Lawrenceville School
10-Year Land Stewardship Plan

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FoHVOS New Jersey
Invasive Species
Strike Team

Intrepid students helping the Strike Team map invasive species on a very, very hot summer day!

Introductory Information

Property:	Lawrenceville School
Property Acreage:	624 acres
County, Municipality:	Mercer County, Lawrence Township
Wildlife Action Plan Conservation Zone:	Central Piedmont Plains (14)
NJDEP Watershed Management Area:	Central Delaware (WMA 11)
Waterbodies:	Shipetauken Creek tributaries: 1st Order = 2.1 miles, 2nd Order = 0.8 miles Unnamed Ponds (5): Total Acreage = 4.3; Sizes range from 0.3 to 2.5 acres
Numbers of Rare Species Conservation Targets[1]:	Total Number of Animal Species: 4 Total Number of Plant Species: 0 Total Number of Ecological Communities: 0 *Note: Categories below are not mutually exclusive.* Globally Rare Species: 0 Federally Endangered Species: 0 Federally Threatened Species: 0 State Endangered Species: 1 State Threatened Species: 0 State Special Concern Species: 3 State Game Species of Concern: 0 Globally Rare Ecological Communities: 0 State Rare Ecological Communities: 0
Habitat Conservation Targets:	1) Mature Forest, 2) Meadow, 3) Habitat Corridors
Landscape-Scale Conservation Areas:	*ENSP Landscape Project Importance Summary* - Largest Habitat Patch - Forest, 63 contiguous acres *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 no sites that overlap with the Property.

Species Conservation Target List[1]:

Birds (1)
Bald Eagle (S1B, S2N, Endangered), Coopers Hawk (S3B, S4N, Special Concern), Wood Thrush (S3B, S4N, Special Concern), Great Blue Heron (S3B, S4N, Special Concern)

Amphibians (0)
None

Retiles (0)
None

Insects (0)
None

Habitats (1)
Potential Vernal Pool (ID #1595, located off site)

Plants ()
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: 56

Action Code = 1 (18 species)
Amur Maple, Blue Plantain Lilly, Callery (Bradford) Pear, Chocolate Vine, Golden Raintree, Japanese Clematis, Japanese Holly, Japanese Maple, Japanese Snowball, Japanese Snowbell, Jetbead, Mimosa, Porcelain Berry, Princess Tree, Rose (unknown), Sapphire Berry, Siebold's Viburnum, Weeping Cherry

Action Code = 2 (27 species)
Amur Corktree, Amur Honeysuckle, Autumn Olive, Border Privet, Burning Bush, Chinese Bushclover, Chinese Wisteria, Common Reed, English Ivy, Garlic Mustard, Japanese Barberry, Japanese Honeysuckle, Japanese Knotweed, Japanese Stiltgrass, Japanese Zelkova, Linden Viburnum, Mile-a-Minute, Multiflora Rose, Morrow's Honeysuckle, Norway Maple, Oriental Bittersweet, Oriental Photinia, Siebold's Crabapple, Sweet Cherry, Wineberry, Winter Creeper, Yellow Iris

Action Code = 3 (6 species)
Black Locust, Canada Thistle, Mugwort, Mulberry, Norway Spruce, Periwinkle, Purple Loosestrife, Reed Canarygrass, Small Carpetgrass, Southern Catalpa, Tree of Heaven

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 #12 and Deer Management Units 269 and 282 (southwest corner only). 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 10-year stewardship plan includes results of field investigations with recommendations to improve ecological health of natural areas at the Lawrenceville School.

There are three main purposes of this plan. The first is to clearly state the vision and goals including protection of biodiversity, and provision of recreational and educational opportunities. 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 for the Property is to provide a model of stewardship for biodiversity, encouraging student land stewardship, research, and exploration. The four primary recommendations include: 1) Conduct an Effective White-tailed Deer Management Program, 2) Perform Strategic Invasive Species Control; 3) Restore and Protect Forest, Meadow, and Riparian Corridors, and 4) Encourage Student Land Stewardship, Research, and Exploration. Each of these recommendations includes action-oriented goals (See Section IV) to support both flora and fauna.

The primary habitat conservation target are mature forest, meadow, and habitat corridors. Importantly, the Property provides steppingstone habitat and existing wildlife corridors connecting to other core habitats (e.g., Mercer Meadows, Institute Woods, and Mercer County Park. All habitats and species are under immediate threat from overabundant deer and invasive species.

Deer management was established on the Property in 2021, however, lack of past 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” (only 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 56 invasive species were detected with 72% of the Property having severe infestations of one or more species. Only 8% of the Property is considered virtually free of invasive species, while approximately 20% are lightly to moderately infested. The three most abundant species are Border Privet, Multiflora Rose, and Linden Viburnum. Importantly, there were 18 detected 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 15,000 hours of effort). This plan recommends a strategic approach involving protection and enhancement of the highest ecological quality areas. The ultimate goal is significantly reducing invasive species through directed active control and ultimate reliance on ecological control through deer herd reduction to both reverse current infestations and resist future infestations.

The plan provides four primary recommendations with nine associated goals (see next page). Full plan implementation is estimated to require 1,200 hours of staff time (estimated cost of $60,000), 10,000 student volunteer hours (estimated value of $240,00), and $184,750 of purchased material costs and contractor costs over the next 10 years - total cost is estimated at $244,750 (See Table 25 for additional details).

Primary Plan Recommendations

This 10-year plan has four primary recommendations and nine associated goals. A key element of goal implementation is student engagement and active participation in the natural world. Goals are further divided into specific tasks with associated level-of-effort and cost estimates (Table 25).

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

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

- The goal is meeting forest health goals including a dense understory with native shrubs and wildflowers. Deer density should be kept below 20 deer per square mile but allowing full recovery of forest wildflowers may require a density of 10 deer per square mile. Significant progress toward this goal can be made through an annual Deer Management Program but reaching this goal will ultimately require participation of neighboring landowners. 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 18 emerging invasive species (Action Code 1 species)

- The goal is intended to reduce future damage by addressing species that have not yet established large, extensive populations throughout the Property. Accomplishing this goal will also fulfill 'ecological responsibility' by preventing spread of newly emerging harmful invasive species beyond the Property.

Recommendation #3: Restore and Protect Forest, Meadow, and Riparian Corridors

Goal #3-1: Restore and protect 16 acres of highest-quality old growth forest habitat

- Includes Bowl Woods (Patches #77/78) and Old Ropes Course Woods (Patches #31/34)
- Requires considerable but selective invasive species control efforts (Action Code 2 species)
- Install and maintain deer exclosures – options include complete perimeter protection through professionally installed fencing or protection of small exclosures installed by students
    - Plant forest wildflowers or just protect existing plants? Propagate from existing plants?

Goal #3-2: Restore 18 acres of mature forest

- Ropes Course Area (Patch #42) contains significant invasive species cover, but also contains significant native shrub cover and wildflower diversity
- Requires long-term selective control of multiple invasive species

Goal #3-3: Guide development of a 5-acre successional shrubland/forest (Patch #24)

- High-quality shrubland is temporary (but very rare) habitat on the landscape
- Requires selective control of various invasive species to foster establishment of mature forest
- Area currently has few woody invasive species making this goal easily feasible

Goal #3-4: Maintain and restore 12 acres of meadow habitat

- Enhance 3 acres of existing meadow habitat (Patch #38)
- Create 9 acres of new meadow habitat including three detention basins, golf course rough areas, and stream buffers

Recommendation #4: Encourage Student Land Stewardship, Research, and Exploration

Goal #4-1: Perform land stewardship

- Assist in implementation Recommendations #2 and #3 above

Goal #4-2: 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 #4-3: Develop and maintain a trail system to encourage student study of the Property

- Develop trail system to provide access throughout the Property

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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 Lawrenceville School consists of 624 acres in Lawrence Township, Mercer 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 significant examples of the natural heritage contained within the Piedmont physiographic region, especially those areas containing old growth, mature forests. There were 25 different plant community types identified during field surveys, including old growth forests with magnificent large trees. The Property contains Shipetauken Creek tributaries, and the main stem lies just east of the Property. These waterways form important habitat corridors to nearby natural areas.

Stewardship Vision and Goals

The stewardship vision for the Property is to provide a model of stewardship for biodiversity, encouraging student land stewardship, research, and exploration. The four primary recommendations include: 1) Conduct an Effective White-tailed Deer Management Program, 2) Perform Strategic Invasive Species Control; 3) Restore and Protect Forest, Meadow, and Riparian Corridors, and 4) Encourage Student Land Stewardship, Research, and Exploration. 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 by wise stewardship fueled by deep appreciation of the natural world. Because of 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 exemplary stewardship, involving students toward fostering the land ethic.

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).

Annual Hopewell Valley deer counts far exceed these statewide estimates (Figure 3). In 2021, over 100 deer per square mile were documented, with an estimate of 155 deer per square mile post-birthing. Results would likely be similar in Lawrence Township.

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 important 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

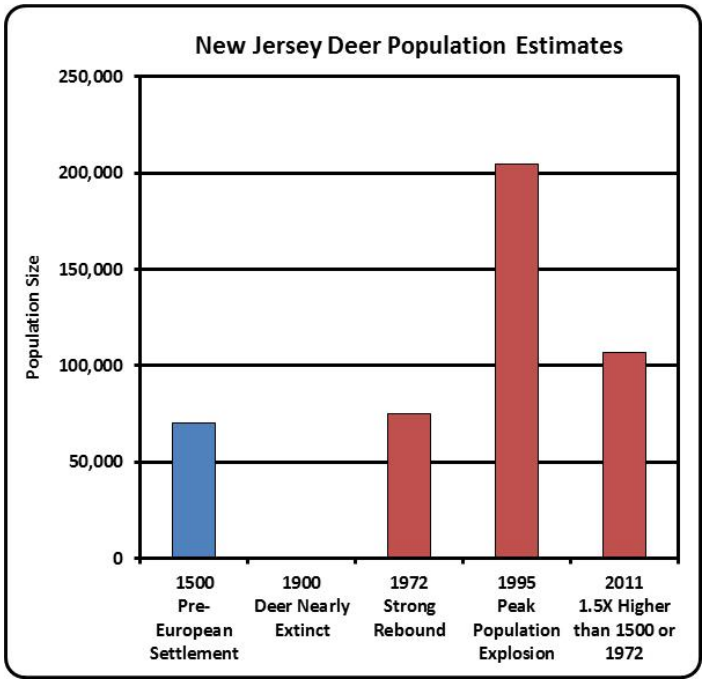
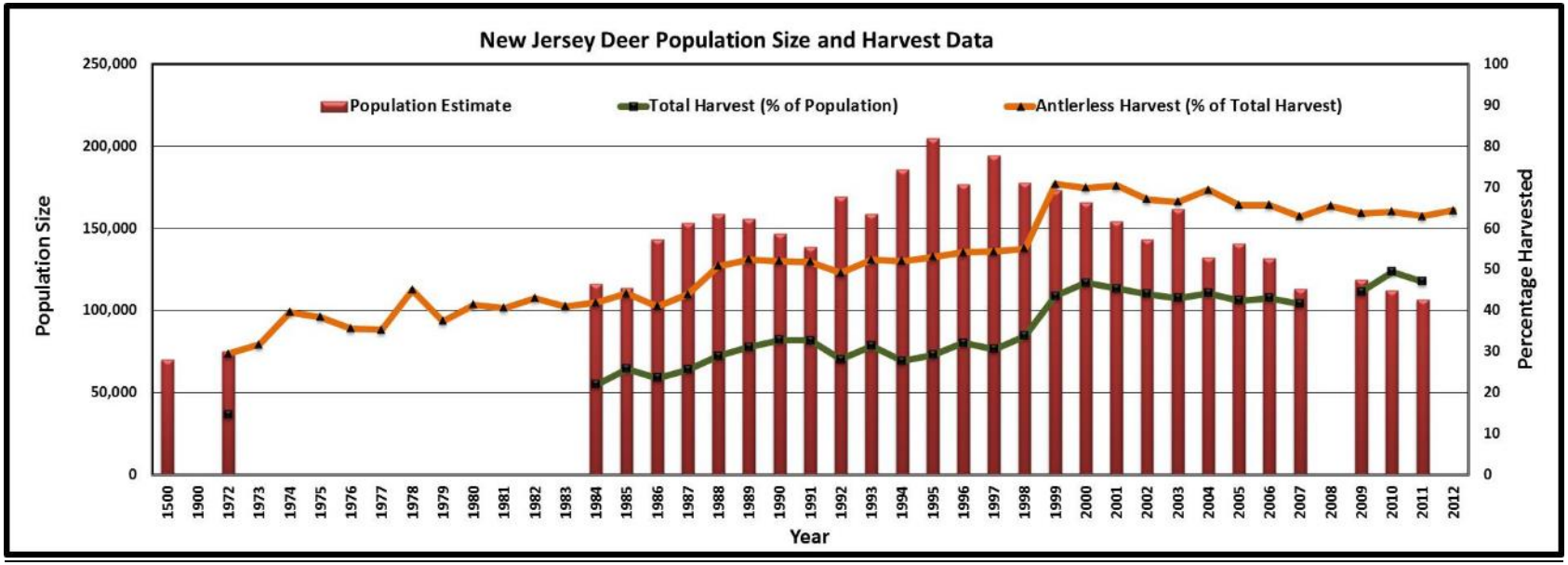


Figure 2. New Jersey Deer Population Size and Harvest Data



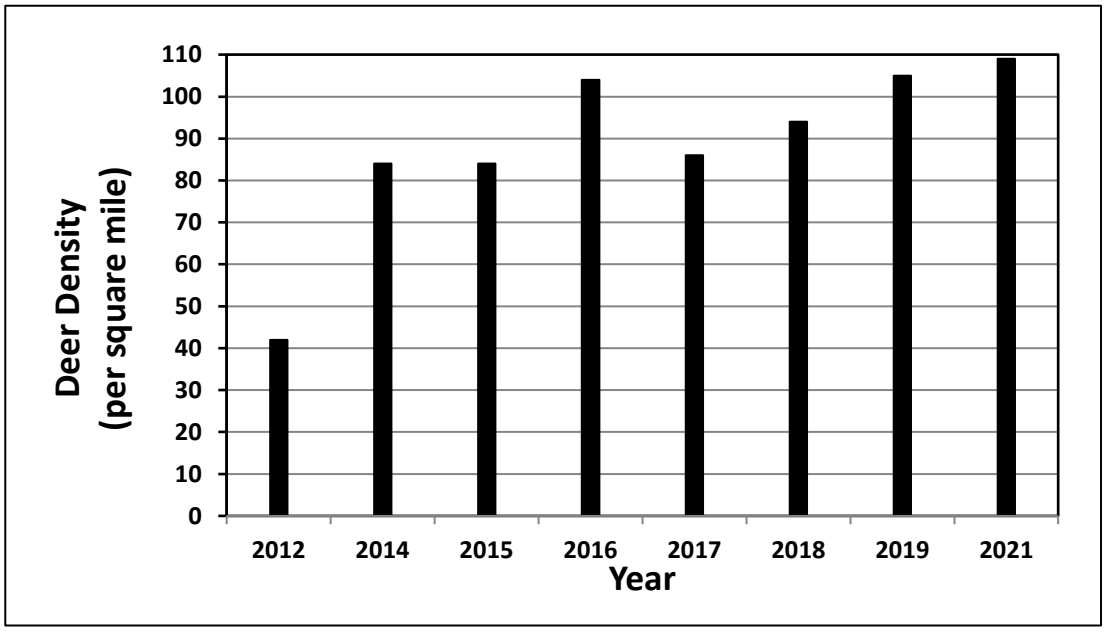
Graph prepared using NJ Division of Fish & Wildlife data sources. The estimated number of deer in 1500 is based upon the average deer density across North America (9.5/square mile) reported by McCabe and McCabe (1984) and the NJ land area reported by the US Census Bureau (7,417 square miles). Using this 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-Columbian 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-Columbian estimates [but see special note #1 above].

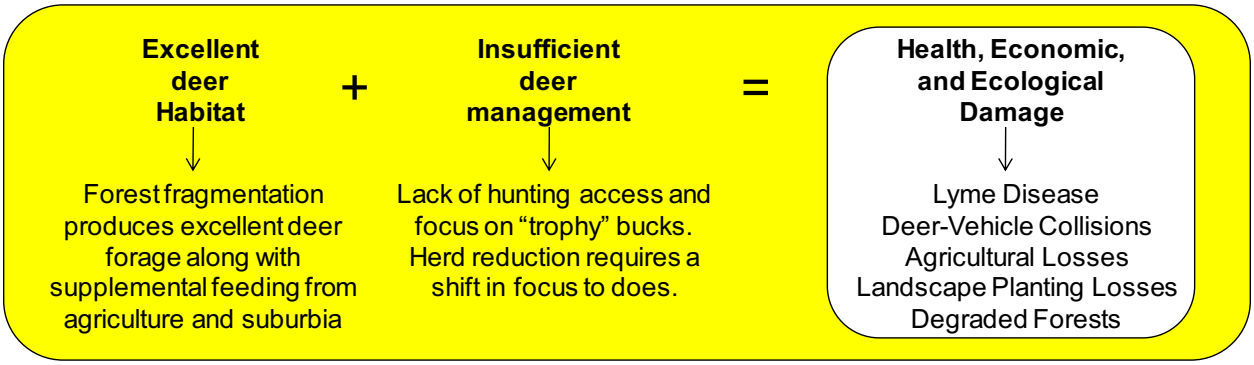
It should be noted that the deer population size or density is less significant than their overall impacts on ecosystem health, which should be measured to inform deer management goals.

Figure 3. Hopewell Valley Deer Population Density



A simplified explanation of deer management issues and consequences are depicted in Figure 4. All deer management efforts must consider the current habitat conditions that serve deer population growth. Deer prefer forest edges and fields for feeding and utilize forests for cover and supplemental feeding. Deer also utilize agricultural crops as food sources and residential areas for both food and cover from hunters (state regulations prohibit firearm hunting within 450 feet of an occupied or potentially occupied structure unless written permission is provided by the owner, bow hunting is prohibited within 150 feet). Both restrictions on hunting access and insufficient hunting efficacy, plus the ability of the landscape to serve as an excellent incubator for deer population growth, combine to cause severe deer impacts.

Figure 4. 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 problems 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 significant 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 Hutchinson 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 generally 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 concert 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.

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).

Multiflora Rose is prevalent on the Property, while Rose Rosette Disease is beginning to kill plants growing in sunny areas, the majority of plants are growing in forest conditions where they are not severely impacted.

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 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 5. Suspected Impacts of Past Agricultural Tilling

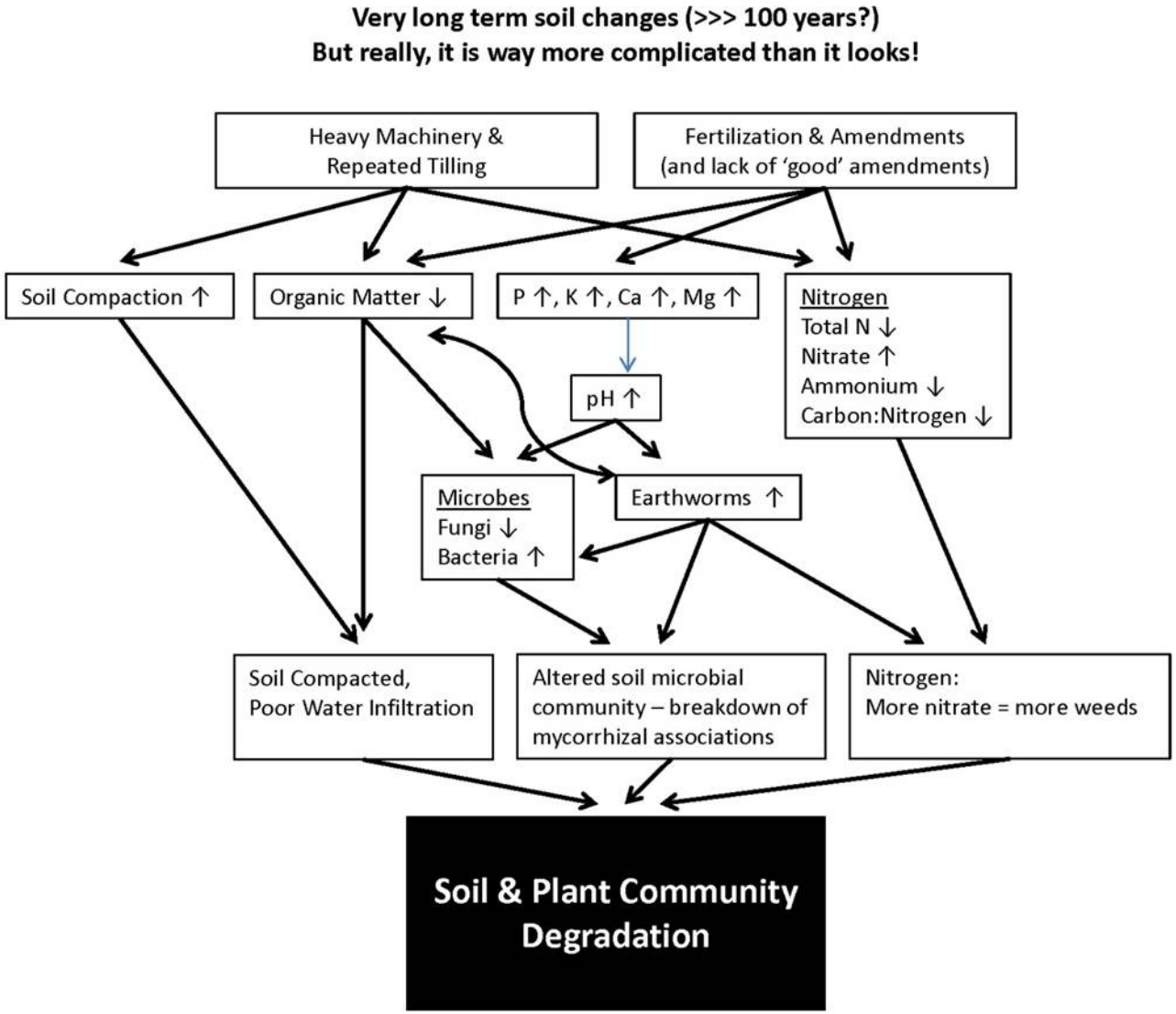
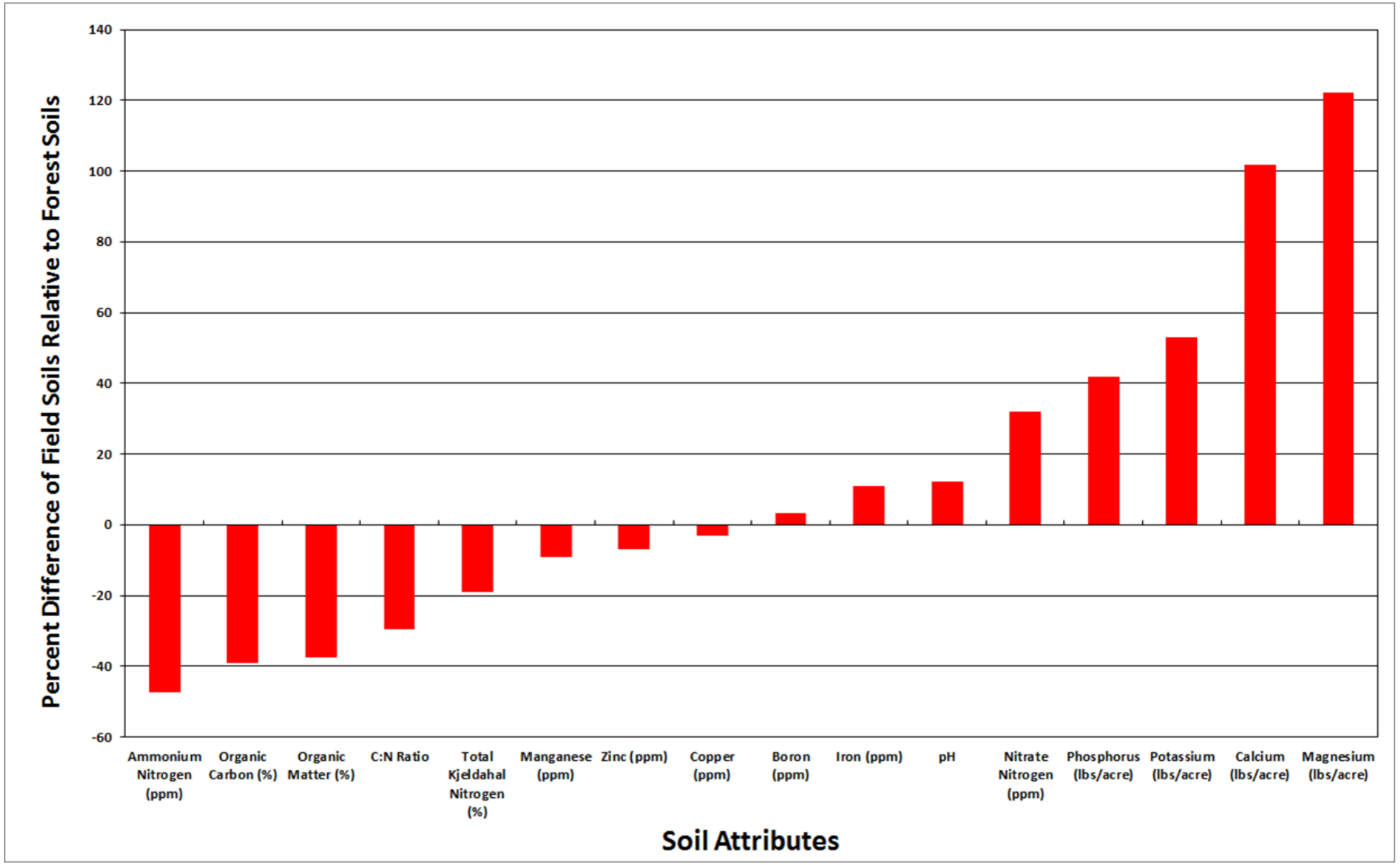


Figure 6. Measured Chemical Changes in Soils from Tilled and Untilled Soils



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 occurs on the Stockton Formation (Table 3, Map 2). The Property has a generally flat topography with elevations ranging from 60 to 100 feet above sea level. The majority ranges from 80-100 feet with a large marsh dipping down to 60 feet in the southeastern portion of the Property. Topography is depicted in Map 3.

Table 3. Bedrock Geology Summary

Name	LITHOLOGY	Acres	Percent of Property
Stockton Formation	sandstone, mudstone, silty mudstone, argillaceous siltstone, and shale	624	100
Totals		**624**	**100**

Soils - There are 27 unique soil types within the Property (USDA soil survey report provided as Appendix A). The three most predominant soils are 1) Matapeake loam, 2 to 5 percent slopes (31% of Property), 2) Bucks silt loam, 2 to 6 percent slopes (26%), and 3) Othello silt loams, 0 to 2 percent slopes, northern coastal plain (6%). The majority of unique soil types are minor (each ≤ 5% of the Property). A summary of soil types is provided in Table 4 and their distribution is depicted in Map 4.

Sessile Bellwort making fruit in Bowl Woods –
it's a very infrequent occurrence in New Jersey!

Table 4. Soil Type Summary

Soil Symbol	Description	Acres	Percent of Property
BhnA	Birdsboro silt loam, 0 to 2 percent slopes	0.3	< 1
BhnB	Birdsboro silt loam, 2 to 6 percent slopes	0.4	< 1
BHRSB	Birdsboro sandy subsoil variant soils, 2 to 6 percent slopes	13.1	2
BHRSC	Birdsboro sandy subsoil variant soils, 6 to 12 percent slopes	1.0	< 1
BoyAt	Bowmansville silt loam, 0 to 2 percent slopes, frequently flooded	21.4	3
BucB	Bucks silt loam, 2 to 6 percent slopes	159.5	26
BucB2	Bucks silt loam, 2 to 6 percent slopes, eroded	0.1	< 1
BucC	Bucks silt loam, 6 to 12 percent slopes	9.1	1
BucC2	Bucks silt loam, 6 to 12 percent slopes, eroded	5.2	1
MbaAt	Marsh, fresh water, 0 to 2 percent slopes, frequently flooded	20.1	3
MbpA	Matapeake loam, 0 to 2 percent slopes	16.9	3
MbpB	Matapeake loam, 2 to 5 percent slopes	195.7	31
MbpC2	Matapeake loam, 5 to 10 percent slopes, eroded	12.7	2
MBYB	Mattapex and Bertie loams, 0 to 5 percent slopes	32.4	5
OthA	Othello silt loams, 0 to 2 percent slopes, northern coastal plain	36.5	6
PHG	Pits, sand and gravel	4.7	1
QukB2	Quakertown silt loam, 2 to 6 percent slopes, eroded	1.8	< 1
QukC2	Quakertown silt loam, 6 to 12 percent slopes, eroded	1.6	< 1
REFA	Readington and Abbottstown silt loams, 0 to 2 percent slopes	11.0	2
RehA	Reaville silt loam, 0 to 2 percent slopes	4.0	1
RorAt	Rowland silt loam, 0 to 2 percent slopes, frequently flooded	20.6	3
SacB	Sassafras sandy loam, 2 to 5 percent slopes, Northern Coastal Plain	3.4	1
SacC	Sassafras sandy loam, 5 to 10 percent slopes, Northern Coastal Plain	2.5	< 1
SadB	Sassafras gravelly sandy loam, 2 to 5 percent slopes	0.6	< 1
UdbB	Udorthents, bedrock substratum, 0 to 8 percent slopes	17.3	3
UdcB	Udorthents, clayey substratum, 0 to 8 percent slopes	28.3	5
WATER	Water	4.4	1
Totals		**624**	**100**

Water - Water and wetlands are depicted on Map 5. A main tributary of Shipetauken Creek flows west to east through the approximate southern-center of the Property, additional tributaries feed this tributary from the south and north. The main branch Shipetauken lies just to the east of the Property. Swaths of wetlands are centered around the Shipetauken Creek and its tributaries located on the Property. Wetland and transitional areas were field mapped and reported in Section II. A vernal pool is located just to the northeast of the Property.

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 60% of the surrounding area is developed or barren, with 10% cover as agricultural lands. The high percentage of developed and agricultural lands

creates ongoing challenges toward the stewardship of the Property (e.g., deer refugia, sources of invasive species, crops supporting high deer populations). The majority of natural cover is represented by forest habitat (25% of area), with small amounts of shrubland and meadow habitats.

The Property contains a significant amount of urban cover (47%) and agricultural cover (25%). The majority of natural cover consists of forests and woodlands (ca. 25%), with only 4% of total cover as shrubland and meadow.

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 Acres
Urban	293	47.0	28621	57.0
Barren	3	0.5	326	0.6
Agriculture	158	25.3	4991	9.9
Water	4	0.6	1001	2.0
Forest - Coniferous - Upland	0	0.0	266	0.5
Forest - Coniferous - Wetland	0	0.0	1	0.0
Forest - Deciduous - Upland	50	8.0	4738	9.4
Forest - Deciduous - Wetland	59	9.5	6077	12.1
Woodland - Coniferous - Upland	1	0.2	63	0.1
Woodland - Coniferous - Wetland	0	0.0	0	0.0
Woodland - Deciduous - Upland	31	5.0	1028	2.0
Woodland - Deciduous - Wetland	0	0.0	0	0.0
Shrubland - Coniferous - Upland	0	0.0	160	0.3
Shrubland - Coniferous - Wetland	0	0.0	40	0.1
Shrubland - Deciduous - Upland	5	0.8	1243	2.5
Shrubland - Deciduous - Wetland	8	1.3	504	1.0
Meadow - Upland	1	0.2	521	1.0
Meadow - Wetland	11	1.8	669	1.3
Totals	**624**	**100**	**50249**	**100**

The 1930 aerial photography (Map 8) shows that the Property was largely agricultural cover along with the main campus. Two small forest patches occurred in 1930, namely the currently old, mature forests known as Bowl Woods and Old Ropes Course Woods. The overlap of 1930 and current forests is summarized in Table 6 and depicted on Map 9. Field surveys conducted in 2021 show that forest and woodland habitats cover 16% of the Property. Currently forested areas considered to be 'old forest' (i.e., present since at least 1930) account for approximately 7% of the Property.

Table 6. Historic and Current Forest Cover

Year	Acres	% of Property
1930	14.0	2.2
2021	164.0	26.3
1930 and 2020	13.5	6.9

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 area seen in 1930 present the best opportunity to maintain and improve forest health.

Current shrublands and meadows are unlikely to develop into healthy forest habitat, possibly for many hundreds of years or longer as the soils slowly recover. This problem is exasperated but overabundant deer and would be significantly ameliorated by deer herd reduction allowing native plants to compete against less palatable invasive plants, even on altered soils. However, some meadow and shrubland habitat occurs in saturated floodplain soils and are relatively healthy.

Protected Lands - There are numerous patches of protected open space within five miles of the Property, the majority existing as natural islands in a developed and agricultural landscape (Map 10). These lands include the Mercer Meadows, Mercer County Park, Maher Park, and Institute Woods with multiple small pockets of protected lands. While each of these natural lands are significant, protected connections between them are generally lacking (see Section II).

Very unusual ‘arched’ tree in the floodplain

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, meadow, and riparian corridors. 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 too small to provide nesting habitat for area-demanding species such as Kentucky Warbler, but it provides stopover feeding opportunities for Neotropical migrant birds and can provide nesting habitat for many other species (e.g., Wood Thrush). Riparian wildlife corridors are especially important in the highly developed central New Jersey region and the Property support travel to support larger nearby core habitats if habitat corridors are maintained and enhanced. Meadow corridors along waterways can also improve stream health.

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. Developed areas are not ranked as potential wildlife habitat.

Patch ranks on the Property are depicted in Map 11 and summarized in Table 7. Habitat patches that intersect with the Property are primarily Rank 1 (33% of Property) or Rank 2 (11%, associated with Great Blue Heron habitat). The Landscape Project also characterizes habitat patch sizes, which are shown in Map 12 and summarized in Table 8. The property contains 131 acres of patches in the 50–100-acre size class, The majority of habitat patches are < 10 acres. While the Property is too small for area-demanding species, it can provide significant stop-over habitat for migrating birds and other species of resident birds, reptiles and amphibians as well as providing a significant riparian wildlife corridor.

Table 7. Landscape Project Patch Rank Summary

Rank	Acres	% of Property
5	0	0
4	0	0
3	0	0
2	69	11
1	207	33
Not Evaluated	348	56
Totals	**624**	**100**

Table 8. Landscape Project Patch Size Summary

Patch Size	Number of Patches	Total Property Acres within Patch Size Class	% of Property
< 10 acres	81	111	18
10-25 acres	2	13	2
25-50 acres	1	22	3
50-100 acres	2	131	21
100-1000 acres	0	0	0
Not Evaluated	N/A	348	56
Totals	**86**	**624**	**100**

The Landscape Project maps vernal habitat and waterbodies that harbor rare species. There is one potential vernal pool habitat located just outside of the Property and waterbodies are not known to harbor rare aquatic species (Map 13). 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.

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 14. The Property contains steppingstone and corridor designations associated with Shipetauken Creek tributaries. Lands connected to the Property via corridors includes Mercer Meadows, Mercer County Park, Maher Park, and Institute Woods.

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. There were no rare plant species associated with the Property as provided in their official report (Appendix B), but the grid data suggests some potential Smooth Hedge Nettle (S3, "Special Concern"), occurring in a grid that overlaps the Property's southeastern corner (See Map 15). However, this is likely to be an occurrence no longer considered extant or it would have been part of their official report.

Ecological Communities

Ecological communities were mapped at the Property from June through August 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 xx different types). See Appendix C for raw mapping data for each mapped patch.

There was a total of 52 mapped ecological community patches across 196 mapped acres (Map 16). 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:

- Map 17 and 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. 26% of Property and 82% of natural habitats) are the dominant natural ecological communities with meadow (< 4% and 11%), and shrubland (< 2% and 6%) communities accounting for lesser, but still significant coverage. Developed lands, agricultural lands, and water are approximately 46%, 22% and 0.7%, respectively.

  Natural communities were also divided into moisture categories determined by affinities of plant species present and landforms (Map 18). These categories included upland, wetland and transitional (areas with components including upland and wetland species and mixed landforms). Upland, transitional, and wetland types accounted for approximately 18%, 30%, and 52% of natural habitats on the Property, respectively.

Table 9. Broad Ecological Community Type Summary

Broad Habitat Type	Acres	Percent of Property	Percent of Natural Habitats
Forest	76	12.2	38.8
Woodland	88	14.0	44.7
Shrubland	11	1.7	5.5
Meadow	22	3.5	11.1
Water	4	0.7	N/A
Agriculture	137	21.9	N/A
Urban	287	46.0	N/A
Totals	**624**	**100**	**100**

Habitat Type Moisture Categories (Natural Habitats Only)	Acres	Percent of Property
Upland	36	18.2
Transitional	59	29.8
Wetland	102	51.8
Totals	**196**	**100**

Interesting mushrooms occur through the forest

- Table 10 – Specific Plant Community Types

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

The most common type was mixed deciduous types, sometimes with dominates including Red Maple. Areas influenced by past plantings include White Pine and Sugar Maple.

Table 10. Specific Ecological Community Type Summary

Specific Community Type	Acres	Percent of Property	Percent of Natural Habitats
Upland - Forest - Mixed Deciduous	4	0.6	1.8
Upland - Forest - Planted Sugar Maple, Mixed Deciduous	1	0.1	0.4
Upland - Forest - White Pine, American Holly, Mixed Deciduous	3	0.5	1.7
Upland - Forest - White Pine, Mixed Deciduous	3	0.4	1.3
Upland - Forest - American Holly, Mixed Deciduous	0	0.0	0.2
Transitional - Forest - Mixed Deciduous	21	3.4	10.8
Transitional - Forest - Mixed Deciduous	9	1.4	4.3
Transitional - Forest - Red Maple, Box Elder Maple, Sugar Maple, Mixed Deciduous	2	0.3	1.0
Transitional - Forest - Planted Sugar Maple	1	0.1	0.3
Wetland - Forest - Mixed Deciduous	11	1.8	5.6
Wetland - Forest - Red Maple, Mixed Deciduous	12	1.9	6.1
Wetland - Forest - Mixed Deciduous	9	1.5	4.6
Upland - Woodland - Mixed Deciduous	4	0.6	1.9
Upland - Woodland - Mixed Deciduous	12	1.9	6.0
Transitional - Woodland - Mixed Deciduous	9	1.4	4.5
Transitional - Woodland - Mixed Deciduous	13	2.1	6.5
Transitional - Woodland - White Pine, American Holly, Mixed Deciduous	2	0.3	1.1
Transitional - Woodland - White Pine, Mixed Deciduous	3	0.5	1.7
Wetland - Woodland - Mixed Deciduous	30	4.8	15.3
Wetland - Woodland - Black Walnut, Mixed Deciduous	4	0.6	1.8
Wetland - Woodland - Red Maple, Mixed Deciduous	12	1.9	6.0
Wetland - Shrubland	11	1.7	5.5
Upland - Meadow	9	1.5	4.6
Transitional - Meadow	1	0.1	0.3
Wetland - Meadow	12	2.0	6.3
Water	4	0.7	N/A
Agriculture	137	21.9	N/A
Urban	287	46.1	N/A
Totals	**624**	**100**	**100**

- Maps 19 - 20; Tables 11 - 13 – Understory Cover of Native Shrubs, Regenerating Trees and Native Herbaceous Cover

The regeneration of native trees is abysmal on the Property (Table 11). There were five patches with trace amounts of trees seedlings > 3' tall. One patch with 11-25% cover of native tree seedlings and one small patch with 26-50% native tree cover. Species are generally those considered to be the least palatable native tree species.

Table 11. Tree and Shrub Regeneration Summary

Patch ID	Patch Acres	Cover Category	Species
19	11.3	Trace, <1%	Pin Oak
31	6.0	Trace, <1%	Hickory, White Ash, Ironwood, Sassafras
34	6.4	Trace, <1%	White Ash, Black Cherry, Sassafras
42	17.5	Trace, <1%	Boxelder, American Beech, Sassafras
77	2.3	Trace, <1%	Sassafras, Black Cherry
78	1.4	Trace, <1%	White Ash
24	4.6	2, 11-25%	Red Maple
53	0.2	3, 26-50%	Black Walnut, Sweet Gum
Totals	**49.8**		

Native shrubs and herbaceous species (both vulnerable to deer browse) were low across a majority of the Property (Maps 19 and 20, respectively). Ideally, native woody understory cover in healthy forests would be above 70%. Across New Jersey, native understory cover averages less than 20%. Approximately 72% of forest and 66% of woodland communities had < 10% native woody understory cover. Nearly all of the remaining forest and woodland communities has less than 50% cover. Areas with the greatest understory cover were associated with older forest patches and the area adjacent to the current ropes course.

Native shrub cover was low in most shrubland habitat, which tended to be dominated by unpalatable invasive species. The most significant exception occurred on 8 acres where native cover was 50-75%, this area contains saturated soils that likely inhibit easy deer movement.

Native herbaceous species (wildflowers and grasses) were very sparse throughout the Property, especially in forest and woodland habitats where > 67% and 76% of areas had less than 10% cover and showed intense 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). Similar to shrub cover in shrublands, saturated areas had more native herbaceous species.

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	5	7.0
Forest	< 1%	12	15.6
Forest	1-10%	37	49.6
Forest	11-25%	3	4.4
Forest	26-50%	18	23.4
Forest	51-75%	0	0.0
Forest	76-100%	0	0.0
Forest - Total		**75**	**100**
Woodland	Absent	4	4.6
Woodland	< 1%	29	33.5
Woodland	1-10%	24	27.6
Woodland	11-25%	1	1.0
Woodland	26-50%	21	24.3
Woodland	51-75%	8	8.9
Woodland	76-100%	0	0.1
Woodland - Total		**88**	**100**
Shrubland	Absent	0	0.6
Shrubland	< 1%	1	5.4
Shrubland	1-10%	0	0.0
Shrubland	11-25%	2	16.7
Shrubland	26-50%	8	72.2
Shrubland	51-75%	1	5.2
Shrubland	76-100%	0	0.0
Shrubland - Total		**11**	**100**
Meadow	Absent	5	25.3
Meadow	< 1%	10	48.0
Meadow	1-10%	2	8.8
Meadow	11-25%	4	18.0
Meadow	26-50%	0	0.0
Meadow	51-75%	0	0.0
Meadow	76-100%	0	0.0
Meadow - Total		**22**	**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	0.4
Forest	< 1%	40	53.0
Forest	1-10%	11	14.4
Forest	11-25%	6	7.6
Forest	26-50%	8	10.7
Forest	51-75%	10	13.9
Forest	76-100%	0	0.0
Forest - Total		**75**	**100**
Woodland	Absent	2	2.4
Woodland	< 1%	42	48.1
Woodland	1-10%	23	26.0
Woodland	11-25%	0	0.0
Woodland	26-50%	4	4.9
Woodland	51-75%	12	13.5
Woodland	76-100%	5	5.1
Woodland - Total		**88**	**100**
Shrubland	Absent	0	0.0
Shrubland	< 1%	0	0.0
Shrubland	1-10%	1	12.0
Shrubland	11-25%	2	21.3
Shrubland	26-50%	5	48.1
Shrubland	51-75%	2	18.5
Shrubland	76-100%	0	0.0
Shrubland - Total		**11**	**100**
Meadow	Absent	1	4.6
Meadow	< 1%	4	18.1
Meadow	1-10%	0	0.0
Meadow	11-25%	9	42.6
Meadow	26-50%	3	12.5
Meadow	51-75%	2	7.4
Meadow	76-100%	3	14.8
Meadow - Total		**22**	**100**

- Map 21 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, presence of regenerating native trees, and invasive species cover. The relative quality ranks were 'High' or 'Moderate' across 51 acres (ca. 26% of the Natural Habitats) and 'Low' for remaining areas (See Map 21).

  Community quality rankings were used to determine strategies in Section IV and a summary of the highest quality areas are provided in Table 15. For this plan, seven unique mapped patches have been identified as having higher conservation value and it is recommended that these areas receive the greatest stewardship efforts. An additional five mapped patches have relatively higher quality, but these areas are heavily saturated and regular stewardship efforts are impractical.

Table 14. Relative Patch Quality Summary

Relative Quality Rank	Acres	Percent of Natural Habitats
High	14	7.3
Moderate	37	18.8
Low	145	73.8
Totals	**196**	**100**

Arrow Arum flowering in a saturated meadow

Table 15. Priority Highest Quality Patches

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

Project Area	Patch ID	Broad Community Types	Patch Acres	Native Trees	Native Shrubs	Native Herbs	Invasive Species
A	77	Upland - Forest - Mixed Deciduous	2.3	American Basswood, Boxelder, White Oak, Mockernut Hickory, Shagbark Hickory, Sugar Maple, American Beech, Black Tupelo, Shellbark Hickory	Witch-hazel, Allegheny Blackberry, Maple-leaved Viburnum, Spicebush, Black Cherry regeneration, American Holly regeneration	False Solomon's Seal, Mayapple, Stoneroot, White Wood Aster	Although heavily infested by multiple invasive species, this location is part of the 1930's old growth forest patches and should be restored. Trace amounts of 13 species. Cover of each of the following species is 1-10%: Norway Maple, Garlic Mustard, Burning Bush, and Border Privet. Cover of Linden Viburnum and Japanese Zelkova are each 11-25%. Cover of Amur Corktree is 26-50%.
A	78	Wetland - Woodland - Mixed Deciduous	1.4	Red Oak, Red Maple, White Oak, Mockernut Hickory, Boxelder, American Beech, American Holly, Ironwood	Blackhaw, Maple-leaved Viburnum, Arrowwood, Allegheny Blackberry, White Ash regeneration	None	Adjacent to Patch #77, this location is part of the 1930's old growth forest patches and should be restored. Trace amounts of 10 species. Cover of each of the following species is 1-10%: Burning Bush, Linden Viburnum, Japanese Zelkova and Amur Corktree.
B	31	Upland - Woodland - Mixed Deciduous	6.0	White Oak, Black Oak, Red Maple, American Beech, Sweet Birch, Red Oak, White Ash, Black Cherry	Spicebush, Allegheny Blackberry, Ironwood, American Holly regeneration, Hickory regeneration, Catbriar	Canada Mayflower, Blue-leaved Sedge, Pennsylvania Sedge, Mayappe, False Solomon's Seal, Jumpseed, Beech Drops, Enchanter's Nightshade, New York Fern, Hayscneted Fern, Pokeberry	This location is part of the 1930's old growth forest patches and should be restored (area specifically described by Aldo Leopold). Wildflower and shrub layer diversity is relatively high. Trace amounts of 12 species. Cover of Oriental Bittersweet and Border Privet are each 1-10%. Cover of Garlic Mustard is 11-25%
B	34	Wetland - Forest - Mixed Deciduous	6.4	Pin Oak, Black Tupelo, Red Maple, Black Cherry	Spicebush, Allegheny Blackberry, Blackhaw, White Ash regeneration, American Holly regeneration, Sassafras regeneration	Jumpseed, White Grass, False Solomon's Seal, Mayapple, Sensitive Fern, Skunk Cabbage	Moderate amounts of Border Privet and low amounts of multiple species. Primary goal is protection of Patch #31.
C	24	Wetland - Shrubland (successional)	4.6	White Ash, Pin Oak, Sweet Gum	Silky Dogwood, Allegheny Blackberry, Red Maple regeneration	New York Ironweed, Field Aster, Goldenrod species, Seed Box, Dogbane, [Non-native cool season grasses]	Recently abandoned farmland with good native tree and shrub regeneration. Trace amounts of 3 species. Cover of Autumn Olive is 1-10%.
D	38	Upland - Meadow	3.2	None	Elderberry, Allegheny Blackberry, Gray Dogwood, Black Walnut regeneration	Goldenrod species, Daisy Fleabane, Bindweed, White Vervain, Dogbane, Horse Nettle, Common Milkweed, [Non-native cool season grasses]	Meadow requires regular mowing and could be restored through native species plantings. Trace amounts of 5 species. Cover of Autumn Olive is 1-10%
E	42	Transitional - Forest - Mixed Deciduous	17.5	Slippery Elm, Sugar Maple, Black Cherry, Red Maple, American Beech, Black Walnut, Red Maple	Boxelder, Spicebush, Blackhaw, Silky Dogwood, Elderberry, Arrowwood, Staghorn Sumac, Sassafras rengeration, American Beech regeneration, White Ash regeneration, Catbriar	Jumpseed, White Snakeroot, Skunk Cabbage, Pokeweed, Jack-in-the-Pulpit, Virginia Stickseed	Located around ropes course. Relatively degraded with low to moderate amounts of 28 invasive species, but area has potential for long-term restoration. Native shrub layer cover is higher than nearly all areas on the Property and there is a diversity of species.
TOTAL			**41.5**				

Table 15 (continued). Priority Highest Quality Patches

Project Area	Patch ID	Broad Community Types	Patch Acres	Native Trees	Native Shrubs	Native Herbs	Invasive Species
None	8	Wetland - Woodland - Mixed Deciduous -- Portions too wet for regular stewardship	6.9	Silver Maple, Pin Oak	Arrowood, White Ash regeneration, vine species	Sensitive Fern, Jewelweed, White Avens, Jumpseed	Trace amounts of 7 species. Cover of Border Privet and Japanese Honeysuckle is each 1-10%
None	14	Wetland - Forest - Red Maple, Mixed Deciduous -- Portions too wet for regular stewardship	4.8	Red Maple	None	Jewelweed, Halberd-leaved Tearthumb, Stinging Nettle, Wood Reed, White Grass	Trace amounts of 2 species
None	25	Wetland - Woodland - Red Maple, Mixed Deciduous -- Too wet for regular stewardship	4.3	Red Maple	Arrowwood	Skunk Cabbage, Jewelweed, Meadow Rue, Spotted Joe-pye, Sensitive Fern	Trace amounts of 2 species. Cover of Border Privet is 1-10%
None	26	Wetland - Shrubland -- Too wet for regular stewardship	0.6	None	Swamp Rose, Silky Dogwood	Jewelweed, Arrow-leaved Tearthum, Arrowhead, Halberd-leaved Tearthumb, Rush and Sedge species, Skunk Cabbge, Dodder	Trace amounts of 2 species. Cover of Reed Canarygrass is 11-25%.
None	46	Wetland - Woodland - Mixed Deciduous -- Portions too wet for regular stewardship	5.4	Red Maple, Green Ash	Spicebush, Winterberry Holly, Arrowwood	Moneywort, Canadian Bluejoint, Rush and Sedge species, Jewelweed, White Grass, Sensitive Fern, Arrow-leaved Tearthumb, Skunk Cabbage, Jack-in-the-Pulpit, Agrimony	Low to moderate amounts of Border Privet and Japanese Stiltgrass.

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 significant number of the total plant species. A more complete list could be compiled with additional surveys focusing on graminoids (grasses, rushes, sedges) and ferns.

A total of 203 species were documented on the Property (Appendix D, summarized by growth form in Table 16). This included 145 native species (71% of total number of species) and 58 non-native species (56 mapped as invasive species, see Section III).

Table 16. Plant Species Summary

Growth Form	Native	Non-native	Totals
Tree	35	21	**56**
Shrub	16	14	**30**
Vine	6	8	**14**
Herbaceous	88	15	**103**
Totals	**145**	**58**	**203**

Fauna

There is one rare bird species, Great Blue Heron, which had been documented on the Property based upon Landscape Project Version 3.3 (Table 17). But this species is only rare in breeding and that habitat is not available on the Property. Three additional species, Bald Eagle, Coopers Hawk, and Wood Thrush are documented nearby, and it is likely that Coopers Hawk and Wood Thrush nest on the Property (but this is not documented).

Table 17. Rare Species of the Property
(See Notes on Page ii regarding state status)

Taxa	Location	Common Name	Scientific Name	Global Rank	State Rank	State Status	Stewardship Notes
Community	Possible in Vicinity	Potential Vernal Habitat Area	Potential Vernal Habitat Area	N/A	N/A	None	Located off property
Bird	Confirmed Near Property	Bald Eagle	Haliaeetus leucocephalus	G5	S1B, S2N	Endangered	Riparian habitat stewardship
Bird	Confirmed Near Property	Coopers Hawk	Accipiter cooperii	G5	S3B, S4N	Special Concern	Forest / Woodland / Shrubland stewardship
Bird	Confirmed Near Property	Wood Thrush	Hylocichla mustelina	G4	S3B, S4N	Special Concern	Forest / Woodland / Shrubland stewardship
Bird	Confirmed on Property	Great Blue Heron	Ardea herodias	G5	S3B, S4N	Special Concern	Riparian habitat stewardship

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 from June to August 2021. Deer management was initiated on the Property in fall 2021; a consistent, successful deer management program can significantly improve ecological health in coming years.

The scope of the invasive species problem is significant with 76% of the natural cover on the Property having severe infestations of one or more species. Only 4% of the Property is considered virtually free of invasive species, while approximately 20% was lightly to moderately infested.

Photographic documentation of current conditions is provided below.

Evaluation of White-tailed Deer Impacts

All forest 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. However, there are several exceptions with relatively higher shrub layer cover – these areas exhibit that greatest relative quality and should be the focus of stewardship activities.

The regeneration of native trees is abysmal on the Property (Table 11). There were five patches with trace amounts of trees seedlings > 3' tall. One patch with 11-25% cover of native tree seedlings and one small patch with 26-50% native tree cover. Species are generally those considered to be the least palatable native tree species. Native shrubs and herbaceous species (both vulnerable to deer browse) were low across a majority of the Property (Maps 19 and 20, respectively). Ideally, native woody understory cover in healthy forests would be above 70%. Across New Jersey, native understory cover averages less than 20%. Approximately 72% of forest and 66% of woodland communities had < 10% native woody understory cover. Nearly all of the remaining forest and woodland communities has less than 50% cover. Areas with the greatest understory cover were associated with older forest patches and the area adjacent to the current ropes course.

Native herbaceous species (wildflowers and grasses) were very sparse throughout the Property, especially in forest and woodland habitats where > 67% and 76% of areas had less than 10% cover and showed intense deer browse.

However, there are opportunities for ecological recovery, especially in forest areas that had never been under agricultural uses. These areas have significant invasive species cover but directed stewardship activities can begin the restoration process, especially toward fostering growth of native forest wildflowers that are most underrepresented on the Property.

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 52 unique mapped patches totaling 196 acres were recorded (Table 18). The scope of the invasive species problem is significant with 72% of the Property having severe infestations of one or more species (i.e., infestation category of High, Very High, or Extremely High). Only 8% of the Property is considered virtually free of invasive species, while approximately 20% was lightly to moderately infested. Map 23 depicts the cumulative infestation scores by mapped patches.

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

Mapped Patch Infestation Summary

Combined Infestation Score per Patch	Combined Infestation Score Category	Total Acreage	Percentage of Natural Habitats
0*	"Clean"	7.9	4.0
1	Low	12.6	6.4
2	Moderate	17.1	8.7
3	Moderate	7.9	4.0
4	High	24.3	12.4
5	High	22.7	11.6
6	Very High	22.2	11.3
7	Very High	13.7	7.0
8	Extremely High	7.4	3.8
9	Extremely High	6.8	3.5
10	Extremely High	6.5	3.3
11	Extremely High	2.5	1.3
12	Extremely High	8.7	4.4
13	Extremely High	5.2	2.7
14	Extremely High	9.5	4.8
15	Extremely High	18.6	9.5
16	Extremely High	1.5	0.8
Totals		**195**	**100**

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

Mapped Patch Infestation Summary

Combined Infestation Score per Patch	Combined Infestation Score Category	Total Acreage	Percentage of Natural Habitats
0*	"Clean"	7.9	4.0
1	Low	12.6	6.4
2-3	Moderate	25.0	12.8
4-5	High	47.0	24.0
6-7	Very High	35.9	18.3
> 7	Extremely High	66.7	34.0
Totals		**195**	**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, 56 species are considered invasive – eighteen should be subject to an eradication program and twenty-seven 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 Property	Eradicate	18	Amur Maple, Blue Plantain Lilly, Callery Pear, Chocolate Vine, Golden Raintree, Japanese Clematis, Japanese Holly, Japanese Maple, Japanese Snowball, Japanese Snowbell, Jetbead, Mimosa, Porcelain Berry, Princess Tree, Rose (unknown), Sapphire Berry, Siebold's Viburnum, Weeping Cherry
2	Species has widespread distribution within the Property and is considered highly threatening	Selective Control	27	Amur Corktree, Amur Honeysuckle, Autumn Olive, Border Privet, Burning Bush, Chinese Bushclover, Chinese Wisteria, Common Reed, English Ivy, Garlic Mustard, Japanese Barberry, Japanese Honeysuckle, Japanese Knotweed, Japanese Stiltgrass, Japanese Zelkova, Linden Viburnum, Mile-a-Minute, Multiflora Rose, Morrow's Honeysuckle, Norway Maple, Oriental Bittersweet, Oriental Photinia, Siebold's Crabapple, Sweet Cherry, Wineberry, Winter Creeper, Yellow Iris
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 Property	No Treatment	11	Black Locust, Canada Thistle, Mugwort, Mulberry, Norway Spruce, Periwinkle, Purple Loosestrife, Reed Canarygrass, Small Carpgrass, Southern Catalpa, Tree of Heaven
TOTAL			**56**	

Species Patterns

There were 18 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 Corktree	*Phellodendron amurense*		2				2
Amur Maple	*Acer ginnala*		3				3
Blue Plantain Lilly	*Hosta ventricosa*		2				2
Callery Pear	*Pyrus Calleryana*		3				3
Chinese Wisteria	*Wisteria sinensis*		1	1		1	3
English Ivy	*Hedera helix*			1			1
Golden Raintree	*Koelreuteria elegans*		1				1
Japanese Holly	*Ilex crenata*		1				1
Japanese Knotweed	*Polygonum cuspidatum*					1	1
Japanese Maple	*Acer palmatum*	1	1				2
Japanese Snowball	*Viburnum plicatum*		2				2
Japanese Snowball	*Styrax japonicus*		1				1
Japanese Zelkova	*Zelkova serrata*		3				3
Jetbead	*Rhodotypos scandens*		1				1
Linden Viburnum	*Viburnum dilatatum*		1				1
Mile-a-minute	*Persicaria perfoliata*		2	1			3
Mimosa	*Albizia Julibrissin*		2				2
Mystery Rose	*Rose (unknown)*		3	1			4
Oriental Photinia	*Photinia villosa*		7	4			11
Porcelain Berry	*Ampelopsis brevipedunculata*		1	1			2
Princess Tree	*Paulownia tomentosa*		1				1
Reed Canarygrass	*Phalaris arundinacea*					1	1
Siebold's Crabapple	*Malus sieboldii*		1				1
Siebold's Viburnum	*Viburnum sieboldii*		3				3
Tree of Heaven	*Ailanthus altissima*	1					1
Weeping Cherry	*Prunus Subhirtella*		2				2
Winter Creeper	*Euonymus fortunei*		6	4	1		11
Totals		**2**	**50**	**13**	**1**	**3**	**69**

Table 21. Invasive Species - Point Locations

Point ID	Common Name	Species Code	Pop_Size	Latitude	Longitude
1	Winter Creeper	EUFO	101-1000	-74.72219277	40.30477418
2	English Ivy	HEHE	11-100	-74.72204766	40.30478154
3	Callery Pear	PYCA	2-10	-74.72203963	40.30441468
4	Chinese Wisteria	WISI	11-100	-74.72183369	40.30419189
5	Golden Raintree	KOEL	2-10	-74.72141661	40.30389064
6	Japanese Maple	ACPA	1	-74.72447872	40.30223133
7	Blue Plantain Lilly	HOVE	2-10	-74.72431172	40.30222365
8	Winter Creeper	EUFO	2-10	-74.72435698	40.30215500
9	Winter Creeper	EUFO	11-100	-74.72366187	40.30178871
10	Japanese Snowball	VIPL	2-10	-74.72342458	40.30168134
11	Mile-a-minute	POPE	2-10	-74.72385918	40.30043646
12	Mile-a-minute	POPE	11-100	-74.72345584	40.30006204
13	Callery Pear	PYCA	2-10	-74.72322657	40.30005330
14	Siebold's Viburnum	VISI	2-10	-74.72312484	40.29885404
15	Weeping Cherry	PRSU	2-10	-74.72290800	40.29835171
16	Winter Creeper	EUFO	2-10	-74.72182288	40.30005106
17	Chinese Wisteria	WISI	2-10	-74.72099056	40.29714933
18	Rose (unknown)	ROXX	2-10	-74.72048823	40.29711010
19	Rose (unknown)	ROXX	2-10	-74.71940973	40.29611316
20	Japanese Snowbell	STJA	2-10	-74.71593694	40.29507942
21	Callery Pear	PYCA	2-10	-74.71776654	40.29286190
22	Mimosa	ALJU	2-10	-74.71608689	40.29307480
23	Rose (unknown)	ROXX	2-10	-74.71513144	40.29242956
24	Winter Creeper	EUFO	11-100	-74.71459969	40.29346263
25	Oriental Photinia	PHVI	11-100	-74.71465384	40.29277297
26	Rose (unknown)	ROXX	11-100	-74.71486481	40.29140781
27	Mile-a-minute	POPE	2-10	-74.71102937	40.29365720
28	Oriental Photinia	PHVI	2-10	-74.71086564	40.29372415
29	Chinese Wisteria	WISI	> 1000	-74.70807513	40.29364779
30	Reed Canarygrass	PHAR	> 1000	-74.71467328	40.30089939
31	Siebold's Crabapple	MASI	2-10	-74.71580568	40.30277073
32	Oriental Photinia	PHVI	2-10	-74.71247924	40.29578090
33	Amur Corktree	PHAM	2-10	-74.71269700	40.29544160
34	Amur Corktree	PHAM	2-10	-74.71336596	40.29503223
35	Tree of Heaven	AIAL	1	-74.71323406	40.29502100
36	Oriental Photinia	PHVI	11-100	-74.71334270	40.29493144
37	Weeping Cherry	PRSU	2-10	-74.71810358	40.29095024
38	Oriental Photinia	PHVI	11-100	-74.71884848	40.29090741
39	Japanese Zelkova	ZESE	2-10	-74.72300406	40.28991289

Table 21. (continued) Invasive Species - Point Locations

Point ID	Common Name	Species Code	Pop_Size	Latitude	Longitude
40	Japanese Holly	ILCR	2-10	-74.72489493	40.28971927
41	Siebold's Viburnum	VISI	2-10	-74.73282421	40.29285830
42	Winter Creeper	EUFO	2-10	-74.72897491	40.29201709
43	Linden Viburnum	VIDI	2-10	-74.72843176	40.29316189
44	Japanese Zelkova	ZESE	2-10	-74.72836884	40.29319503
45	Siebold's Viburnum	VISI	2-10	-74.72816857	40.29254934
46	Winter Creeper	EUFO	2-10	-74.72767672	40.29342290
47	Japanese Zelkova	ZESE	2-10	-74.72770762	40.29333723
48	Japanese Maple	ACPA	2-10	-74.72646721	40.29193679
49	Oriental Photinia	PHVI	2-10	-74.72603487	40.29205749
50	Princess Tree	PATO	2-10	-74.72514748	40.29202254
51	Winter Creeper	EUFO	11-100	-74.72364536	40.29224139
52	Amur Maple	ACGI	2-10	-74.72323213	40.29229621
53	Amur Maple	ACGI	2-10	-74.72196923	40.29271220
54	Winter Creeper	EUFO	11-100	-74.72258245	40.29413126
55	Amur Maple	ACGI	2-10	-74.72187661	40.29387368
56	Oriental Photinia	PHVI	2-10	-74.72074522	40.29398650
57	Mimosa	ALJU	2-10	-74.72053383	40.29352223
58	Porcelain Berry	AMBR	2-10	-74.72066056	40.29353958
59	Oriental Photinia	PHVI	11-100	-74.71921703	40.29334009
60	Oriental Photinia	PHVI	2-10	-74.72019503	40.29483056
61	Jetbead	RHSC	2-10	-74.72024566	40.29498822
62	Oriental Photinia	PHVI	2-10	-74.72067146	40.29506106
63	Blue Plantain Lilly	HOVE	2-10	-74.72102643	40.29518025
64	Oriental Photinia	PHVI	2-10	-74.72115367	40.29501739
65	Porcelain Berry	AMBR	11-100	-74.72144863	40.29516089
66	Winter Creeper	EUFO	2-10	-74.72142432	40.29520498
67	Japanese Knotweed	POCU	> 1000	-74.72091093	40.29541947
68	Winter Creeper	EUFO	2-10	-74.72190318	40.29501488
69	Japanese Snowball	VIPL	2-10	-74.72194593	40.29470852

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.

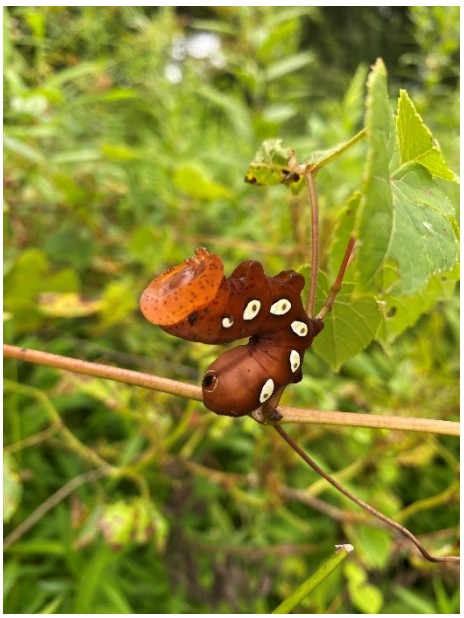
In order of abundance, the three most abundant species are Border Privet, Multiflora Rose, and Linden Viburnum. Five additional moderately abundant species include Norway Maple, Japanese Stiltgrass, Japanese Honeysuckle, Black Locust, and Garlic Mustard.

Spatial Patterns

The most severe combined infestations and number of invasive species per patch, and maximum single species infestations (See Maps 22-24, respectively) tended to occur in former agricultural areas. Importantly, Multiflora Rose is beginning to succumb to Rose Rosette Disease in sunny areas.

Areas without a history of agricultural tilling and a relatively dense tree canopy 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 (e.g., Bowl Woods with significant infestations of Japanese Zelkova, Amur Corktree, and others).

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.



Pandorus Sphinx moth caterpillar (Eumorpha pandorus)
found in a wet shrubland

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

Invasive Plant Species Distribution and Infestation Severity
Emerging invasive species are highlighted in yellow (See www.njisst.org)

							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 Corktree	Phellodendron amurense	2	43.0	Medium	16	48.9	222.6	17.9	25.8	1.3	2.8	1.1	0.0	430
Amur Honeysuckle	Lonicera maackii	2	24.9	Medium	36	46.5	225.0	30.6	10.0	5.9	0.0	0.0	0.0	249
Amur Maple	Acer ginnala	1	2.0	Low	2	19.6	251.9	19.6	0.0	0.0	0.0	0.0	0.0	20
Autumn Olive	Elaeagnus umbellata	2	9.7	Low	12	15.2	256.3	6.1	9.1	0.0	0.0	0.0	0.0	97
Black Locust	Robinia pseudoacacia	3	61.2	Medium	27	32.5	239.0	3.0	6.6	18.3	1.4	2.5	0.7	612
Blue Plantain Lilly	Hosta ventricosa	1	2.9	Low	5	29.0	242.5	29.0	0.0	0.0	0.0	0.0	0.0	29
Border Privet	Ligustrum obtusifolium	2	258.4	High	52	145.6	125.9	24.2	39.9	51.0	9.5	19.4	1.6	2584
Burning Bush	Euonymus alatus	2	48.0	Medium	26	71.4	200.1	46.8	11.6	11.1	0.0	0.0	1.9	480
Callery (Bradford) Pear	Pyrus Calleryana	1	5.8	Low	6	23.5	248.0	22.3	0.0	0.0	1.2	0.0	0.0	58
Canada Thistle	Cirsium arvense	3	2.8	Low	5	5.4	266.1	3.8	1.0	0.4	0.2	0.0	0.0	28
Chinese Bushclover	Lespedeza cuneata	2	3.3	Low	1	1.1	270.4	0.0	0.0	0.0	1.1	0.0	0.0	33
Chinese Wisteria	Wisteria sinensis	2	26.2	Medium	8	11.1	260.4	5.9	0.0	0.0	0.0	0.4	4.8	262
Chocolate Vine	Akebia quinata	1	2.5	Low	2	2.5	269.0	0.0	2.5	0.0	0.0	0.0	0.0	25
Common Reed	Phragmites australis	2	11.0	Medium	3	2.2	269.3	0.0	0.0	0.0	0.0	0.0	2.2	110
English Ivy	Hedera helix	2	20.3	Medium	34	79.4	192.1	67.5	11.1	0.0	0.8	0.0	0.0	203
Garlic Mustard	Alliaria petiolata	2	60.5	Medium	33	80.8	190.7	45.9	16.3	16.2	2.4	0.0	0.0	605
Golden Raintree	Koelreuteria elegans	1	0.1	Low	1	1.3	270.2	1.3	0.0	0.0	0.0	0.0	0.0	1
Japanese Barberry	Berberis thunbergii	2	4.8	Low	13	47.8	223.7	47.8	0.0	0.0	0.0	0.0	0.0	48
Japanese Clematis	Clematis terniflora	1	0.1	Low	1	0.5	271.0	0.5	0.0	0.0	0.0	0.0	0.0	1
Japanese Holly	Ilex crenata	1	1.8	Low	6	17.5	254.0	17.5	0.0	0.0	0.0	0.0	0.0	18
Japanese Honesuckle	Lonicera japonica	2	72.2	Medium	43	112.5	159.0	48.2	61.5	2.5	0.3	0.0	0.0	722
Japanese Knotweed	Polygonum cuspidatum	2	15.6	Medium	9	32.6	238.9	18.9	13.7	0.0	0.0	0.0	0.0	156
Japanese Maple	Acer palmatum	1	1.9	Low	3	5.9	265.6	4.5	1.4	0.0	0.0	0.0	0.0	19
Japanese Snowball	Viburnum plicatum	1	0.2	Low	2	1.7	269.8	1.7	0.0	0.0	0.0	0.0	0.0	2
Japanese Snowbell	Styrax japonicus	1	0.1	Low	1	1.1	270.4	1.1	0.0	0.0	0.0	0.0	0.0	1
Japanese Stiltgrass	Microstegium vimineum	2	84.3	Medium	41	100.2	171.3	58.8	14.5	19.2	5.8	1.4	0.5	843
Japanese Zelkova	Zelkova serrata	2	14.6	Medium	21	34.3	237.2	27.5	2.9	2.8	1.1	0.0	0.0	146

Table 22. (continued) 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]
Jetbead	Rhodotypos scandens	1	2.0	Low	2	19.6	251.9	19.6	0.0	0.0	0.0	0.0	0.0	20
Linden Viburnum	Viburnum dilatatum	2	104.6	High	39	102.3	169.2	55.1	12.9	16.7	17.6	0.0	0.0	1046
Mile-a-Minute	Persicaria perfoliata	2	2.5	Low	6	10.1	261.4	8.7	1.2	0.2	0.0	0.0	0.0	25
Miltiflora Rose	Rosa Multiflora	2	187.1	High	74	174.0	97.5	78.8	47.1	34.1	0.2	5.7	8.1	1871
Mimosa	Albizia Julibrissin	1	1.9	Low	2	18.9	252.6	18.9	0.0	0.0	0.0	0.0	0.0	19
Morrow's Honeysuckle	Lonicera morrowii	2	7.3	Low	10	11.9	259.6	7.9	1.5	2.5	0.0	0.0	0.0	73
Mugwort	Artemisia vulgaris	3	15.2	Medium	18	38.8	232.7	32.7	1.4	4.0	0.5	0.0	0.2	152
Mulberry	Morus alba	3	6.7	Low	16	37.2	234.3	33.9	3.3	0.0	0.0	0.0	0.0	67
Norway Maple	Acer platanoides	2	92.1	Medium	24	59.1	212.4	27.4	9.8	4.0	0.0	17.9	0.0	921
Norway Spruce	Picea abies	3	48.2	Medium	2	20.8	250.7	0.0	0.0	17.5	0.0	3.3	0.0	482
Oriental Bittersweet	Celastrus orbiculatus	2	49.1	Medium	43	99.6	171.9	59.2	37.6	2.8	0.0	0.0	0.0	491
Oriental Photinia	Photinia villosa	2	19.4	Medium	10	36.9	234.6	19.4	17.5	0.0	0.0	0.0	0.0	194
Periwinkle	Vinca minor	3	1.9	Low	9	18.7	252.8	18.7	0.0	0.0	0.0	0.0	0.0	19
Porcelain Berry	Ampelopsis brevipedunculata	1	2.3	Low	3	18.8	252.7	18.3	0.5	0.0	0.0	0.0	0.0	23
Princess Tree	Paulownia tomentosa	1	0.9	Low	5	6.7	264.8	6.6	0.0	0.1	0.0	0.0	0.0	9
Purple Loosestrife	Lythrum salicaria	3	1.3	Low	3	13.1	258.4	13.1	0.0	0.0	0.0	0.0	0.0	13
Reed Canarygrass	Phalaris arundinacea	3	56.7	Medium	10	18.8	252.7	4.6	2.0	1.1	0.0	3.5	7.6	567
Rose (unknown)	Unknown	1	1.0	Low	4	9.8	261.7	9.8	0.0	0.0	0.0	0.0	0.0	10
Saphire Berry	Symplocos paniculata	1	0.2	Low	2	2.1	269.4	2.1	0.0	0.0	0.0	0.0	0.0	2
Siebold's Crabapple	Malus sieboldii	2	2.8	Low	10	27.8	243.7	27.8	0.0	0.0	0.0	0.0	0.0	28
Siebold's Viburnum	Viburnum sieboldii	1	1.0	Low	5	10.0	261.5	10.0	0.0	0.0	0.0	0.0	0.0	10
Small Carpetgrass	Arthraxon hispidus	3	0.2	Low	1	1.6	269.9	1.6	0.0	0.0	0.0	0.0	0.0	2
Sweet Cherry	Prunus Avium	2	23.9	Medium	6	27.3	244.2	3.8	23.5	0.0	0.0	0.0	0.0	239
Southern Catalpa	Catalpa bignonioides	3	3.7	Low	11	28.4	243.1	27.4	1.0	0.0	0.0	0.0	0.0	37
Tree of Heaven	Ailanthus altissima	3	0.6	Low	2	6.4	265.1	6.4	0.0	0.0	0.0	0.0	0.0	6
Weeping Cherry	Prunus Subhirtella	1	12.7	Medium	14	26.6	244.9	18.1	7.1	0.9	0.0	0.5	0.0	127
Wineberry	Rubus phoenicolasius	2	29.0	Medium	36	68.2	203.3	46.1	20.7	0.5	0.9	0.0	0.0	290
Winter Creeper	Euonymus fortunei	2	6.4	Low	24	52.2	219.3	50.9	1.3	0.0	0.0	0.0	0.0	64
Yellow Iris	Iris pseudacorus	2	5.7	Low	5	21.9	249.6	18.0	3.9	0.0	0.0	0.0	0.0	57
Totals					**805**									**14641**

[1] The Infestation Index Score combines the extent of acreage infested and the intensity of the infestation. It was derived by multiplying the cover class number by the number of acres within each cover class.

[2]The Relative Infestation Index Categories include Low, Medium and High to represent Infestation Index Scores of < 10, 10-100 and > 100, respectively.

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

Common Name	*Scientific Name*	Growth Form	Action Code	Control Strategy	Control Methods
Amur Corktree	*Phellodendron amurense*	Tree	2	Selective control - Focus on highest quality areas only	Basal Bark, Foliar Spray, Cut Stump (winter only if using glyphosate), EZ-Ject w/imazapyr
Amur Honeysuckle	*Lonicera maackii*	Shrub	2	Selective control - Focus on highest quality areas only	Basal Bark, Foliar Spray, Cut Stump
Amur Maple	*Acer ginnala*	Tree	1	Eradicate all known occurrences; Maintain continual searching and eradication	Basal Bark, Foliar Spray, Cut Stump (winter only if using glyphosate), EZ-Ject w/imazapyr
Autumn Olive	*Elaeagnus umbellata*	Shrub	2	Selective control - Eradicate in patch ID's 23 and 24 only; Maintain continual searching and eradication in these areas	Basal Bark, Foliar Spray, Cut Stump (winter only if using glyphosate), EZ-Ject w/imazapyr
Black Locust	*Robinia pseudoacacia*	Tree	3	No direct action	Basal Bark, Hack-and-Squirt, Foliar Spray, Cut Stump (winter only if using glyphosate) - Most effective herbicide is aminopyralid
Blue Plantain Lilly	*Hosta ventricosa*	Herb	1	Eradicate all known occurrences; Maintain continual searching and eradication	Foliar Spray
Border Privet	*Ligustrum obtusifolium*	Shrub	2	Selective control - Focus on highest quality areas only; Watch for emergence in Patch ID 24	Basal Bark, Foliar Spray, Cut Stump
Burning Bush	*Euonymus alata*	Shrub	2	Selective control - Focus on highest quality areas only	Basal Bark, Foliar Spray, Cut Stump
Callery Pear	*Pyrus calleryana*	Tree	1	Eradicate all known occurrences; Maintain continual searching and eradication	Basal Bark, Foliar Spray, Cut Stump (winter only if using glyphosate), EZ-Ject w/imazapyr
Canada Thistle	*Cirsium arvense*	Herb	3	No direct action	Foliar Spray
Chinese Bushclover	*Lespedeza cuneata*	Herb	2	Selective control - Focus on highest quality areas only; Watch for emergence in Patch ID 24	Foliar Spray (aminopyralid or triclopyr) - Consider cutting in early June and allowing regrowth to 2' tall before treating
Chinese Wisteria	*Wisteria sinensis*	Vine	2	Selective control - Eradicate in patch ID's 1, 2, 89, 90, 91; Contain in other areas by minimizing expansion of existing occurences; remove vertical growth climbing up trees	Basal Bark, Foliar Spray, Cut Stump (winter only if using glyphosate if using glyphosate), EZ-Ject w/imazapyr
Chocolate Vine	*Akebia quinata*	Vine	1	Eradicate all known occurrences; Maintain continual searching and eradication	Foliar Spray (Utilize Clean Cut surfactant or equivalent); Cut stems infesting trees prior to treatment
Common Reed	*Phragmites australis*	Grass	2	Selective control - Focus on highest quality areas only	Foliar Spray, Cut Stump - Most effective herbicide is imazapyr; Consider cutting in early June and allowing regrowth to 3' tall before treating
English Ivy	*Hedera helix*	Vine	2	Selective control - Focus on highest quality areas only; Treat large fruiting vines with dense vertical growth	Basal Bark, Foliar Spray (utilize Clean Cut surfactant or equivalent), Cut Stump (winter only if using glyphosate)
Garlic Mustard	*Alliaria petiolata*	Herb	2	Selective control - Focus on highest quality areas only; Hand-pulling may be done by students in the selected areas for 3 consecutive seasons	Foliar Spray, Hand Pulling in May to avoid seed set (species is biennial)
Golden Raintree	*Koelreuteria elegans*	Tree	1	Eradicate all known occurrences; Maintain continual searching and eradication	Foliar Spray, Basal Bark, Cut Stump

Table 23 (continued). Invasive Species - Species-Specific Control Strategies and Methods

Common Name	*Scientific Name*	Growth Form	Action Code	Control Strategy	Control Methods
Japanese Barberry	*Berberis thunbergii*	Shrub	2	Selective control - Focus on highest quality areas only	Basal Bark, Foliar Spray, Cut Stump
Japanese Clematis	*Clematis terniflora*	Vine	1	Eradicate all known occurrences; Maintain continual searching and eradication	Foliar Spray (Utilize Clean Cut surfactant or equivalent); Cut stems infesting trees prior to treatment
Japanese Holly	*Ilex crenata*	Shrub	1	Eradicate all known occurrences; Maintain continual searching and eradication	Basal Bark, Foliar Spray, Cut Stump
Japanese Honeysuckle	*Lonicera japonica*	Vine	2	Selective control - focus on highest quality areas only; Aim to control, not eradicate. Treat large fruiting vines with dense vertical growth	Foliar Spray (cut stems infesting trees prior to treatment)
Japanese Knotweed	*Polygonum cuspidatum*	Herb	2	Selective control - Focus on highest quality areas only	Foliar Spray, Cut Stump, Stem Injection; Consider cutting in early June and allowing regrowth to 3' tall before treating
Japanese Maple	*Acer palmatum*	Tree	1	Eradicate all known occurrences; Maintain continual searching and eradication	Basal Bark, Foliar Spray, Cut Stump (winter only if using glyphosate), EZ-Ject w/imazapyr
Japanese Snowball	*Viburnum plicatum*	Shrub	1	Eradicate all known occurrences; Maintain continual searching and eradication	Basal Bark, Foliar Spray, Cut Stump (winter only if using glyphosate)
Japanese Snowbell	*Styrax japonicus*	Shrub	1	Eradicate all known occurrences; Maintain continual searching and eradication	Basal Bark, Foliar Spray, Cut Stump (winter only if using glyphosate)
Japanese Stiltgrass	*Microstegium vimineum*	Grass	2	Selective control - Focus on highest quality areas only; Hand-pulling may be done by students in the selected areas for 3 consecutive seasons	Foliar Spray, Pre-Emergent Spray, Well-timed cutting (ca. mid August)
Japanese Zelkova	*Zelkova serrata*	Tree	2	Selective control - Focus on highest quality areas only	Basal Bark, Foliar Spray, Cut Stump (winter only if using glyphosate), EZ-Ject w/imazapyr
Jetbead	*Rhodotypos scandens*	Shrub	1	Eradicate all known occurrences; Maintain continual searching and eradication	Foliar Spray, Cut Stump
Linden Viburnum	*Viburnum dilitatum*	Shrub	2	Selective control - Focus on highest quality areas only	Basal Bark, Foliar Spray, Cut Stump (winter only if using glyphosate), EZ-Ject w/imazapyr
Mile-a-Minute	*Persicaria perfoliatum*	Vine	2	Selective control - Treat large fruiting vines with dense vertical growth	Foliar Spray, Pre-Emergent Spray, Well-timed cutting (by early July and/or mid August); Species is annual
Multiflora Rose	*Rosa multiflora*	Shrub	2	Selective control - Focus on highest quality areas only	Foliar Spray, Cut Stump
Mimosa	*Albizia Julibrissin*	Tree	1	Eradicate all known occurrences; Maintain continual searching and eradication	Foliar Spray, Basal Bark

Table 23 (continued). Invasive Species - Species-Specific Control Strategies and Methods

Common Name	*Scientific Name*	Growth Form	Action Code	Control Strategy	Control Methods
Morrow's Bush Honeysuckle	*Lonicera morrowii*	Shrub	2	Selective control - Focus on highest quality areas only	Basal Bark, Foliar Spray, Cut Stump
Mugwort	*Artemisia vulgaris*	Herb	3	No direct action	Foliar Spray (aminopyralid or triclopyr only) - Consider cutting in early June and allowing regrowth to 2' tall before treating
Mulberry	*Morus alba*	Tree	3	No direct action	Foliar Spray, Basal Bark (July-September), EZJect (imazapyr), Cut Stump (winter only)
Norway Maple	*Acer platanoides*	Tree	2	Selective control - Focus on highest quality areas only; Treat saplings only unless resources allow for treatment of larger individuals	Basal Bark, Hack-and-Squirt, Foliar Spray, Cut Stump (winter only if using glyphosate), EZ-Ject w/imazapyr
Norway Spruce	*Picea abies*	Tree	3	No direct action	Basal Bark, Hack-and-Squirt, Foliar Spray, Cut Stump (winter only if using glyphosate), EZ-Ject w/imazapyr
Oriental Bittersweet	*Celastrus orbiculata*	Vine	2	Selective control - Focus on highest quality areas only	Basal Bark, Foliar Spray, Cut Stump (winter only if using glyphosate), EZ-Ject w/imazapyr
Oriental Photinia	*Photinia villosa*	Shrub	2	Selective control - Focus on highest quality areas only	Basal Bark, Foliar Spray, Cut Stump (winter only if using glyphosate), EZ-Ject w/imazapyr
Periwinkle	*Vinca minor*	Vine	3	No direct action	Basal Bark, Foliar Spray (utilize Clean Cut surfactant or equivalent), Cut Stump (winter only if using glyphosate)
Porcelainberry	*Ampelopsis brevipedunculata*	Vine	1	Eradicate all known occurrences; Maintain continual searching and eradication	Basal Bark, Foliar Spray, Cut Stump (winter only if using glyphosate), EZ-Ject w/imazapyr
Princess Tree	*Paulownia tomentosa*	Tree	1	Eradicate all known occurrences; Maintain continual searching and eradication	Foliar Spray, Basal Bark (July-September), EZJect (imazapyr), Cut Stump (winter only)
Purple Loosestrife	*Lythrum salicaria*	Herb	3	No direct action	Foliar Spray, Presence of biological control beetles often preclude need for herbicide treatments

Table 23 (continued). Invasive Species - Species-Specific Control Strategies and Methods

Common Name	*Scientific Name*	Growth Form	Action Code	Control Strategy	Control Methods
Reed Canary Grass	*Phalaris arundinacea*	Grass	3	No direct action	Foliar Spray; Consider cutting in early June and allowing regrowth to 1' tall before treating
Rose (Unknown)	*ROXX*	Shrub	1	Eradicate all known occurrences; Maintain continual searching and eradication	Foliar Spray, Basal Bark, Cut Stump
Saphire Berry	*Symplocos paniculata*	Shrub	1	Eradicate all known occurrences; Maintain continual searching and eradication	Foliar Spray, Basal Bark, Cut Stump
Siebold's Crabapple	*Malus sieboldii*	Tree	2	Selective control - Focus on highest quality areas only; Search for and eradicate any emergences in Patch ID 31	Foliar Spray, Basal Bark (July-September), EZJect (imazapyr), Cut Stump (winter only)
Siebold's Viburnum	*Viburnum sieboldii*	Shrub	1	Eradicate all known occurrences; Maintain continual searching and eradication	Basal Bark, Foliar Spray, Cut Stump (winter only if using glyphosate), EZ-Ject w/imazapyr
Small Carpgrass	*Arthraxon hispidus*	Grass	3	No direct action	Foliar Spray, Pre-Emergent Spray; Species is annual
Southern Catalpa	*Catalpa bignonioides*	Tree	3	No direct action	Basal Bark, Foliar Spray, Cut Stump (winter only if usiing glyphosate), EZ-Ject w/imazapyr
Sweet Cherry	*Prunus Avium*	Tree	2	Selective control - Focus on highest quality areas only	Foliar Spray, Basal Bark (July-September), EZJect (imazapyr), Cut Stump (winter only)
Tree-of-Heaven	*Ailanthus altissima*	Tree	3	No direct action	Basal Bark, Foliar Spray, Cut Stump (winter only if using glyphosate), EZ-Ject w/imazapyr
Weeping Cherry	*Prunus subhirtella*	Tree	1	Eradicate all known occurrences; Maintain continual searching and eradication. Mark tree when flowering to facilitate identification.	Basal Bark, Hack-and-Squirt, Foliar Spray, Cut Stump (winter only if using glyphosate), EZ-Ject w/imazapyr
Wineberry	*Rubus phoenicolasius*	Shrub	2	Selective control - Focus on highest quality areas only	Foliar Spray, Cut Stump
Wintercreeper	*Euonymous fortunei*	Vine	2	Selective control - Focus on highest quality areas only; Treat large fruiting vines with dense vertical growth	Basal Bark, Foliar Spray (utilize Clean Cut surfactant or equivalent), Cut Stump (winter only if using glyphosate)
Yelllow Iris	*Iris pseudacorus*	Herb	2	Selective control - Focus on highest quality areas only	Foliar Spray

Photographic Documentation

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

Nearly all forests on the Property exhibit either the "Infested Forest Syndrome" (above; condition occurs where high deer densities occur in areas formerly plowed for agricultural use) or the "Empty Forest Syndrome" (below; condition occurs where high deer densities occur in areas without past agricultural plowing, and existing soils resemble native forest soils).

With minor exceptions, native shrubs and small trees are very sparse on the Property.
Native shrubs and tree seedlings (above).
Native Maple-leaved Viburnum, healthy and making fruit (below).

Native shrubs and trees are heavily browsed Maple-leaved Viburnum (below).

Native forest wildflowers are sparse and severely browsed where they occur.
Jewelweed being browsed amidst less palatable native Skunk Cabbage (above).
False Solomon's Seal, plants mostly healthy but browsed too much to make flowers and fruit (below).
There should be hundreds of thousands of individual wildflowers across the Property.

Canopy gaps (above) are natural and facilitate forest regeneration, but are filling with unpalatable invasive species, sometimes with weedy native species, instead of native trees to restore the canopy (above). But there are some exceptions, this abandoned farm field is filling with fast growing trees such as Pin Oak.
Presumably the wet soils allow growth that exceeds browse rates in this area.

Invasive Species of Particular Concern:
Wintercreeper is forming dense tree-killing growth in areas but is not yet widespread on the Property.

Invasive Species of Particular Concern:
Linden Viburnum (above) has few, small populations but is highly threatening.
Mimosa (below) occurs as individual species in few locations.

Invasive Species of Particular Concern:
Golden Rain Tree (above) occurs at a single location.
Chinese Wisteria (below) is uncommon but forms a massive infestation in one location.

Invasive Species of Particular Concern:
Japanese Zelkova (above) was planted follow loss of American Elm but has come to infest the Bowl Woods.
Amur Corktree also (below) infests Bowl Woods,
it is likely that it was planted long ago in the landscape but has since been removed.

Section IV. Strategies and Actions

Figure 7. 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 performing meadow restoration. The fourth encourages student land stewardship, research and exploration. Each of these recommendations is accompanied by specific goals - there is a total of nine specific 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. Table 23 provides a guide to methods and strategies by particular species.

A summary of specific goals with estimated costs is summarized in Table 25. Full plan implementation is estimated to require 2,060 hours of staff time (estimated cost of $103,000), 1,925 student volunteer hours (estimated value of $46,200), and $12,600 of purchased material costs over the next 10 years - total cost is estimated at $115,600.

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 by unpalatable invasive species. The school-initiated deer management in 2021, and it is recommended that this program, focusing on the removal of antlerless deer, remain in place in perpetuity. 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). These goals will be challenging to meet on the Property, but it is hoped that a maximum density of 30 deer per square mile can be reached. Recommendation #4 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 $111,500 over the 10-year implementation period (See Table 24). This includes staff time and paid contractor fees that include harvesting and venison donation / butcher costs. It assumes approximately 50 deer are harvested annually.

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 25 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 18 emerging 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. Nascent populations of 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 18 emerging and nascent widespread species designated as 'Action Code 1' (i.e., complete eradication is the ultimate goal). Currently, there are 39 mapped known populations of these 18 species (Table 21), but additional searching is likely to detect additional populations. Additional guidance 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 $17,750 over the 10-year implementation period (See Table 25).

Recommendation #3: Protect and Restore Highest Quality Forest Areas

The protection and restoration of highest-quality forest habitat is an important goal. There are a total of 16 acres of old forest habitat and 18 additional acres of mature forest (Map. higher quality forest patches (Table 15). Goal #3-1 includes Bowl Woods (Patch #77/#78) and Old Ropes Course Woods (Patches #31 and nearby Patch #34). Goal #3-2 involves invasive species control in the 18-acre forest surrounding the current ropes course (Patch #42). Goal #3-3 involves invasive species control to guide succession in the 5-acre abandoned farmland (Patch #24). Goal #3-4 includes maintaining and restoring meadow habitat in detention basins, stream buffer areas and golf course rough areas.

Goal #3-1: Restore and Protect 16 Acres of Highest-quality Old Growth Forest Habitat

This goal includes the oldest forest patches on the Property, where impressive old oak trees dot the landscape (Patches #77, #78, #31, and #34). The focus of this work is to reduce invasive species cover, including reduction of Action Code #2 invasive species (see Table 19 and notes provided in Table 15). emerging and widespread species to allow increased cover and reproductive success for native species. Control work within existing and future canopy gaps will be a high priority. This work was initiated in Fall 2021 with student biology labs cutting down vegetation in preparation for contractor-applied cut stump herbicide applications. Invasive species control work will never be "done", but reductions year after year will improve ecological health.

The construction of exclosures should encourage tree regeneration, shrub-layer formation, and healthy forest wildflowers. Small deer exclosures may be constructed using simple 5-foot tall, galvanized metal mesh fencing held up using rebar with zip ties (50-foot roll will make a 200 square foot exclosed area). Fencing can be installed by students and staff. A total of 10 exclosures are recommended for each named area (20 exclosures in total). Exact locations should be selected based upon occurrence of existing patches of native wildflowers, shrubs, or regenerating trees to hasten success of the restoration effort.

PREFERRED SOLUTION: The alternative exclosure strategy, not calculated below or Table 25, would be professionally installed 7.5-foot New Zealand woven wire fencing on pressure treated pine posts. Exact costs would include multiple variables, but a ballpark estimate would be approximately $30,000 to exclude deer in the core of each area (Patch #77 and Patch #31). Although expensive, this could restore ecological health over the next 10 years on these very special old growth forest areas.

The estimated cost to complete this goal is $25,000 over the 10-year implementation period (See Table 25).

Goal #3-2: Restore 18 Acres of Mature Forest

The 18-acre woods surrounding the current ropes course (Patch #42) appeared to have past agricultural activity, but it has a surprising number of native shrubs in the understory. However, it also contains significant amounts of invasive species. Invasive species control efforts would have the goal of increasing the ratio of native to non-native species in the forest understory over time. Table 15 provides broad recommendations for prioritization. Fuller recovery of this area (e.g., reinvigoration of native forest wildflower community) will rely on reduction of the deer population.

The estimated cost to complete this goal is $15,000 over the 10-year implementation period (See Table 25).

Goal #3-3: Guide development of a 5-acre Successional Shrubland/Forest Patch

In another surprising area, native trees and some shrubs appear to have grown quickly enough to escape deer browsing in a 5-acre recently abandoned farmland (Patch #24, See Table 15). There are also a number of relatively unpalatable native wildflowers and grasses. Invasive species are currently relatively light in this area. Treatment of all invasive species should be conducted to further guide the establishment of native woody species. Ultimately, this area will grow into a forest. In the meantime, it can serve as a high-quality native shrubland used by multiple bird species and mammals. In New Jersey, successional lands not dominated by invasive species is extremely rare, making this area quite special.

The estimated cost to complete this goal is $8,000 over the 10-year implementation period (See Table 25).

Goal #3-4: Maintain and Restore 12 Acres of Meadow Habitat

A total of nine acres of meadow restoration is recommended across 16 areas (Table 24, Map 25).

Table 24. Meadow Restoration Areas

Area ID	Area Description	Acres
1	Detention Basin	0.3
2	Detention Basin	0.6
3	Detention Basin	0.9
4	Stream Buffer Area	0.0
5	Stream Buffer Area	1.3
6	Stream Buffer Area	1.6
7	Stream Buffer Area	0.8
8	Golf Course Rough	1.2
9	Golf Course Rough	0.3
10	Golf Course Rough	0.2
11	Golf Course Rough	0.3
12	Golf Course Rough	0.8
13	Golf Course Rough	0.1
14	Golf Course Rough	0.2
15	Golf Course Rough	0.1
16	Golf Course Rough	0.1
Total		**8.7**

The general procedure would be hiring a contractor to 1) Eliminate existing lawn, 2) Apply native wildflower and grass seeds, 3) Spot treat for weeds as necessary. The areas would be mowed annually in

late winter. Students can add to these efforts by planting clusters of native species to enhance diversity and hasten development of mature meadow community (See Recommendation #4) by planting purchased wildflower plugs. The goal for all of these areas is to provide beauty and pollinator habitat. In addition, basin and streamside meadow restoration can filter out pollutants before they enter waterways. They can also form dense, deep root systems that prevent soil erosion. Another benefit of restoring lawn to meadow is reduction in use of pesticides to kill pests / weeds and fossil fuels from repeated mowing. Finally, the return-on-investment for lawn to meadow is approximately 5 years (primarily in reduced mowing costs relative to lawn).

There are three detention basins and four streamside areas currently managed as lawn. There are nine golf course rough areas that appear to be former lawn areas that were left to go wild and generally contain weedy species. The beauty and ecological function of these areas can be significantly increased through restoration.

There is also a 3-acre maintained meadow (Patch #38). This are is relatively free of woody invasive species, but stewardship is required to maintain this area. Additional plantings could also be conducted by students (see below, required efforts is not included under this goal).

The estimated cost to complete this goal is $25,000 over the 10-year implementation period (See Table 25).

Recommendation #4: Encourage Student Land Stewardship, Research, and Exploration

This recommendation includes various elements that encourage student interaction on the Property. Activities include selected stewardship efforts presented in this plan, research and ecological monitoring, (which provides accountability and forms the basis or the adaptive stewardship over time) and developing and maintaining a property-wide trail system to facilitate the above mentioned activities and encourage exploration and interaction with nature.

Goal #4-1: Perform Land Stewardship

Students will assist with multiple stewardship tasks related to Recommendations #2 and #3 (See Table 25). This work is intended to complement and supplement work completed by contractors (e.g., mimicking work conducted in Bowl Woods in fall 2021). The work includes invasive species management (cutting / pulling), searching for and mapping emerging invasive species (Action Code #1), supplementing wildflower meadow plantings, and installing and maintaining deer exclosure fencing. The maintenance and improvement of existing meadow patch (Patch #38) is included in this goal.

It should also leave room for creative faculty and/or student led projects. As an example, students can grow “Heritage Trees” from oaks and hickories in Bowl Woods and Old Ropes Course Woods for distribution to student families and restoration within the Property.

The estimated cost to complete this goal is $17,500 over the 10-year implementation period (See Table 25). It also requires 5,000 hours of student volunteer support.

Goal #4-2: Perform Ecological Health Monitoring to Guide Adaptive Stewardship

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. Contact the Strike Team for details, but also see Appendix E (recently published paper outlining methodologies).

In addition to basic forest health monitoring, there are endless possibilities to study nature on the Property. This could include intensive study on single species to surveys for groups of species (e.g., birds, salamanders, mammals, etc.). Topics can be chosen at the discretion of faculty and students.

The estimated cost to complete this goal is $12,500 over the 10-year implementation period (See Table 25). It also requires 2,500 hours of student volunteer support.

Goal #4-3: Develop and Maintain a Trail System to Encourage Student Study of the Property

This recommendation includes maintaining the existing trail network through Bowl Woods and the current ropes course woods. But these limit student exploration to only a portion of the Property. It is recommended that students develop and maintain a property-wide trail system to allow easy access for the activities mentioned above. This would allow for exploration of developed, agricultural, and natural habitats of various types.

The estimated cost to complete this goal is $12,500 over the 10-year implementation period (See Table 25). It also requires 2,500 hours of student volunteer support.

Platform and viewing deck at Old Ropes Course Woods. This area does not currently have a trail leading to this amazing forest with a view of a Shipetauken Creek tributary floodplain.

Table 25. Goals and Estimated Costs for 10-Year Plan Implementation Period

Recommendation	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 Student Volunteer Hours	Volunteer Value @ $15/hour	Notes
Reduce deer density to meet ecological health goals	1-1	Administer Deer Management Program	200	$10,000	$1,500	$100,000	**$111,500**	$11,150	0	$0	
Strategic Invasive Species Control	2-1	Eradicate Amur Maple (3 populations)	0	$0	$150	$300	**$450**	$45	0	$0	See Table 23. Activities begin in 2022 with decreasing efffort required over time.
Strategic Invasive Species Control	2-1	Eradicate Blue Plantain Lily (1 population)	0	$0	$50	$200	**$250**	$25	0	$0	
Strategic Invasive Species Control	2-1	Eradicate Callery Pear (3 [populations)	0	$0	$150	$300	**$450**	$45	0	$0	
Strategic Invasive Species Control	2-1	Eradicate Chocolate Vine (Low amounts in 2 patches)	0	$0	$250	$2,000	**$2,250**	$225	0	$0	
Strategic Invasive Species Control	2-1	Eradicate Golden Raintree (1 population)	0	$0	$50	$200	**$250**	$25	0	$0	
Strategic Invasive Species Control	2-1	Eradicate Japanese Clematis (Low amounts in 1 patch)	0	$0	$250	$1,250	**$1,500**	$150	0	$0	
Strategic Invasive Species Control	2-1	Eradicate Japanese Holly (Low amounts in 6 patches)	0	$0	$150	$750	**$900**	$90	0	$0	
Strategic Invasive Species Control	2-1	Eradicate Japanese Maple (Low amounts in 3 patches)	0	$0	$150	$750	**$900**	$90	0	$0	
Strategic Invasive Species Control	2-1	Eradicate Japanese Snowball (2 populations)	0	$0	$150	$300	**$450**	$45	0	$0	
Strategic Invasive Species Control	2-1	Eradicate Japanese Snowbell (1 population)	0	$0	$50	$200	**$250**	$25	0	$0	
Strategic Invasive Species Control	2-1	Eradicate Jetbead (Low amounts in two patches)	0	$0	$150	$300	**$450**	$45	0	$0	
Strategic Invasive Species Control	2-1	Eradicate Mimosa (2 populations)	0	$0	$150	$300	**$450**	$45	0	$0	
Strategic Invasive Species Control	2-1	Eradicate Porcelain Berry (Low amounts in 3 patches)	0	$0	$250	$2,000	**$2,250**	$225	0	$0	
Strategic Invasive Species Control	2-1	Eradicate Princess-tree (Low amounts in 4 patches)	0	$0	$150	$300	**$450**	$45	0	$0	

Table 25. Goals and Estimated Costs for 10-Year Plan Implementation Period (continued)

Recommendation	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 Student Volunteer Hours	Volunteer Value @ $15/hour	Notes
Strategic Invasive Species Control	2-1	Eradicate Unknown Rose (Low amounts in 5 patches)	0	$0	$150	$450	**$600**	$60	0	$0	
Strategic Invasive Species Control	2-1	Eradicate Sapphire Berry (Low amounts in 2 patches)	0	$0	$150	$300	**$450**	$45	0	$0	
Strategic Invasive Species Control	2-1	Eradicate Siebold's Viburnum (Low amounts in 4 patches)	0	$0	$150	$300	**$450**	$45	0	$0	
Strategic Invasive Species Control	2-1	Eradicate Weeping Cherry (Low to Moderate amounts in 15 patches)	0	$0	$1,250	$3,750	**$5,000**	$500	0	$0	
Restore and Projtect Forest, Meadow, and Riparian Corridors	3-1	Restore and protect 16 acres of highest-quality old growth forest habitat	100	$5,000	$5,000	$15,000	**$25,000**	$2,500	0	$0	Note: Professionally installed fencing not counted here, but would be ca. $300 for the majority of Patch #77 and # 31.
Restore and Projtect Forest, Meadow, and Riparian Corridors	3-2	Restore 18 acres of mature forest	100	$5,000	$2,500	$7,500	**$15,000**	$1,500	0	$0	
Restore and Projtect Forest, Meadow, and Riparian Corridors	3-3	Guide development of a 5-acre successional shrubland / forest	100	$5,000	$500	$2,500	**$8,000**	$800	0	$0	
Restore and Projtect Forest, Meadow, and Riparian Corridors	3-4	Maintain and restore 12 acres of meadow habitat	100	$5,000	$0	$20,000	**$25,000**	$2,500	0	$0	
Encourage Student Land Stewardship, Research, and Exploration	4-1	Perform land stewardship	200	$10,000	$7,500	$0	**$17,500**	$1,750	5000	$120,000	Includes: Searching/Mapping (Goal #2-1); Invasive Control / Cutting or Pulling (Goals #3-1, #3-2, #3-3); Fencing under Goal #3-1; Wildflower planting (Goal #3-4)
Encourage Student Land Stewardship, Research, and Exploration	4-2	Perform ecological monitoring to guide adaptive stewardship over time	200	$10,000	$2,500	$0	**$12,500**	$1,250	2500	$60,000	Includes: Forest Health Monitoring related to Goal #3-1; Based upon the direction of faculty and students, study of a variety of taxa
Encourage Student Land Stewardship, Research, and Exploration	4-3	Develop and maintain a trail system to encourage student study of the Property	200	$10,000	$2,500	$0	**$12,500**	$1,250	2500	$60,000	Includes: Trail creation and maintenance allowing easy travel to all corners of the Property
Totals			**1,200**	**$60,000**	**$25,800**	**$158,950**	**$244,750**	**$24,475**	**10,000**	**$240,000**	

Table 25. Goals and Estimated Costs for 10-Year Plan Implementation Period (continued)

Costs	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Total
Staff	$5,500	$5,500	$6,500	$6,500	$6,500	$6,500	$6,500	$5,500	$5,500	$5,500	**$60,000**
Materials	$3,050	$2,900	$2,900	$2,350	$2,350	$2,450	$2,450	$2,450	$2,450	$2,450	**$25,800**
Contractors	$15,300	$15,300	$19,000	$17,550	$17,550	$17,250	$17,250	$13,250	$13,250	$13,250	**$158,950**
Totals	**$23,850**	**$23,700**	**$28,400**	**$26,400**	**$26,400**	**$26,200**	**$26,200**	**$21,200**	**$21,200**	**$21,200**	**$244,750**
Student Hours	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	10000

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.

Massive oaks can be found in old growth forest areas on the Property.