Yards Creek Preserve
10-Year Stewardship Plan

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Rattlesnake Plantain and Ground Cedar found together on the Preserve

Introductory Information

Property:	Yards Creek Preserve
Owners:	The Land Conservancy of New Jersey
Property Acreage:	114 acres
County, Municipality:	Warren County, Blairstown Township
Wildlife Action Plan Conservation Zone:	Upper Delaware River Valley & Kittatinny Ridge (20)
NJDEP Watershed Management Area:	Upper Delaware (WMA 01)
Waterbodies:	Paulins Kill tributary: 0.68 miles Unnamed tributary: 0.43 miles Wetlands: 36.4 acres
Numbers of Rare Species Conservation Targets[1]:	Total Number of Animal Species: 26 Total Number of Plant Species: 0 Total Number of Ecological Communities: 2 *Note: Categories below are not mutually exclusive.* Globally Rare Species: 0 Federally Endangered Species: 0 Federally Threatened Species: 1 State Endangered Species: 5 State Threatened Species: 2 State Special Concern Species: 19 State Game Species of Concern: 0 Globally Rare Ecological Communities: 0 State Rare Ecological Communities: 0
Habitat Conservation Targets:	1) Mature Forest, 2) Restored Areas 3) Vernal Pools
Landscape-Scale Conservation Areas:	*ENSP Landscape Project Importance Summary* - Largest Habitat Patch - Forest, 37 contiguous acres Potential Vernal Pool Habitat *New Jersey Natural Heritage Program Priority Sites* - There are no sites that overlap with the property. *New Jersey Audubon Society Important Bird and Birding Areas* - There are several sites that overlap with the Property. • Kittatinny Mountain Eastern Slope • Walpack Valley • Stokes State Forest and High Point State Park • Old Mine Road • Mount Tammany Cliffs • Bear Swamp

Species Conservation Target List[1]:

Birds (19)
Barred Owl (S2B, S2N, Threatened), Blackburnian Warbler (S3B, S4N, Special Concern), Black-throated Blue Warbler (S3B, S4N, Special Concern), Black-throated Green Warbler (S3B, S4N, Special Concern) Blue-headed Vireo (S3B, S4N, Special Concern), Canada Warbler (S3B, S4N, Special Concern), Cooper's Hawk (S3B, S4N, Special Concern) Great Blue Heron (S3B, S4N, Special Concern), Hooded Warbler (S3B, S4N, Special Concern), Kentucky Warbler (S3B, S3N, Special Concern) Northern Goshawk (S1B, S3N, Endangered), Red-Shouldered Hawk (S1B, S3N, Endangered, Special Concern), Veery (S3B, S4N, Special Concern) Wood Thrush (S3B, S4N, Special Concern) Worm-eating Warbler (S3B, S4N, Special Concern) Bald Eagle (S1B, S2N, Endangered) Black-billed Cuckoo (S3B, S4N, Special Concern) Cerulean Warbler (S3B, S4N, Special Concern) Northern Parula (S3B, S4N, Special Concern)

Mammals (2)
Bobcat (S2, Endangered)
Northern Myotis (S1, Federally Listed Threatened)

Amphibians (1)
Fowlers Toad (S3, Special Concern)

Retiles (4)
Eastern Box Turtle (S3, Special Concern)
Northern Copperhead (S3, Special Concern)
Timber Rattlesnake (S1, Endangered)
Wood Turtle (S2, Threatened)

Insects (0)
None

Habitats (2)
Potential Vernal Pool Habitat Area (ID 2266)
Potential Vernal Pool Habitat Area (ID 2252)

Plants (0)
None

Plant Communities (0)
None

[1] Species include those confirmed to be present within the Property or its contiguous habitat patch based upon Natural Heritage Grid GIS Layer and Landscape Project Version 3.3. Rank Key: S1=Critically Imperiled/Endangered (< 5 known populations); S2=Imperiled/Threatened (6-20 known populations), S3=Rare/Special Concern (21-100 populations). Plant species ranked S2 or S3 are equivalent to Threatened and Special Concern, but do not have official state status.

Invasive Plant Species List:

Each invasive plant species was assigned an 'Action Code' based upon observations of current extent of infestations on the Property and within New Jersey. Code Key: "1" = immediate implementation of an eradication program across the entire Property, "2" = selective control measures to minimize negative impacts, especially in particular habitats, and "3" = no direct control measures due to low probability of causing significant harm or species is very abundant and control measures are impractical. See report for additional information on distribution, infestation severity, and control recommendations.

Total Number of Mapped Invasive Species: 14

Action Code = 1 (9 species)
Amur Honeysuckle, Autumn Olive, Burning Bush, Common Reed, Garlic Mustard, Japanese Honeysuckle, Mile-a-Minute, Mugwort, Siebold's Crabapple

Action Code = 2 (3 species)
Japanese Barberry, Japanese Wineberry, Multiflora Rose

Action Code = 3 (2 species)
Japanese Stiltgrass, Norway Spruce

Overabundant Native Animal Species:

This plan will address management of invasive species in the context of an overabundant deer population, which has a profound negative impact on conservation values. The Property is located within the NJ Division of Fish & Wildlife's Deer Management Zone #5 and Deer Management Unit 52. Hunting dates and harvest regulations may vary by season, but unlimited antlerless deer harvests are allowed throughout most seasons ranging from early September to mid-February.

Executive Summary

This plan applies to the Yards Creek Preserve. This 10-year stewardship plan includes results of field investigations with recommendations to improve ecological health by the FoHVOS New Jersey Invasive Species Strike Team.

There are three main purposes of this plan. The first is to clearly state the vision and goals including protection of biodiversity. The second is to carefully define conservation values, threats to their health, and strategies/actions to mitigate identified threats. The third purpose is to provide baseline conditions and ample sources of reference material to effectively navigate the many aspects of the Property and guide its adaptive stewardship over time.

The vision is to provide model stewardship of biodiversity. The primary objective is the enhancement and recovery of native flora and fauna. The primary habitat conservation target is mature forest, but there are also important restoration areas and wetland habitat. These habitats support multiple common and rare species of our flora and fauna. A total of 26 rare species have been documented within or nearby the Property (See page ii) and there are multiple potential vernal pool habitats. Importantly, the Property provides important core habitat throughout its entirety and connects with other existing wildlife corridors connecting to other core habitats (e.g., The Delaware Water Gap National Recreation Area). All habitats and species are under immediate threat from overabundant deer and invasive species.

Deer management has occurred on the Property, but likely focused on harvesting bucks. In addition, heavy selective removal of mature oak trees has led to large clearings (now being restored) and shifting of the balance to American Beech in traditionally fire-maintained oak forests. This past lack of appropriate management has led to severe ecological degradation. Virtually all forests fall into two impaired categories – “Empty Forest Syndrome” (few understory plants) or “Infested Forest Syndrome” (dense patches of unpalatable invasive understory plants). Reduction of the deer density to 20 per square mile (or as low as 10 per square mile to allow recovery of the most sensitive forest wildflowers) is critical to allow native species, freed from excessive browse, to exert ecological control over invasive species and produce healthy native plant communities.

The extent of invasive species infestation is severe. A total of 14 invasive species were detected with 48% of the Property having severe infestations of one or more species. Approximately 40% of the Property is considered virtually free of invasive species, while approximately 12% are lightly to moderately infested. The three most abundant species are Multiflora Rose, Japanese Stiltgrass, and Japanese Barberry. Additional moderately abundant species include Autumn Olive, Norway Spruce, and Wineberry. There are nine emerging invasive species or nascent populations of widespread species that should be considered for eradication to avoid future degradation of ecological health.

A “brute force” approach that seeks direct control of all invasive species is not practical (estimated to require 4,000 hours of effort). This plan recommends a strategic approach involving protection and enhancement of the highest quality areas (ca. 50% of the Preserve) and use of prescribed fire to reduce dense infestations in selected portions of the Property. The ultimate goal is significantly reducing invasive species through directed active control and reliance on ecological control through deer herd reduction to both reverse current infestations and resist future infestations.

The plan provides five primary recommendations with nine associated goals (see next page). Full plan implementation is estimated to require 645 hours of staff time (estimated cost of $32,250), 197 volunteer hours (estimated value of $4,728), $36,025 of total contractor cost, and $2,550 of purchased material costs over the next 10 years - total cost is estimated at $70,825 (See Table 24 for additional details).

Primary Plan Recommendations

This 10-year plan has five primary recommendations and nine associated stewardship goals. Goals are further divided into specific tasks with associated level-of-effort and cost estimates (Table 24).

Recommendation #1: Conduct an Effective White-tailed Deer Management Program

Goal #1-1: Reduce deer density to meet ecological health goals

- Deer density should be kept below 20 per square mile but allowing full recovery of forest wildflowers may require a density of only 10 per square mile. Considerable progress toward this goal will be made through an annual Deer Management Program but participation from neighboring landowners will be important. Goals include 70% native shrub cover within the browse zone and a healthy, robust population of reproducing forest wildflowers.

Recommendation #2: Perform Strategic Invasive Species Control

Goal #2-1: Eradicate nine emerging invasive species (Action Code 1 species)

- Reduce future damage by addressing species that have not yet established extensive populations throughout the Property. This includes nascent populations of eight species that are widespread in New Jersey, but uncommon on the Property and one emerging species. Accomplishing this goal fulfills 'ecological responsibility' by preventing spread beyond the Property.

Recommendation #3: Protect and Restore Highest Quality Forest Areas and Rare Species Habitat

Goal #3-1: Protect 70.3 acres of highest quality forest

- Requires considerable but selective invasive species control efforts (Action Code 2 species)
- Goals in order include Stewardship Units A-C, followed by unit D
- Construct multiple mini-exclosures in highest value Units

Goal #3-2: Protect 3.6 acres of restored areas to allow forest formation (see Map 30)

- Requires selective control of invasive species

Goal #3-3: Protect and enhance rare species habitat

- Consult with ENSP for protection and enhancement of Box Turtle and Wood Turtles
    - May include protection of nests or installation of nesting structures
- Conduct surveys and mapping of all documented and potential vernal pool areas (Map 16), including surveys during breeding seasons for Fowler's Toads, Wood Frogs, and Salamanders
- More recommendations for multiple species, including importance of deer management, tree girdling for Northern Myotis, and other rare species can be found in Table 17

Recommendation #4: Consult with NJ FFS to Plan Ecological Prescribed Burns

Goal #4-1: Conduct prescribed burn to re-establish native fire-based communities

- Consult with NJFFS to develop burn plans within mapped patches where American Beech is becoming predominant in oak-huckleberry communities created by the historical fire regime
- Conduct prescribed burn in patches 7, 25, 56, 57, and 59 in order to allow historically native communities opportunity to re-establish (See Map 31)

Goal #4-2: Conduct prescribed burn to control Japanese Barberry infestation along stream corridor

- Most other options are either not desirable or not practical. A minimum of two burns and spot treatment would be the most effective manner to reduce such a heavy infestation.
- Short of prescribed fire, full removal of the Japanese Barberry would require considerable effort over a large span of time

Recommendation #5: Conduct Ecological Health Monitoring and Rare Plant Inventory

Goal #5-1: Perform ecological health monitoring to guide adaptive stewardship over time

- Ongoing implementation of forest health monitoring protocols; Measurements should be conducted every 3-5 years

Goal #5-2: Perform complete botanical survey including rare plant surveys

- Professional botanical survey of property including comprehensive plant species list
- Large areas of high-quality habitat may harbor undocumented rare plants

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Individual Invasive Species Maps (arranged alphabetically by common name)

*Maps include field mapped polygons and points entered in the New Jersey Invasive Species Strike Team database (for selected species and areas of the Property).

Section I. Overview

Introduction

The Yards Creek Preserve consists of 114 acres in Blairstown Township, Warren County (Map 1). This 10-Year Stewardship Plan was created to collect and consolidate relevant information to develop strategies that improve ecological health. This section provides a brief overview of vision and goals for the Property as well as a summary of conservation values, threats to conservation values, and the context for stewardship actions.

Conservation Values

The Property contains excellent examples of the natural heritage contained within the Ridge and Valley physiographic region, especially those areas containing mature forests. There were 18 different plant community types identified during field surveys, including communities dominated by oaks and red maples. Although no rare plants have been documented on the Property, the large sections of mature forest may harbor undocumented rare species. The Property contains portions of a Paulinskill River tributary as well as other unnamed tributaries. The Property serves as a core habitat linked to nearby core habitats via habitat corridors (see Section II).

Stewardship Vision and Goals

The vision for the Property is to provide a model of stewardship for biodiversity. The four primary recommendations include: 1) Conduct an Effective White-tailed Deer Management Program, 2) Perform Strategic Invasive Species Control; 3) Protect and Restore Highest Quality Forest Areas and Rare Species, 4) Plan and Utilize Prescribed Burns for Habitat Improvement and Invasive Control, and 5) Conduct Ecological Health Monitoring and Full Botanical Survey. Each of these recommendations includes action-oriented goals (See Section IV) to support both flora and fauna.

Complete realization of the vision and goals for the Property can only be met through owners and their partners implementing wise stewardship fueled by deep appreciation of the natural world. Due to the complexity of the task at hand, this plan is considered a living document subject to change over time as additional information becomes available and results from ongoing efforts are evaluated. At a minimum, this stewardship plan should be revised every ten years. The careful stewardship of the Property will provide concrete examples of informed stewardship that can be applied throughout New Jersey.

Threats to Conservation Values

This section provides a brief overview of three significant factors that impact ecological health. These factors are interrelated and impact ecological health synergistically. In isolation, deer overabundance is the most severe threat, followed by invasive species and continuing impacts of altered soils from past agricultural use.

Degraded forests in New Jersey generally fall under two ‘syndromes’. The first is the “Empty Forest Syndrome” where all native species have been removed from the forest understory by overabundant deer. These forests also have low invasive species cover, except where canopy gaps provide additional light resources. This syndrome is usually associated with areas that have never received agricultural soil tillage and associated soil alterations (1930 aerial photography showing mature forest cover can act as a guide to determine the lack of past agricultural land use). The second syndrome is the “Infested Forest Syndrome”, which includes dense invasive species cover and small amounts of native cover that is severely browsed by deer. This syndrome is associated with 1) upland forests with past agricultural tillage that has dramatically altered soil characteristics, 2) many wetland forests regardless of past land use, and 3)

riparian forests, especially where unnaturally high-water flows create severe and repeated physical disturbances.

White-tailed Deer

Statewide deer population size has varied significantly over the last one hundred years (Figure 1). The historical analysis of the white-tailed deer population density in North America (pre-European colonization) is approximately 10 per square mile (McCabe and McCabe 1984). Figure 1 shows the estimated statewide population size based upon the historical estimate for North America and deer population estimates reported by the New Jersey Division of Fish & Wildlife. By 1900, deer were nearly extinct in New Jersey because of unregulated market hunting for the sale of venison. The recovery of the deer population, through the implementation of various game regulations, is a significant conservation success story. However, the deer population mushroomed during the 1900's and peaked in 1995 with 3X more individuals than pre-European estimates. In 2011, there was 1.5X more individuals than pre-European estimates (See notes under Figure 2 for details).

In the late 1990's, the NJ Division of Fish & Wildlife implemented changes to reduce the deer herd (e.g., "Earn-A-Buck" program that encouraged harvest of antlerless deer). It is important to note that deer population reduction has occurred when 40-50% of the population is harvested annually (green line in Figure 2) and 60-70% of the harvest is comprised of antlerless deer (orange line in Figure 2). Although there have been recent significant changes to facilitate hunting success (e.g., Sunday bow hunting, use of crossbows, reduction in the bow hunting safety zone), population levels continue to exceed pre-European densities with noticeable ecological, economic, and human health impacts.

Figure 1. Historic and Current New Jersey Deer Population Estimates

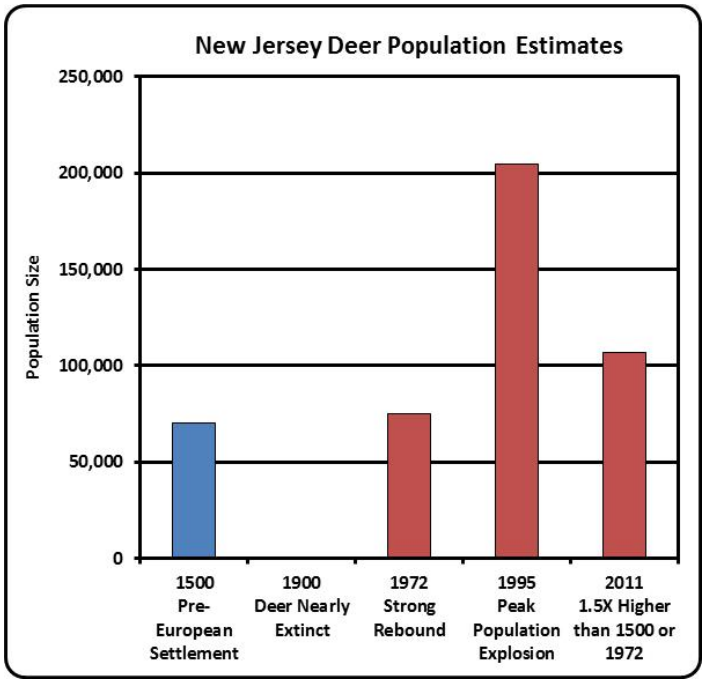
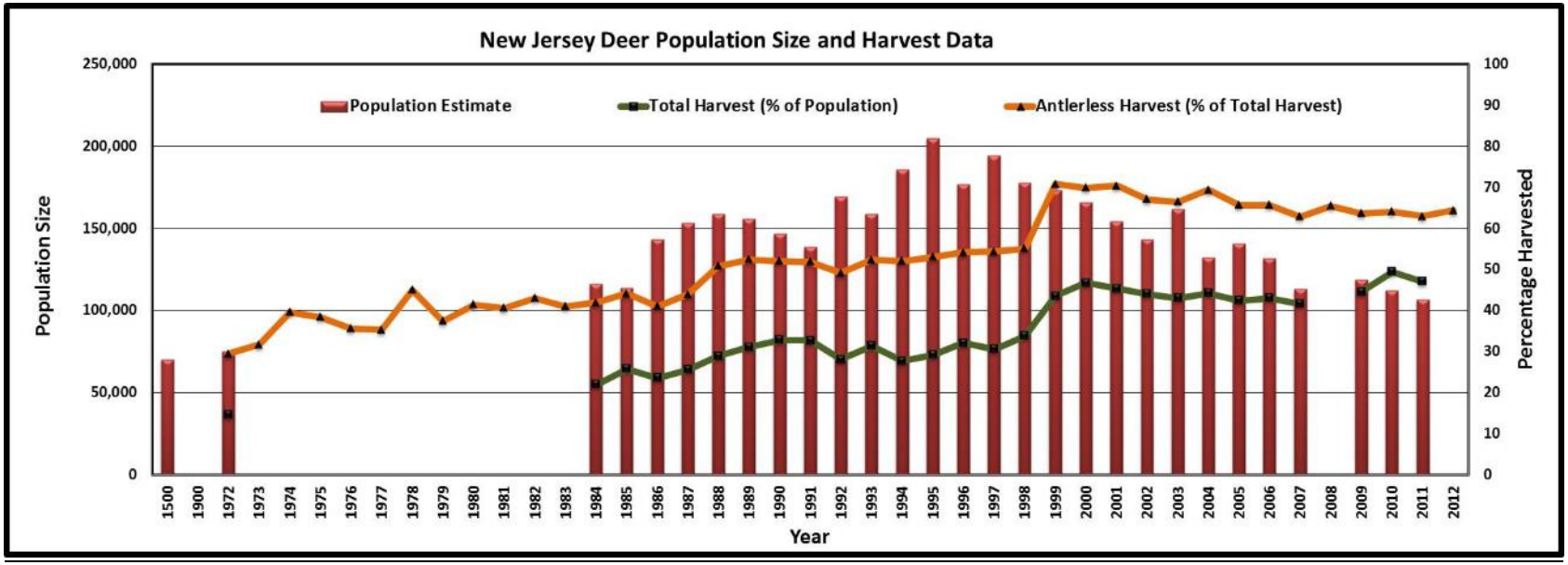


Figure 2. New Jersey Deer Population Size and Harvest Data



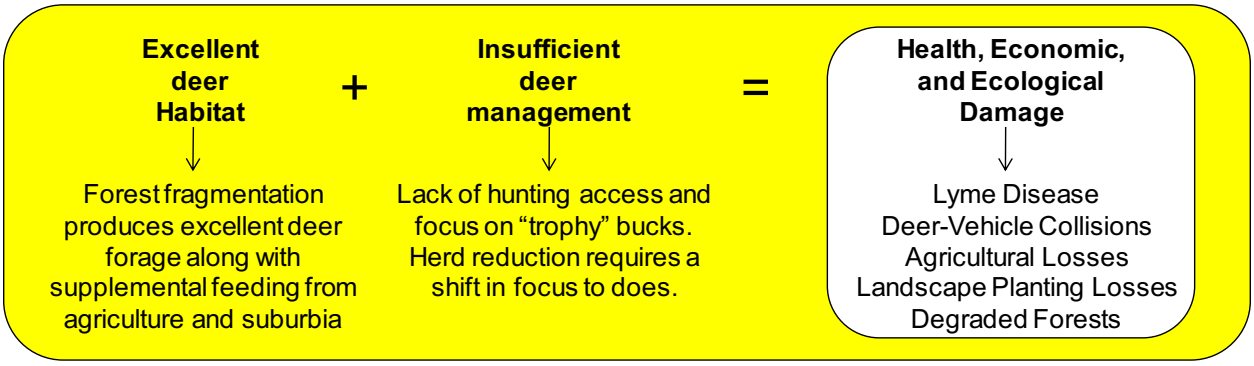
Graph prepared using NJ Division of Fish & Wildlife data sources. The estimated number of deer in 1500 is based upon the average deer density across North America (9.5/square mile) reported by McCabe and McCabe (1984) and the NJ land area reported by the US Census Bureau (7,417 square miles). Using this method, overall deer densities in particular years are: 1972 – 10.1; 1995 – 27.6 and 2011 – 14.4

Special Note #1: Deer densities calculated by the Division of Fish & Wildlife are derived from harvest data and do not account for land inaccessible to hunting; therefore, they represent an under-estimate of actual deer population size. Species Note #2: Total population estimates are not available for 2008 or 2012.

The current effective deer densities on forested habitats are significantly greater than pre-European densities because a considerable amount of land in New Jersey is developed / agricultural (ca. 50% of the total land area). In absolute numbers, the New Jersey deer population peaked in 1995 with 2.9X more individuals than pre-Columbian estimates. There is currently 1.5X more individuals than pre-European estimates [but see special note #1 above].

It should be noted that the deer population size or density is less significant than their overall impacts on ecosystem health, which should be measured to inform deer management goals.

Figure 3. Deer Population Growth Factors and Impacts



The current statewide deer population cannot support healthy forests (and creates significant human health and economic impacts). A healthy forest consists of a canopy of tall, mature trees, a sub-canopy of smaller tree species and an understory of tree saplings & seedlings, shrubs, and wildflowers. Deer prefer to eat native plants over non-native invasive plants leading to further degradation of our forests by allowing invasive species to proliferate. The combination of elevated deer numbers and their preference for native plants has led to degradation of New Jersey's forests by eliminating native understory growth and reducing the abundance of animals that require those plants for their survival. Although the 'correct' number of deer may vary depending upon site and regional conditions, the goal of healthy forest communities that support a diversity of plants and animals is universal.

Deer are having a dramatic negative impact on the Property. Most native forest wildflowers are severely browsed, and populations are sparse. Both the "Empty Forest Syndrome" (no understory plants) or "Infested Forest Syndrome" (only unpalatable invasive understory plants) can be found on the Property. Herd reduction to 20 deer per square mile (or as low as 10 per square mile to restore forest wildflowers) is absolutely critical to allow native species, freed from excessive browse, to exert ecological control of invasive species and produce healthy native plant communities. This will require a robust deer management program with paid hunters to dramatically reduce herd size.

Invasive Species

Humans have introduced non-native species, both intentionally and unintentionally, to parts of the world outside of their natural range. Only a small percentage of these introduced species become invasive, which is formally defined by the National Invasive Species Council as "a species that is 1) non-native (or alien) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health" (NISC 2001). The financial impacts of invasive species are enormous. Pimentel et al. (2005) estimate an annual cost of $120 billion dollars to agriculture, forestry, and recreation. In addition, invasive species have long been considered the greatest threat to global biodiversity after outright habitat destruction (Wilcove et al. 1998).

From nature's perspective, this problem is relatively new with the first signs becoming apparent in the 1950's (Elton 1958). Accelerating infestations have only been occurring over the last 30 - 60 years in New Jersey (coincident with dramatic increases in the deer herd) with our most serious invasive species originating from areas with similar temperate climates (i.e., Europe and Asia).

Plants - In addition to being less palatable to deer, invasive plant species appear to have left behind many of their native pests and pathogens, which provide them additional benefits. In general, invasive plants are

'weedy' - maturing quickly, producing large seed crops, and having tolerance to a variety of disturbed or human-altered growing conditions. Overall, there are nearly 1,000 non-native plants in New Jersey. There are currently 35 widespread invasive plants and 101 emerging or potentially invasive plants in New Jersey (see New Jersey Invasive Species Strike Team). Unfortunately, the rate of new plant introduction continues to rise. Snyder and Kaufman (2004) estimate fifty new plant introductions to New Jersey over the last twenty-five years (these are species with individuals growing in natural or semi-natural areas outside of human cultivation). There are no estimates of the area infested by invasive plants in New Jersey, but it is likely that hundreds of thousands of acres are impacted.

Some of our most notorious invasive plants include Japanese Barberry, Japanese Stiltgrass and Garlic Mustard. Although these widespread species cause severe harm, they are likely to be significantly reduced through ecological control exerted by taller, shade tolerant native species if deer populations are reduced. Among the emerging invasive species, a new class of invasive species is more threatening to forests than our existing invasives. These new species would be resistant to ecological control by native species because they are very tall (15- 20 feet), shade tolerant (can establish under closed forest canopy) and produce large amounts of bird dispersed seed capable of quickly reaching new locations. The five most troubling species are Oriental Photinia, Common Buckthorn, Siebold's Viburnum, Linden Viburnum (now considered widespread) and Japanese Aralia.

Animals - Invasive animals also cause significant harm to native ecosystems. There are currently 21 widespread invasive animals and 23 emerging or potentially invasive animals in New Jersey (see New Jersey Invasive Species Strike Team). Our most widespread invaders (with impacts in parentheses) include: several earthworm species (all earthworms in New Jersey are non-native and severely alter native soils), Brown-headed Cowbird (nest parasite of many birds including forest interior birds - impacts are highest in fragmented forests), Feral Cats (kill large numbers of birds), European Starling (nest competition, primarily in human-dominated areas), Asian Tiger Mosquito (human pest and unknown ecological damage), Rusty Crayfish (alter aquatic communities), Asiatic Clam (impact aquatic systems), and Red-eared Slider (competes with native turtles, especially painted turtles).

The most troubling emerging or potentially invasive species include Feral Hog, Zebra and Quagga Mussels, Mute Swan, and Nutria, which all cause considerable damage in the region. Feral Hogs have been noted in several locations across New Jersey with a significant population in Gloucester County that is has been targeted for eradication by the Division of Fish & Wildlife. This species causes severe harm to forest communities in other parts of eastern North America and is a considerable new threat to New Jersey. Zebra and Quagga Mussels cause significant harm to freshwater systems (zebra mussel has been documented in eastern Pennsylvania). Large populations of Mute Swan impact native waterfowl populations and Nutria (not yet present in New Jersey) compete with native wildlife and alter wetland communities.

Pests and Pathogens - Invasive pest and pathogens have the potential to radically alter plant and animal communities. There are currently 12 widespread invasive pests & pathogens and 20 emerging or potentially invasive pests & pathogens in New Jersey (see New Jersey Invasive Species Strike Team). Some of the most notorious invaders include Chestnut Blight, Hemlock Wooly Adelgid and Gypsy Moth. Chestnut Blight has reduced the once dominant American Chestnut to a transient understory tree that rarely produces fruit, Hemlock Wooly Adelgid has killed over half of the state's Eastern hemlocks (ca. 13,000 acres destroyed) with many remaining trees in poor health, and Gypsy Moth periodically ravages oaks leading to localized death of mature trees (including many 300+ year old trees at Hutcheson Memorial Forest). The Gypsy Moth is the subject of an intensive treatment program that utilizes a bacterium called *Bacillus thuringiensis* to mitigate their impacts and they are also partially controlled by a naturally occurring fungus. The Gypsy Moth Suppression Program consists of a voluntary cooperative between the NJ Department of Agriculture, US Department of Agriculture, NJ Department of

Environmental Protection, county agencies and municipalities. Treatments are performed via aerial spraying to mitigate periodic large outbreaks. While control of pests and pathogens are uncommon, the intensive work on Asian Long Horned Beetle has led to its eradication in New Jersey.

Other important widespread invasive pathogens include Dutch Elm Disease (continuing to cause damage, but moderately aged American Elm and Slippery Elm are still common), Beech Bark Disease (caused tree death throughout the state, remaining trees appear to be mostly immune) and Dogwood Anthracnose (causes sudden death of infected plants, but many plants are not impacted).

There are a number of emerging and potential pests and pathogens that may impact New Jersey. Emerging species already present in New Jersey include Viburnum Leaf Beetle (discovered in 2009, has potential to severely impact species such as maple-leaved viburnum, arrowwood, and other viburnums as evidenced in New York state over the past 10 years) and Bacterial Leaf Scorch (BLS). BLS may infest species within the red oak group (e.g., red oak, scarlet oak, black oak, pin oak). Currently, BLS is associated with street trees and other ornamental plantings (40% of recently tested trees were infested across the state) but spread into more natural settings appears to be occurring (J. Arsenault, personal communication). Ultimate impacts of BLS in natural areas are unknown, but the risk should be considered moderate at this time. Sudden Oak Death (SOD) is also a significant potential threat. The NJ Department of Agriculture was quick to respond to the unintentional introduction of SOD in Cape May in 2004 (introduced via contaminated nursery stock from California). Surveys were conducted for SOD and no infections have been found in wild plants, but there is continued threat of additional introductions to New Jersey. Other potential threats include Pine Flat Bug, Asian Gypsy Moth, Eurasian Nun Moth, Dutch Elm Disease 2, Phytophthera Root Rot, European Oak Bark Beetle, and two species of Ambrosia Beetle.

Unfortunately, Emerald Ash Borer has become established in New Jersey and its impacts are widespread. While a biological control agent (parasitic wasp) is being released currently, it is likely that New Jersey will lose over 90% of its ash trees even if the control agent eventually becomes effective. The latest insect invader, Spotted Lantern Fly, has spread across New Jersey in only several years. This species has a broad diet but requires the invasive Tree-of-Heaven to complete its lifecycle. Impacts on natural systems have not yet been completely realized at this point in time but local impacts include killing of vegetation below Tree-of-Heaven and grape species as the insect releases honeydew that fosters growth of black sooty mold.

Overview of Invasive Species Management - The underlying philosophical context for invasive species management is the obligation to counteract negative human impacts on natural systems, which is often referred to as “stewardship”. The guiding principle of stewardship is fostering health of native plant communities that support our flora and fauna, which is indirectly accomplished through the management of invasive species. Management of invasive species is achieved through targeted control measures that minimize, but do not eradicate, particular invasive species. Eradication within pre-defined boundaries should only be considered a valid goal when populations are relatively small, and the threat of continued spread is significant. Eradication should also be considered at ‘showcase’ lands. In all cases, invasive species management should aim to stimulate native plant communities to resist infestation and minimize the use of pesticides and any other intervention. However, human impacts on natural systems are diverse and perpetual, which will necessitate continuing stewardship of natural lands within the context of a human-dominated environment in order to support healthy native plant and animal communities.

There are two general approaches related to invasive species management. These involve a species-led approach or a habitat-led approach. A species-led approach should be employed when an invasive or potentially invasive species can either be eradicated or contained to reduce impacts across an entire Property or to minimize spread onto surrounding areas. This approach is warranted for invasive species

that are emerging locally or regionally and for widespread invasive species with limited distribution at a particular property.

A habitat-led approach should be employed when conservation values within a defined area are threatened by invasive species that are widespread throughout the region and the Property. This approach involves holistic strategies to promote native plant species assemblages that reduce overall invasive species cover through direct competition for light and soil nutrients. The ultimate goal is to foster native plant communities that resist future infestations.

The management of invasive species can be classified into five broad methods referred to as mechanical, chemical, biological, cultural, and ecological control (Table 1). Each control method utilizes multiple techniques and control methods may be used alone or in combination depending upon the resource to be protected and practical constraints (Table 2).

Mechanical control involves physical removal or cutting of invasive species. In the past, many groups performing invasive species control relied entirely on mechanical methods. Although mechanical methods can be the most appropriate choice in limited situations, many groups have abandoned this option because progress is exceedingly slow, and methods are often ineffective.

Chemical control is the most commonly used method. It can be used in coordination with mechanical control (e.g., cutting plants and applying herbicide to the stump) or alone (e.g., basal bark applications). However, herbicide use to control invasive species should be judicious to avoid impacts to non-target plants and animals. In all cases, herbicide use should involve the most benign formulations and application methods that effectively control the invasive species being treated.

The application of pesticides is regulated by the NJ Department of Environmental Protection - Pesticide Control Program (PCP). Lead staff members involved with the application of herbicides must become ‘commercial pesticide applicators’, which requires attendance in a one-day course on pesticide safety, passing PCP’s core exam and at least one PCP category exam and completing 40 hours of on-the-job training for each category of pesticide application. There are two categories that cover any potential applications in natural areas and stewards would be required to pass both category exams along with the core exam. These categories include Category 2: Forest Pest Control and Category 5: Aquatic Pest Control (required for wetland applications).

Additional staff or seasonal interns may opt to become ‘certified pesticide operators’, which requires attendance in a one-day training course on pesticide safety and receipt of 40 hours of on-the-job training for each category of pesticide application. Operators are not required to pass any examinations and must be directly supervised by a certified pesticide applicator. According to current regulations, direct supervision beyond the 40-hour on-the-job training consists of operators being within “very timely voice contact” and within “three travel hours by land”. Staff members, interns or volunteers that are not certified applicators or operators may still apply herbicides if a certified applicator is always physically present and, in the line-of-sight of the non-certified staff member or volunteer. These restrictions are only relevant if invasive control work with herbicides is not contracted out.

The PCP also requires a permit for any wetland applications of pesticides. Currently, this involves a simple reporting form and an associated $75 fee. In some cases, the PCP may require an additional permit from the NJ Department of Environmental Protection - Division of Land Use when control work is deemed to significantly alter the vegetative structure of a wetland (e.g., removal of significant invasive shrub cover to promote an herbaceous wetland).

Table 1. Description of Invasive Plant Control Methods

Control Method	Description	Pros	Cons	Notes
Biological	Introduction of a biocontrol agent (e.g., insect, pathogen) from the invasive species' native range	Dramatic reduction in abundance with minimal costs; minimal accessibility issues	Limited number of invasive species have agents	Requires extensive resources to provide effective host-specific agents; Numerous federal regulations provide significantly reduced risk of impacts to non-targets species
Mechanical	Physical removal of all or portions of an invasive species	No requirement for specialized training; can be performed by volunteers	Very labor intensive; may require specialized equipment; site accessibility issues, impractical for large infestations; re-sprouting or further invasive species dissemination may occur	Common techniques include mowing, cutting, pulling, and girdling
Chemical	Application of herbicide to all or portions of a plant	Most effective and efficient method in most cases; trained staff can be assisted by volunteers	Labor intensive; site accessibility issues; requires specialized training/license and equipment; may require repeated applications for more difficult species	Common applications include foliar, cut stump, basal bark, and injection; Mechanical and chemical controls may be combined for cut stump and hack-and-squirt methods
Cultural	Removal of invasive species through broad land use activities	Very cost effective	Does not apply well to forest habitats	Primarily applies to agricultural or horticultural systems, but may apply to the maintenance of early successional natural systems including grasslands; Techniques include prescribed fire and prescribed grazing
Ecological	Allowing natural ecological processes (e.g., competition for light and soil resources, predator-prey relationships, etc.) to reduce invasive species over time	Very cost effective; utilizes natural processes	May not occur in many systems due to persistent or continuing human impacts (e.g., overabundant deer, continual physical disturbance, habitat fragmentation, etc.)	Primarily applies to forest systems; As an example, strong anecdotal evidence suggests that overabundant deer facilitate infestations by Japanese Stiltgrass and other invasive species in forests by removing the native shrub layer

Table 2. Specific Control Techniques by Invasive Plant Class

Invasive Species Class	Suggested Treatment Techniques [1]	Notes
Large tree	Basal Bark, Girdling or Harvesting	May be combined with herbicide application to girdled area
Large shrub / small tree	Basal bark, Hack-and-Squirt, Cut Stump, Girdling	Mowing may be used as a pre-treatment to reduce plant size prior to chemical treatments
Small shrub / tree sapling	Basal Bark, Foliar Spray, Cut Stump, Pulling	Mowing may be used as a pre-treatment to reduce plant size prior to chemical treatments; Prescribed Fire or Prescribed Grazing may be used in grassland habitat
Large vines	Basal Bark, Cut Stump, Hack-and-Squirt	Many vine species have extensive root systems that require herbicide treatment
Forest herbs, woody seedlings, and small vines	Foliar Spray, Pulling	Mulching may be utilized in garden beds or other human-modified areas

Biological control involves the purposeful introduction of an insect or pathogen (biocontrol agent) that attacks an invasive species. The biocontrol agent is usually native to the same point of origin as the invasive species. Biological control is the most effective treatment technology for the limited number of invasive species where biocontrol agents have been developed. Biological control has had notable success stories and notorious failures. For example, the non-native Indian mongoose was released to control non-native rats (European and Asian) in sugarcane plantations in the West Indies. The mongoose was only partially effective (only controlled the Asiatic rat), but proceeded to consume native birds, amphibians, and reptiles and ten species were driven to extinction. They also preyed upon domesticated poultry. Finally, the mongoose became a vector of infectious diseases such as rabies. The total economic cost of that biocontrol agent approaches $50 million dollars per year (Pimentel et al. 2005). Notable success stories include the control of alligator weed (New Zealand, Australia, US), mist flower (Hawaii), nodding thistle (New Zealand), prickly pear (Australia), ragwort (New Zealand) and St. John's wort (New Zealand, Canada). In New Jersey, biological control of purple loosestrife has been remarkably effective toward eliminating persistent infestations, making loosestrife a small component of plant communities with only transient outbreaks that are quickly tamped down. Modern biological control involves thorough testing for 'host specificity' (making sure that the newly released biocontrol agent does not harm anything but the invasive species being targeted). This does not guarantee unintended consequences but provides a reasonable reduction of risk that is assumed to be lower than the risk of damage known to occur through the unchecked spread of the targeted invasive species.

Biological control agents for Mile-a-Minute were introduced by the New Jersey Department of Agriculture in 2007 and again in 2013. They have successfully dispersed throughout the state but have yet to have significant impacts on the plant population. Researchers are developing a biocontrol agent for garlic mustard, which is one of New Jersey's worst invasive species (Van Driesche et al. 2002). Research to determine natural enemies of garlic mustard began in 1998. Five weevil species and one flea beetle species were selected as potential biocontrol agents based upon field observations of host specificity and extent of damage created on garlic mustard in its native range. Researchers are currently in the process of performing laboratory tests of host specificity that includes related native species and agricultural crops in the mustard family (Brassicaceae). In addition, studies will be conducted to determine which biocontrol agents or combination of agents may lead to the greatest impacts on garlic mustard. Some of this research will be conducted during field trials in garlic mustard's native range, while others will occur under laboratory conditions. All testing will be done using widely standardized techniques and following guidelines established in the literature and by the U.S. Department of Agriculture.

Cultural control is similar to the concept of agricultural best management practices but can be applied to early successional natural systems (e.g., grasslands, meadows). There are numerous practices that could have the effect of reducing invasive species as well as native woody species. These practices could involve planting native warm season grasses, prescribed fire, prescribed grazing, and elimination of hedgerows to promote grassland or meadow plant communities that sustain themselves with minimal use of mowing and herbicide application. Prescribed fire can be an effective technique to maintain grasslands and the use of fire for ecological purposes has received attention across the world (Myers 2006 and references therein). The primary benefit of prescribed fire is its combination of cost efficiency and efficacy, especially where native warm season grasses have been established.

Prescribed grazing is defined as the application of a specific kind of livestock at a determined season, duration, and intensity to accomplish defined vegetation or landscape goals (Launchbaugh 2006). The benefits of using livestock to control invasive species have been demonstrated for New Jersey's bog turtles (Tesauro 2001). This work primarily involved the use of cows to consume and destroy root mats of invasive species such as Phragmites and purple loosestrife. Another potential application may be the use of goats or other livestock to consume dense thickets of multiflora rose or autumn olive. There are a

number of practical considerations (e.g., cost associated with fencing materials), but targeted grazing may be the best option for land managers under certain conditions.

Ecological control of invasive species refers to the reduction of invasive species through competitive interactions with native species. Strong anecdotal evidence of other sites in New Jersey (e.g., portions of Cushetunk Mountain, Stephens State Park, Wawayanda State Park and Ted Stiles Preserve at Baldpate Mountain) indicate that a healthy native forest can ***resist and reverse*** infestations even when invasive species are located nearby or within the forest (invasive species may be restricted to highly disturbed trail edges without proliferating in the forest interior).

Although the removal of invasive species by any method has the implicit goal of fostering native species that will resist future infestations, there are a variety of factors that limit native species ability to exert ecological control. The single largest factor that can be locally remedied is overabundance of white-tailed deer.

Altered Soils from Past Agricultural Use

Natural plant communities growing on former agricultural areas are often beset with infestations of invasive species due to degradation of soils. It is not uncommon to find clear demarcations of infestations in forest habitat (e.g., one side of stone wall or stream is severely infested while the other side is minimally infested). Anecdotally, these demarcations are correlated with former agricultural areas as shown in 1930 historical aerial photography. Presumably, areas showing forest cover in 1930 had never been plowed. It appears reasonable to assume that formerly tilled areas are much more susceptible to invasion than untilled areas.

Native forest soils consist of a series of layers. The "O Horizon" is the top layer and consists of fresh and incompletely decomposed organic matter (i.e., leaves and humus). The next layer is the "A Horizon", which consists of mineral soil mixed with organic material leached down from the O Horizon. The remaining horizons (E, B and C) are defined by chemical leaching and accumulation of minerals over time and contain little or no organic material. Bedrock is located under the C Horizon.

Formerly tilled agricultural soils are quite different than native soils. In general, all soil horizons within one foot of the surface have been mixed into a uniform and unnatural soil horizon. In addition, traditional agricultural activities (e.g., repeated tilling, application of lime and phosphorous, utilization of heavy machinery) create long-term soil changes including loss of organic matter, elevated pH, increased amounts of calcium and phosphorous, and compaction from machinery causing poor water infiltration. These changes also induce fundamental changes in nitrogen cycles and composition of soil microorganism species composition. All of these changes have implications for seed germination and root growth. Although many common native species can grow on these altered soils, it appears that weedy invasive species are most aggressive under these conditions.

The impact of earthworms is also associated with former agricultural activity, but adjacent unplowed forest soils can also be infested. Over time, earthworms mix and eliminate the topsoil horizons and virtually eliminate the O Horizon and change soil microorganism species composition. In addition to changing physical properties of the soil (i.e., removing the O Horizon), earthworms change the natural nitrogen cycle. The result is the conversion of nitrogen into a form more readily used by plants, but this increased availability also increases leaching of nitrogen out of the soils. In addition, this change in nitrogen availability causes a shift in soil microorganisms from being dominated by fungi to being dominated by bacteria. This change may impact roots of many native plants that can be physically connected to particular soil fungi (called mycorrhizal fungi) in a symbiotic relationship that allows plants to absorb particular nutrients from the soil.

Suspected relationships and impacts are presented in Figure 5. Actual data showing changes in forest and untilled soil measured in Hopewell Township, Mercer County, New Jersey are presented as a case study in Figure 6.

The combined impacts of past agricultural tilling, alone or in concert with changes induced by invasive earthworms, are profound. However, it is important to note that even though impacted forests may not achieve perfect health, substantial improvements in most New Jersey forests can be obtained by reducing deer browse pressure on native plants that have the ability to survive these altered soil conditions.

Figure 4. Suspected Impacts of Past Agricultural Tilling

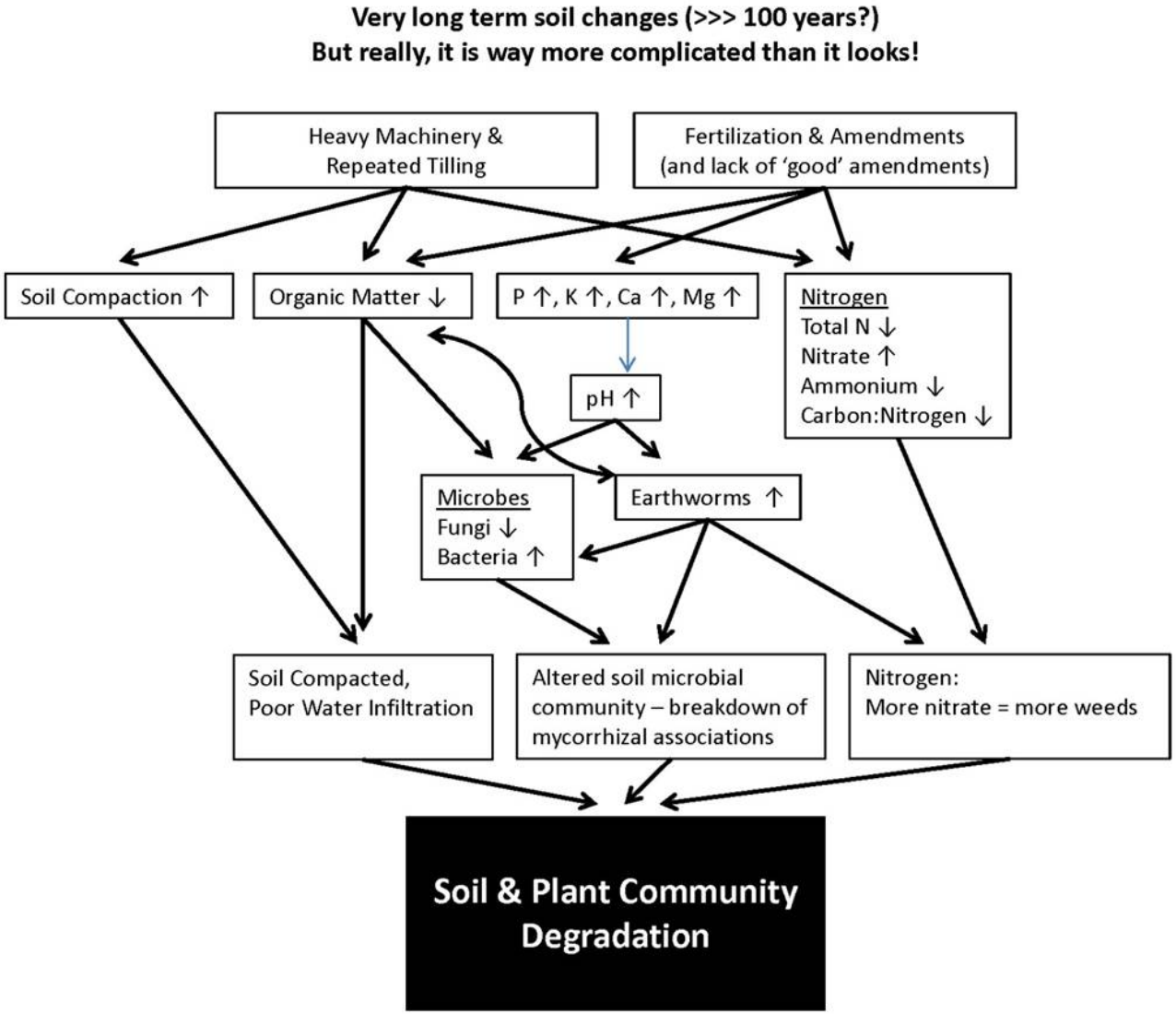
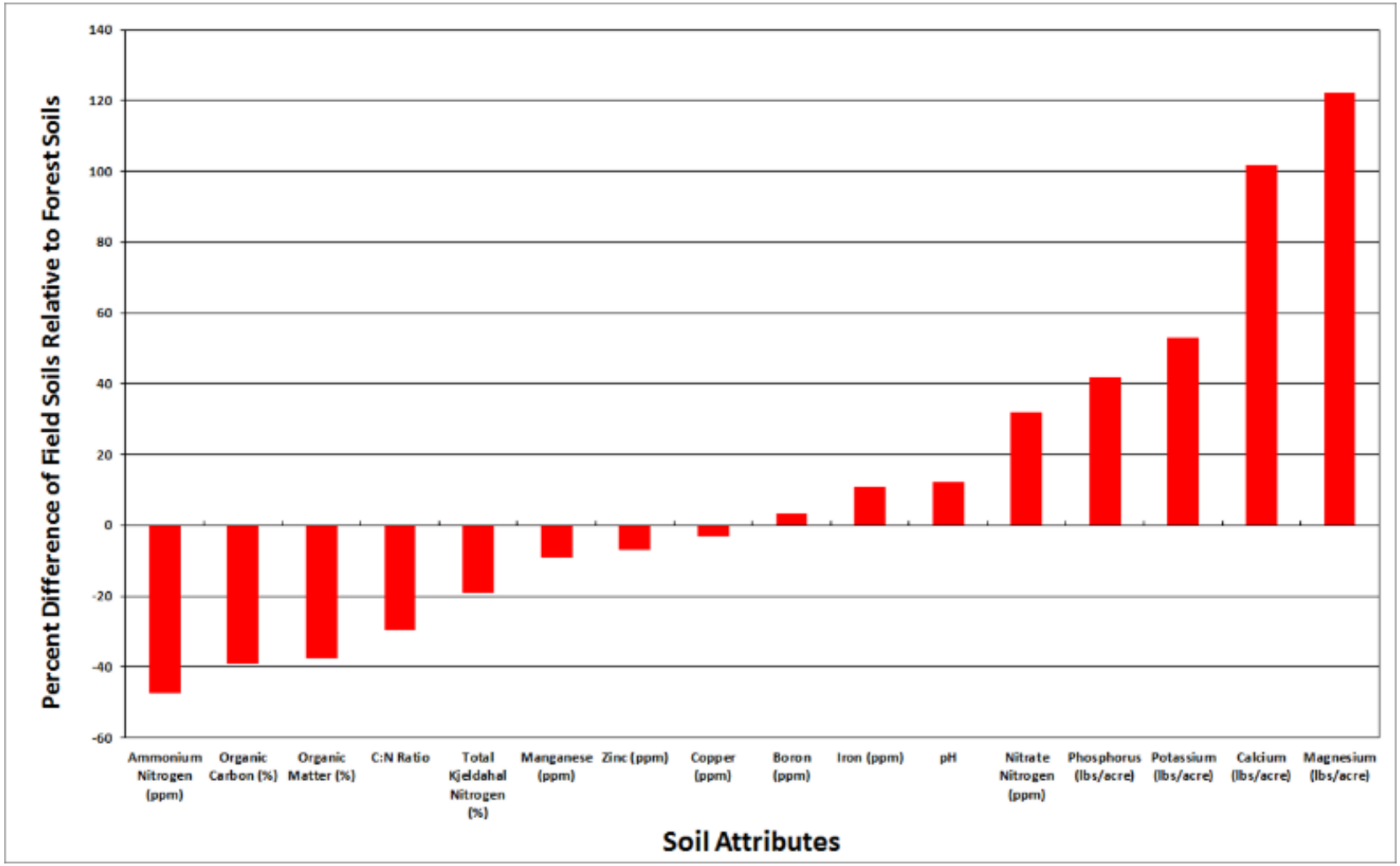


Figure 5. Measured Chemical Changes in Soils from Tilled and Untilled Soils



Stewardship Context

Stewardship activities must consider the context of the Property to maximize effectiveness. This plan section considers physical features and land cover (both historic and current).

Physical Features

Geology **-** The Property fully occurs on the Ramseyburg Member formation, composed of graywacke sandstone and siltstone, shale, and slate. Table 3 provides a summary of the bedrock geology and Map 2 depicts bedrock distribution.

The topography within the Property gradually increases from approximately 800 to 900 feet above sea level. Topography is depicted in Map 3.

Table 3. Bedrock Geology Summary

Name	Lithology	Acres	Percent of Property
Ramseyburg Member	Graywacke sandstone and siltstone, shale and slate	114	100
Totals		**114**	**100**

Soils - There are three unique soil types within the Property (USDA soil survey report provided as Appendix A). They are 1) Alden silt loam, 0 to 8 percent slopes, extremely stony (37.7% of Property), 2) Wurtsboro-Swartswood complex, 8 to 15 percent slopes, extremely stony (30.8%), and 3) Wurtsboro-Swartswood complex, 15 to 35 percent slopes, extremely stony (31.5%). The Alden silt loam is typically associated with the wetland areas throughout the Property, which also contains heavier Japanese barberry infestations than other areas of the preserve (Species Map 6).

A summary of soil types is provided in Table 4 and their distribution is depicted in Map 4.

Table 4. Soil Type Summary

Soil Symbol	Description	Acres	Percent of Property
AhbBc	Alden silt loam, 0 to 8 percent slopes, extremely stony	42.8	37.7
WusCc	Wurtsboro-Swartswood complex, 8 to 15 percent slopes, extremely stony	35.0	30.8
WusDc	Wurtsboro-Swartswood complex, 15 to 35 percent slopes, extremely stony	35.8	31.5
Totals		**114**	**100**

Water - Water and wetlands are depicted on Map 5. Paulins Kill Tributary flows northeast to southwest for 0.7 miles through the approximate center of the Property. An unnamed tributary in the Property splits from Paulins Kill Tributary and travels 0.4 miles. Wetlands are sparingly represented on the NJDEP GIS data layer, but community mapping identified approximately 36.4 acres of wetlands.

Land Cover - Historic and Current

The 2015 land use for the Property and within five miles of the Property are summarized below (Table 5 and depicted in Maps 6 & 7, respectively). Approximately 13.8% of the surrounding area is developed or barren, with 12.1% cover as agricultural lands. The majority of natural cover is represented by forest habitat (56% of area), with lesser amounts of woodland and shrubland habitats. The Property itself contains 97% cover as forest habitat.

Table 5. Land Cover Types for Property and Surrounding Area (2015)

Type	Property Acres	% of Property Acres	5 Mile Radius Acres	% of 5 Mile Radius
Urban	3	2.2	5923	13.7
Barren	0	0	55	0.13
Agriculture	1	1	5202	12.1
Water	0	0	1920	4.5
Forest - Coniferous - Upland	0	0	1867	4.3
Forest - Coniferous - Wetland	0	0	58	0.13
Forest - Deciduous - Upland	74	64.7	20256	47.1
Forest - Deciduous - Wetland	36	32	2029	4.7
Woodland - Coniferous - Upland	0	0	199	0.46
Woodland - Deciduous - Upland	0	0	2179	5.1
Shrubland - Coniferous - Upland	0	0	400	0.92
Shrubland - Coniferous - Wetland	0	0	18	0.04
Shrubland - Deciduous - Upland	0	0	1574	3.7
Shrubland - Deciduous - Wetland	0	0	401	0.93
Meadow - Upland	0.02	0.01	552	1.3
Meadow - Wetland	0	0	402	0.93
Totals	**114**	**100**	**43035**	**100**

Maps 8-12 compare forest patches on the Property from 1890 to 2015. The overlap of 1890s forest patches onto 2015 aerial photography (Map 9) and the overlap of 1930s forest patches onto 2015 aerial photography (Map 11) show that the Property was evenly divided between forest and agricultural cover (or recovering from agricultural cover). Map 12 shows these patches overlapping each other for a better depiction of how the land changed in that time.

As mentioned above, forest lands occurred where agricultural tillage would have been impractical. The overlap of forest coverage between 1890, 1930 and current forest is summarized in Table 6 and depicted on Map 12. Field surveys conducted in 2021 show that forest and woodland habitats cover almost 97% of the Property. Approximately 33% of the Property appears to have had continuous forest cover from 1890 to 1930, and 46% of the Property appears to have had continuous forest cover between 1930 and 2021.

Table 6. Historic and Current Forest Cover

Year	Acres	% of Property
1890	50.1	44.1
1930	52.2	46
1890 and 1930	37.9	33.3
2015	110	96.8
1930 and 2015	52.2	46

These patterns of land use require careful consideration toward the development of stewardship recommendations. For example, former agricultural lands that have developed into forests are now heavily infested with invasive species, while the original forest areas seen in 1890 and 1930 presents the best opportunity to maintain and improve forest health. Similarly, the riparian areas of the Property that are now heavily infested with invasive species, presenting a challenge for healthy forest development. Disturbances in these riparian areas could lead to even more invasive introductions, as these areas typically offer their optimal growing conditions.

It is important to note that intensive timber extraction occurred on the Preserve for at least the last 20 years. Logging focused on removal of high value oak species, leaving behind less desirable species such as American Beech. These activities, along with fire suppression and excessive deer herbivory contribute to existing forest composition.

Protected Lands - There are numerous patches of protected open space within five miles of the Property, the majority existing around the Delaware Water Gap (Map 13). These lands include the Delaware Water Gap National Recreation Area, Worthington State Forest, White Lake Wildlife Management Area, and multiple locations of preserved farmland.

Section II. Conservation Values

Introduction

This section provides conservation values within the Property and landscape-scale values provided through review of information available from the Endangered and Nongame Species Program and Natural Heritage Program of the NJ Department of Environmental Protection. This section provides results of ecological community mapping performed throughout the Property.

The primary habitat conservation values include forest and woodland. Forest communities serve as the basis for a broad range of common plant and animal species typical of the Eastern United States. The Property is large enough to provide nesting habitat for area-demanding species (e.g., Kentucky Warbler) and can act as habitat for many rare species, providing stopover feeding opportunities for Neotropical migrant birds and nesting habitat for many other species (e.g., Wood Thrush).

Landscape-scale Conservation Values

The Landscape Project (Version 3.3) is a product of the New Jersey Department of Environmental Protection, Division of Fish & Wildlife, Endangered and Nongame Species Program (ENSP). The Landscape Project prioritizes sites based upon the biodiversity significance of animal species utilizing patches of habitat. Habitat patches are ranked from 5 (highest) to 1 (lowest). Patch ranks are based upon the level of rarity of the rarest species known to occur within the patch (Note: A single habitat patch may contain multiple species with various ranks, but the overall patch ranking is derived from the occurrence of the species with the highest rank.). A rank of '5' signifies patches containing federally endangered or threatened species, Rank 4 patches contain state endangered species, Rank 3 patches contain state threatened species, Rank 2 patches contain state species of concern, and Rank 1 patches have suitable habitat for rare animals, but do not contain confirmed occurrences.

Patch ranks on the Property are depicted in Map 14 and summarized in Table 7. Habitat patches that intersect with the Property are primarily Rank 5 (97% of the Property).

The Landscape Project also characterizes habitat patch sizes, which are shown in Map 15 and summarized in Table 8. The largest patch is associated with Rank 5 forest habitat. Approximately 37 acres of the 442-acre patch are located within the Property (remaining patch area is located northeast and west of the property). Being that the Property is large enough on its own and is connected to such a large habitat patch, it provides area-demanding species ample room to breed within the boundaries, while also providing significant stop-over habitat for migrating birds and other species of resident birds, reptiles, and amphibians, acting as a significant riparian wildlife corridor.

Table 7. Landscape Project Patch Rank Summary

Rank	Acres	% of Property
5	110	97
4	0.015	0.013
3	0	0
2	4	3
1	0	0
Totals	**114**	**100**

Table 8. Landscape Project Patch Size Summary

Patch Size	Number of Patches	Total Property Acres within Patch Size Class	% of Property
<10 acres	27	33	29
10-25 acres	2	44	39
25-50 acres	1	37	32
50-100 acres	0	0	0
100-1000 acres	0	0	0
Totals	30	114	100

The Landscape Project maps vernal habitat and waterbodies that harbor rare species. There is one potential vernal pool habitat area noted in the Landscape Project (Map 16). The importance of vernal habitat to many amphibians warrants additional surveys to confirm vernal habitat presence important for a number of relatively common salamanders (e.g., Spotted Salamanders) and frogs (e.g., Wood Frogs) that require such habitats. During field studies in 2021, there were several potential vernal pool areas documented, and are also depicted in Map 16.

Connecting Habitat Across New Jersey (CHANJ) is a project of the Endangered and Nongame Species Program (ENSP). The project is an effort to make the landscape and roadways more permeable for terrestrial wildlife by identifying key areas and actions needed to achieve habitat connectivity across the state. CHANJ offers two main products including a statewide mapping and guidance document to help prioritize land protection, inform habitat restoration and management, and guide mitigation of road barrier effects on wildlife and their habitats. Mapping products identify core habitats (largest habitat patches > 200 acres), steppingstone habitats (smaller habitats from 30 to 200 acres) and corridor habitats that connect core and steppingstone habitats. Corridors are categorized from 1 (easiest wildlife passages) to 5 (more difficult wildlife passages). Finally, road culverts and road segments are identified in places where mitigation efforts would be most beneficial.

The context of the Property relative to core, steppingstones, and corridors is depicted in Map 17. The Property is considered part of a large core habitat patch with a majority of the patch extending northwest into the Delaware Water Gap.

The New Jersey Natural Heritage Program (NJNHP) is part of the New Jersey Department of Environmental Protection, Division of Parks and Forestry, Office of Natural Lands Management. The Heritage Program identifies significant natural lands throughout the state, designating them as Natural Heritage Sites or Macrosites. The Property does not contain any Natural Heritage sites or macrosites. The Heritage Program also provides a GIS layer consisting of 368-acre grids covering the entire state that identify rare species known to occur within the grids. The Property does not contain any Natural Heritage grids (See Map 18).

The National Audubon Society identifies and monitors Important Bird Areas (IBAs) across the country to assist in conserving important bird habitat areas. There are six IBAs potentially overlapping or being within the vicinity of the Property. These large areas are not firmly distinguished from each other in their GIS shapefile, resulting in some areas being labeled as being more than one IBA, despite these areas actually being in separate geographical areas. It is for this reason that the Property is documented as falling in the same range as the Kittatinny Mountain Eastern Slope, Walpack Valley, Stokes State Forest and High Point State Park, Old Mine Road, Mount Tammany Cliffs and Bear Swamp Important Bird Areas, as seen in Map 19. We believe that the Yards Creek Preserve is most likely part of the Kittatinny Mountain Eastern Slope IBA.

Ecological Communities

Ecological communities were mapped at the Property in October 2021. Communities were mapped through a process of crosschecking between four sources of information, which included field survey, 2015 aerial orthophotography, GIS-based 2015 land cover classifications and NJDEP GIS wetland status. Field observations of species present within the canopy, shrub, and herbaceous layers were recorded and correlated with a ‘signature’ on aerial photography. Ecological community patches occurring within the Property were assigned one of four broad natural types (Table 9); forests and woodlands were further characterized by predominant tree species (Table 10 shows acreage for 18 different types). See Appendix B for raw mapping data for each mapped patch.

There was a total of 60 mapped ecological community patches across 114 mapped acres. In some cases, adjacent patches with the same ecological community designation were provided separate patch designations because of differences in the mapped invasive species cover, which is often a proxy for differences in past land use and canopy density (former agricultural lands and forests with more open canopies have higher amounts of invasive species). Maps depicting various attributes reported in Appendix B are found in the following maps and summarized in associated tables below:

- Maps 20 and 21, Table 9 - Broad ecological communities

  Forests are defined as having > 75% canopy cover, while woodlands are defined by having 25 - 75% canopy cover. Shrublands have < 25% tree canopy and > 50% shrub cover. Meadows have < 50% shrub cover and >75% herbaceous cover.

Forest and woodland habitats (ca. 97% of Property) are the dominant natural ecological communities with meadow (ca. 2%), and shrubland (ca. 1%) communities accounting for far lesser coverage (Map 20).

Natural communities were also divided into moisture categories determined by affinities of plant species present and landforms (Map 21). These categories included upland, wetland and transitional (areas with components including upland and wetland species and mixed landforms). The three categories were remarkably evenly represented with upland, transitional, and wetland types accounting for approximately 33%, 34%, and 33% of the Property, respectively.

Table 9. Broad Ecological Community Type Summary

Broad Habitat Type	Acres	Percent of Property
Forest	55.2	48.4
Meadow	2.5	2.2
Shrubland	0.9	0.8
Woodland	55.4	48.6
Totals	**114**	**100**

Habitat Moisture Type	Acres	Percent of Property
Upland	37.8	33.2
Transitional	38.9	34.1
Wetland	37.3	32.7
Totals	**114**	**100**

- Table 10 – Specific Plant Community Types

Forest and woodland communities are variable and distinct types often blend into each other. However, an effort was made to simplify these communities by noting predominant tree species, genera, and/or types.

Almost the entirety of the Property was comprised of mixed deciduous types of forest and woodland (ca. 96%). Within the mixed deciduous classification, red maple, oak and beech dominated patches were observed with percent coverages of 18%, 12%, and 3% respectively.

Table 10. Specific Ecological Community Type Summary

Community Type	Acres	Percent of Property
Forest - Transitional - Mixed Deciduous	11.4	10
Forest - Transitional - Red Maple-Mixed Deciduous	1.7	1.5
Forest - Upland - Beech-Mixed Deciduous	3.9	3.4
Forest - Upland - Mixed Deciduous	15.7	13.8
Forest - Upland - Oak-Mixed Deciduous	10.1	8.9
Forest - Wetland - Mixed Deciduous	2.1	1.8
Forest - Wetland - Red Maple-Mixed Deciduous	10.3	9
Meadow - Upland - Planted Trees	0.9	0.8
Meadow - Wetland	0.3	0.3
Meadow - Wetland - Planted Trees	1.3	1.1
Shrubland - Upland	0.9	0.8
Woodland - Transitional - Mixed Deciduous	23.8	20.9
Woodland - Transitional - Red Maple - Mixed Deciduous	2.1	1.9
Woodland - Upland - Mixed Deciduous	3.9	3.4
Woodland - Upland - Oak-Mixed Deiduous	3.4	3
Woodland - Upland - Planted	1.4	1.2
Woodland - Wetland - Mixed Deciduous	14.4	12.6
Woodland - Wetland - Red Maple-Mixed Deciduous	6.4	5.6
Totals	**114**	**100**

- Maps 23 - 24; Tables 11 - 13 – Regenerating Trees, Native Shrub and Tree Cover, and Native Herbaceous Cover

Native Tree Regeneration (seedlings > 3 foot tall) are summarized in Table 11. There were only 8.9 acres of observed regeneration. A vast majority of this regeneration, 98%, was categorized as covering <25% of the surveyed patches.

Across New Jersey, native understory cover averages less than 20%. Ideally, native understory cover in healthy forests would be above 70%. Native shrubs and herbaceous species (both vulnerable to deer browse) were low across a majority of the Property.

Native Shrub and Tree Cover (Map 23, Table 12). Approximately 43% of forest and 48% of woodland communities had < 1% native tree and shrub understory cover. When looking at cover < 25%, these numbers increased to 74% of forest and 67% of woodland communities. There were, however, notable patches of quality. Native tree and shrub understory cover >50% accounted for 6% of forest patches and 33% of woodland patches. Within the shrubland habitat, which tended to be dominated by unpalatable invasive species, native tree and shrub cover was almost non-existent, <1%. All meadow communities also contained < 1% cover.

Native herbaceous species (wildflowers and grasses) were sparse throughout much of the Property (Map 24, Table 13). 28% of meadows, 100% of shrubland, 71% of woodland, and 91% of forests add had less than 10% cover and showed deer browse. Unlike forests, meadows can grow dense patches of native wildflowers (primarily due to the sheer number of plants) and grasses (unpalatable to deer). The meadow patches showed the highest herb cover with 72% containing at least 10% native cover.

Table 11. Tree and Shrub Regeneration Summary

Final Patch ID	Acres	Cover Category	Species
47	1.8	1-10%	American Beech, White Pine, Sweet Birch
56	1.4	11-25%	American Beech, White Pine, Sweet Birch
59	0.2	75-100%	American Beech, White Pine, Sweet Birch
51	3.1	11-25%	American Beech
32	1.8	1-10%	Sweet Birch, American Beech
15	0.6	11-25%	American Beech
Totals	**8.9**		

Table 12. Native Shrub and Tree Understory Cover by Community Type

Community Type	Native Shrub and Tree Cover Category	Acres	Percent of Total Community Type Area
Forest	Absent	0	0
Forest	< 1%	23.6	42.9
Forest	1-10%	14.3	26
Forest	11-25%	2.5	4.6
Forest	26-50%	11.5	20.9
Forest	51-75%	0	0
Forest	76-100%	3.1	5.6
Forest - Total		**55**	**100**
Woodland	Absent	1.4	2.5
Woodland	< 1%	25	45.3
Woodland	1-10%	4.9	8.9
Woodland	11-25%	2.5	4.5
Woodland	26-50%	3.1	5.6
Woodland	51-75%	10	18.1
Woodland	76-100%	8.3	15.1
Woodland - Total		**55.2**	**100**
Shrubland	Absent	0	0
Shrubland	< 1%	0.9	100
Shrubland	1-10%	0	0
Shrubland	11-25%	0	0
Shrubland	26-50%	0	0
Shrubland	51-75%	0	0
Shrubland	76-100%	0	0
Shrubland - Total		**0.9**	**100**
Meadow	Absent	0.4	14
Meadow	< 1%	2.1	84
Meadow	1-10%	0	0
Meadow	11-25%	0	0
Meadow	26-50%	0	0
Meadow	51-75%	0	0
Meadow	76-100%	0	0
Meadow - Total		**2.5**	**100**

Table 13. Native Herbaceous Cover by Community Type

Community Type	Native Herb Cover Category	Acres	Percent of Total Community Type Area
Forest	Absent	0	0
Forest	< 1%	36.3	66
Forest	1-10%	13.5	24.5
Forest	11-25%	2.5	4.5
Forest	26-50%	2.3	4.2
Forest	51-75%	0.4	0.8
Forest	76-100%	0	0
Forest - Total		**55**	**100**
Woodland	Absent	0	0
Woodland	< 1%	25.4	46
Woodland	1-10%	14	25.4
Woodland	11-25%	6.5	11.8
Woodland	26-50%	0	0
Woodland	51-75%	2	3.6
Woodland	76-100%	7.3	13.2
Woodland - Total		**55.2**	**100**
Shrubland	Absent	0	0
Shrubland	< 1%	0	0
Shrubland	1-10%	0.9	100
Shrubland	11-25%	0	0
Shrubland	26-50%	0	0
Shrubland	51-75%	0	0
Shrubland	76-100%	0	0
Shrubland - Total		**0.9**	**100**
Meadow	Absent	0	0
Meadow	< 1%	0	0
Meadow	1-10%	0.7	28
Meadow	11-25%	1.4	56
Meadow	26-50%	0.4	16
Meadow	51-75%	0	0
Meadow	76-100%	0	0
Meadow - Total		**2.5**	**100**

- Map 25 and Tables 14-15 - Relative patch quality

This is a subjective characterization based upon the following attributes: land use history, amount of invasive species cover, amount of native shrub and herbaceous cover, and presence of regenerating native trees. The relative quality ranks were 'High' or 'Moderate' across 75.9 acres (ca. 67% of the Property) and 'Low' for remaining areas (ca. 33%) (Map 25).

Community quality rankings were used to determine strategies in Section IV and a summary of the relative patch quality is provided in Table 14. For this plan three main stewardship units were selected based on location, quality, and habitat characteristics. These units consist of the Northern Unit, Central Eastern unit, and Southeastern corner unit. These units are comprised of high-quality patches with adjacent moderate quality patches that should be considered for stewardship efforts. In conjunction to these cohesive units, additional high quality patches were documented and listed below. A summary of native species and invasive species threats in each stewardship unit is provided in Table 15. Table 15 is segmented into 4 parts to denote the different stewardship units.

Table 14. Relative Patch Quality Summary

Relatively Quality Rank	Acres	Percent of Natural Cover
High	49.2	43.3
Moderate	26.7	23.5
Low	37.7	33.2
Totals	**113.6**	**100**

Table 15. Highest Quality Habitat Patches

(Species codes for trees and shrubs provided in Appendix C)

Stewardship Unit A: Northern Section

Final Patch ID	Broad Community Type	Patch Acres	Native trees	Native Shrubs	Native Herbs	Inavsive Species	Patch Quality
7	Forest - Upland - Oak-Mixed Deiduous	8.5	QUAL, ACRU, FAGR, BELE, QUVE, NYSY	FAGR, GABA, VAPA, TSCA, SMRO, CACA	partridgeberry, tiny azaeleas, white grass, ground pine, ground cedar, white snakeroot, rattlesnake plantain, beech drops, indian cucumber root, striped wintergreen, wintergreen	Trace amounts of Japanese barberry and Japanese stiltgrass	High
5	Woodland - Wetland - Mixed Deciduous	1.0	FAGR, CAOV, ACRU, LITU, QURU, QUVE,	FAGR, GABA, HAVI, shadbush	hay scented fern, wood fern	Trace amounts of Japanese barberry and Norway spruce. 1-10% cover of Japanese Stiltgrass	High
8	Woodland - Transitional - Mixed Deciduous	2.6	ACRU, BELE, FAGR, QUVE, NYSY, BEAL	GABA, FAGR, RUAL, VAPA	solomon's seal, cinnamon fern, partridgeberry, hay scented fern, wintergreen, indian cucmber root, canada mayflower, ground cedar, striped wintergreen	No observed invasive species	High
9	Forest - Upland - Mixed Deciduous	3.1	FAGR, QUAL, QURU, ULAM	FAGR, GABA, CACA	hay scented fern, ground cedar, striped wintergreen, partridgeberry	No observed invasive species	High
11	Woodland - Transitional - Mixed Deciduous	0.9	ACRU, BELE, FAGR, QUVE, NYSYS, BEA	GABA, FAGR, RUAL, VAPA	solomon's seal, cinnamon fern, partridgeberry, hay scented fern, wintergreen, indian cucmber root, canada mayflower, ground cedar, striped wintergreen	No observed invasive species	High
1	Woodland - Upland - Mixed Deciduous	0.7	QUAL, TIAM, ACSA, NYSY, ACRU, CALA	FAGR, GABA	white wood aster, white snakeroot, goldenrod, hayscented fern, broadleaf sedge	Trace amounts of multiflora rose and Japanese wineberry. 11-25% cover of Japanese Barberry. 51-75% cover of Japanese Stiltgrass	Moderate
2	Forest - Upland - Mixed Deciduous	1.9	FAGR, NYSY, LITU, CAOV, CALA	FAGR, BELE, GABA	hay scented fern, canada mayflower, white grass, partridgeberry, goldenrod, white snakeroot, indian cucumnber root	Trace amounts of multiflora rose. 1-10% cover of Japanese barberry. 26-50% cover of Japanese stiltgrass	Moderate
3	Oak-Mixed Deiduous	1.5	QUVE, QUAL, FAGR, CAOV	FAGR, OSVI, GABA	white wood aster, white snakeroot, partridgeberry, hayscented fern, broad leaf sedge	Trace amounts of Japanese barberry. 1-10% cover of Japanese barberry and multiflora rose	Moderate
4	Forest - Wetland - Mixed Deciduous	1.5	DEAD FRAM, CACA, CAOV, ACRU, NYSY	VACO, CACA, OSVI, ULAM, FRAM, SMRO	sedge, sensitive fern, wild yam, partridgeberry, halbeard leaf tear thumb, cinncamon fern, white wood aster, viola spp	1-10% cover of Japanese barberry. 76-100% cover of Japanese stiltgrass	Moderate
6	Forest - Upland - Mixed Deciduous	2.5	CAOV, OSVI, QUAL, ACRU, FRAM(DEAD)	SMRO, ULAM	broad leaf sedge, goldenrod, white wood aster, partridgeberry, marginal wood fern	Trace amounts of multiflora rose. 1-10% cover of Japanese barberry. 76-100% cover of Japanese stiltgrass	Moderate
10	Forest - Transitional - Mixed Deciduous	1.6	BELE, FAGR, ACRU, NYSY, QUVE	FAGR, SMRO	hay scented fern, christmas fern, ground cedar, white snakeroot	1-10% cover of Japanese barberry and Japanese stiltgrass	Moderate
12	Woodland - Transitional - Mixed Deciduous	0.8	ACRU, QUAL, CAOV	SMRO, FAGR, CACA	NY fern, white grass, jack in the pulpit, hay scented fern, white snakeroot	1-10% cover of Japanese barberry, multiflora rose, and Japanese stiltgrass	Moderate
13	Meadow - Wetland	0.1	None	None	rush, sedge, sensitive fern, narrowleaf goldenrod, arrowhead	Trace amounts of Japanese barberry and multiflora rose. 11-25% cover of common reed. 76-100% cover of Japanese stiltgrass	Moderate
17	Woodland - Upland - Mixed Deciduous	1.1	CAOV, QUAL, CACA, FAGR	FAGR, VIPR, GABA	white snakeroot, partridgeberry	Trace amounts of burning bush and multiflora rose. 11-25% cover of Japanese barberry. 26-50% cover of Japanese stiltgrass	Moderate
	Totals	**27.8**					

Table 15 (continued). Highest Quality Habitat Patches

Stewardship Unit B: Central Eastern Section

Final Patch ID	Broad Community Type	Patch Acres	Native trees	Native Shrubs	Native Herbs	Inavsive Species	Patch Quality
22	Woodland - Transitional - Mixed Deciduous	6.4	CACA. ACRU, QUMO, CAOV	FAGR, GABA, SMRO	beech drops, azaleas, ground cedar, partridgeberry, indian cucumber root	No observed invasive species	High
23	Forest - Transitional - Red Maple-Mixed Deciduous	1.7	ACRU, CAOV, OSVI	FAGR	hay scented fern	Trace amounts of Japanese barberry and multiflora rose	High
31	Forest - Transitional - Mixed Deciduous	1.4	QUMO, QURU, CAOV, ACRU, ACSA	PIST, FAGR, VAPA	white wood aster, partridgeberry	Trace amounts of Japanese barberry, Japanese stiltgrass, an multiflora rose	High
24	Meadow - Wetland	0.2	None	RUAL	white snakeroot, wool grass, wood nettle, pilewort, wood reed, field aster, canada goldenrod, narrow leaf goldenrod, dogbane, milkweed	Trace amounts of multiflora rose. 1-10% cover of Japanese wineberry. 76-100% cover of Japanese stiltgrass	Moderate
25	Forest - Upland - Beech-Mixed Deciduous	3.9	BELE, FAGR, ACRU, NYSY, QUVE	FAGR, SMRO	hay scented fern, christmas fern, ground cedar, white snakeroot	1-10% cover of Japenese barberry and Japanese stiltgrass	Moderate
29	Woodland - Transitional - Mixed Deciduous	1.2	CAOV, QUAL, ACRU, QURU	FAGR, VIPR, VAPA, SMRO	white snakeroot, white wood aster, violet spp, broad leaf sedge, white grass, partridgeberry	Trace amounts of garlic mustard and multiflora rose. 11-25% cover of Japanese barberry and Japanese stiltgrass	Moderate
	Totals	**14.8**					

Table 15 (continued). Highest Quality Habitat Patches

Stewardship Unit C: Southeast Corner Section

Final Patch ID	Broad Community Type	Patch Acres	Native trees	Native Shrubs	Native Herbs	Inavsive Species	Patch Quality
56	Woodland - Upland - Oak-Mixed Deiduous	1.4	QUVE, QURU, QUMO, BELE, FAGR	FAGR, SMRO, HAVI, PIST, GABA, VAPA, VACO, ILOP	partridge berry, striped wintergreen, indian cucumber root, wintergreen, tiny azaleas, Solomon's seal, ground pine, cinnamon fern	No observed invasive species	High
59	Forest - Upland - Mixed Deciduous	0.2	BELE	PIST, FAGR		Trace amounts of Japanese barberry	High
60	Forest - Wetland - Mixed Deciduous	0.6	ACRU, SAAL, FAGR, QUAL, NYSY	VACO, FAGR, BELE, SMRO, OSVI	cinnamon fern, rush, sedge, Solomon's Seal, New York fern, partridgeberry, indian cucumber root, royal fern, blue flag iris, tiny azaleas	Trace amounts of Japanese barberry	High
57	Oak-Mixed Deiduous	2.0	QUVE, QURU, QUMO, BELE, FAGR	FAGR, SMRO, HAVI, PIST, GABA, VAPA, VACO, ILOP	partridge berry, striped wintergreen, indian cucumber root, wintergreen, tiny azaleas, Solomon's seal, ground pine, cinnamon fern	Trace amounts of Japanese barberry	High
53	Mixed Deciduous	4.8	BELE, CAOV, ACRU, CACA	BELE, FAGR, SMRO, VACO	New York fern, royal fern, cinnamon fern, rush, sedge, violet, tall meadow rue, bracken fern	Trace amounts of Japanese barberry and Japanese stiltgrass	High
54	Mixed Deciduous	4.2	ACRU, CAOV, CACA	BELE, FAGR, VACO	ground pine, hay scented fern, christmas fern, New York fern	Trace amounts of Japanese barberry and multiflora rose	High
51	Mixed Deciduous	3.1	LITU, QUAL, FAGR, CATO, QURU, ACRU	FAGR	Beech drops	Trace amounts of Japanese barberry	High
48	Forest - Transitional - Mixed Deciduous	0.7	BEAL, BELE, ACRU, QUAL, NYSY,FAGR,	HAVI, Male Berry, ILOP, FAGR, VAPA, GABA, shad bush	partridgeberry, hay scented fern, striped wintergreen, broad leaf sedge, TORA, Solomon's Seal, PIST, pinkster azaelea, PAQU	Trace amounts of Japanese barberry and Japanese stiltgrass	High
50	Red Maple-Mixed Deciduou	2.1	ACRU, FRAM (DYING,1)	FAGR	FRAM, NY fern, wood fern, white snakeroot, hog peanut	1-10% cover of Japanese barberry and 75-100% cover of Japanese Stiltgrass	Moderate
52	Red Maple-Mixed Deciduou	0.3	ACRU, BEAL	ILVE, VACO	wood reed, cinnamon fern, rush, sedge, horehound	26-50% cover of Japanese stiltgrass	Moderate
55	Meadow-Planted Trees	0.4	planted trees	RUAL, GABA	white snakerrot, wool grass, wood reed, interrupted fern, sedge, marsh fern, spirea	Trace amounts of Japanese barberry. 1-10% cover of Japanese wineberry. 51-75% cover of Japanese stiltgrass	Moderate
58	Red Maple-Mixed Deciduou	1.4	ACRU, CAOV	BELE, SMRO, CACA	white grass, rush, sedge, violet, jack in the pulpit	Trace amounts of Japanese barberry. 26-50% cover of Japanese stiltgrass	Moderate
	Totals	**21.2**					

Table 15 (continued). Highest Quality Habitat Patches

Stewardship Unit D: Remaining Patches

Final Patch ID	Broad Community Type	Patch Acres	Native trees	Native Shrubs	Native Herbs	Inavsive Species	Patch Quality
43	Forest - Transitional - Mixed Deciduous	0.4	BEAL, BELE, ACRU, QUAL, NYSY,FAGR	HAVI, Maleberry, ILOP, FAGR, VAPA, GABA	partridgeberry, hay scented fern, striped wintergreen, broad leaf sedge, TORA, Solomon's Seal	Trace amounts of Japanese wineberry, Japanese barberry, Japanese stiltgrass, and Norway spruce	High
44	Forest - Transitional - Mixed Deciduous	1.1	BEAL, BELE, ACRU, QUAL, NYSY,FAGR,	HAVI, Male Berry, ILOP, FAGR, VAPA, GABA, shad bush	partridgeberry, hay scented fern, striped wintergreen, broad leaf sedge, TORA, Solomon's Seal, PIST, pinkster azaelea	Trace amounts of Japanese wineberry, Japanese barberry, and Japanese stiltgrass. 1-10% cover of Norway Spruce	High
45	Forest - Transitional - Mixed Deciduous	0.9	NYSY, FAGR, ACRU, QUAL, BELE, BEAL,	PIAB, HAVI, VAPA, ILOP, PAQU	hay scented fern, rattlesnake plantain, spirea alba, RUFL, wood reed, partridge berry, striped wintergreen, woodfern, SMRO, white snakeroot, wild yam, stone root, Solomon's seal, violet spp, hog peanut	Trace amounts of Japanese barberry, Japanese stiltgrass, autumn olive, Norway spruce, and multiflora rose	High
38	Forest - Upland - Mixed Deciduous	2.5	QURU, ACRU, CAOV, NYSY, PIST, POGR,	FAGR	hay scented fern, striped wintergreen, white snakeroot, partridgeberry	Trace amounts of Japanese barberry and Japanese stiltgrass	High
16	Forest - Transitional - Mixed Deciduous	1.6	BELE, ACRU, CAOV, QUAL	GABA, SMRO, FAGR, VIPR	hay scented fern, striped winteergreen, solomon's seal, partridgeberry, ebony spleenwort, broad leaf sedge	Trace amouts of Japanese stiltgrasss. 1-10% cover of Japanese Barberry	High
	Totals	**6.5**					

Flora

Plant species were recorded during field surveys that had the primary purpose of mapping ecological communities and invasive species. Therefore, this list is not considered comprehensive, but it does represent a substantial number of the total plant species. A more complete list could be compiled with additional intentional surveys.

A total of 130 species were documented on the Property (Appendix C). This included 111 native species (85% of total number of species) and 19 non-native species (14 mapped as invasive species, see Section III). A broad breakdown of native and invasive species composition is provided in Table 16.

Table 16. Plant Species Summary

Growth Form	Native	Non-Native	Totals
Trees	22	2	**24**
Shrubs	16	7	**23**
Vines	4	1	**5**
Herbs-Graminoids	7	3	**10**
Herbs- Ferns	10	0	**10**
Herbs- Wildflowers	52	6	**58**
Totals	**111**	**19**	**130**

No rare plant species were observed during the field surveys. The Natural Heritage Program GIS grid layer did not identify any rare plant species on the Property (Map 18, Table 17).

Fauna

There are 19 rare bird, two rare mammal, four rare reptile and one rare amphibian species that have been documented on or in the vicinity of the Property based upon Landscape Project Version 3.3. Table 17 summarizes species status along with stewardship recommendations. One particularly notable species is the Northern Myotis, or the long-eared bat, which has been federally listed as a threatened species. This species has been spotted during its active and dormant seasons and would benefit from the creation of more shelter spaces inside snags and cavities around the Property.

One of many juvenile Eastern Newts observed wandering the forest floor

Wood Frog observed hiding in a small divot on the preserve

Table 17. Rare Species of the Property

Taxa	Scientific Name	Common Name	Location	Global Rank	State Rank	State Status	Stewardship Notes
Bird	Haliaeetus leucocephalus	Bald Eagle	Sited in vicinity of property	G5	S1B, S2N	Endangered	Foraging and nesting habitat likely located off property
Bird	Strix varia	Barred Owl	Sited on property and in vicinity of property	G5	S2B, S2N	Threatened	Maintain forest cover to provide contiguous nesting and breeding habitat. Leave large dead standing trees. Allow forest to mature to increase nesting tree population
Bird	Dendroica fusca	Blackburnian Warbler	Sited on property and in vicinity of property	G5	S3B, S4N	Special Concern	Forest and woodland stewardship. Prefer conifers for nesting. Limited opportunities occur on property
Bird	Coccyzus erythropthalmus	Black-billed Cuckoo	Sited in vicinity of property	G5	S3B, S4N	Special Concern	Sited off property. Habitat limited on site. Restored areas will provide shrubby habitat as they mature
Bird	Dendroica caerulescens	Black-throated Blue Warbler	Sited on property and in vicinity of property	G5	S3B, S4N	Special Concern	Require mature forest with adjacent restored shrubby understory habiat. Effective deer management plan would allow for early successional development. Restored areas would provide required shrubby habitat in the future.
Bird	Dendroica virens	Black-throated Green Warbler	Sited on property and in vicinity of property	G5	S3B, S4N	Special Concern	Forest and woodland stewardship. Prefer conifers for nesting. Limited opportunities occur on property
Bird	Vireo solitarius	Blue-headed Vireo	Sited on property and in vicinity of property	G5	S3B, S4N	Special Concern	Habitat includes mature coniferous and deciduous forests. Prefer to nest in closed canopy habitat with healthy understory. Effective deer management plan would allow for understory to develop
Bird	Wilsonia canadensis	Canada Warbler	Sited on property and in vicinity of property	G5	S3B, S4N	Special Concern	Could use property as breeding or migratory stopover area. Require mixed forest with dense, shrubby understory for food source and nesting (ground nesters). Effective deer management plan for understory, and migratory habitat in shrubland
Bird	Dendroica cerulea	Cerulean Warbler	Sited in vicinity of property	G4	S3B, S4N	Special Concern	Enjoy large patches of deciduous forest. Nest in tall trees, like white oak. Need shrubby understory and open canopy areas
Bird	Accipiter cooperii	Cooper's Hawk	Sited on property and in vicinity of property	G5	S3B, S4N	Special Concern	Habiat is available on property. Maintain forest cover
Bird	Ardea herodias	Great Blue Heron	Sited on property and in vicinity of property	G5	S3B, S4N	Special Concern	Nesting habitat most likely not on property. Riparian areas may serve as foraging habiat

Table 17. Rare Species of the Property (continued)

Taxa	Scientific Name	Common Name	Location	Global Rank	State Rank	State Status	Stewardship Notes
Bird	Wilsonia citrina	Hooded Warbler	Sited on property and in vicinity of property	G5	S3B, S4N	Special Concern	Require deciduous forest with dense understory. Nest in areas of dense shrub cover, near forest edges or in clearings. Restored areas would provide required shrubby habitat in the future.
Bird	Oporornis formosus	Kentucky Warbler	Sited on property and in vicinity of property	G5	S3B, S3N	Special Concern	Need large patches of contiguous forest with dense understory. Enjoy bottomland areas. As ground nesters, they require dense understory coverage. Maintain forest coverage and riparian areas. An effective deer management plan would allow for undestory to provide enough coverage/protection for nests
Bird	Accipiter gentilis	Northern Goshawk	Sited on property and in vicinity of property	G5	S1B, S3N	Endangered	Enjoy more closed canopy forest area, but will nest near breaks in the canopy. Hunt throughout forest and along riparian corridors. Nest in largest trees available. Maintain forest cover and riparian areas
Bird	Parula americana	Northern Parula	Sited in vicinity of property	G5	S3B, S4N	Special Concern	Sited off property
Bird	Buteo lineatus	Red-Shouldered Hawk	Sited on property and in vicinity of property	G5	S1B, S3N	Endangered, Special Concern	Tends to occupy forests near water or bottomland habitat. Typically nest near streams, ponds and wetlands. Maintain forest cover and riparian areas
Bird	Catharus fuscescens	Veery	Sited on property and in vicinity of property	G5	S3B, S4N	Special Concern	Enjoy dense, damp deciduous forests with a dense understory for nesting. Maintain forest cover and riparian areas. An effective deer management plan would allow for undestory to provide enough coverage/protection for nests
Bird	Hylocichla mustelina	Wood Thrush	Sited on property and in vicinity of property	G4	S3B, S4N	Special Concern	Enjoy mature forests with tall trees and moderate understory growth. Water nearby is beneficial as well. Known for nesting in young trees or shrubs. Maintain forest cover and riparian areas
Bird	Helmitheros vermivorum	Worm-eating Warbler	Sited on property and in vicinity of property	G5	S3B, S4N	Special Concern	Breeds in deciduous and mixed forests with dense understory. Does not typically nest in fragmented areas. As ground nesters, they will usually pick a spot on a slope, at the base of a shrub or young tree, near water source. Maintain forest cover and riparian areas. Restored areas will provide shrubby habitat as they mature

Table 17. Rare Species of the Property (continued)

Taxa	Scientific Name	Common Name	Location	Global Rank	State Rank	State Status	Stewardship Notes
Mammal	Lynx rufuf	Bobcat	Sited on property and in vicinity of property	G5	S2	Endangered	Habitat is available on property. Maintain forest cover to promote foraging
Mammal	Myotis septentrionalis	Northern Myotis	Sited on property and in vicinity of property	G1G2	S1	Federally Listed Threatened	Shelter in cavitys and shaggy bark trees during active months. Encourage tree regeneration to create more habitat. Leave large dead standing trees. Allow forest to mature to increase nesting tree population. Consider creating snags throughout the property by girdling or topping trees
Reptile	Terrapene carolina caroliina	Eastern Box Turtle	Occupied habitat on property and in vicinity of property	G5T5	S3	Special Concern	Bask and nest in open, sunny areas. Cut back vegetation sharply in multiple small areas to encourage nesting and to throw predators off. Potentially put predator fencing around nest sites if spotted
Reptile	Agkistrodon contortix mokasen	Northern Copperhead	Occupied habitat on property and in vicinity of property	G5T5	S3	Special Concern	Encourage overall forest health to promote foraging habitat
Reptile	Crotalus horridus horridus	Timber Rattlesnake	Occupied habitat on property and in vicinity of property	G4T4	S1	Endangered	Encourage overall forest health to promote foraging habitat
Reptile	Glyptemys insculpta	Wood turtle	Occupied habitat on property and in vicinity of property	G3	S2	Threatened	Both aquatic and terrestrial, overwintering in streams. Can benefit from building anthropogenic nesting areas by distrubing soil. Attempt to keep nesting sites close to stream to avoid turtles travelling far
Amphibian	Anaxyrus fowleri	Folwer's Toad	Occupied habitat in vicinity of property	G5	S3	Special Concern	Breeds in shallow bodies of water. Promote vernal pool health
Community	Potential Vernal Habitat Area (ID # 2266)	Potential vernal habitat area	Possible on property and in vicinity of property	N/A	N/A	None	Not observed, but targeted searching/evaluation should be conducted. Encourage forest health in vicinity of pool location
Community	Potential Vernal Habitat Area (ID # 2252)	Potential vernal habitat area	Possible in vicinity of property	N/A	N/A	None	Located off property

Section III. Conservation Challenges

Introduction

This section describes an evaluation of the two primary threats to ecological health – overabundance of white-tailed deer and invasive species. The impacts of white-tailed deer and the extent and severity of invasive plant infestations were mapped in early October 2021. No known deer management has occurred on the preserve. The effects of this can be seen below.

The scope of the invasive species problem is significant with 48% of the natural cover on the Property having severe infestations of one or more species. A near equal portion, 40%, is virtually free of invasives. The remaining 12% is lightly to moderately infested.

Photographic documentation of current conditions is provided below.

Evaluation of White-tailed Deer Impacts

Nearly all forest and woodland habitats on the Property show either the "Empty Forest Syndrome" or the "Infested Forest Syndrome" (See Section I). Ecological impacts of white-tailed deer are severe with little forest understory growth of native trees, shrubs, and wildflowers and/or significant infestations of unpalatable invasive species. Tree regeneration to secure the future forest is very low and is absent the more palatable oak species (Table 11).

Native shrubs and herbaceous species (both vulnerable to deer browse) were low across a majority of the Property. Ideally, native woody understory cover in healthy forests would be above 70%. Across New Jersey, native understory cover averages less than 20%. Approximately 69% of forest communities had <10% native woody understory cover coupled with only 6% showing healthier levels, >50%, of woody cover. Woodland communities had similar levels of poor woody cover with 57% exhibiting cover <10%. However, woodland communities also showed much higher levels of healthier shrub cover with 33% showing cover >50%. Native tree and shrub regeneration (seedlings > 3 foot tall) was sparse (Table 11). A total of 8.9 acres showed regeneration, but a majority, 98%, of regeneration was of cover class <25%. Only one small patch, 0.2 acres, showed strong regeneration of 75% cover.

Native herbaceous species (wildflowers and grasses) were very sparse throughout the Property, especially in forest and woodland habitats where > 90% of the areas had less than 10% cover and showed intense deer browse (Table 13).

However, there are opportunities for ecological recovery, especially in forest areas that had never been under agricultural uses. These areas have relatively low levels of invasive species (except for canopy gaps) and directed stewardship activities can begin the restoration process, especially toward fostering growth of native forest wildflowers that are most underrepresented on the Property (See Table 13 and Section IV).

Evaluation of Invasive Species Impacts

Mapping Protocols

The method used to map invasive plant species involved the delineation of mapping areas. The mapping area technique is a coarse method to broadly define the extent and intensity of invasive species infestations. Mapping areas were delineated as locations containing relatively uniform ground cover for each invasive species present within the defined area or 'patch'. Within each patch, each invasive plant species was assigned a cover class score. Cover class scores included: "0": absent, "Trace" or < 1% cover, "1": 1-10% ground cover, "2": 11-25% ground cover, "3": 26-50% ground cover, "4": 51-75%, and "5": 76-100% ground cover. See Appendix B for raw mapping data for each mapped patch.

Overall Scope

A total of 60 unique mapped patches totaling nearly 114 acres were recorded (Table 18). The scope of the invasive species problem is significant with 48% of the Property having severe infestations of one or more species (i.e., infestation category of High, Very High, or Extremely High). In contrast to the heavily infested areas, 40% of the preserve is virtually free of invasives while and additional 12% shows only light to moderate infestation. Map 25 depicts the cumulative infestation scores by mapped patches.

Table 18. Invasive Species - Summary of Infestations by Mapped Patch

Combined Infestation Score per Patch	Combined Infestation Score Category	Total Acreage	Percent of Natural Cover
0*	"Clean"	45.6	40.1
1	Low	3.7	3.3
2	Moderate	7.5	6.6
3	Moderate	2.4	2.1
4	High	3.8	3.3
5	High	6.6	5.8
6	Very High	11.6	10.2
7	Very High	6.9	6.1
8	Extremely High	19.6	17.3
10	Extremely High	5.9	5.2
Totals		**113.6**	**100**

*May Contain one or more species at "Trace" amounts

Combined Infestation Score per Patch	Combined Infestation Score Category	Total Acreage	Percent of Natural Cover
0*	"Clean"	45.6	40.1
1	Low	3.7	3.3
2-3	Moderate	9.9	8.7
4-5	High	10.4	9.2
6-7	Very High	18.5	16.3
>7	Extremely High	25.5	22.4
Totals		**113.6**	**100**

*May Contain one or more species at "Trace" amounts

Each invasive species was assigned an 'Action Code' based upon its threat level to conservation values, current extent of infestation on the Property, and known invasive status in New Jersey (Table 19). Overall, 14 species are considered invasive – nine should be subject to an eradication program and three should be subject to a selective control program. Species-specific control strategies and methods are provided in Table 23.

Table 19. Invasive Species - Action Code Summary

Action Code	Action Code Explanation	Treatment Recommendations	Number of Species	Listed Species
1	Species has limited distribution (but is highly threatening) within the preserve	Eradicate	9	Amur Honeysuckle, Autumn Olive, Burning Bush, Common Reed, Garlic Mustard, Japanese Honeysuckle, Mile-a-Minute, Mugwort, Siebold's Crabapple
2	Species has widespread distribution within the preserve and is considered highly threatening	Selective Control	3	Japanese Barberry, Japanese Wineberry, Multiflora Rose
3	Species has limited distribution and/or is not considered to be highly threatening to conservation values and/or meaningful control is not feasible within the preserve	No Direct Treatment	2	Japanese Stiltgrass, Norway Spruce
Total			**14**	

Species Patterns

There were 14 detected emerging invasive plant species or nascent widespread species that should be considered for eradication (See Action Code 1 species in Table 19 above). All of these species are considered highly threatening to ecological health. Every invasive species, both emerging and widespread, have maps depicting their coverage within mapped patches – this includes cover category across the mapped patch as well as specific GPS locations for selected populations (See "Individual Invasive Species Maps"). Table 20 includes population sizes for points taken for emerging and notable widespread invasive species (this list is not exhaustive) and Table 21 provides GPS coordinates.

Table 20. Invasive Species - Points Summary

		Population Size					
Common Name	**Scientific Name**	**1**	**2-10**	**11-100**	**101-1000**	**>1000**	**Totals**
Amur Honeysuckle	*Lonicera maackii*	1					1
Burning Bush	*Euonymous alatus*	1	3				4
Common Reed	*Phragmites austalis*			1			2
Mile-a-Minute	*Persicaria perfoliata*		1	2			3
Mugwort	*Artemisia vulgaris*		1				1
Norway Spruce	*Picea abies*			2			2
Siebold's Crabapple	*Malus toringo*	1					1
Totals		**3**	**5**	**5**	**0**	**0**	**13**

Table 21. Invasive Species - Point Locations

Final Point ID	Common Name	Species Code	Population Size	Latitude	Longitude
7	Mila-a-Minute	PEPE	11-100	41.0092008	-75.00342113
8	Siebold's Crabapple	MATO	1	41.00955527	-75.00395573
9	Burning Bush	EUAL	2-10	41.00978795	-75.00262393
10	Amur Honeysuckle	LOMA	1	41.01020571	-75.00283951
11	Burning Bush	EUAL	1	41.01065758	-75.00357703
16	Common Reed	PHAU	11-100	41.01256463	-75.00089742
18	Mila-a-Minute	PEPE	11-100	41.01121967	-75.00128869
19	Burning Bush	EUAL	2-10	41.01183892	-75.00257104
20	Burning Bush	EUAL	2-10	41.01178704	-75.00252351
22	Norway Spruce	PIAB	11-100	41.00756625	-75.00427156
23	Mila-a-Minute	PEPE	2-10	41.00740205	-75.00411666
24	Norway Spruce	PIAB	11-100	41.00737757	-75.00406159
25	Mugwort	ARVU	2-10	41.00664935	-75.00430844

Table 22 contains data for each invasive species from mapped patches, including the "Relative Infestation Index Category." This index provides a coarse characterization of both distribution and intensity of infested acreage. It is intended to provide a rapid assessment of species that currently have the greatest impacts. Values include 'High', 'Medium', and 'Low', which correspond to ranges of Infestation Index Scores derived by multiplying the number of acres where a species was present by its cover class score within mapped patches. Species labeled as 'High' are those with widespread distributions and/or consist of dense stands. Conversely, 'Low' species have limited distribution and/or primarily occur at low cover classes.

In order of abundance, the three most abundant species are Japanese Barberry, Japanese Stiltgrass, and Multiflora Rose. Additional moderately abundant species include Norway Spruce, Japanese Wineberry, and Autumn Olive.

Spatial Patterns

The most severe combined infestations and number of invasive species per patch, and maximum single species infestations (See Maps 26-28 respectively) tended to occur in former agricultural areas. Importantly, Multiflora Rose is beginning to succumb to Rose Rosette Disease in sunny areas. While ash decline may initially promote rose growth, increased light may ultimately reduce its cover over time in particular woodland habitats.

Along with a correlation to past agricultural land use, moisture category also shows a strong influence on the presence and density of invasive cover. The wetland category of moisture shows the highest cumulative infestation rate as well having remarkably high coverages of single invasive species cover.

Areas without a history of agricultural tilling tended to be areas considered to be "Clean" or have "Low" or "Moderate" infestation levels. However, some areas without agricultural tilling still had significant infestations of species, especially Japanese Stiltgrass in particular areas within forest and woodland habitat.

Regardless of past agricultural land use, canopy gaps and thinner canopy woodland habitat were infested by a variety of invasive species. Deer frequent these areas (probably instinctively to seek plants with robust growth due to increased sunlight) and remove palatable native species while leaving behind unpalatable invasive species.

Mile-a-Minute (*Persicaria perfoliata*) shown above in a small meadow on the Property poses a significant risk in areas with canopy or light gaps

Table 22. Invasive Species – Individual Species and Their Relative Infestation Levels

							Acreage by Percent Ground Cover Categories							
Common Name	Scientific Name	Action Code	Infestation Index Score[1]	Relative Infestation Index Category[2]	Number of Recorded Populations	Total Acres Present	Category 0: 0%	Category Trace: < 1%	Category 1: 1-10%	Category 2: 10-25%	Category 3: 25-50%	Category 4: 50-75%	Category 5: 75-100%	LOE Estimate[3]
Amur Honeysuckle	*Lonicera maackii*	1	0.4	Low	1	3.5	110.1	3.5	0.0	0.0	0.0	0.0	0.0	4
Autumn Olive	*Elaeagnus umbellata*	1	3.4	Low	8	10.8	102.8	9.2	0.7	0.9	0.0	0.0	0.0	34
Burning Bush	*Euonymous alatus*	1	1.0	Low	4	10.0	103.6	10.0	0.0	0.0	0.0	0.0	0.0	10
Common Reed	*Phragmites australis*	1*	0.2	Low	1	0.1	113.5	0.0	0.0	0.1	0.0	0.0	0.0	2
Garlic Mustard	*Alliaria petiolata*	1	0.6	Low	3	5.7	107.9	5.7	0.0	0.0	0.0	0.0	0.0	6
Japanese Barberry	*Berberis thunbergii*	2	177.2	High	50	96.0	17.6	35.7	19.6	8.3	2.8	19.0	10.6	1772
Japanese Honeysuckle	*Lonicera japonica*	1	0.5	Low	3	5.4	108.2	5.4	0.0	0.0	0.0	0.0	0.0	5
Japanese Stiltgrass	*Microstigeum vimium*	3	173.2	High	43	73.0	40.6	15.8	9.2	11.3	12.3	19.1	5.3	1732
Japanese Wineberry	*Rubus phoenicolasius*	2	3.1	Low	15	17.7	95.9	16.2	1.5	0.0	0.0	0.0	0.0	31
Mile-a-Minute	*Persicaria perfoliata*	1	0.2	Low	3	2.3	111.3	2.3	0.0	0.0	0.0	0.0	0.0	2
Mugwort	*Artemisia vulgaris*	1	0.5	Low	1	4.7	108.9	4.7	0.0	0.0	0.0	0.0	0.0	5
Multiflora Rose	*Rosa multiflora*	2	28.9	Moderate	30	46.0	67.6	27.5	10.9	7.6	0.0	0.0	0.0	289
Norway Spruce	*Picea abies*	3	9.2	Low	6	5.7	107.9	2.3	2.0	0.0	0.0	0.0	1.4	92
Siebold's Crabapple	*Malus toringo*	1	0.1	Low	1	0.8	112.8	0.8	0.0	0.0	0.0	0.0	0.0	1

Table 23. Invasive Species - Species-Specific Control Strategies and Methods

Common Name	Scientific Name	Action Code	Control Strategy	Control Methods
Amur Honeysuckle	*Lonicera maackii*	1	Eradicate all known occurences. Maintain continual searching and eradication	Basal Bark, Foliar Spray, Cut Stump (winter only if using glyphosate), EZ-Jext w/ imazapyr
Autumn Olive	*Elaeagnus umbellata*	1	Eradicate all known occurences. Maintain continual searching and eradication	Basal Bark, Foliar Spray, Cut Stump (winter only if using glyphosate), EZ-Jext w/ imazapyr
Burning Bush	*Euonymous alatus*	1	Eradicate all known occurences. Maintain continual searching and eradication	Basal Bark, Foliar Spray, Cut Stump
Common Reed	*Phragmites australis*	1*	Eradicate known occurrence if desired. Reinfestation is likely due to nearby infestation off of preserve property	Foliar Spray or Cut Stump. Most effective herbicide is imazapyr. Consider cutting in early June and allowing regrowth to 3' before treatment
Garlic Mustard	*Alliaria petiolata*	1	Eradicate all known occurences. Maintain continual searching and eradication	Foliar Spray or Hand pulling (both in Spring to avoid seed set)
Japanese Barberry	*Berberis thunbergii*	2	Selective Control-Focus on highest quality areas	Basal Bark, Foliar Spray, Cut Stump
Japanese Honeysuckle	*Lonicera japonica*	1	Eradicate all known occurences. Maintain continual searching and eradication	Foliar Spray (cut stems infesting trees prior to treatment)
Japanese Stiltgrass	*Microstigeum vimium*	3	No direct action	Foliar Spray, Pre-Emergent Spray, Well timed cutting (ca. mid August)
Japanese Wineberry	*Rubus phoenicolasius*	2	Selective Control-Focus on highest quality areas	Basal Bark, Foliar Spray, Cut Stump
Mile-a-Minute	*Persicaria perfoliata*	1	Eradicate all known occurences. Maintain continual searching and eradication	Foliar Spray, Pre-Emergent Spray,
Mugwort	*Artemisia vulgaris*	1	Eradicate all known occurences. Maintain continual searching and eradication	Foliar Spray (Milestone in October)
Multiflora Rose	*Rosa multiflora*	2	Selective Control-Focus on highest quality areas	Basal Bark, Foliar Spray, Cut Stump
Norway Spruce	*Picea abies*	3	No direct action	Basal Bark, Hack-and-Squirt, Foliar Spray, Cut Stump (winter only if using glyphosate) EZ-Ject w/ imazapyr
Siebold's Crabapple	*Malus toringo*	1	Eradicate all known occurences. Maintain continual searching and eradication	Foliar Spray, Basal Bark (July-September), EZ-Ject w/ imazapyr, Cut Stump (winter only)

Photographic Documentation

A series of photographs with captions are provided below to highlight deer and invasive species impacts.

(Top) An infested forest with all understory growth dominated by invasives
(Bottom) An empty forest where excess deer pressure has removed nearly all understory growth

(Top) excessive deer browse shown on this Pinxster Azalea limits its growth
(Bottom) A sweet birch with lower growth all completely browsed by deer

(Top) Two white wood asters both shown with deer browse.
Even the native herbs that are found are heavily pressured by deer.
(Bottom) A single, isolated small patch of Wreath Goldenrod in flower.
Typically, these would number in the tens of thousands across the Property.

(Top Left) Bark blonding shown on a mature ash tree.
Damaged caused by woodpeckers predating the Emerald Ash Borer larvae beneath the bark.
(Top Right) Long term effects of Emerald Ash Borer lead to tree death
(Bottom) The forest floor is overtaken by Japanese stiltgrass
due to excess light reaching the forest floor from ash canpoy loss

(Top) An oak seedling present in the herbaceous layer that would flourish with reduced deer pressure. (Bottom) A patch of forest with dense Beech regeneration, Beech is a less palatable native to deer.

(Top) A small group of white coral fungi observed growing on the ground.
(Bottom) A large chicken of the woods and group of puffballs growing together on an old log.

(Top Left) An amanita mushroom with a second small mushroom growing beneath.
(Top Right) A bright orange jelly fungi growing on a Sweet Birch.
(Bottom) A group of beautiful blue cup fungi growing with moss on a decaying log.

Section IV. Strategies and Actions

Figure 6. Stewardship Philosophy

'Nature manages itself' is commonly heard from those that feel stewardship of natural lands is inappropriate. In some cases, this is based upon a simplistic understanding of natural systems and the forces that create or maintain them. Some proponents of this view fail to acknowledge that there are many indirect impacts of human activities on natural systems (e.g., introductions of non-native species, irreversible fragmentation of natural areas that support deer population growth, profound alteration of soils from past agricultural use, etc.). Other proponents of this view suggest that nature will have to balance itself within the framework established by human activities and that we should not intervene further. Finally, there are well-qualified experts including some experienced natural historians and research professors that understand that our knowledge of natural systems is incomplete and suggest that stewardship should not be practiced until we learn more about natural systems and how they will react to particular management regimes.

In contrast, proponents of stewardship proceed from the viewpoint that human activities directly and indirectly shape the remainder of our natural world and that there is an obligation to intervene to promote ecological health and avoid further losses to biodiversity. In short, stewardship may be defined as 'the mitigation of human impacts on natural systems'. Stewards feel that action is required when human impacts severely threaten ecological health, thereby consciously reducing human impacts through management strategies and actions.

In most cases, stewards strive for short-term interventions that correct natural systems with declining trajectories. Examples of short-term interventions include significant reductions of the white-tailed deer population (i.e., culling) and control of nascent populations of invasive species. In other cases, the continuing needs of the human population require that active management be perpetual (e.g., creation and maintenance of early successional habitats because catastrophic wildfires must be suppressed or a continuing Deer Management Programs to maintain a smaller deer herd).

In general, there are relatively few compromises available to proponents of the extremes of these two opposing viewpoints. However, most individuals realize that a balance is possible, especially when stewardship is coupled with careful monitoring or designed research experiments that provide greater insights to practice adaptive management. Overall, stewardship strategies should seek to utilize minimal human intervention to foster ecological health and stimulate research to provide a better understanding of the natural world.

Introduction

A significant and persistent effort will be required to improve ecological health. This plan has four primary plan recommendations. The first involves significant reduction of the deer population so that native plants can exert ecological control over invasive species. The second involves strategic invasive species control to eliminate newly emerging species and nascent populations of widespread invasive species. The third involves protecting and restoring the highest ecological quality areas and fostering rare species. The fourth involves the use of prescribed fire to restore fire-dependent native communities and control dense infestations of Japanese Barberry. The fifth involves implementation of ecological health monitoring protocols to determine success of the first three goals and guide adaptive stewardship over time along with a detailed botanical survey. Each of these recommendations is accompanied by specific goals - there is a total of nine specific stewardship goals.

It is essential that a highly effective Deer Management Program continue in perpetuity. Significant reduction of the deer herd is absolutely critical to improve ecological health through increased native plant growth, which in turn will exert ecological control over invasive species (thereby lessening the need for ongoing labor-intensive chemical control methods). Invasive species will be present in perpetuity, but they are much less likely to form dense infestations with lower deer densities.

Recommendations for control of particular invasive species were prioritized based upon their level of threat to further degrade ecological health (e.g., potential to significantly increase their abundance). Treatment prescriptions and species phenology are provided through the New Jersey Invasive Species Strike Team, which updates its recommendations annually.

A summary of specific goals with estimated costs is summarized in Table 24. The plan provides five primary recommendations with nine associated goals (see next page). Full plan implementation is estimated to require 645 hours of staff time (estimated cost of $32,250), 197 volunteer hours (estimated value of $4,728), $36,025 of total contractor cost, and $2,550 of purchased material costs over the next 10 years - total cost is estimated at $70,825 (See Table 24 for additional details).

Recommendation #1: Implement an Effective White-tailed Deer Management Program

Goal #1-1: Reduce deer density to meet ecological health goals

The current deer population is exceptionally high, and decades of overabundance have led to profound ecological damage including the removal of most native vegetation below five feet and fostering extensive infestations of unpalatable invasive species. It is recommended that an effective annual deer management program focusing on the removal of antlerless deer is instituted and upheld. In order to be the most effective, a well-rounded deer management strategy will work with efficient hunters and in cooperation with neighboring landowners. Deer density must be reduced to 20 deer per square mile (or as low as 10 per square mile to allow recovery of forest wildflowers). Goal #5-1 provides information on an ecological health monitoring program to track progress of native vegetation response to reduced deer density. A brief literature review to support this goal is provided below.

- The historical analysis of the white-tailed deer population density in North America (pre-European colonization) is approximately 10 per square mile (McCabe and McCabe 1984).
- In general, native species diversity / abundance and overall forest health drop significantly with increasing deer herd size. An often-cited research project that provides quantitative guidance on deer population levels associated with ecological damage was performed by David deCalesta, based at the US Forest Service in Pennsylvania (deCalesta 1994, deCalesta 1997). Over the course of a 10-year study using forest enclosures with known densities of deer, deCalesta determined that native forest herbs and tree seedlings became less abundant with deer densities between 10 and 20 per square mile. At densities exceeding 20 per square mile, palatable native plant species disappear, and forest shrub-nesting songbirds drop in abundance with the loss of the shrub layer.
- Human health impacts may also be associated with deer densities exceeding 10 deer per square mile. According to a study reported from Connecticut (Stafford 2007), deer population size is linked to incidences of Lyme disease. This relationship is dependent upon a threshold deer population size, requiring a population size of 10-12 deer per square mile to show substantial reduction in human cases of Lyme disease.

The estimated cost to complete this goal is $15,000 over the 10-year implementation period (See Table 24).

Recommendation #2: Perform Strategic Invasive Species Control

A complete list of invasive species along with control goals (i.e., "Action Code") is provided in Table 19, number of populations by size categories is provided in Table 20 and GPS locations are provided in Table 21. Treatment prescriptions are available through the New Jersey Invasive Species Strike Team, which updates them annually based upon newly available information, but Table 23 provides a summary of species-specific control strategies and methods. Table 24 provides cost estimates and timeframes. Ecological control exerted by native species is the ultimate goal to curb invasive plant species, but this should not be expected without significant reduction of the deer herd (See Goal #1-1).

Goal #2-1: Eradicate 9 high priority invasive species (Action Code 1 species)

Emerging invasive species should be the highest priority for control efforts because they threaten the Property and the region with future ecological degradation. One emerging species, Siebold's Crabapple, is found on the Property and should be directly targeted. Nascent populations of eight widespread invasive species are also included in this goal to prevent their inevitable spread. This strategy, known as Early Detection & Rapid Response, represents an efficient and effective strategy to prevent damage (and minimize future stewardship costs). There are currently nine total emerging and nascent widespread species designated as 'Action Code 1' (i.e., complete eradication is the ultimate goal). Currently, there are eleven mapped known populations of these nine species (Table 20) but continued searching is likely to detect additional populations. Guidance regarding control strategies and methods is provided in Table 23. Initial priority should be placed on species with the fewest populations so that they can be completely eliminated before spreading further.

The estimated cost to complete this goal is $9,075 over the 10-year implementation period (See Table 24). An additional $720 of volunteer value is also required for this goal.

Recommendation #3: Protect and Restore Highest Quality Forest Areas and Rare Species Habitat

The protection and restoration of highest-quality forest habitat is an important goal. There are a total of approximately 70 acres of quality forest patches made up of high-quality patches and immediately adjacent moderate quality patches. Patches were grouped into 4 stewardship areas based on location, habitat structure, and proximity (Map 29, Table 15). Goal #3-1 includes management of the entirety of these quality patches. Goal #3-2 involves protection of 3.6 additional acres where restoration tree planting has already taken place. Goal #3-3 involves bolstering habitat for a variety of rare species at or near Property.

Goal #3-1: Protect and Enhance 70.3 acres of Highest Quality Forest

This goal includes 70.3 acres of highest quality forest habitat sectioned into 4 main stewardship areas (see Table 15 and Map 29). Stewardship areas A, B, and C should be the highest priority. These stewardship areas consist of high-quality patches mixed with adjacent moderate quality patches that can be easily treated to improve the group as a whole. They are all interconnected and improving these patches first will have the largest overall benefit to the Property. Subsequent work should then be conducted in the remaining high-quality patches grouped in area D. The focus of this work is to reduce invasive species cover, including emerging and widespread species, to allow increased cover and reproductive success for native species.

The use of mini-exlcosures can protect small areas of forest within high quality Units. A mini-exlcosure can consist of a 50' roll of 5-foot-tall galvanized metal mesh fencing, using rebar posts to minimize cost.

The budget provides for 10 mini-exclosures, but more may installed as resources allow. The goal of these mini-exclosures is to protect local areas, allowing for the formation of healthy patches of native wildflowers and tree regeneration. They should be sited based upon occurrences of existing (but browsed) wildflowers or within canopy gaps that support rapid tree growth.

The estimated cost to complete this goal is $15,750 over the 10-year implementation period (See Table 24).

Goal #3-2: Protect 3.6 Acres of Restored Areas to Foster Forest Regeneration

Outside the areas highlighted in goal #3-1, there are additional 3.6 acres of area that has already been subject to stewardship projects (see Map 30). These areas include planted seedlings protected in tree tubes. These areas are also at higher risk from to invasive species because of the open canopy and disturbance history. In order to protect these past projects, invasive species should be managed yearly to ensure their continued success.

The estimated cost to complete this goal is $21,250 over the 10-year implementation period (See Table 24). An additional $1,480 of volunteer value is also required for this goal.

Goal #3-3: Protect and enhance rare species habitats

There are 26 documented rare species that utilize either the Yards Creek Preserve or surrounding natural areas (see Table 17), as such, there exists tremendous opportunity to improve habitats for these species. First, contact should be made with ENSP to determine what measures can be taken to improve nesting habitat for wood and box turtles. This may include protection of turtle nests or installation of nesting structures. Other notable areas include two known vernal pool locations as well as multiple documented potential vernal pools (see Map 5). In order to verify the nature of these wetland areas, surveys should be conducted to search for vernal pool obligate species during breeding season. These species include wood frogs, spotted salamanders, and marbled salamanders. Due to the life cycle of these species, surveys should take place both in the early Spring and Fall. The majority of rare species on the Property are birds. A wide range of these birds' habitat can be bolstered by promoting a shrubby understory as well as maintaining forest cover. An effective deer management plan would play a vital role in improving these conditions by allowing native tree and shrub regeneration. Other birds and the Northern Myotis would all benefit from selectively choosing individual trees to girdle and leave as standing dead wood. This provides perching areas for predatory birds as well as nesting and shelter areas for the myotis.

The estimated cost to complete this goal is $5,000 over the 10-year implementation period (See Table 24). An additional $1,800 of volunteer value is also required for this goal.

Recommendation #4: Conduct Prescribed Burning Program to Enhance Ecological Health

The NJFFS service has recently been granted permission to conduct prescribed burns for ecological reasons. There are two issues facing the Property that fire may be the best tool to utilize for the job. The first issue is the change in community structure from fire regulated oak dominated forest to fire suppressed beech dominated forest and the second is the large, dense infestation of Japanese Barberry along the stream corridor. The creation and implementation of burn plans will be necessary to tackle these larger tasks.

Goal #4-1: Burn to Re-Establish Native Fire Based Communities

Across the preserve there are numerous areas dominated by oak trees in the canopy and huckleberry in the understory. These communities are typically brought about by a historical fire regime in which these species are suited to thrive. Their presence helps infer the past presence of fire on the landscape. In some patches of the preserve, the forest composition is changing to be heavily beech dominated in these historical oak forests. Beech is not resistant against fire and shows how human centric fire suppression has impacted the natural landscape. In order to restore native communities a prescribed burn is recommended in patches 7, 25, 56, 57, and 59. These patches comprise a total area of 16 acres. See Map 31.

The estimated cost to complete this goal is $3,500 over the 10-year implementation period (See Table 24). Estimation was derived using the NJFFS prescribed burn price guideline. For a full breakdown of cost calculation see Appendix E.

Goal #4-2: Burn to Reduce Heavy Japanese Barberry Infestation

Japanese Barberry is one of most abundant and widespread invasive species found on the Property, see Species Map 6. The largest infestations are found along the main stream corridor and cover approximately 28 acres. There are many challenges regarding the management of this species. Due to the proximity to the stream, broadcast application of foliar spray is not desirable. These wetland areas are home to a variety of native amphibians and are environmentally sensitive. As such, attempting to remove the barberry with mechanical methods, i.e., forestry mowing, would do more damage to these areas than the benefit the removal of barberry would bring. A non-feasible option would be manually cutting and dabbing stems with herbicide (i.e., cut stump application). The infestation is too severe and would take thousands of hours with staff and volunteers. Considering the challenges listed above, burning the areas most densely infested with barberry will be the best method of control. Anecdotal evidence suggests a minimum of two burns, conducted in early Spring as growing begins, and spot treating missed or resprouted individuals is most effective. Spot treatments could include directed foliar spray of remaining stems or cut stump applications.

The estimated cost to complete this goal is $3,500 over the 10-year implementation period (See Table 24). Estimation was derived using the NJ FFS prescribed burn price guideline (Appendix E).

Recommendation #5: Conduct Ecological Health Monitoring and Rare Plant Inventory

This recommendation includes ecological monitoring, which provides accountability and forms the basis for adaptive stewardship over time. Monitoring should be performed by staff with experience with the flora of the Property and monitoring techniques including the Forest Secchi protocol and use of ground plots. It also includes a professional botanical survey in order to document potential previously undocumented rare plant species.

Goal #5-1: Perform ecological health monitoring to guide adaptive stewardship over time

Ecological health should be monitored every 3-5 years. Key attributes should include the density of native trees and shrubs within the deer browse zone (Forest Secchi), canopy cover, quantification of trees and saplings within plots, and quantifying the presence of regenerating trees, shrubs, and herbaceous plants in ground plots. The implementation of a monitoring protocol is vital to guide future stewardship activities as well provide feedback on the efficacy of past projects.

The estimated cost to complete this goal is $4,250 over the 10-year implementation period (See Table 24). An additional $768 of volunteer value is also required for this goal.

Goal #5-2: Perform complete botanical survey including rare plant searches

A vast majority of the Property is filled with high and moderate quality patches of forest that may harbor currently undocumented rare plant species. In order to guide future stewardship action, a full and comprehensive botanical survey should be conducted. This survey would need to be conducted by a professional botanist over the course of several sampling occasions to search for plants at different life stages at various times of the year.

The estimated cost to complete this goal is $5,000 over the 10-year implementation period (See Table 24).

Table 24. Goals and Estimated Costs for 10-Year Plan Implementation Period

Goal #	Goal Description	Total Estimated Level of Effort (Staff Hours)	Estimated Staff Costs @ $50/hour	Estimated Material Cost	Estimated Contractor Cost	Total Plan Cost	Average Cost per Year	Total Estimated Volunteer Hours	Volunteer Value @ $24/hour	Notes
1-1	Administer Deer Management Program	300	$15,000	$0	$0	**$15,000**	$1,500	0	$0	
2-1	Eradicate Amur Honeysuckle (1 populations)	0	$0	$0	$1,000	**$1,000**	$100	0	$0	See Table 22. Activities begin in 2022 with decreasing efffort required over time.
2-1	Eradicate Autumn Olive (Present in 8 Patches)	0	$0	$0	$1,150	**$1,150**	$115	0	$0	
2-1	Eradicate Burning Bush (4 populations)	0	$0	$0	$1,050	**$1,050**	$105	0	$0	
2-1	Eradicate Common Reed (1 population)	0	$0	$0	$1,000	**$1,000**	$100	0	$0	
2-1	Eradicate Garlic Mustard (3 populations)	0	$0	$50	$0	**$50**	$5	30	$720	Material for volunteers
2-1	Eradicate Japanese Honeysuckle (3 populations)	0	$0	$0	$1,125	**$1,125**	$113	0	$0	
2-1	Eradicate Mile-a-Minute (3 populations)	0	$0	$0	$1,600	**$1,600**	$160	0	$0	
2-1	Eradicate Mugwort (Low amounts in 3 patches)	0	$0	$0	$1,100	**$1,100**	$110	0	$0	
2-1	Eradicate Siebold's Crabapple (1 population)	0	$0	$0	$1,000	**$1,000**	$100	0	$0	
3-1	Control Invasives in Stewardship Area A	30	$1,500	$600	$4,250	**$6,350**	$635	20	$480	Staff and volunteers install 4 mini-exclosures
3-1	Control Invasives in Stewardship Area B	25	$1,250	$450	$4,250	**$5,950**	$595	20	$480	Staff and volunteers install 3 mini-exclosures
3-1	Control Invasives in Stewardship Area C	25	$1,250	$450	$4,250	**$5,950**	$595	20	$480	Staff and volunteers install 3 mini-exclosures
3-1	Control Invasives in Stewardship Area D	0	$0	$0	$3,000	**$3,000**	$300	0	$0	

Table 24. Goals and Estimated Costs for 10-Year Plan Implementation Period (continued)

Goal #	Goal Description	Total Estimated Level of Effort (Staff Hours)	Estimated Staff Costs @ $50/hour	Estimated Material Cost	Estimated Contractor Cost	Total Plan Cost	Average Cost per Year	Total Estimated Volunteer Hours	Volunteer Value @ $24/hour	Notes
3-2	Control Invasives in Restored Areas	0	$0	$0	$4,250	**$4,250**	$425	0	$0	
3-3	Consult with ENSP for Box and Wood Turtle Enhancements	25	$1,250	$500	$0	**$1,750**	$175	25	$600	Materials for nest protection and nesting site construction
3-3	Conduct Surveys and Mapping of Potential Vernal Pools	20	$1,000	$0	$0	**$1,000**	$100	25	$600	
3-3	Bolster Habitat for Numerous Assorted Rare Species	40	$2,000	$250	$0	**$2,250**	$225	25	$600	Tree girdling materials
4-1	Burn patches to restore native fire based communties	50	$2,500	$0	$1,000	**$3,500**	$350	0	$0	
4-2	Burn to reduce infestation of Japanese Barberry	50	$2,500	$0	$1,000	**$3,500**	$350	0	$0	
5-1	Perform Ecological Monotoring	80	$4,000	$250	$0	**$4,250**	$425	32	$768	
5-2	Perform Full Botanical Survey	0	$0	$0	$5,000	**$5,000**	$500	0	$0	
		645	**$32,250**	**$2,550**	**$36,025**	**$70,825**	**$7,083**	**197**	**$4,728**	

Literature Cited

Brand, M.A. 2007. UCONN Plant Database. http://www.hort.uconn.edu/plants/index.html. University of Connecticut. Accessed: September 2007.

CDMS. 2007. CDMS Agro-Chemical Information Website. Accessed: September 2007. www.cdms.net

deCalesta, D. S. 1994. Effects of white-tailed deer on songbirds within managed forests in Pennsylvania. Journal of Wildlife Management 58:711-717.

deCalesta, D. S. 1997. Deer and ecosystem management. Pages 267-279 *in* W. J. McShea, H. B. Underwood, and J. H. Rap-pole, eds. The science of overabundance: deer ecology and population management. Smithsonian Inst. Press, Washing-ton, D.C.DVRPC. 2010. Environmental Resource Inventory for the Township and Borough of Princeton, Mercer County, New Jersey. Delaware Valley Regional Planning Commission. 215 pages.

DVRPC. 2010. Environmental resource inventory for the Township and Borough of Princeton. Delaware Valley Regional Planning Commission. Philadelphia, PA. 215 pages.

Elton, C.S. 1958. The ecology of invasions by animals and plants. Chapman and Hall Ltd., London.

Hough, M.F. 1983. New Jersey Wild Plants. Harmony Press, Harmony, NJ. 414 pages.

Kramer, R.J. 1971. Herrontown Woods, A Guide to a Natural Preserve. Stony Brook – Millstone Watershed Association, Inc. 45 pages.

Launchbaugh, K. 2006. Targeted grazing – a natural approach to vegetation management. American Sheep Industry Association. Cottrell Printing, Centennial, CO. 199 pages.

McCabe, R.E. and T.R. McCabe. 1984. Of slings and arrows: An historical retrospection. Pages 19-72 in White-tailed deer: Ecology and management (L.K. Halls, ed.), Stackpole Books, Harrisburg, PA.

MOBOT. 2007. Kemper Center for Home Gardening - Plant Finder. http://www.mobot.org/gardeninghelp/plantfinder/serviceplantfinder.shtml. Missouri Botanic Garden. Accessed: September 2007.

Myers, R.L. 2006. Living with fire – Sustaining ecosystems and livelihoods through integrated fire management. The Nature Conservancy, Global Fire Initiative. Arlington, VA. 28 pages.

NISC. 2001. Meeting the invasive species challenge – Management Plan. National Invasive Species Council, Washington DC. 74 pages.

PFAF. 2007. Plants for a Future Database. http://www.pfaf.org/index.html. Plants for a Future. Accessed: September 2007.

Pimentel, D., R. Zuniga, and D. Morrison. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52: 273-288.

Snyder, D. and S.R. Kaufman. 2004. An overview of nonindigenous plant species in New Jersey. New Jersey Department of Environmental Protection, Division of Parks and Forestry, Office of Natural

Lands Management, Natural Heritage Program, Trenton, NJ. 107 pages. www.state.nj.us/dep/parksandforests/natural/heritage/InvasiveReport.pdf

Stafford, K.C. III. 2007. Tick Management Handbook. Connecticut Agricultural Extension Service, New Haven, CT. Bulletin No. 1010. 78 pages.

State of New Jersey, Department of Environmental Protection, Endangered and Nongame Species Program. 2012. List of Species of Special Concern (21 February 2012). Retrieved from https://www.state.nj.us/dep/fgw/ensp/pdf/spclspp.pdf

State of New Jersey, Department of Environmental Protection, Natural Heritage Program. 2016. List of Endangered Plant Species and Plant Species of Concern (June 2016). Retrieved from https://www.nj.gov/dep/parksandforests/natural/heritage/njplantlist.pdf

Tesauro, J. 2001. Restoring Wetland Habitats with Cows and other Livestock. A prescribed grazing program to conserve bog turtle habitat in New Jersey. Conservation in Practice 2 (2), 26–31.

Tu, M., Hurd, C. & J.M. Randall. 2001. Weed Control Methods Handbook, The Nature Conservancy, http://tncweeds.ucdavis.edu, version: April 2001.

Van Driesche, R., B. Blossey, M. Hoddle, S. Lyon, and R. Reardon. 2002. Biological Control of invasive plants in the Eastern United States. United States Department of Agriculture. Forest Health Technology Enterprise Team. FHTET-2002-04. Washington DC. 413 pages.

Wilcove, D.S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. BioScience 48: 607-615.

Freyman, W.A., L.A. Masters, and S. Packard. 2016. The Universal Floristic Quality Assessment (FQA) Calculator: an online tool for ecological assessment and monitoring. Methods in Ecology and Evolution 7(3): 380–383.

Gleason, Henry A., and Arthur Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada, 2nd edition. The New York Botanical Garden Press, Bronx, NY.

Kartesz, J.T., The Biota of North America Program (BONAP). 2015. Taxonomic Data Center. (http://www.bonap.net/tdc). Chapel Hill, N.C. [maps generated from Kartesz, J.T. 2015. Floristic Synthesis of North America, Version 1.0. Biota of North America Program (BONAP). (In press)]

USDA, NRCS. 2018. The PLANTS Database (http://plants.usda.gov, 4 December 2018). National Plant Data Team, Greensboro, NC 27401-4901 USA.

An Indian Cucumber Root, a palatable native for deer,
produced flowers and was developing fruit while partially hidden close to a downed tree.