cover) after frequent fire regimes, a severe fire or disturbance event (SPL) or in some seasonally flooded sites • swamp hardwoods absent or < 5% cover, 5-25% in a PA/PL ecotone • heath stratum with huckleberry, sheep laurel, inkberry, highbush blueberry, fetterbush, leatherleaf, etc. depending on hydrology • herbs layer include pyxie moss, turkey beard, grasses, peat moss, providing critical habitat for rare Leps and plants • hydric to subhydric sites near swamps or in headwater swales	**G3 S3
pitch pine-reedgrass savanna (**PL4**) (potentially at WWMA)	• pitch pine in open canopy with 5-25% cover, more with fire exclusion • pine barren reedgrass dominates ground cover, maintained by frequent or severe fires and seasonal flooding in wetter PL4 site, providing critical habitat for rare Leps and plants • heaths form an open shrub stratum mixed with reedgrass, including dwarf huckleberry, sheel laurel, highbush blueberry, leatherleaf	**G1 S1
pitch pine-sand myrtle lowland (**PL7**) (potentially at WWMA)	• pitch pine in open canopy with 5-25% cover, more with fire exclusion • sand myrtle dominates sandy ground cover, probably after a severe fire or disturbance history reduces heath shrub stratum, providing critical habitat for rare Leps and plants • heaths can include black huckleberry, sheep laurel, staggerbush	**G1 S1
pine upland-lowland ecotone (**PU/PL**)	• pitch pine dominates canopy which is closed after fire exclusion, open after crown fire, and < 25% cover (SPU/PL) after severe fires • swamp hardwoods, tree-oaks and shrub oaks absent or < 5% cover • heath stratum with huckleberry, staggerbush, sheep laurel, sand myrtle • herbs layer include bracken, broomsedge, switchgrass, little bluestem, providing critical habitat for rare Leps and plants • subhydric sites at upper edge of pitch pine lowlands or broad plains	**G3 S3
successional pitch pine lowland (**SPL**)	• pitch pine cover < 25% after a severe fire or disturbance event • ground cover dominated by grasses and herbs for years after event, including turkey beard, gentian, bartonia, pyxie moss, broomsedge, panic grasses, switchgrass, providing critical habitat for rare Leps and plants • heath stratum open or sparse after fire/disturbance, returns with time	**G3 S2S3
successional pine upland-lowland ecotone (**SPU/PL**) (potentially at WWMA)	• pitch pine cover < 25% after a severe fire or disturbance event • ground cover dominated grasses and herbs for years after event, including lichens, hudsonia, broomsedge, switchgrass, and bracken, as well as bare sand, providing critical habitat for rare Leps, snakes and plants • heath stratum open or sparse after fire/disturbance, returns with time	**G3 S2S3

Wetland Vegetation Types (part 2)

ONLM - Wetland Vegetation Types (map code)	Diagnostic Traits	Rarity Ranks
pitch pine-red maple swamp (**PA**)	• pitch pine and hardwoods codominate • > 25% red maple / swamp hardwoods, providing forest interior deciduous habitat and critical habitat for a rare Lep • closed canopy • dense heath shrub stratum • seasonally saturated soils	G3G4 S3S4
pitch pine-red maple-cedar swamp (**PAC**)	• mixture of pitch pine, swamp hardwoods and Atlantic white cedar with > 5% cover of each • dense heath shrub stratum • seasonally saturated organic soils	GNR SNR
red maple-black gum swamp (**AN**)	• swamp hardwoods dominate canopy and midstory**,** providing forest interior deciduous habitat • pitch pine minor or absent • closed canopy • dense heath shrub stratum • seasonally saturated organic soils	G3G4 S3S4
mixed cedar - hardwood swamp (**CAN**)	• cedar and swamp hardwoods codominate • closed canopy • dense heath shrub stratum • seasonally saturated organic soils	GNR S4
Atlantic white cedar swamp (**C**)	• cedar dominates canopy, minor hardwood and pitch pine cover • closed canopy, providing forest interior habitat • heath shrub stratum present but sometimes sparse under heavy shade • seasonally saturated organic soils • providing critical habitat for timber rattlesnake dens, rare plants and a rare Lep	**G3 S3
Palustrine Herbland / Shrubland – undifferentiated (**PH/PS**) (includes many types)	• palustrine herblands (PH) dominated by grass, sedge, or herbaceous species tolerant of seasonal flooding/saturation, e.g. palustrine grasslands (PG), riverside savannas (RS), intermittent ponds (IP), providing critical habitat for rare plants and insects • palustrine shrublands (PS) dominated by shrub species tolerant of seasonal flooding/saturation, e.g. leatherleaf, highbush blueberry, other heaths, providing critical habitat for rare plants and insects • seasonally to semi-permanently flooded or saturated intermittent ponds, swales, and floodplains with groundwater seepage • treeless or nearly so	G? S1S3*
aquatic/emergent (**A/E**)	• permanently flooded ponds and lakes with emergent shore zones • dominated by aquatic vegetation, e.g. water lily, floating heart, bladderworts, rushes, sedges, yellow-eyed grass, providing critical habitat for rare plants, insects, birds • treeless	GNR SNR

M. Classification Crosswalk of Berkeley Triangle Vegetation Types,

Office of Natural Lands Management (ONLM), Land Dimensions Engineering (LDE), and Pinelands Comprenensive Management Plan (Pinelands CMP)

UPLANDS

ONLM **Ecological Community Types** (* rare types & critical habitats)	**LDE** **Forest types**	**Pinelands CMP** **Native Forest Types**
* pitch pine-scrub oak mesic barrens (Pb2)	Pitch pine-scrub oak (PPSO)	Pine-shrub oak
* pitch pine-scrub oak barrens (Pb5)		
* pitch pine-blackjack oak barrens (Pb4)	Pitch pine-shrub tree oak (PPSTO)	
* pitch pine-shrub oak barrens (Pb4/5)		
* pitch pine-treeform blackjack oak-shrub oak woodland (POw8)		
* pine-oak-shrub oak woodland (POw) (Alliance of serveral types)		
* pitch pine-shrub oak barrens - open variant (Pb4/5-o, or Pb-o)	Pitch pine open (PPop)	
* pitch pine-shrub oak-sedge paleodune barrens (Pb7)		
* paleodune pine upland (PD)		Upland Savanna and Grassland
* successional pine upland (SPU)		
* successional pitch pine-sedge upland savanna (SPU7, SPU7/8)		

ONLM Ecological Community Types (* rare types & critical habitats)	**LDE Forest types**	**Pinelands CMP Native Forest Types**
pitch pine-heath upland (PU1)	Pitch pine-shrub tree oak (prescribed burned) (PPSTOb)	Pine-dominated Forest
mixed pine-heath upland (PU2)	Pitch pine-Shortleaf pine (PPSL)	
mixed pine-sedge upland (PU7/8)		
doghair pine upland (DPU)	Not Addressed	
pine-oak upland (POU)	Pitch pine-tree oak (PPO)	
pine-oak forest (PO)		
oak-pine forest (OP)	Not present in planning area	Oak-dominated Forest
successional uplands (SU1)	Disturbed/Regeneration (DIS)	Upland Savanna and Grassland
successional grasslands (SG)	Fields - Grass (FIELD)	
non-native vegetation (NNV)	Not Addressed	Not Addressed

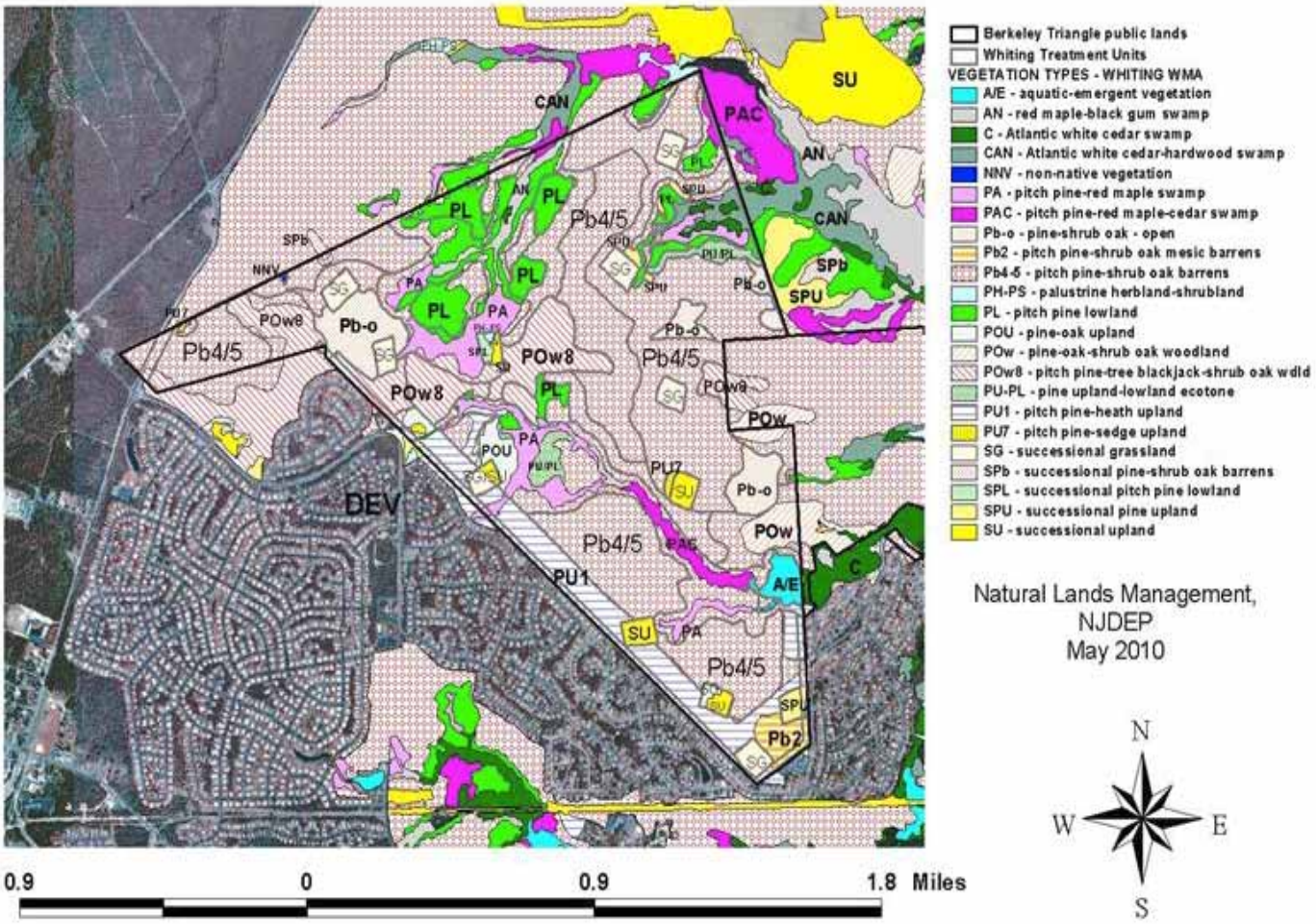
WETLANDS

ONLM Ecological Community Types (* rare types & critical habitats)	**LDE Forest types**	**Pinelands CMP Native Forest Types**
* Atlantic white cedar swamp (C)	Atlantic white cedar (CED)	Atlantic white cedar swamp
Atlantic white cedar-hardwood swamp (CAN)	Atlantic white cedar (CED)	Atlantic white cedar swamp
red maple-black gum swamp (AN)	Not Addressed	Hardwood Swamp
pitch pine-red maple-cedar swamp (PAC)	Pitch pine-maple-cedar (PMC)	Hardwood Swamp ? (Pine-Hardwood type needed)
pitch pine-red maple swamp (PA)	Pitch pine-maple-cedar (PMC)	Pitch pine lowland ? (Pine-Hardwood type needed)
successional pitch pine-red maple swamp (SPA)	Pitch pine-maple-cedar fire regeneration (PMCf)	
* pitch pine lowland (PL) (Alliance of below PL types)	Pitch pine lowland (PPlo)	Pitch pine lowland
* pitch pine-leatherleaf lowland (PL1)		
* pitch pine-highbush blueberry-inkberry lowland (PL2/3)		
* pitch pine-reedgrass savanna (PL4)		
* pitch pine-mixed heath lowland (PL5)		
* pitch pine-black huckleberry-sheep laurel lowland (PL6)		
* pitch pine-sand myrtle lowland (PL7)		
* pitch pine upland-lowland ecotone (PU/PL)		
* successional pitch pine lowland (SPL)	pitch pine lowland fire regeneration(PPlof)	

ONLM Ecological Community Types (* rare types & critical habitats)	**LDE Forest types**	**Pinelands CMP Native Forest Types**
*palustrine shrubland (PS) (Alliance of serveral types)	Not addressed	Bogs
* leatherleaf bog (Eps1)	Not addressed	
* highbush blueberry bog (Eps2)	Not addressed	
successional palustrine shrubland (Sps)	Disturbed/Regeneration Lowland (DISlo)	
* palustrine grassland (PG) (Alliance of serveral types)	Not addressed	Inland Marshes
* riverside savanna (RS) (Alliance of serveral types)	Not addressed	
* successional palustrine grassland (SPG) (Alliance of serveral types)	Disturbed/Regeneration Lowland (DISlo)	
* palustrine herbland – undif. (PH) (Alliance of serveral types)	Not addressed	Inland Marshes, Lakes and Ponds
* coastal plain intermittent pond (IP) (Alliance of serveral types)	Not addressed	Lakes and Ponds
* aquatic/emergent (A/E)	Lake-1	Lakes and Ponds
* successional palustrine herbland (SPH)	Disturbed/Regeneration Lowland (DISlo)	Inland Marshes, Lakes and Ponds

N. ONLM Vegetation Map

Vegetation Map - Whiting WMA



O. Geology

The WWMA lies in the Outer Coastal Plain geologic formation, formed as a result of deposition and erosion over the last 170 to 200 million years. It is characterized by gently rolling terrain, sandy and droughty soils lacking rock outcrops, and steep slopes or mountain peaks. In general, it is comprised of a wedge shaped series of unconsolidated layers of sands, clays, and marls on gently sloped southeastward dipping bedrock 1,300 to 6,000 feet below the ground surface. These layers extend seaward into the submerged Continental Shelf. The lowest geologic beds originate from continental deposits (Lower Cretaceous Age). These are overlain by deposits of both continental and marine origin (Upper Cretaceous Age) dating from 136 to 65 million years before present time. Specific formations within this group are (oldest to youngest): the Potomac, Raritan-Magothy, Merchantville, Woodbury, Englishtown, Wenonah, Mount Laurel Sand, and the Red Bank Sand. During the nest period of the Tertiary Age (65 to1.8 million years before present time), the sea covered the Outer Coastal Plain several times. After depositing the Cohansey Sand, the sea retreated for the last time and the present day topography began to form (about 5 million years before present time). The Beacon Hill Gravel was deposited over the Cohansey Sand in the northern and central portions of the Coastal Plain. Composed of quartzose as well as cherty sand and gravel, the Beacon Hill Gravel resulted from extensive stream channel development. The geologic strata of the Tertiary Age are (oldest to youngest): the Hornerstown Sand, Vincentown and Manasquan Formations, Kirkwood Formation, Cohansey Sand, and Beacon Hill Gravel. The Bridgetown and Pennsauken Formations in the southwest portion of the Pinelands are also thought to be Tertiary deposits, as they appear fluvial in origin. Overlying the Tertiary deposits are those laid down during the Pleistocene glaciation (1.8 million years before present time) and the Holocene period (10,000 years before present time). The Cape May Formation deposited during this time extends from sea level to approximately 30 to 50 feet above sea level, and is considered to be of marine origin. The Holocene deposits, alluvial and eolian in origin, are a redeposition of the older material. The Tertiary and Quaternary periods remain ecologically vital to the Pinelands region and serve as potable water sources.

The Potomac and Raritan-Magothy Formations are the oldest, thickest, and most extensive units known to occur throughout the entire Pinelands portion of the Outer Coastal Plain. These interrelated units consist of alternating layers of clay, silt, sand, and gravel. They range in combined thickness from a feather edge to over 3000 feet. These beds are overlain by the Merchantville Clay and Woodbury Formations which together form a thick and extensive confining unit throughout much of the Pinelands region. The Potomac and Raritan Formations are believed to be continental in origin. The Magothy is believed to be both marine and non-marine in origin.

The Englishtown Formation overlies the Merchantville Clay and Woodbury Formations which is then overlain by a thin confining layer called the Marshalltown Formation. The outcrop of the Englishtown Formation ranges in thickness from 50 to 140 feet. This formation uniformly dips to the southeast at a rate of 40 feet per mile and is 1000 feet below sea level in southern Burlington County. The Englishtown Formation is believed to be both marine and non-marine in origin. In the northern half of Ocean County and the northeast corner of Burlington County, the aquifer ranges from 40 to 140 feet thick. In the southern third of Ocean and Burlington Counties the sand component is minimal and the unit is comprised primarily of silt and clay.

The Wenonah and Mount Laurel Sand Formations function hydraulically as one, with the latter predominating. The unit outcrops from Raritan Bay Southwestward to Delaware Bay, and reaches a thickness of over 200 feet in the subsurface. The upper layer of the Mount Laurel Sand Formation dips at a rate of about 40 feet per mile to the southeast. It ranges in elevation from over 100 feet above sea level at its outcrop in the northern end of the Coastal Plain to over 1200 feet below sea level near the barrier beach in northeast Ocean County. This formation is believed to underlie the entire Pinelands area.

The Kirkwood Formation overlaps several other formations including Piney Point, Marshalltown, Hornerstown, and Navesink. It is also overlain by the Cohansey Sand Formation. The top of the Kirkwood Formation ranges in elevation from over 100 feet above sea level at its outcrop area to over 300 feet below sea level along the eastern edge

of the Cape May Peninsula. It has an irregular surface and ranges in thickness from 50 to 100 feet at its outcrop to over 800 feet thick in the Atlantic City area.

The Cohansey Sand Formation outcrops at the surface, or is overlain by a thin veneer of Pleistocene deposits. The aerial extent of the Cohansey outcrop is 2,350 square miles, and southeast of the Kirkwood outcrop. The combined thickness of the Cohansey and overlying Pleistocene deposits, range from less than 20 feet to more than 300 feet thick. The Cohansey Sand Formation typically consists of fine to coarse grained quartzose sand with lenses of gravel one foot or less thick. Lenses of white, yellow, red, and light gray clay generally occur in the upper part of the formation and may be as much as 25 feet thick. The sand component is mostly yellow, but also exhibits shades of white, red, brown and gray. The Cohansey Formation is considered a mixed or transitional deposit partly dissected ancient subdelta plain. This is exhibited through deposits identified as stream, fluvial, deltaic, estuarine, lagoonal, beach, and nearshore marine in origin.

Quaternary Deposits form a discontinuous veneer above the Cohansey Formation throughout much of the Pinelands region. These deposits, from oldest to youngest are: the Bridgeton, Pennsauken and Cape May Formations. The Bridgeton and Pennsauken deposits are generally derived from erosion and redepostion of Cohansey Sand and Beacon Hill Gravel. They cap the tops and mantle the upper slopes of most of the pronounced hills and narrow ridges, and can be as much as 20 feet thick. The most important hydrological function of these deposits is the ability to absorb precipitation and transmit water to underlying aquifers. The hydraulic continuity with the underlying Cohansey Formation is excellent therefore it is considered a part of the Cohansey Sand-upper Kirkwood aquifer system (US EPA 2010).

P. Hydrogeology

The special characteristics of the Pinelands geology–low relief with sandy, droughty soils, underlain by a number of water bearing sand layers, alternating with confining clay layers give rise to a unique and fragile surface and ground water system. Precipitation is

rapidly absorbed and infiltrated through by the droughty sand, percolates to the relatively shallow water table, and ultimately supports the region's stream flow as groundwater seepage.

The most important abiotic element of the Pinelands ecosystem is water, considering its availability and characteristic chemistry. Water is stored in the extensive sand aquifers below the surface. This groundwater supports 89% of the flow in the Pinelands streams which discharges primarily through swamps and marshes. It is replenished by precipitation, of which, 44 % of the annual total is percolated through the sandy soil surface. Although highly permeable, the uppermost soil tends to be chemically inert with a low adsorptive capacity. It is therefore incapable of filtering out wastes. In addition, the waters are susceptible to various forms of pollution because they are weakly buffered against chemical change. As a result, groundwater contamination in the Pinelands is a significant threat.

Numerous aquifer systems, aquifers, and sub-aquifers occur throughout the New Jersey Coastal Plain. However, only five can be considered regional in nature and capable of producing substantial quantities of water. These aquifers, from oldest to youngest are: the Potomac-Raritan-Magothy Aquifer System, Englishtown, Wenonah-Mount Laurel, Kirkwood and Cohansey. The sand strata within the Potomac-Raritan-Magothy Aquifer System are believed to be hydraulically connected, making them function as an aquifer system. At present, this system is not an important water supply for the Pinelands area. In most of the Pinelands region the Englishtown Formation is considered a confining bed rather than an aquifer. This formation is not expected to produce additional water supply for the Pinelands. The Wenonah-Mount Laurel is a minor aquifer system in the Pinelands region. The aquifer has generally low values of transmissivity, with an average permeability value of 97 gallons per day per square foot (gpd/ft^2), low for the Pinelands. Water supply in the Pinelands should not be developed from this aquifer. The Kirkwood is the most highly developed aquifer along the shore and barrier beaches. In the central Pinelands, the Kirkwood contains fewer and less permeable water-bearing sands compared to the coast. Recharge in the Kirkwood aquifer is from precipitation, vertical

leakage from the overlying Cohansey, and release of water stored in the clay layers above, beneath, and within the formation. The quantity of available water and the permeability of the formation make it a vital aquifer for the coastal area. The Cohansey is the most important fresh water aquifer in the New Jersey Coastal Plain. This is based on its extensive storage capacity estimated to be about 17 trillion gallons, its high permeability (660 to 1,885 gpd/ft^2), and availability of direct recharge (2,350 square mile outcrop). The water table in the Cohansey Formation is typically shallow and generally less than 10 feet below the surface over much of the area. The fluctuations in response to discharge and recharge rarely exceed 7 feet. Although the Cohansey stores a large volume of water developing it for water supply without adequate recharge would significantly lower the water table. Since much of the Pinelands unique flora and fauna are adapted to wetland environments, lowering the water table could disrupt entire ecosystems. The cranberry industry which relies heavily on large volumes of water would also be placed in jeopardy, furthermore possibly increasing the frequency and/or risk of wildfire.

Precipitation that recharges the Pinelands groundwater supply percolates through the forest litter and enters a porous groundwater reservoir that is chemically inert. The underground water is generally low in dissolved solids and is weakly buffered against chemical change. Hardness and nitrate concentrations are low. Dissolved iron content is often higher than drinking water standards. As the rainwater percolates through the forest litter dissolved carbon dioxide is picked up from biological decomposition. Reacting with the water the carbon dioxide is converted to carbonic acid which gives the ground water its typical acidic character and common pH values ranging from 4.5 to 5.0. Acidic groundwater with low dissolved solids becomes corrosive and readily dissolves iron from decaying vegetation, soil, and sediment minerals. Bog iron, common in the Pinelands, is a result of oxidation and precipitation of the dissolved iron when water is exposed to air through seepage.

The ground surface of the Pinelands, consisting primarily of unconsolidated sands, holds a vast quantity of clean filtered water. However, based on other areas with similar

hydrogeologic characteristics, the Cohansey and Kirkwood aquifers can be highly susceptible to pollution. Actual and potential pollution and contamination sources include septic tanks, landfills, chemical spills and dumping, chemical storage leaks, industrial waste lagoons, highway de-icing, underground oil and gas storage tanks, and agricultural chemicals. These sources may have immediate local impacts and could also pose long-term cumulative threats (US EPA 2010).

Q. Hydrology

The WWMA is located within the Barnegat Bay Watershed also known as the Toms River Watershed. The NJ DEP labels this as Watershed Management Area 13, the smallest of the state's watersheds. Totaling about 660 square miles, this watershed management area encompasses all of the land and water in Ocean County in addition to portions of Monmouth County. Also associated with the Toms River Watershed are the following subwatersheds located in:

- A portion of Jackson Township
- A portion of Manchester Township
- A portion of Berkeley Township
- A small portion of Lakewood Township (the south west corner)
- Most of Toms River Township
- Lakehurst Borough
- South Toms River Borough
- Pine Beach Borough
- Beachwood Borough
- Island Heights Borough
- Roughly half of Ocean Gate Borough (northern portion)

The largest river system in the watershed is Toms River which and drains 124 square miles. It flows from western Ocean and Monmouth Counties southeast to Barnegat Bay and the town of Toms River, 11 miles north of Barnegat Inlet. This is an area of low

relief with dozens of small tributaries feeding into the Toms River. The larger tributaries include Davenports Branch, Union Branch, Ridgeway Branch, and Wrangle Brook. The watershed also drains a large area of the Pinelands. Population centers include Toms River, Lakehurst, Dover, and Manchester. There are four other smaller drainage systems including the Westecunk Creek, Cedar Creek, Mill Creek, and Wrangle Brook. All of these streams and rivers drain into Barnegat Bay before discharging to the ocean. The Toms River flows past the "river towns" of Toms River, South Toms River, Pine Beach, Beachwood, Island Heights, and Ocean Gate on its way to the Barnegat Bay. Major impoundments of the Toms River are Lake Success in Jackson Township, Pine Lake in Manchester Township (where the Union and Ridgeway Branches meet), and Horicon Lake in the Borough of Lakehurst.

Wetland forests cover approximately 25% of the total watershed. In the Barnegat Bay watershed salt marshes, freshwater marshes, and forested wetlands create natural buffers minimizing the impacts of coastal storms and wind on coastal and inland habitats. Coastal wetlands are able to withstand major storms without suffering lasting damage while at the same time protecting inland communities. In addition, freshwater wetlands have the capacity of temporarily storing large quantities of floodwaters, releasing water over an extended period of time into groundwater and adjacent water bodies. The wetlands also effectively filter sediments and reduce erosion affects.

WWMA contains three sections of drainages associated with Wrangle Brook and Michael's Branch. These three drainages equate to about 2.5 linear miles and affect about 250 acres (US EPA 2010).

R. Climate

Southern New Jersey has a humid subtropical climate and can be vastly affected by its proximity to the Atlantic Ocean. **Winter** is typically cold. The lows usually hover in the 20s °F (down to -10 °C) and can frequently dip below 0 °F (−18 °C) in the northwestern sections of the state. New Jersey winters often feature snowstorms known as Nor'easters that can paralyze the area with over a foot of snow. However, a variation in the climate

also occasionally renders winter mild and almost snowless in sections of South Jersey near the Atlantic coastline. In the Coastal and southern portions of the state, frequently precipitation falls as rain in the winter despite it snowing in the northwestern portion. **Springs** are mild, averaging in the 50s °F (10 to 15 °C) in late March to the lower 80s °F (25-30 °C) in early June. The weather is unpredictable and brings relatively cool summers as an occasional surprise, and huge snowstorms arriving as late as the second week in April (significant snow after mid-March is fairly rare though). Thunderstorms are common in spring. **Summers** in New Jersey tend to be hot and humid with temperatures often exceeding 90 °F (32 °C), although high temperatures above 100 °F (38 °C) are uncommon. Humidity levels are usually quite high in July and August. Thunderstorms are common in summer. Hurricanes are considered to be a major threat to the area (and especially the Jersey Shoreline communities in Monmouth, Ocean, Atlantic, and Cape May counties). While relatively infrequent compared to areas south and east, a direct hit could cause large loss of life and billions of dollars in damage due to the high population in coastal areas. **Autumns** are comfortable in New Jersey and similar to spring in temperature. However, the weather is notably unpredictable and temperatures do fluctuate quickly at these times of year (Office of the New Jersey State Climatologist 2013).

The temperatures vary greatly from the northernmost part of New Jersey to the southernmost part of New Jersey. For example, these are the average high and low temperatures for Cape May, near the state's southernmost ocean-facing point; Sussex, in the mountainous northwest; and Trenton, the state capital located roughly midway between the two (Office of the New Jersey State Climatologist 2013):

	Sussex		Trenton		Cape May	
Month	**High**	**Low**	**High**	**Low**	**High**	**Low**
January	34	14	38	24	42	27
February	38	16	41	26	43	28
March	47	25	51	33	51	35
April	59	35	61	42	60	43
May	70	45	71	52	69	53
June	78	54	80	61	78	62
July	83	59	85	67	84	67
August	82	57	83	65	83	66
September	74	49	75	57	77	60
October	63	37	64	45	66	49
November	51	30	54	37	56	40
December	39	21	43	28	47	31
All Temperatures are in Fahrenheit						

Some climatic facts are as follows.

Temperature:	Mean Annual Temperature	Max. 65 degrees; Min. 43 degrees	
	Extreme temperature	Below zero to a high of 100+ degrees	
	Mean date of first frost	October 8th	
	Mean date of last frost	May 1st	
	Mean length of growing season	178 days	
Precipitation:	Mean Annual Precipitation	44 inches	
	High Month	August (4.9 inches)	
	Low Month	February (2.9 inches)	
Sunlight:	Mean number of days:	Clear	100
		Partly Cloudy	111
		Cloudy	154