Final White-tailed Deer Management Plan for John Heinz National Wildlife Refuge at Tinicum, Philadelphia, Pennsylvania

USFWS

Forested area of refuge showing low regeneration

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John Heinz National Wildlife Refuge at Tinicum

Final Deer Management Plan

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TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

SECTION 1: INTRODUCTION and BACKGROUND

The white-tailed deer (*Odocoileus virginianus*) population on John Heinz National Wildlife Refuge at Tinicum (herein, JHNWR or Refuge) was believed to surpass the carrying capacity of available habitat, causing severe ecological damage that negatively affected all other native species of flora and fauna. Refuge staff consulted with the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services (herein, USDA APHIS WS) to study the deer population on JHNWR and the effects of deer on habitat, wildlife, and humans. The purpose of this deer management plan is to institute a sound biological program to efficiently manage the deer population within a sustainable healthy balance with the habitat and objectives of the Refuge.

Refuge History

JHNWR was established under Public Law 92-326 (86 Stat. 392), passed by Congress in June 1972, in which authorization was given to the Secretary of the Interior to acquire 1,200 acres to establish the Tinicum National Environmental Center to be administered as a unit of the National Wildlife Refuge System (Refuge System). In November 1991 the name of the refuge was changed to John Heinz National Wildlife Refuge at Tinicum to honor the late Senator who helped preserve Tinicum Marsh. The Refuge currently holds title to approximately 993 acres of the authorized 1,200 acres. These 993 acres consist of 324 acres of upland habitat, as well as 337 acres of wetlands, and 332 acres of open water.

JHNWR was established to preserve and restore the natural resources of Tinicum Marsh, which represents the largest freshwater tidal marsh that remains in Pennsylvania. It is an urban wildlife refuge located in southeastern Pennsylvania within Delaware County and the City and County of Philadelphia. The areas surrounding the Refuge are highly urbanized and include Philadelphia International Airport; and industrial, commercial and residential areas. Over many years, the refuge has been a resting and feeding area for more than 300 species of birds, 80 of which nest on the refuge. A wide variety of wildlife including mammals, birds, reptiles, amphibians, and fish inhabit the Refuge. JHNWR is a designated Important Bird Area and an Important Mammal Area. The Refuge adjoins or includes portions of six municipalities within Delaware County (Figure 1).

Acreage was acquired under provisions of the Migratory Bird Conservation Act (MBCA) and the Refuge Recreation Act. Land acquired under the MBCA is "...for use as an inviolate sanctuary and for any other management purposes for migratory birds...," Lands acquired under the Refuge Recreation Act permit consumptive and non-consumptive forms of recreation provided that the activity is compatible with the Refuge's establishing purpose and sufficient funds are available to administer those uses. The Refuge Recreation Act also maintains that Refuges are closed to all public use unless the refuge manager expressly "opened" it to that use via publication of a notice in the *Federal Register*.

JHNWR protects the largest remaining freshwater tidal marsh in Pennsylvania, as well as serving as an important link along the Atlantic Flyway for annual bird migrations. The founding purpose of the Refuge by Congress was specifically to protect, preserve and enhance Pennsylvania's largest freshwater tidal marsh; to provide for wildlife orientated recreation; and to provide for environmental education. Beginning in 1972, when the Refuge was first staffed, efforts to achieve this purpose were initiated. Since that time, management programs have been

expanded to other agency objectives, such as the protection of federally listed endangered and threatened species, the conservation of native flora and fauna, and the provision of wildlife-dependent public uses.

While deer were hunted in the area prior to the Refuge establishment, they have had complete protection within the refuge boundaries since establishment including from managerial biological control of the herd. Refuge staff reported a general increase in deer abundance as per annual staff deer surveys (Table 1) and a dramatic shift towards nonnative, invasive vegetation in response to overbrowsing by deer.

Figure 1. JHNWR is located in Philadelphia and Delaware Counties, Pennsylvania. USDA APHIS WS conducted a study examining white-tailed deer ecology on the Refuge during 2008 to 2011.

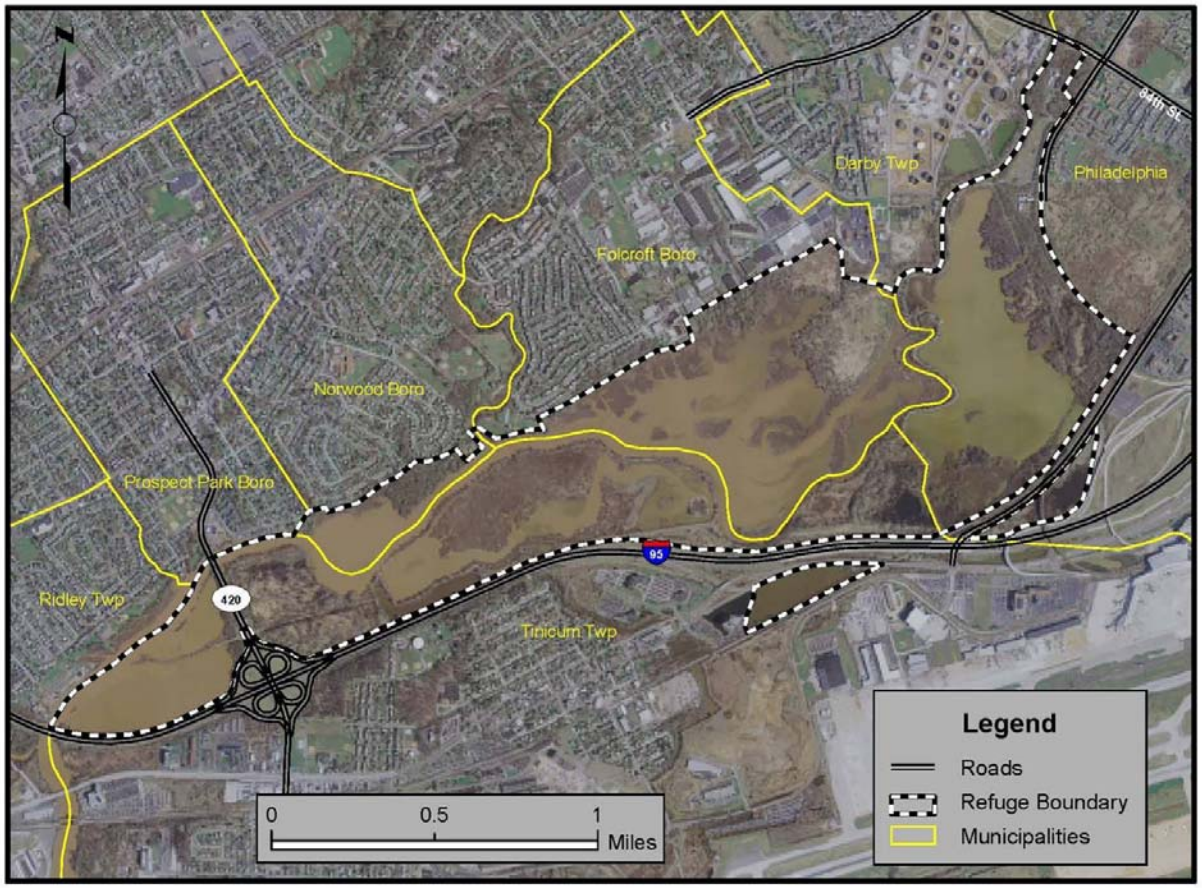


Table 1. Annual white-tailed deer abundance estimates derived from standardized deer drives conducted by staff and volunteers at JHNWR, Philadelphia and Delaware Counties, Pennsylvania from 2001 to 2010.

Date of Survey	Deer Abundance Estimate
2001[a]	86
2002	106
Feb. 2003	136
Jan. 2004	193
Dec. 2004	224
Dec. 2005	245
Dec. 2006	208
Dec. 2007	199
Dec. 2008	191
Dec. 2009	243
Dec. 2010	188

[a] Months of surveys during 2001 and 2002 were not specified.

Biological Resources

Vegetation.–Ecologically, the historic vegetation types of JHNWR were primarily subunits of the freshwater tidal marsh of Pennsylvania's Coastal Plain Habitat. The distribution of stands of recognizably different types of vegetation in JHNWR is unique because it was composed of numerous visually distinct subunits that differ in color, height and texture, and that differ in position in relation to drainage channels and micro-topography. Several types of vegetation were represented by "pure stands" composed almost entirely of plants of a single species or of a few, closely related species. This was true of wild rice, common reed (phragmites), spatterdock, creeping willow, and smartweed types. Over much of the area in which they occurred, the cattail stands were pure, but in part of the area cattail was mixed with aquatic plants of various other species.

The other vegetation types recognized in surveys from the 1983 Tinicum Master Plan were much broader, more subjective categories. For example, a mixed-aquatics type was mapped in much of the tidal marsh. Generally, stands of mixed aquatics were composed of two or more species of smartweed in a mixture with arrowheads, beggerticks, jewelweed, burreed, cattail, spatterdock, wild rice, iris, sedges, and grasses. They were woven together in many places by masses of dodder, a parasitic, orange colored, herbaceous vine.

Woody or semi-woody vegetation is not abundant in the Tinicum area. It may be divided on the basis of form and height into a shrub type and a tree type. The shrub type actually is composed largely of shrub-like herbs which die to the ground in winter. Stands of the shrub type

occur primarily in impounded areas. They are developed particularly well in the former Bow Creek Strip and in the unmapped Green Creek Strip south of the Industrial Highway. Invasive purple loosestrife is the most common plant, but rose mallow is scattered throughout the stands. In some places, the shrub types are formed by dogwoods and willows and in other places by alders and other woody shrubs. The tree type is composed of several dozen species in the mapped area, but willows are the chief components in stands on dredged materials and on sites adjacent to the tidal marsh.

Another habitat type, characterized as old field herbaceous vegetation, is composed of many kinds of grasses, goldenrods, asters, fleabanes, and similar plants. This habitat occupies fields on higher lands around the marsh that formerly were cultivated, and covers the dikes that exist within wetlands.

When the Tinicum Marsh was inventoried in 1968, the marsh consisted of approximately 523 acres of tidal wetlands, and 8 tidal marsh vegetation types were identified. The wild rice type occupied the greatest acreage of the tidal wetlands (138 acres), but the spatterdock type (108 acres) and the mixed aquatic type (103 acres) were nearly as widespread. The common reed type was predominant throughout the region that was mapped, but the type occupied only 13 acres of the tidal wetlands. It was most characteristic of areas covered with dredged materials.

Wildlife.–JHNWR provides habitat for the majority of wildlife species known to occur in southeastern Pennsylvania. More than 375 vertebrate species and approximately 166 plant species have been documented on JHNWR. The Refuge encompasses many of the vegetation types found on the southeastern Pennsylvania Coastal Plain, providing habitat for a variety of wildlife ranging from forest interior nesting, neotropical migrant birds to freshwater tidal marsh species. JHNWR is part of a major migration corridor for a variety of birds including waterfowl, waterbirds, raptors, and songbirds along the Atlantic Flyway.

Birds represent the largest single class of vertebrates on JHNWR, with 300 bird species documented on the Refuge and 80 species known to nest there. Waterfowl use is extensive and the Refuge serves as important wintering habitat for waterfowl particularly from September through April. The coastal location of the Refuge makes it an important migratory habitat for waterfowl and raptors. Songbirds are a conspicuous component on JHNWR and a major attraction for many of the visitors. The songbird community is diverse and includes many neotropical migrant species during both spring and fall migrations. Approximately 20 species of mammals have been documented on the Refuge. Fifteen species of reptiles and amphibians occur at the Refuge, including State endangered coastal plain (southern) leopard frogs.

Threatened and Endangered Species.– There are no federally designated endangered and threatened species known to occur on JHNWR. Bald eagles, currently delisted, are regular year-round residents that nest on the refuge and use it for diurnal hunting when open water is available. They are associated with aquatic and wetland habitats and adjacent terrestrial borders.

Pennsylvania State-designated threatened and endangered species occurring on JHNWR include great egret, American bittern, least bittern, black-crowned night heron, king rail, least bittern, eastern redbelly turtle, and eastern mud turtle. Eastern box turtle is a species of concern due to major recent population declines in Pennsylvania, where it was once considered an abundant species and was proposed for State protection in 2007.

Statement of Refuge Objectives

Goals of the National Wildlife Refuge System.–The goals established for the Refuge System are delineated as follows:

- To preserve, restore, and enhance in their natural ecosystems (when practicable) all animal and plant species that are endangered or threatened with becoming endangered.

- To perpetuate the migratory bird resource.

- To preserve a natural diversity and abundance of fauna and flora on refuge lands.

- To provide an understanding and appreciation of fish and wildlife ecology and man's role in his environment, and to provide refuge visitors with high quality, safe, wholesome, and enjoyable recreational experiences oriented toward wildlife to the extent these activities are compatible with the purpose for which the refuge was established.

Purposes of John Heinz National Wildlife Refuge at Tinicum .– John Heinz NWR was established in 1972, under special legislation, for the following purpose:

- "To acquire lands necessary for the purpose of preserving, restoring, and developing the natural area known as Tinicum Marsh. Also, to construct, administer and maintain a wildlife interpretive center for the purpose of environmental education and to afford visitors an opportunity for the study of wildlife in its natural habitat" (86 Stat. 891, dated June 30, 1972).

Some additional refuge lands were acquired under the following authorities:

- To be of "particular value in carrying out the national migratory bird management program." 16 U.S.C. §667b (An Act Authorizing the Transfer of Certain Real Property for Wildlife).

- "Development, advancement, management, conservation, and protection of fish and wildlife resources...(16 U.S.C. §742f (a)(4))...for the benefit of the United States Fish and Wildlife Service, in performing its activities and services...." 16 U.S.C. §742f(b)(1) (Fish and Wildlife Act of 1956).

- "[F]or use as an inviolate sanctuary, or for any other management purpose, for migratory birds…." 16 U.S.C. §715d (Migratory Bird Conservation Act).

Deer Ecology and Management

History of Deer in Southeastern Pennsylvania.–It is estimated that white-tailed deer have been in existence for some 4.5 million years. Yet, with the exception of the Ice Ages, never

before have deer populations seen such change in their habitat as those created by urbanization in the last several decades. Deer have adapted well to this change, and their numbers throughout the U.S. are estimated to be higher than at any other time in history. Today, the landscape of southeastern Pennsylvania presents an ideal combination of ample food resources, few natural predators, and sanctuary from hunting in close proximity to human development, which enabled the deer population to grow overabundant.

Within the last 10,000 years, growth of white-tailed deer populations was controlled by predators including wolves, mountain lions, and bears; natural mortality such as starvation and disease; and harvest by Native Americans. Deer were also limited by the productivity of their habitat. Prior to European settlement, much of southeastern Pennsylvania was virgin forests with few openings to offer deer young nutritious vegetation. Although Native Americans cultivated agricultural crops, it was documented that they reduced damage by deer through persistent harvest of deer in the vicinity of their crops and by non-lethal means including fencing and harassment.

Although it is difficult to determine at what densities deer historically occupied southeastern Pennsylvania, studies which have examined deer remains at Native American encampments suggest that deer densities were far lower than we see today–perhaps less than 10 deer per square mile. Even at presumably lower densities, deer were an important component of the Native American culture. Pennsylvania's founding father, William Penn, once noted that Native American men attained esteem among their tribesman "…by a good return of [deer] skins…".

By the turn of the 20th century in Pennsylvania and throughout much of its range, the white-tailed deer was nearly driven to extinction primarily by unregulated market hunting and habitat loss via commercial logging. The reestablishment of white-tailed deer populations has been regarded as one of the greatest successes in the history of wildlife conservation. In Pennsylvania restocking of deer began in 1906 and continued into the 1920s with deer relocated from areas within the State and from stock animals brought from other states including Virginia, Wisconsin, and Texas among others. The population increase of deer was also enabled by the burgeoning growth of young forests after logging with soft mast available during warm months and ample woody browse in the winter. By 1923, the Pennsylvania Game Commission began receiving complaints of widespread crop damage due to deer. To better manage deer populations in balance with the habitat and to reduce damage to agriculture, harvest of antlerless deer (i.e., female deer and males with antlers less than 3 inches) became an annual strategy in the wildlife management regime of Pennsylvania by the late 1950's.

Deer continue to be valued by humans as an important big game animal hunted for recreation and a favorite of wildlife watchers. With their voracious consumption of vegetation, however, deer have a tremendous impact across the landscape. Deer are the keystone herbivores in most ecosystems in which they exist. The shaping of the plant species composition and the physical structure of plants by deer determines the ability of other wildlife species to subsist in the same habitat.

Deer-human conflicts occur when overabundant deer threaten human livelihood, health and safety, property; and natural resources. These conflicts are common to communities throughout the whitetail's range–especially along the eastern seaboard. Controversy often arises at the community level when lethal management is proposed to reduce deer densities and associated damage. However, in the absence of natural sources of mortality, managers have a responsibility to properly regulate deer populations for the good of humans and deer alike.

Deer Ecology.–White-tailed deer are found in a variety of habitats throughout most of the United States, Canada, Mexico, Central America and northern South America. Deer almost exclusively consume plants. They are ruminants and have a highly specialized four-chambered stomach, which allows them to digest a wide variety of plant species. Deer choose the most nutritious plants and plant parts available. Deer thrive in areas with young vegetation, especially where the edges of several habitat types converge, such as the suburban/agricultural interface.

Adult white-tailed deer on average weigh between 100 and 300 pounds with males being larger than females. Bucks produce their first set of antlers during their second year of life. Females do not grow antlers. The basic social group is the doe family unit including an adult doe, and her offspring. Outside of the breeding season, or rut, males may form small herds known as bachelor groups. In Pennsylvania, deer breed in the fall, and most fawns are born in late May and early June. Does generally produce one or two fawns each year. In ideal habitats, does may breed at approximately 6 months of age and some adult does may produce triplets.

Deer are crepuscular (primarily active near dawn and dusk), with their main movements occurring from daytime bedding areas to and from nighttime feeding locations. Bucks have larger home ranges than does, especially during the rut when bucks travel widely in search of mates. In Pennsylvania, deer home ranges average between 150 and 1,000 acres depending on the availability of local resources (Appendix A).

Winter months in Pennsylvania can be stressful for deer depending on the amount of snow fall, days with freezing temperatures, and availability of food (e.g., browse, mast crops, supplemental feeding, etc.). Deer populations are normally at their lowest just following the winter months, before birthing. The change in population size from year to year is defined as the growth rate, which is mainly driven by successful recruitment of young into the population.

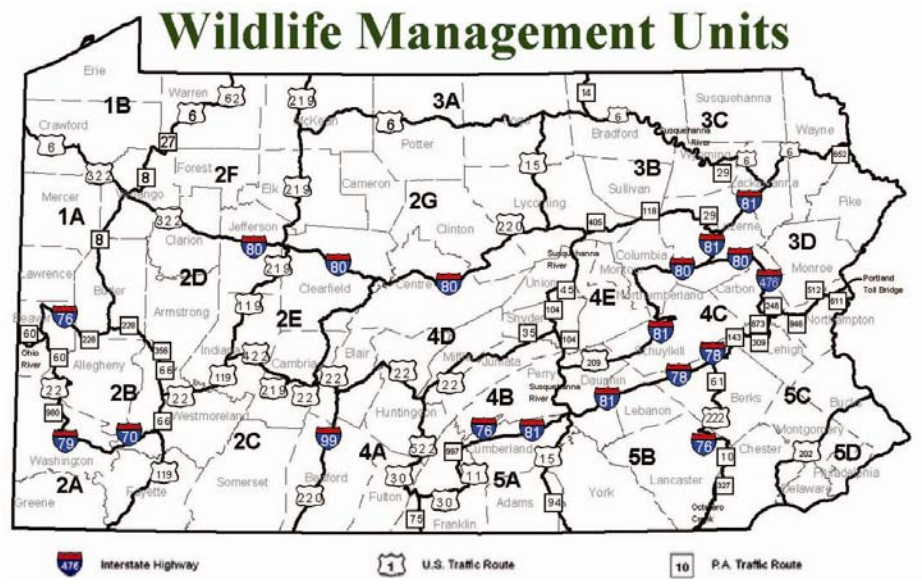
Deer managers must balance the birth and death rates within a population to maintain herd health, reduce disease risks, protect ecosystems, and to reduce damage. In natural settings deer populations eventually reach the biological carrying capacity, which is the point at which deer consume most of the available browse in an area. At this point, the population is unable to sustain growth and reproduction. Each habitat has a different biological carrying capacity, which is continually dynamic in response to deer numbers, weather conditions, and other factors.

Although the biological carrying capacity is important to deer population dynamics, the social carrying capacity is more relevant in urban areas. The social carrying capacity is the level at which deer populations can coexist with the human population without negative impacts. Negative impacts on humans can include deer-vehicle collisions, deer damage to landscaping, biological damage, disease threats, and the emotional fear by humans of interaction between deer and humans; and the damages associated with deer. Deer populations can also experience negative impacts in urban settings including stress; trauma from encountering dogs, pools, large glass windows, vehicle traffic; and the lack of adequate habitat. Given these factors, the social carrying capacity may be lower or higher than the biological carrying capacity. It is important to understand that neither the biological or social carrying capacity is static.

Current Deer Management Conditions in Pennsylvania.–Sport hunting is the primary mechanism to regulate deer numbers in Pennsylvania on an annual basis. The Pennsylvania Game Commission regulates deer harvest via prescription of licenses for harvest of antlerless deer per 22 different Wildlife Management Units (WMU; Figure 2). WMU's were based on land use/habitat, human density, public/private land ownership, and recognizable physical features.

The Statewide goals established in the Pennsylvania Game Commission Deer Management Plan include: 1) manage deer for a healthy herd, 2) reduce deer–human conflicts, and 3) manage deer for healthy forest habitat. Allocations of antlerless deer licenses are determined annually to adjust deer densities relative to these goals within each WMU.

Figure 2. Pennsylvania Game Commission Wildlife Management Units designated for licensing and regulatory guidelines for sport-hunting in the Commonwealth of Pennsylvania. Image courtesy of Pennsylvania Game Commission at www.pgc.state.us.



In hunting license year 2008 to 2009, an estimated total of 335,850 deer were harvested in Pennsylvania including 213,440 antlerless deer and 122,410 antlered deer. In WMU 5D, which includes JHNWR, a relatively large number of antlerless deer licenses per square mile of land area are allocated versus other areas of the State to curtail population growth of deer and to reduce deer-human conflicts. For the 2008 to 2009 hunting license year, 22,000 antlerless deer licenses were allocated in WMU 5D and an estimated 4,500 antlerless deer and 1,300 antlered deer were harvested. Sport hunting for deer in WMU 5D occurred, excluding Sundays and 24 to 25 December, 2009, from 19 September, 2009 to 23 January 2010 during 107 days of hunting. This allotment of licenses and days of hunting are similar annually in WMU 5D. Hunters are permitted one antlered deer per hunting license year. In WMU 5D, an individual hunter may harvest unlimited antlerless deer provided they possess the appropriate number of valid WMU-specific antlerless licenses.

Because of dense human housing and development, sport hunters in Philadelphia County are not permitted to discharge firearms and may only use archery equipment to harvest deer. Without specific permission of the occupants, hunters must be a minimum of 50 yards from any occupied residence or building to hunt. Around playgrounds, schools, nursery schools or day-care centers, archery hunters must remain a minimum of 150 yards away. Although hunters are afforded liberal seasons and bag limits for deer in Philadelphia and Delaware Counties, harvest of sufficient numbers of deer is confounded by firearms and safety zone restrictions coupled with extensive division of property ownership.

SECTION 2: PURPOSE and MANAGEMENT STRATEGY

White-tailed Deer Management Plan: Need, Purpose, and Objectives

Need for Deer Management Planning.–Habitats for wildlife have diminished considerably over the past few decades as urban and suburban development has expanded into southeastern Pennsylvania's remaining wildlife habitats. As a result, the remaining protected lands must support a wide variety of wildlife in a limited area. Competition among wildlife species for space and foraging habitat is immense, and white-tailed deer are a major source of damage to forest and herbaceous vegetation.

Deer foraging habits and preferences are known to change plant composition and structure over time (Porter 1991, Van Deelan et al. 1996, Brown and Parker 1997, Augustine 1998, Russell and Fowler 1999) and such alterations have subsequent impacts on other wildlife, such as songbird species richness and abundance (De Calesta 1994). Several other studies (Casey and Hein 1983, McShea and Rappole 1992) found reduced songbird species richness and/or abundance in areas with high deer densities.

A concern of land managers regarding deer populations at high densities is the impact to biodiversity. Because they are large herbivores, white-tailed deer are effective at altering habitat due to their energetic requirements and high reproductive potential (McCullough 1982, 1997). Many authors (Behrend et al. 1970, Tilghman 1989, Warren 1991, McShea and Rappole 1992, Miller et al. 1999) reported that vegetative species richness and the abundance of herbaceous and woody vegetation declined in areas with white-tailed deer densities exceeding 29 deer per square mile. In a northwestern Pennsylvania study, Behrend et al. (1970) and Tilghman (1989) recommended a herd density of 21 deer per square mile to allow for successful hardwood forest regeneration. Refuge staff estimated that the deer herd far exceeded this density for multiple years. It is reasonable to assume, therefore, that these adverse vegetative effects have also occurred on JHNWR for some time. The loss or reduction of woody understories in forests or lack of forest regeneration can impact the habitat of migratory birds as well as other wildlife. In a Pennsylvania study, DeCalesta (1994) found that changes in vegetation via deer browsing impacted intermediate canopy-nesting songbirds and reduced species richness and abundance. That study recommended maintaining herds at a density of between 21 and 39 deer per square mile to reduce impacts on habitats and songbirds. Alverson et al. (1988) suggested a deer density of 10 deer per square mile to minimize impacts caused by overbrowsing.

The damage caused by deer to forest regeneration on JHNWR is evident. The presence of oak and maple saplings within long-term fenced deer exclosures is obvious, while similar vegetation outside of the exclosures is browsed to the ground or is not existent. Invasive species of plants, which are often consumed to a lesser extent by deer, have become dominant vegetation types on the refuge. While such impacts currently affect forest understory and the varied animals dependent on this vegetation zone, the longer term implications are that the refuge's native forested areas could lose the ability to replace themselves through time.

Refuge biologists have been conducting deer population inventories since 2001. These surveys involved counting deer that were driven systematically from various portions of the Refuge. The results of these surveys have recently recorded population numbers greater than 150 deer per square mile.

The need for action on JHNWR is based on the negative impacts to vegetation caused by deer. Such adverse effects are principally impacting two objectives of JHNWR Station Master Plan (USFWS 1983):

- These areas will be managed thereby facilitating the movement of wildlife through this habitat (the refuge provides a diversity of breeding and migration habitats that support 300 species of passerine, waterfowl, raptors and other migratory birds).

- The existing tidal wetlands will be managed to maintain their integrity and to enhance their productivity.

Purpose of Deer Management Planning.–The purpose of developing a deer management plan for JHNWR is to examine the current population ecology of deer on the Refuge, to assess the effects of deer on habitat and humans, and to design deer population management actions to maintain the deer population within the objectives of JHNWR.

Objectives of Deer Management Planning.–

- Quantify deer population characteristics including estimates of deer abundance, and sex and age ratios.

- Characterize suitability of habitats for deer on JHNWR and the surrounding area.

- Examine the effects of browsing by deer on forested areas.

- Examine the effects of deer on humans.

- Recommend strategies to manage deer within the objectives of JHNWR.

An Integrated Approach to Managing Damage by Deer

A well-designed deer damage management program is a progressive approach to wildlife management, which includes developing beneficial relationships among the public, landowners, hunters, and wildlife professionals to reach and maintain deer densities at desirable levels; education about wildlife conservation and deer damage management; implementation of non-lethal deer damage management techniques where practical–fencing, repellents, deterrents; and monitoring the impacts of deer on the environment.

WS recommends that our cooperators adopt an integrated approach to managing damage by white-tailed deer. WS provides Federal leadership in the deer management process by conducting personal consultations with individuals and communities, educational programs, assessments of damage by deer, and direct management in the removal of overabundant deer.

Components of the Integrated Approach

Define Goals.–Those seeking to make deer damage management decisions should involve representatives of all stakeholder groups with an interest in managing deer in the target area. Providing education on basic deer biology and damage management techniques is integral to the process, so that stakeholders may make informed decisions. Goals should define acceptable levels of damage by deer, which minimize deer-human conflicts.

Identify the Problem.–Stakeholder groups should obtain information on the impacts of deer damage such as deer-vehicle accident records, rates of Lyme disease, and estimates of damage to landscape and commercial plants. Establishing the extent and timing of how deer may be impacting the target area is the first step toward identifying whether a problem exists with deer.

Establish Monitoring.–Information collected during the problem identification phase may be used as baseline data for long-term indices relative to goals of the program and as the basis for making management decisions. Estimates of deer abundance are necessary to assess the effects of any management actions relative to the program goals. WS specializes in conducting deer density surveys using a variety of techniques tailored to individual situations.

Develop a Management Plan.–A deer damage management plan should document clearly defined program goals, identify the level of damage caused by deer based on the supporting evidence collected, and should propose management actions to achieve the program goals. Effective management plans must allow for the flexibility to adapt future management actions based on data collected during continued monitoring.

Options for Management

No Action.–The "no action" alternative is appropriate if monitoring indicates that current management practices are maintaining deer densities in balance with program goals. For example, on some public lands such as JHNWR, this means allowing the deer population to grow unrestricted. Often, deer numbers grow above levels which the habitat can support and above that which humans are willing to tolerate. In urban situations, deer densities may be maintained by a high rate of deer-vehicle collisions. In extreme cases, mortality may occur in the form of starvation. Alternatively, the "no action" alternative often means that sport hunting continues as the established management practice because hunters are achieving adequate harvests to meet program goals.

Non-lethal Damage Management.–A myriad of non-lethal deer damage management techniques are available, and fall under three general categories: exclusion, deterrents, and repellents. Research has demonstrated that some practices are effective while others appear to be marketing ploys. Properly installed and maintained fencing 10 feet in height and secured to the ground is the most effective exclusion tactic. Fencing can be cost prohibitive for large acreages, and many communities have ordinances limiting the use or height of fences. However, fencing used to protect young plant growth can be beneficial in deterring deer browsing until plants are

no longer vulnerable. Deterrents use sound, visual, or tactile cues to frighten deer from areas where they are causing damage. Deterrents which are set off by the offending deer or those with irregular cues tend to be most effective since deer may easily become acclimated to deterrents. Repellents use taste or scent to discourage deer from eating treated plants or entering treated areas. A wide variety of commercially available repellents have been reported to be effective in independent research. Repellents require reapplication after rain events and may lose effectiveness at temperatures below freezing.

Population Management.–When deer become overabundant, a rapid reduction in deer density is necessary to suppress annual population growth and to reduce damages. Once management goals are reached, annual deer harvests must be conducted to maintain acceptable population levels. The methods used to remove deer will depend on safety, legal restrictions, financial constraints, timing of the management action, and effectiveness of the removal methods employed (Appendix A). In many deer management situations, using a combination of deer removal methods is necessary to achieve management goals.

Population Management Alternatives

Sport-hunting.–Sport hunting should be encouraged whenever possible as it is generally the most economically feasible strategy to manage deer. However, legal restrictions (e.g., safety zones, timing of hunting activity) and other limitations (e.g., hunters resistant to harvesting adequate numbers of does) may limit the effectiveness of sport hunting in some situations. In recent years, the Pennsylvania Game Commission has provided for additional deer harvest opportunities under depredation permits outside of the normal hunting seasons.

Controlled Hunts.–Controlled hunts using sport hunters can be structured to maximize deer removal efforts. Stipulations may include designated dates and times of hunts, weapon restrictions, and safety certification of hunters. By concentrating hunting pressure during specific times, controlled public hunts usually increase deer harvest and require less time than normal sport hunting.

Professional Deer Removal.–In instances where sport hunting is not practical or effective, deer removal may be conducted under a depredation permit by WS, private contractors, or other agents of the cooperator. Professional deer removal operators are permitted to use specialized equipment and methods such as high-powered rifles fitted with suppressors to minimize noise; infrared and night vision technologies for identification of safe shooting opportunities and to increase the ability to locate deer; baiting; and shooting at night, from vehicles, and in close proximity to buildings. Deer harvested by professional operators provide venison for charitable donation. Professional deer removal usually requires the least amount of time versus other methods to reach population goals.

Relocation.–Capturing deer and relocating them to another location is not an option in Pennsylvania because this practice is not legal. The Pennsylvania Game Commission does not recognize trap and transfer of deer as a viable alternative for localized population reduction and prohibits trap and transfer of deer to prevent the spread of disease (Christopher Rosenberry, personal communication). Legal considerations not withstanding, trap and transfer of deer is

expensive, ideal relocation sites are limited, and relocated deer suffer greater than 50 percent mortality.

Fertility Control.–WS is conducting ongoing research through its National Wildlife Research Center in the development of a fertility control agent to limit deer population growth. To date, tests of fertility control in deer populations in fenced enclosures have demonstrated limited effectiveness. Currently, no fertility control agents for use in white-tailed deer have been approved for use in Pennsylvania. If registered, future use of fertility control will have limited applicability, especially for large populations of free-ranging deer. Implementation of a fertility control program would be costly and herd reductions would still be necessary to reduce damage since fertility control does not directly reduce deer numbers.

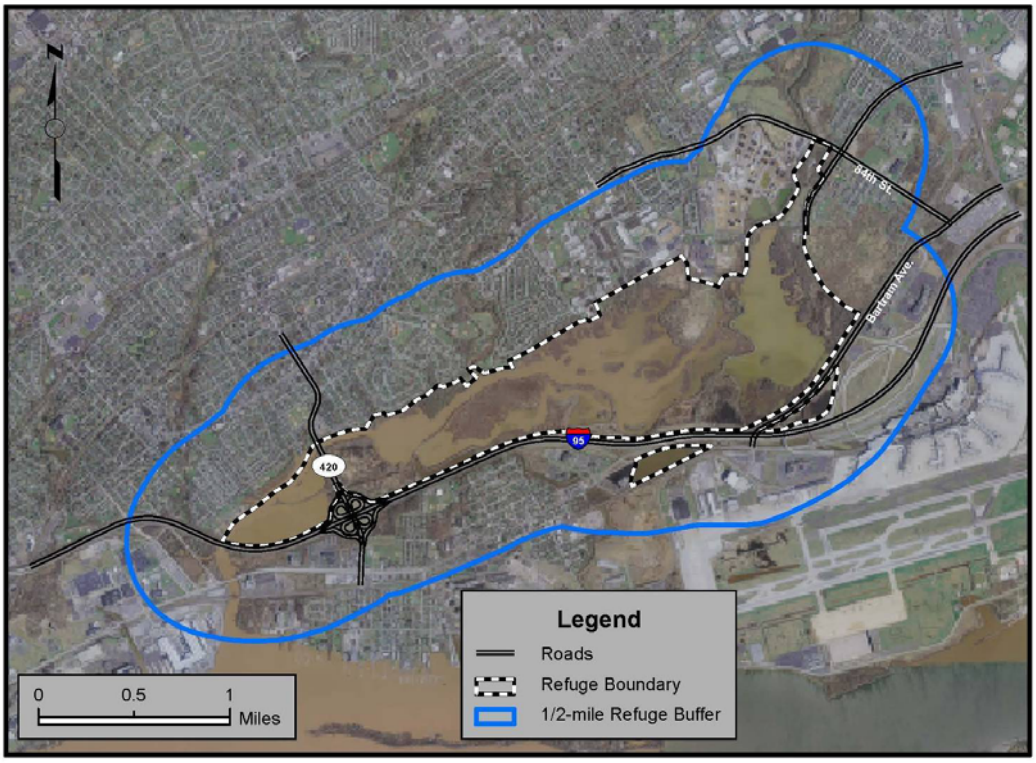
SECTION 3: METHODS of DEER RESEARCH on the REFUGE

To design a long-term management regime for deer on JHNWR, an understanding of localized conditions was necessary. WS established standardized indices relative to the deer population utilizing JHNWR including deer abundance estimation, assessment of deer herd health, characterization of available habitat, and potential effects of deer on humans.

Habitat Analyses

Characterization of Deer Habitat.–WS utilized Global Information Systems (ArcMap 9.1, Environmental Systems Research Institute) to analyze geo-referenced aerial photographs of the area encompassing JHNWR and a one half-mile buffer of the refuge boundary to estimate the amount of terrestrial habitat and its suitability for use by white-tailed deer (Figure 3). The buffer was assumed to contain the home ranges of most deer utilizing JHNWR given the results of previous research on the spatial dynamics of deer in urban habitats. The aerial photographs used were taken during both annual and daily high water inundation. Therefore, estimates of available habitat were conservative. Since JHNWR lies in an urbanized environment and wildlife habitat is limited, any terrestrial habitat is likely used by deer to fulfill some life requisites (i.e., food, water, cover).

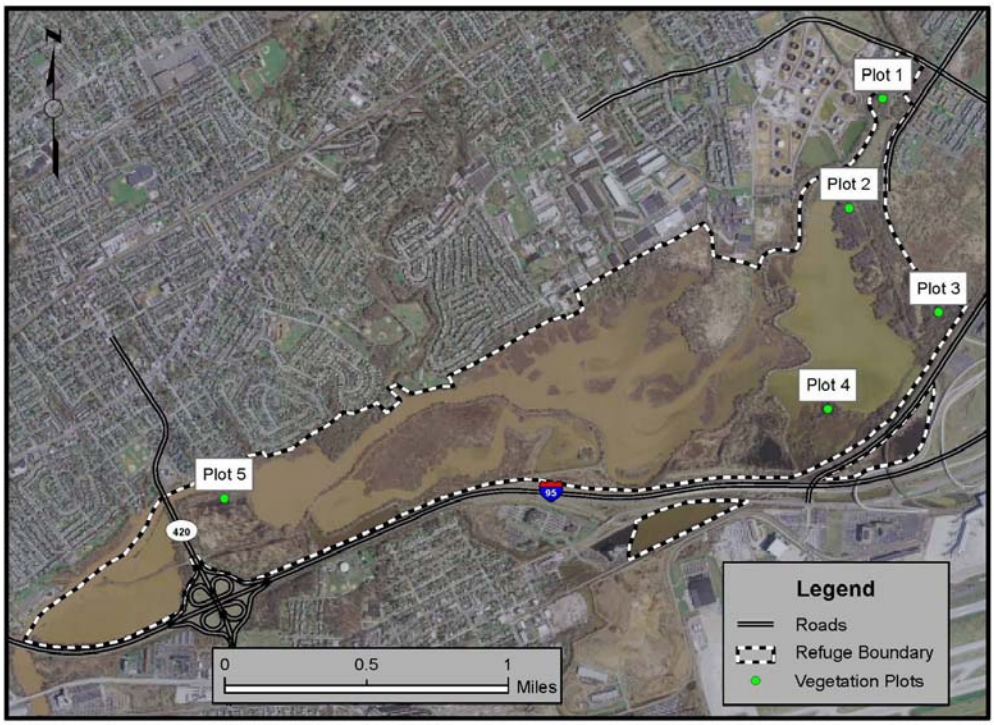
Figure 3. Overview of JHNWR located in Philadelphia and Delaware Counties, Pennsylvania with the approximate boundary of the Refuge outlined and a half-mile buffer around the boundary of the Refuge used to estimate available white-tailed deer habitat. Habitat analyses were conducted by USDA APHIS WS as part of a study examining the ecology of white-tailed deer on the Refuge.



Habitats were characterized in the following manner: (1) *Habitat Unusable for Deer*: These areas included permanent water, industrialized areas, roadways and inaccessible buffers, areas of extremely dense human housing, and high-fenced areas. (2) *Marginal Deer Habitat*: Describes areas with access limited for use by deer due to daily inundation by water (i.e., colonies of phragmites and other plant types that withstand some inundation by water), islands, moderately dense urban neighborhoods and their margins, and roadway buffers with some access. Marginal deer habitat may provide temporary use for deer, whether food or cover. For example, small isolated islands are not typically used by deer, but during fawning season females isolate themselves and when space is limited deer have been known to utilize islands for fawning. (3) *Good Deer Habitat:* included most upland areas because they theoretically provide consistent food and cover resources for deer. On JHNWR, with terrestrial habitats being limited and surrounding urban development, any vegetated land accessible to deer may be considered "good". Therefore, any upland habitat greater than 3 acres with connection to other good or marginal deer habitats was classified as good deer habitat.

Forest Regeneration Surveys.–To collect baseline data of the condition of primary forested areas on JHNWR, WS conducted vegetation surveys at five sites (Figure 4) during two seasonal periods, the early growing season and the late growing season. The center of each site was determined via generation of a random compass azimuth followed from a random distance from the entry point of the woodlot by the observer. The center of the site was marked by a 6-foot steel T–post driven into the ground to a depth of 1.5 feet.

Figure 4. Locations of vegetation plots used by USDA APHIS WS to document the condition of forest understory vegetation as part of a study examining the ecology of white-tailed deer on JHNWR located in Philadelphia and Delaware Counties, Pennsylvania during 2009 and 2010.



At each site, 9 5.5-square foot circular subplots were established including five unfenced control subplots and four fenced treatment subplots (Figure 5). Unfenced controls included a subplot at the center of the site and four subplots radiating 20 feet from the center of the site in the four cardinal directions (i.e., north, south, east, and west).

Fenced treatments radiated 20 feet from the center of the site in the four intermediate directions (northeast, southeast, southwest, and northwest). To exclude deer, a 6-foot by 6-foot exclosure was erected surrounding fenced subplots with 6-feet high welded–wire fencing strung vertically on four 8-feet steel T–posts driven into the ground to a depth of 1.5 feet.

Within each subplot, the following variables were estimated: 1) woody seedling regeneration–species, height, and level of browsing damage by deer; 2) percent ground cover of variables including bare ground, forest litter, forbs, grass, or other species groups; 3) percent plant cover in vertical zones of 0 to 2 feet, 2 to 4 feet, and 4 to 6 feet as viewed against a vertical cover board from a distance of 20 feet at a vertical viewing height of 3 feet.

Reference photographs of each subplot were taken with a digital camera at a lens focal length of 25 mm. The vertical plant cover board was placed in the center of the subplot facing the center of the site to indicate scale and provide a reference to gauge the density of vegetation. Reference photographs for the 8 subplots in the cardinal and intermediate directions were taken from the center of the site toward the center of the subplot. The reference photograph for the central subplot was taken from the center of the north subplot toward the center of the central subplot.

All canopy trees greater than 3 inches in diameter within a 40-foot radius of the center of the site were inventoried according to species and diameter at breast height. Canopy coverage was assessed using a densitometer (Geographic Resource Solutions) at 25 standardized points within a 40-foot radius of the center of the site.

Figure 5. Example of fenced vegetation subplots established in May and June 2009 by USDA APHIS WS to document the condition of forest understory vegetation as part of a study examining the ecology of white-tailed deer on JHNWR located in Philadelphia and Delaware Counties, Pennsylvania. To exclude deer, a 6-foot by 6-foot exclosure was erected surrounding fenced subplots with 6-foot high welded–wire fencing strung vertically on 4 8-foot steel T–posts driven into the ground to a depth of 1.5 feet.

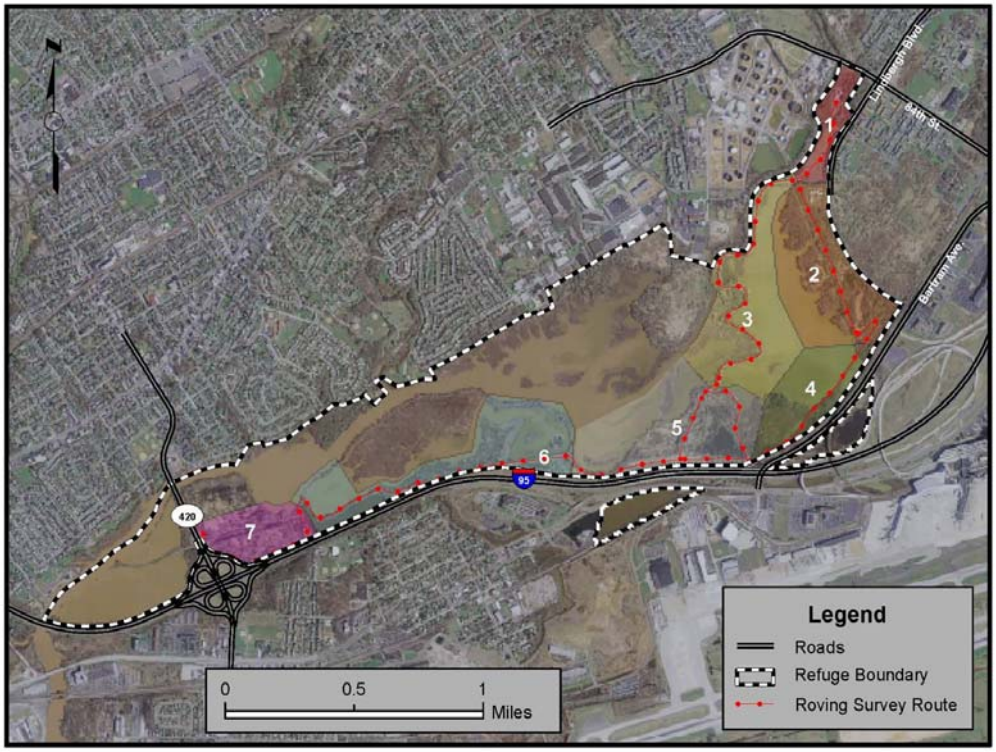
Deer Density Surveys

Two survey methods were chosen to most accurately evaluate the abundance of deer on JHNWR: 1) a roving infrared camera survey from a vehicle (herein, roving survey), and 2) baited infrared camera stations (herein, baited survey). Most areas of the refuge were accessible by vehicle and habitat conditions allowed ready observation of deer along the roving survey route. For areas not fulfilling the requirements of the roving survey, stationary baited infrared cameras were used to estimate deer abundance.

Roving Surveys.–A standardized 6.5-mile survey route was established throughout JHNWR on established roads (Figure 6). WS consulted with JHNWR personnel to design a survey route, which would avoid multiple observations of individual deer during a single survey and would adequately survey a representative sample of terrestrial and wetland habitats.

Roving survey teams of three people consisted of a driver and a data recorder, both personnel of JHNWR, and one observer from WS in the back of a mobile truck. Roving surveys were initiated each night after sunset. A Forward Looking Infrared (FLIR) unit was used to initially observe deer. The observer used a spotlight, binoculars, and a laser rangefinder to verify the age and gender of deer and their perpendicular distance from the survey route. The survey vehicle moved at approximately 5 miles per hour, stopping only to collect data.

Figure 6. Route of roving vehicle traversed for 18 white-tailed deer density surveys completed by USDA APHIS WS on JHNWR located in Philadelphia and Delaware Counties, Pennsylvania during November 2008 through January 2011. Shaded areas indicate zones used to characterize locations of deer observed during surveys.



A standard deer density estimator (Hahn 1949) was modified to derive logical deer density estimates based on available habitat for deer on JHNWR and the surrounding area. The deer density estimator determined area surveyed by factoring the survey route distance and the distance deer were observed from the closest point on the survey route. The estimator then extrapolated deer density estimates by factoring in the proportion of habitat that may be utilized by deer per square mile in the survey area.

Baited Surveys.–Baited surveys were conducted to obtain finer estimates of the number of deer utilizing key areas of JHNWR and to provide an additional index to changes in population abundance. This method was conducted according to previous research by Jacobson et al. (1997). These researchers demonstrated that the abundance of deer in an area could be determined using baited surveys, where bucks could be uniquely identified by antler characteristics (Figure 7) and their number used to infer the number of does and fawns (Figure 8) visiting repeatedly the bait site.

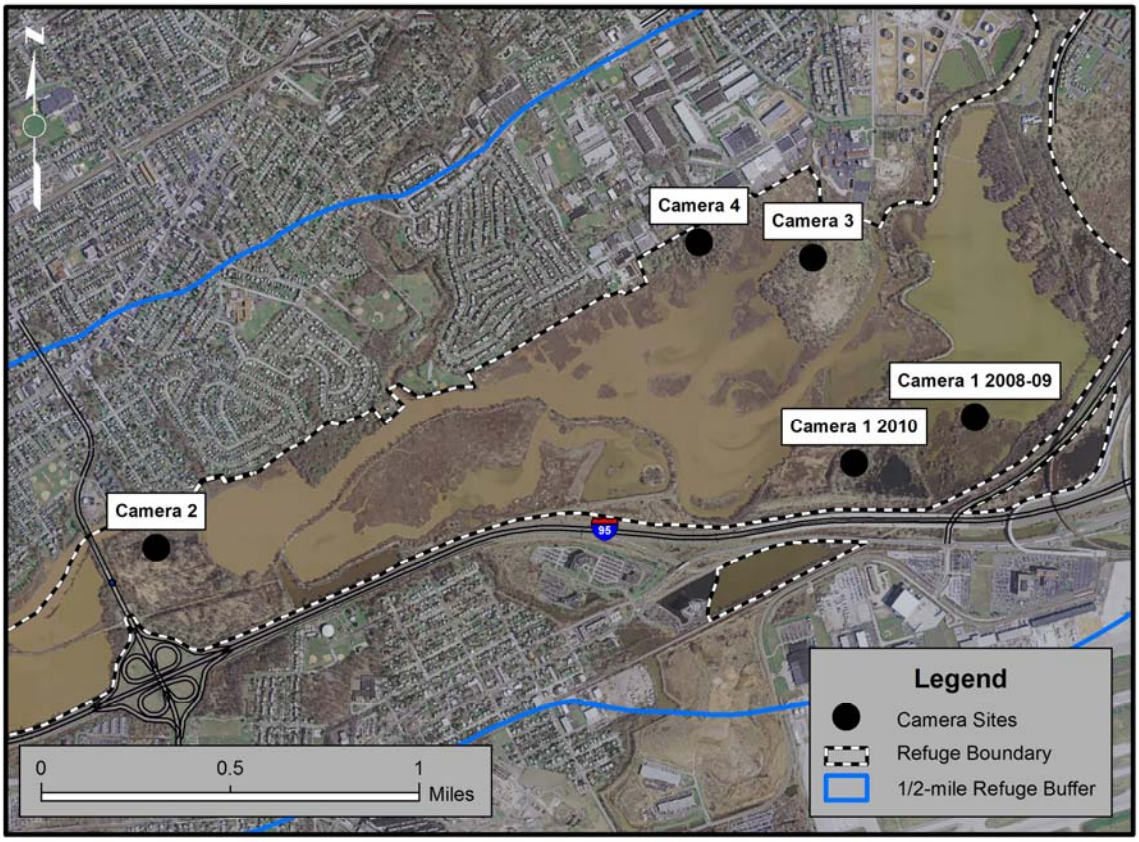
Baited surveys were conducted in four areas per year (Figure 9) that were not directly accessible for roving surveys. However, because of their distribution and limited access by the public, these sites would act as reliable sentinels to gauge deer density across JHNWR as a whole. Criteria for the bait sites included: 1) regular utilization of the area by deer before bait was placed, and 2) uncommon use by humans in the immediate vicinity of the bait site to avoid theft or vandalism of equipment, and to avoid disturbance of deer. During a 7-day pre-baiting period, whole kernel corn was placed at each bait site in a quantity sufficient to maintain consistent access by deer 24 hours per day. Following this acclimatization period, an infrared camera was installed in a stationary position and was set to record still photographs of deer 24 hours a day during a 14-day survey period. As in the pre-baiting period, whole kernel corn was provided ad libitum. The infrared cameras were triggered to photograph by movement and/or changes in heat within a sensing cone, which was 50-feet long and 30-feet wide at the placement of the bait station.

A WS wildlife biologist analyzed photographs from each camera to ascertain the number of deer by age and gender. Photographs selected for analysis were taken $\geq$10 minutes apart during the 14-day survey period. When possible, adult bucks were identified separately by their antler and physical characteristics. To establish an estimator of deer abundance the following analyses were conducted. The number of bucks uniquely identified was divided by the total number of bucks photographed to calculate a population factor. Jacobson et al. (1997) established extrapolation factors for baited cameras set to service particular land areas during differing survey lengths. The extrapolation factor adjusts the estimator to account for the percentage of the total deer population likely to be photographed at the bait site during the survey. Over the 14-day period surveyed in this study, the extrapolation factor used assumed that 90 percent of the total deer population in the area of the bait sites was photographed. The estimate of the total number of bucks was calculated by multiplying the total number of bucks times the extrapolation factor. The total number of does was calculated by multiplying the number of does counted in the photographs times the population factor, and times the extrapolation factor. The total number of fawns was calculated by multiplying the number of fawns counted in the photographs times the population factor, and times the extrapolation factor. The total deer abundance in the area of each bait site was calculated by adding the total number of bucks, the total number of does, and the total number of fawns.

Figure 7. Photograph of two uniquely antlered bucks captured by an infrared-triggered camera during surveys conducted by USDA APHIS WS to estimate white-tailed deer abundance on JHNWR located in Philadelphia and Delaware Counties, Pennsylvania during December of 2008, 2009, and 2010.

Figure 8. Night-time photograph of one adult doe, one yearling doe, and one fawn captured by an infrared-triggered camera during surveys conducted by USDA APHIS WS to estimate white-tailed deer abundance on JHNWR located in Philadelphia and Delaware Counties, Pennsylvania during December of 2008, 2009, and 2010.

Figure 9. Locations of infrared cameras used by USDA APHIS WS to estimate white-tailed deer abundance on JHNWR located in Philadelphia and Delaware Counties, Pennsylvania during December 2008, 2009, and 2010. The location of Camera 1 was changed for 2010 from the location used during 2008 and 2009 to minimize disturbance to an active American bald eagle nest.



The amount of area serviced by each baited infrared camera was analyzed relative to the useable habitat available to deer. This information will be useful to track the number of acres of useable habitat available to deer relative to data from baited infrared camera surveys over time in response to possible management actions. Jacobson et al. (1997) reported that the survey technique was most reliable when cameras were placed at ≤200 acres per camera. Home ranges of female white-tailed deer may vary in different habitats, latitudes, and deer population densities. However, data from previous studies suggested that home ranges for female white-tailed deer in suburban habitats range between approximately 50 to 1,974 acres with most averaging less than 640 acres (1 square mile). At Valley Forge National Historical Park, 18 miles northwest of JHNWR, home ranges for female white-tailed deer averaged 235 acres (Lovallo and Tzilkowski 2003). In general, the home ranges of adult males are twice that of adult females. Likewise, individual deer establish home ranges that are not symmetrical, predictable, or necessarily similar in shape to other deer in the area. Therefore, it is unknown exactly the amount of area serviced by an infrared camera station in different localized areas and habitat types.

Previous research which examined deer movements relative to bait sites determined that deer generally do not leave established home ranges to utilize bait sites (Kilpatrick and Stober 2002), but may shift their centers of activity to be nearer to bait sites. In West Virginia, deer were observed leaving seasonal home ranges to access bait sites, however, these movements were less than 110 yards from their estimated home ranges (Campbell et al. 2006). In the same study, Campbell et al. (2006) found that the maximum average distance deer would travel from the center of their core area to a bait site was 530 yards. A 200-acre circle has a radius of 555.1 yards. Therefore, with the reported limitations of the infrared baited camera survey technique ($\leq$200 acres per camera) and previous findings on the movement behavior of deer relative to bait sites, it was assumed that a circle of 200 acres in area would encompass most deer activity in the area of each camera station. Within a 200-acre circle centered on the bait station for each camera, WS calculated the amount of habitat useable by deer from the habitat characterization portion of this study, accounting for overlap by circles of adjacent camera stations. This would approximate the amount of area of useable deer habitat serviced by each camera.

Deer Herd Health Check

Possible future deer population management actions could result in venison being utilized by sport-hunters or donated to charitable food distribution networks. Since heavy metal contaminants exist on the refuge from past industrial activity and waste soil deposition, contaminants in the venison of deer on the Refuge was a concern. Therefore, WS conducted an experimental removal of three adult female deer to assess potential contamination of venison and to evaluate the current health of the deer herd on the Refuge.

Deer Removal.– WS conducted operations under the Pennsylvania Game Commission (PGC) Special Use Permit (No. 53-2010) issued directly to JHNWR. WS conducted deer removal activities based upon a standard protocol used by WS in urban environments. All deer were removed from a mobile unit. The mobile unit consisted of two WS personnel and one U.S. Fish and Wildlife Service (Service) law enforcement officer. Additional JHNWR staff provided security and logistical support. WS utilized a hand-held infrared camera to locate and observe deer in darkness. These capabilities also further enhanced WS' ability to ensure safe removal operations by detecting people, non-target animals, ricochet hazards, and buildings. Shots were taken using spotlights with red-filtered lights. Shooting was conducted by one WS wildlife control specialist using a .243 caliber sound-suppressed rifle.

Adult female deer were targeted for removal. Adult females maintain established home ranges throughout their lives. Therefore, adult female deer would have the highest probability within the deer population of demonstrating contamination since they had the longest interaction with the local environment and long-term ingestion of potentially contaminated plants and soil. Further, female deer would provide information about reproduction in the herd.

Collection of Biological Data.– Ages of deer were determined by evaluating tooth eruption and wear. Ages were recorded to the nearest half year. Live weight was taken before deer were eviscerated using a suspended spring scale. Chest girth was measured immediately posterior to the front legs. Uteri of female deer were inspected for the presence of fetuses, and fetuses were removed, sexed and aged in estimated days to birth using a fetal aging scale.

Analysis of the deposition and retention of fat reserves in deer gives an indication of their health and nutrition, especially their preparedness to survive winter. WS selected two fat indices commonly used as physiological gauges of health: 1) Kidney Fat Index, and 2) Tail Fat Score. As deer accumulate surplus nutrition, fat reserves are deposited first within the bone marrow, next around the internal organs (e.g., around the kidneys), then along the inside of the body cavity and finally between the muscle and skin (e.g., along the tail).

Fat reserves are used by the body opposite the order of deposition when food resources are limited. Therefore, in years of low or poor food availability, fat will not be deposited throughout the body. Likewise, in difficult winter conditions deer will expend fat quickly starting with subcutaneous fat. Tail Fat Score is an appropriate, rudimentary measure to assess deer health. Tail Fat was scored by palpation at the base of the tail on a scale from 0 to 3. A score of 0 represented no fat under the skin with the bones of the tail readily felt. A score of 3 represented ample fat reserves so that no muscle or bone was readily felt because they were padded with fat. To obtain Kidney Fat Index, one kidney was selected randomly from each deer and removed whole with fat attached. Kidney fat index was determined by dividing the mass of the fat surrounding the kidney by the mass of the bare kidney and the dividend was multiplied by 100.

Contaminants Testing.–Samples of liver and muscle tissue were collected by WS for toxicological screening for concentrations of minerals. Tissue samples were submitted fresh and unfrozen to the Pennsylvania Animal Diagnostic Laboratory at New Bolton Center (Kennett Square, PA) for screening for a panel of common trace mineral elements. Levels of trace mineral elements were reported as parts per million (ppm) wet weight and were compared to normal ranges reported in previous literature.

Other Related Indices

WS contacted the Police and Road Departments of municipalities surrounding JHNWR and requested data on deer-vehicle collision rates for years 2004 to 2009. WS also requested data on deer-vehicle collisions for the same years from the Pennsylvania Department of Transportation for State-controlled roads in the area of JHNWR. The Pennsylvania Game Commission maintains subcontractors to pick up deer carcasses along State-owned roads, and WS contacted the Pennsylvania Game Commission Southeast Regional Office to request data reported by subcontractors in the area of JHNWR. WS contacted the Health Departments of Delaware and Philadelphia Counties and requested data on Lyme Disease infection rates.

SECTION 4: RESULTS, DISCUSSION and RECOMMENDATIONS

Habitat Analyses

Characterization of Deer Habitat.–Previous analysis of habitat on JHNWR estimated that approximately 334 acres of habitat were suitable for deer. While upland areas may be used most by deer throughout the annual cycle, wetlands are critically important to deer on JHNWR for hiding cover, as fawning sites in areas that are not inundated, and for forage. With the extreme daily use of JHNWR by humans, many with dogs, deer rely on wetland areas regularly for hiding to minimize stress and physical exertion. WS commonly observed deer on Refuge roads and trails during roving surveys, which fled into wetland areas to avoid the passing survey vehicle.

Illustrating the importance of wetlands as refuges to deer was the difference in the timing of visitation by deer at Cameras 1 and 2 during 2008. Camera 1 was situated on a small island of hardwood trees with little understory vegetation. The island was separated from the mainland by wetlands of varying degrees of water inundation, and access was closed to the public. Camera 2 was in a relatively large, open stand of hardwood trees that received regular use by visitors of the Refuge. At Camera 1 during 2008, 100 percent of photographs of deer were recorded during daylight or crepuscular periods, whereas only 19 percent of photographs were recorded in daylight at the fully upland site of Camera 2. Presumably, restricted access by the public and the dense wetland cover afforded in the area of Camera 1 allowed deer to maintain regular use of the area throughout the day.

The home ranges of some unknown proportion of deer utilizing JHNWR overlap the boundary of the Refuge and adjacent private lands. WS considered habitat outside of the boundaries of JHNWR because these areas provide additional resources to sustain a greater deer population size than the habitat on the Refuge would provide alone. It should be noted that nearly 70 percent of available habitat for deer in the localized area lies on private lands adjacent to the Refuge. Some hunting occurs legally on adjacent lands, however the annual rate of harvest of deer is unknown.

Approximately 1.6-square miles of deer habitat was classified as good within the Refuge and the one half-mile buffer (Figures 10 and 11). However, in the context of habitat quality throughout the range of white-tailed deer, virtually none of these lands would be considered ideal deer habitat. Juxtaposition to human development, isolation of habitat patches, plant species composition not preferred by deer for forage, and degradation of forest understory due to overbrowsing by deer are several factors limiting the suitability of the habitat for deer. However, from a landscape perspective, JHNWR and the surrounding area provides some of the only habitat for deer in the immediate area of metropolitan Philadelphia.

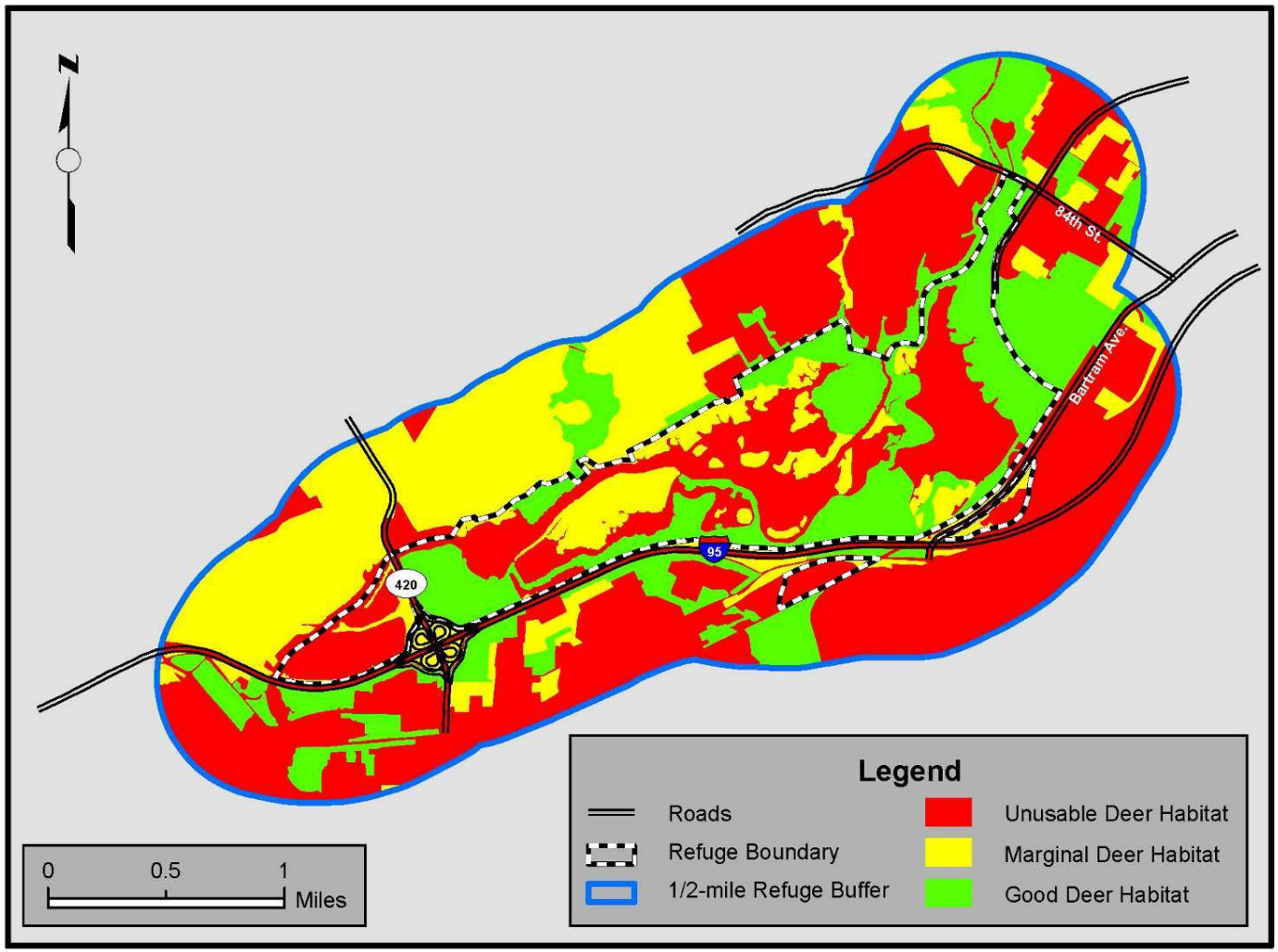
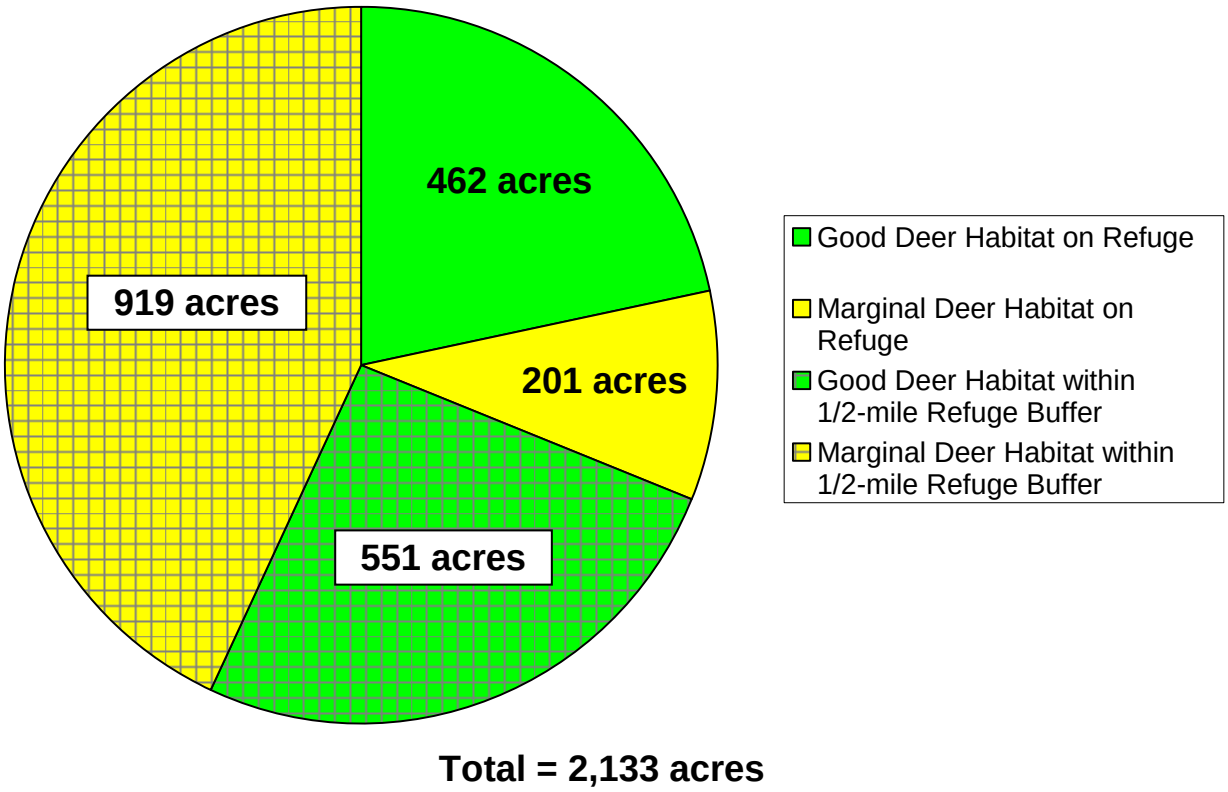


Figure 10. Characterization of available habitat for white-tailed deer on JHNWR located in Philadelphia and Delaware Counties, Pennsylvania and within a half-mile buffer around the boundary of the Refuge. Habitat analyses were conducted by USDA APHIS WS as part of a study examining the ecology of white-tailed deer on the Refuge.

Figure 11. Amount of available habitat for white-tailed deer on JHNWR located in Philadelphia and Delaware Counties, Pennsylvania and within a 1/2-mile buffer around the boundary of the Refuge. Habitat analyses were conducted by USDA APHIS WS as part of a study examining the ecology of white-tailed deer on the Refuge.



Forest Regeneration Surveys.–Forest regeneration surveys were initiated in the early growing season of May 2009. Between 29 May and 16 June 2009, forest regeneration plots were established. Canopy trees within each plot were classified for each plot (Appendix C). After initial surveys were completed, fencing was installed on subplots slated for fenced treatments and the fencing was closed. Late growing season surveys were conducted between 20 to 24 August 2009. Fenced subplots were opened for survey and then closed again to exclude deer. During 2010, early growing season surveys were conducted between 27 to 28 May 2010. Plot 4 was not accessed during the early growing season surveys for 2010 to minimize disturbance to an active American bald eagle nest on the island. Late growing season surveys were conducted on 18 to 19 August 2010.

Prominent browse lines were evident in all forested areas of JHNWR throughout this study as evidenced by lack of understory vegetation, especially woody seedlings, and aerial coverage of the forest floor (Figures 12, 13, 14, Appendices D through K.2). Most soil was either bare of vegetation or dominated by invasive exotic herbaceous plants. Successful regeneration of tree seedlings was not observed to occur on JHNWR during initial forest regeneration surveys conducted by WS in 2009. During the early growing season forest regeneration surveys of 2009, only 2 tree seedlings were recorded, and these were on unfenced control subplots. One seedling was a red maple (*Acer rubrum*) and one was a non-native white mulberry (*Morus alba*). By the late growing season surveys, no tree seedlings were recorded.

The two seedlings recorded during the early growing season had apparently succumbed to browsing by deer and were not found. Thus, data from 2009 on tree seedling regeneration were truly baseline since any regeneration recorded in the future would represent an increase.

During 2010, a total of 15 woody seedlings were observed. Six of 15 (40 percent) were non-native invasive white mulberry. Thirteen of 15 (87 percent) of woody seedlings were observed on fenced plots after installation of fencing. Nine of 15 (60 percent) of woody seedlings were native trees or shrubs, and 9 of 9 (100 percent) native woody seedlings were found on fenced plots after installation of fencing. The native woody seedlings included red maple (*Acer rubrum*), alternate-leaf dogwood (*Cornus alternifolia*), flowering dogwood (*Cornus florida*), sweetgum (*Liquidambar styraciflua*), and *Crataegus spp.*

Apparently, fencing to exclude browsing by white-tailed deer on JHNWR is the only reliable treatment that enables growth of woody seedlings currently. The majority of seedlings observed in fenced plots were native, which suggests that native seedlings may outcompete non-native species (i.e., white mulberry), and deer preferentially browse native species outside of exclosures. At current deer densities, it appears that regeneration of native trees and shrubs is not possible without excluding deer.

Upland habitat provided little preferred forage for deer and hiding cover was limited to low-growing exotic plants. Indices of vertical and aerial plant cover mainly describe coverage by invasive exotic species. Their domination of sunlight, soil nutrients, and space is exacerbated by nearly complete browsing of native herbaceous species by deer. Across surveys in 2009 and 2010 and fenced and unfenced subplots, 64 percent (SE = 6.0) of dominant plants were non-native.

It appears that a stable state of undesirable exotic plants in the forest understory may have been perpetuated by long-term overbrowsing by deer (Stromayer and Warren 1997). Although a reduction in deer densities and associated browsing pressure would stimulate plant growth, correction of this single factor is unlikely to result in production of a forest of desired structure and composition. Other confounding factors included closed overstory canopies in most woodlots restricting light infiltration, a seedbank replete with invasive exotic annual and perennial plants, and poor soil structure with inorganic foreign materials due to prior land uses and soils transported from outside development activities.

Multiple silvicultural treatments will be required to replace existing forest conditions with those more conducive to wildlife. Non-native trees dominating the forest overstory, such as gray poplar, paulownia, and white mulberry should be eliminated to change the composition of the forest to include more native tree species and to stimulate growth of the understory. Treatment of the understory by mechanical means, herbicide, or fire may be required to reduce the abundance of exotic weeds and competition for tree seedlings. If deer densities are reduced, planted seedlings and natural regeneration should still be protected from browsing by temporary exclosures since natural forage for remaining deer may continue to be limited for some time.

At minimum, the forest regeneration plots established for this study should be maintained to gauge the potential for establishment of forest regeneration when browsing by deer is suppressed. Forest regeneration will be deemed within acceptable limits when the number and viability of individuals of desired plant species in unfenced plots is at least 50 percent of those in fenced plots.

Figure 12. Average percent vertical plant cover in unfenced control vegetation subplots during the early and late growing seasons of 2009 and 2010 JHNWR, Philadelphia and Delaware Counties, Pennsylvania. Data on forest regeneration were collected by USDA APHIS WS as part of a study examining white-tailed deer ecology on the Refuge.

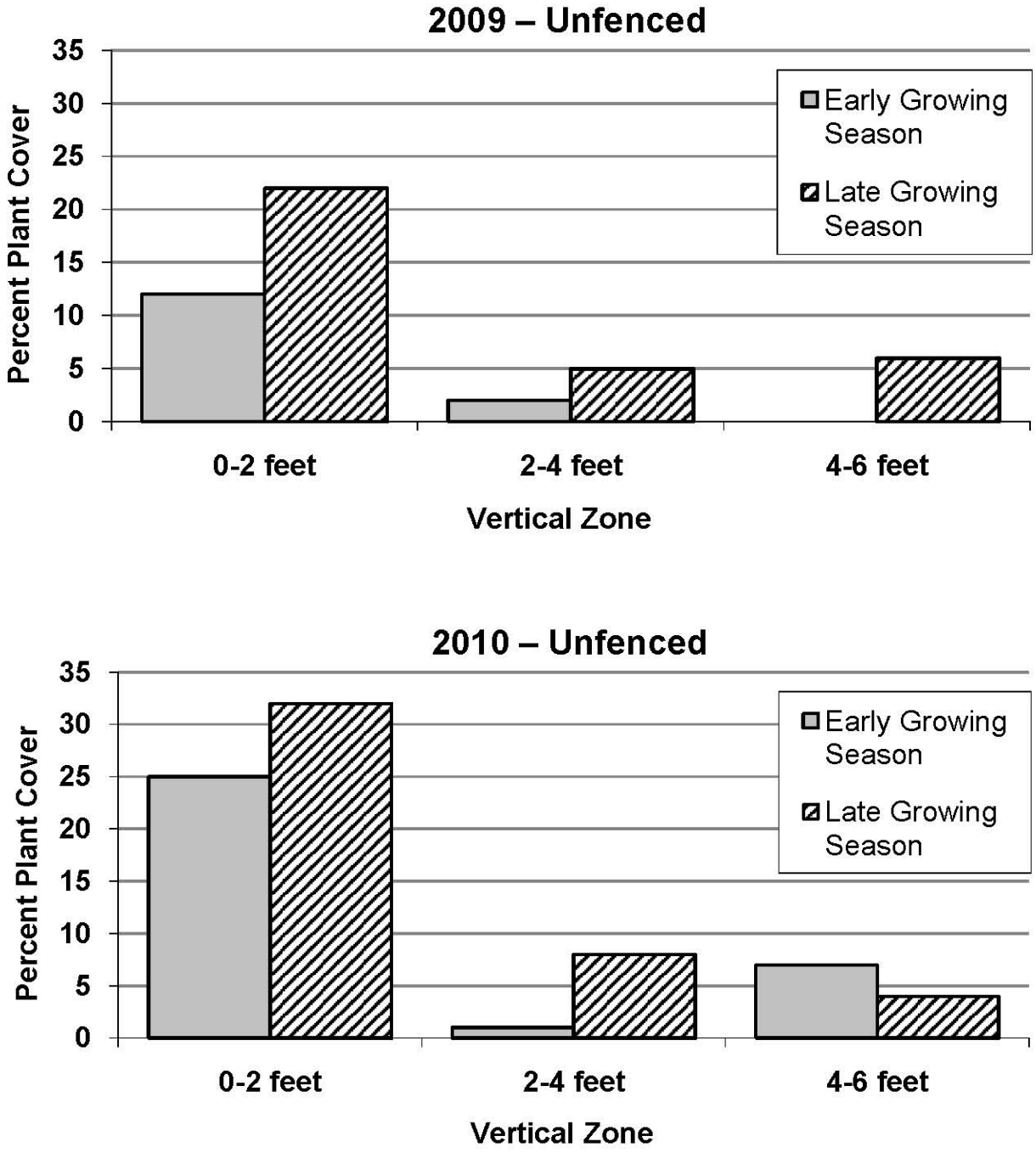
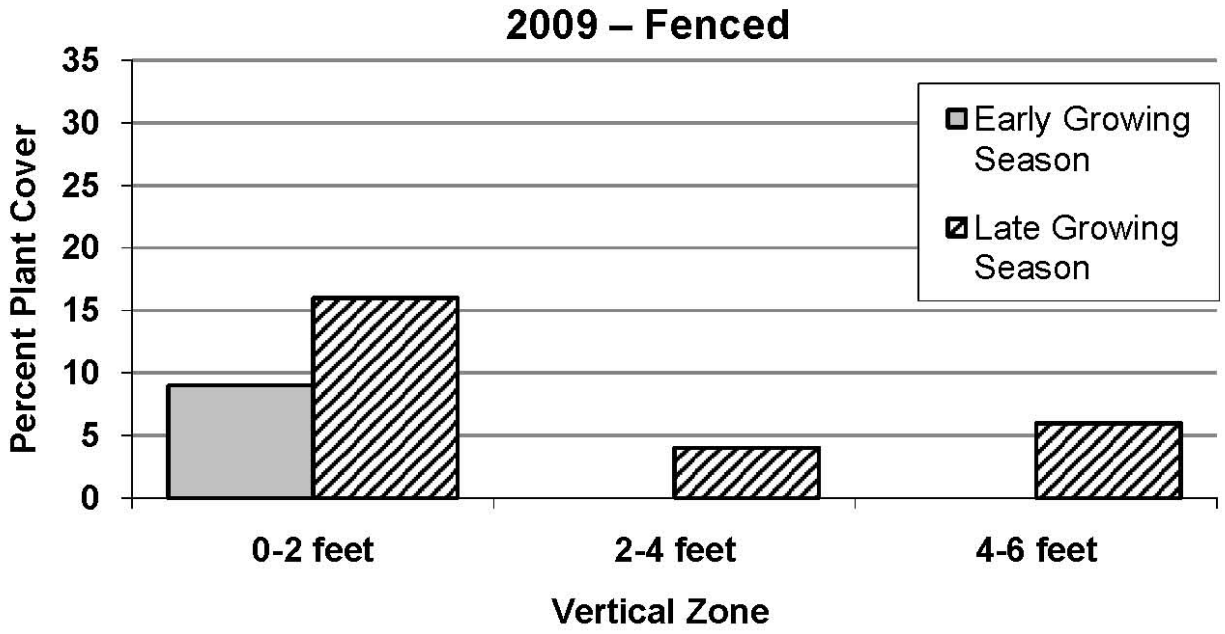


Figure 13. Average percent vertical plant cover in vegetation subplots fenced to exclude browsing by white-tailed deer during the early and late growing seasons of 2009 and 2010 on JHNWR, Philadelphia and Delaware Counties, Pennsylvania. Fencing was installed after data were collected for the early growing season in 2009. Data on forest regeneration were collected by USDA APHIS WS as part of a study examining white-tailed deer ecology on the Refuge.



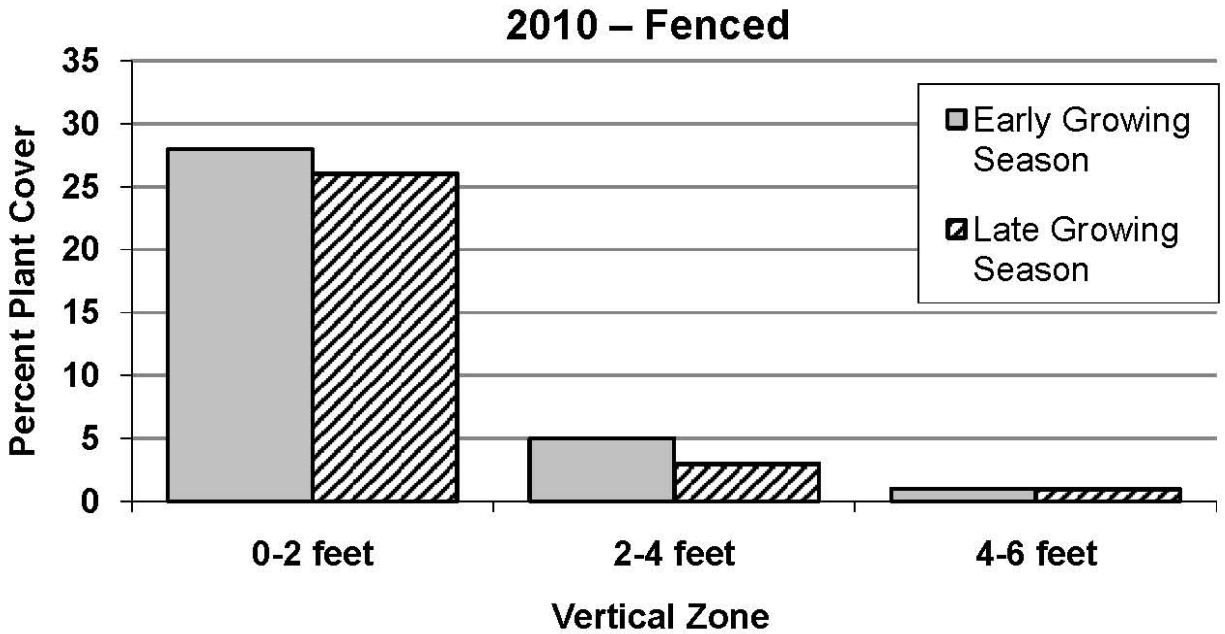
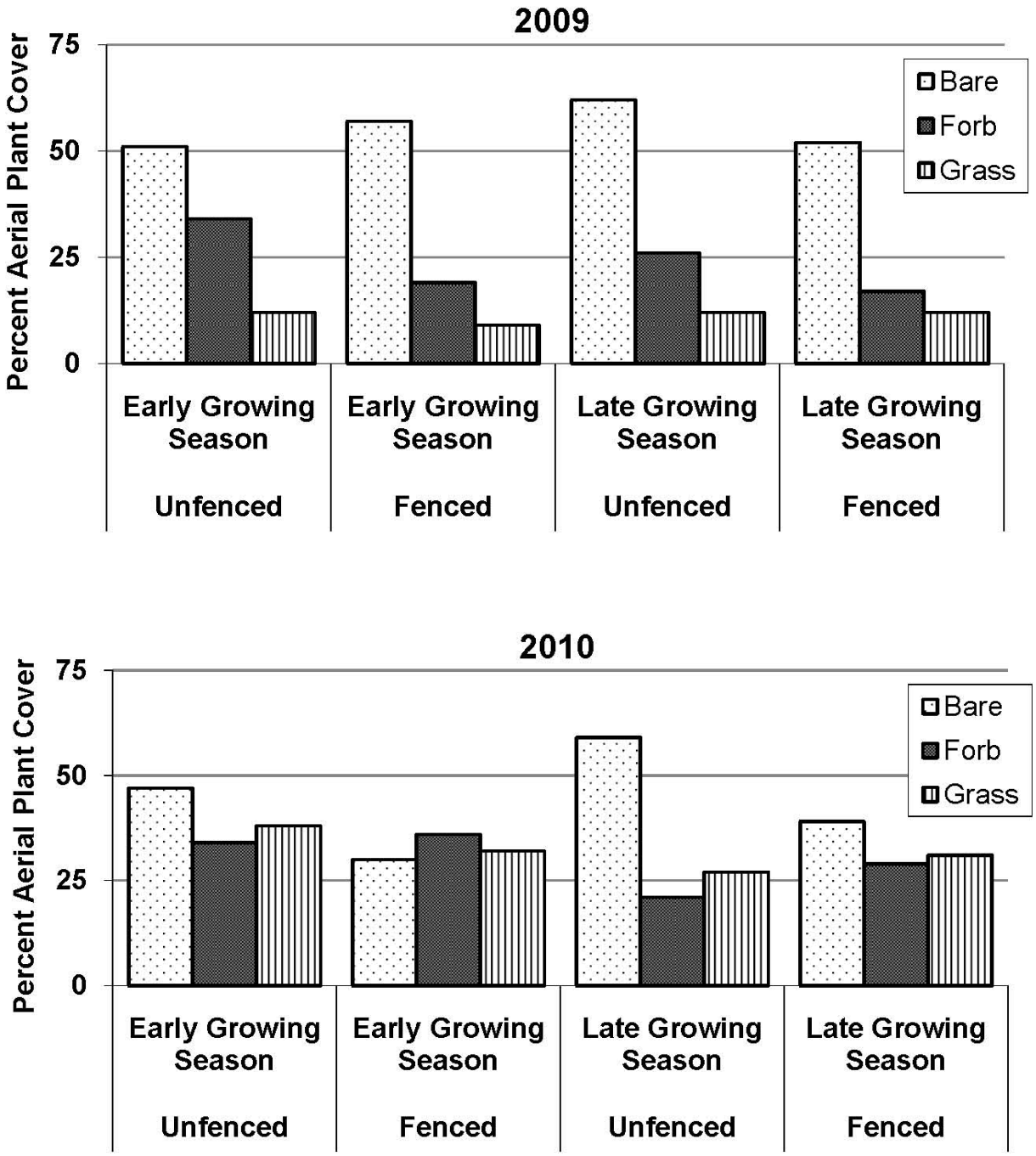


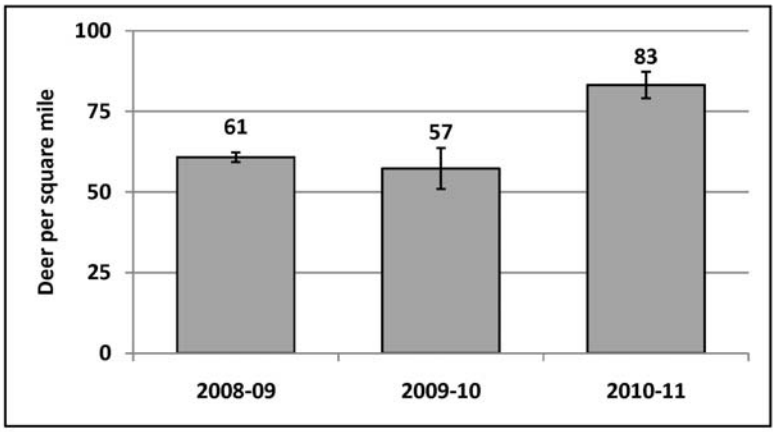
Figure 14. Average percent aerial plant cover in unfenced subplots and fenced subplots to exclude browsing by white-tailed deer during the early and late growing seasons of 2009 and 2010 on JHNWR, Philadelphia and Delaware Counties, Pennsylvania. Fencing was installed after data were collected for the early growing season of 2009. Data on forest regeneration were collected by USDA APHIS WS as part of a study examining white-tailed deer ecology on the Refuge.



Deer Density Surveys

Roving Surveys.–Eighteen separate roving infrared surveys were conducted from November 2008 through January 2011 along the standardized survey route to obtain an average estimate of the over-winter deer density on JHNWR (Figure 15, 16, Appendix L). Characterization of deer habitat on JHNWR and within the one-half mile buffer of the refuge boundary indicated that approximately 2,133 acres (3.3 square miles) of habitat are available to deer. Standard deer density estimators assume that habitat along the survey route is contiguous (i.e., no true barriers) allowing deer accessibility to a 1-square mile area per 1-mile length of survey route. Along the roving survey route on JHNWR only 17.8 percent of habitat was available to deer. The deer density estimator was adjusted accordingly to estimate deer abundance relative to potentially usable habitat for deer. From 2008 to 2011, deer abundance on JHNWR appeared to increase by ≥30 percent based on roving surveys. The average deer density estimate for JHNWR based on roving surveys was 61 (SE = 1.5) deer per square mile during fall/winter 2008 to 2009, 57 (SE = 6.3) deer per square mile during fall/winter 2009 to 2010, and 83 (4.2) deer per square mile during fall/winter 2010-11.

Figure 15. Annual average deer density estimates for 18 white-tailed deer density surveys (2 per month, 6 total per year) completed by USDA APHIS WS on JHNWR located in Philadelphia and Delaware Counties, Pennsylvania during November 2008 to January 2009, November 2009 to January 2010, and November 2010 to January 2011.



The data from roving surveys during 2010 to 2011 indicated with 95 percent statistical confidence that deer densities on JHNWR and the surrounding area were between 75 deer per square mile and 91 deer per square mile prior to recruitment of young deer into the population during 2011. Given an average of 83 deer per square mile on JHNWR and 3.3 square miles of available habitat in the local area, these results would suggest that approximately 274 deer utilize JHNWR and adjoining areas.

Deer observations were evenly distributed across the roving survey zones (Figure 17). The highest density of deer was observed in survey zone 5 during each of the three years of the study. This was likely due to the relatively greater amount of useable deer habitat in this area and improved accessibility for roving survey. Several blocks of useable habitat known to hold deer were not accessible for roving survey including the peninsula west of survey zone 3, and the

woodlot north of survey zone 7. In part for this reason, these areas were targeted during the baited infrared camera surveys.

While not statistically different ($\chi_4^2 = 3.06$, P = 0.548), surveys during December consistently produced deer density estimates, which were less than those during November and January within the same survey season. Deer density estimates during November and January within a survey year did not differ. Therefore, December should be avoided for future surveys that will be used to make management decisions. This difference may be attributed to reduced deer activity after peak breeding season or another unknown factor. Deer may have been drawn away from the roving survey route by bait stations used simultaneously for infrared camera surveys in this study. To avoid possible interactions between baiting for infrared camera surveys and the availability of deer for observation during roving surveys, the two survey techniques should not be conducted simultaneously in the future.

Figure 16. Monthly average deer density estimates for 18 white-tailed deer density surveys (2 per month, 6 total per year) completed by USDA APHIS WS on JHNWR located in Philadelphia and Delaware Counties, Pennsylvania during November 2008 to January 2009, November 2009 to January 2010, and November 2010 to January 2011.

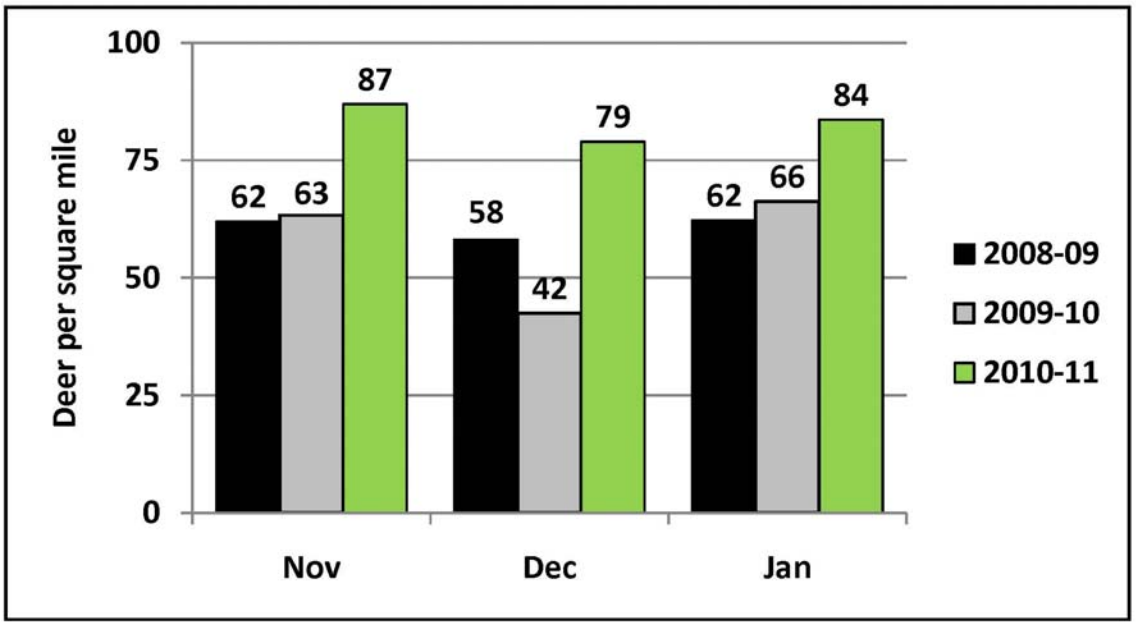
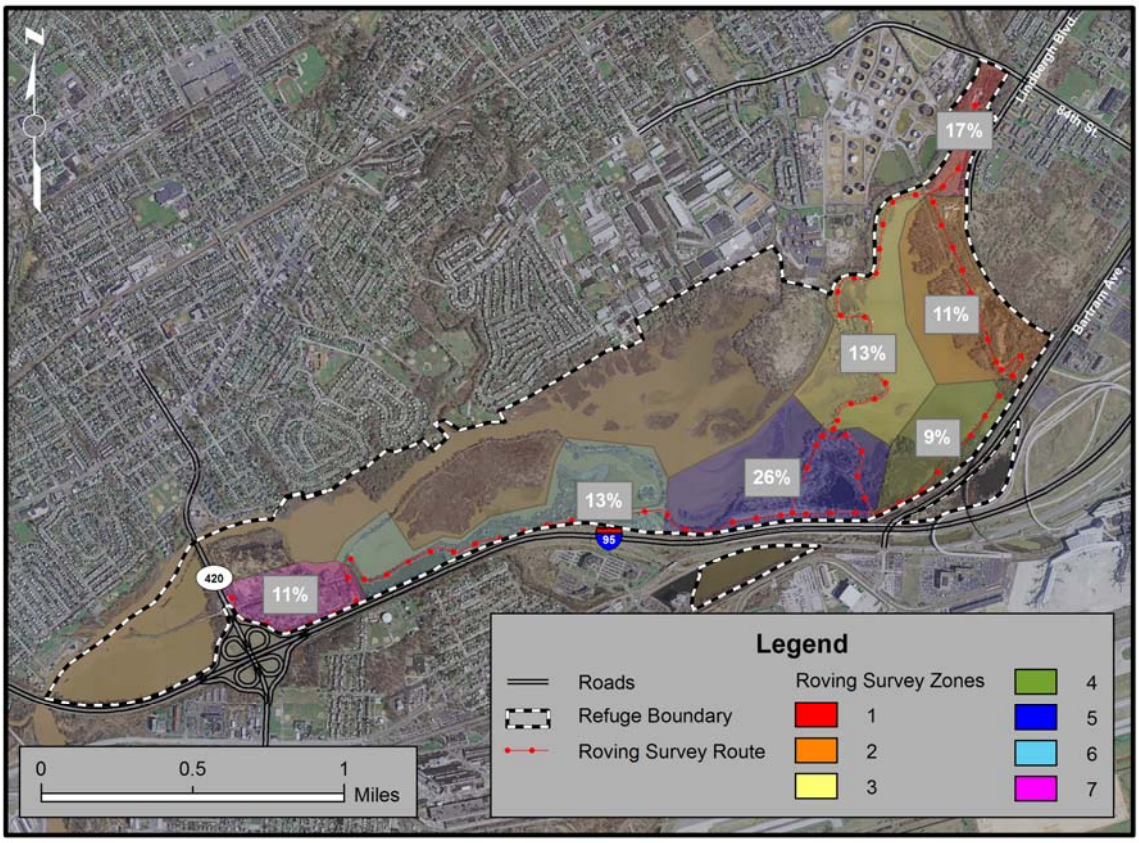


Figure 17. Proportion of total number of deer observed per survey zone during 18 white-tailed deer density surveys completed by USDA APHIS WS on during November 2008 through January 2011.



Baited Surveys.–Baited infrared camera surveys were confined to the month of December during 2008, 2009, and 2010. The pre-baiting period was started in early December and included 7 days of whole kernel corn provided ad libitum. Infrared cameras were installed before day 7 of the pre-baiting period. The 14-day baited surveys concluded on or before 31 December annually. Deer acclimated well to the bait sites and were photographed throughout the day and night. A total of 5,049 photographs with deer, separated by ≥10-minute intervals, were used for analysis. Data for all 4 camera locations cameras were pooled annually (Table 2). Individual bucks were recorded as unique only once regardless of whether they were photographed on multiple cameras. Individual bucks were recorded on both cameras 3 and 4; otherwise, no single buck was recorded on two cameras.

The total number of deer estimated to use the areas surveyed by the infrared cameras were 68 deer in 2008, 84 deer in 2009, and 93 deer in 2010. These data identified an increase of 26.9 percent in deer numbers from 2008 to 2010. This is similar to the ≥30 percent increase in deer abundance estimated by the roving survey technique during the same timeframe. Subsequent use of baited surveys conducted at the same locations and during the same timeframe will provide a reliable index of trends in deer abundance over time and in response to potential management actions. However, results of these baited surveys were not directly interchangeable

with the results of roving surveys and do not approximate an exact population estimate or deer density per square mile.

The infrared camera stations were located in areas with relatively large amounts of useable deer habitat in the context of the JHNWR environment. However, due to fragmentation of useable deer habitat, data from baited infrared camera surveys on JHNWR probably do not represent broad-scale estimates of deer abundance for more contiguous tracts (Figure 18). Deer are artificially concentrated in certain areas during different times of the day or seasons of the year on JHNWR. While most deer herds undergo cycles of social concentration and segregation during reproduction and variations in food abundance, these variables are likely amplified on JHNWR due to high human activity and limited useable habitat. For example, Camera 2 was spatially isolated by water and human development, located within an approximately 66-acre block of upland habitat and was bordered on two sides by water and on the other two sides by major roadways. Therefore, the 200 acres per camera service area normally assumed for baited infrared camera surveys would not apply for Camera 2. WS quantified the amount of area serviced by each baited infrared camera relative to the useable habitat available to deer derived during the habitat characterization portion of this study. During 2008 and 2009, each camera serviced an average of 89 acres of good or marginal habitat for deer. During 2010, the location of Camera 1 was changed from the location used during 2008 and 2009 to minimize disturbance to an active American bald eagle nest. During 2010, each camera serviced an average of 93 acres of good or marginal habitat for deer. Data for number of acres per deer were quantified using these guidelines. As deer densities are reduced in possible future management actions, the amount of acreage of useable habitat per deer would be expected to increase.

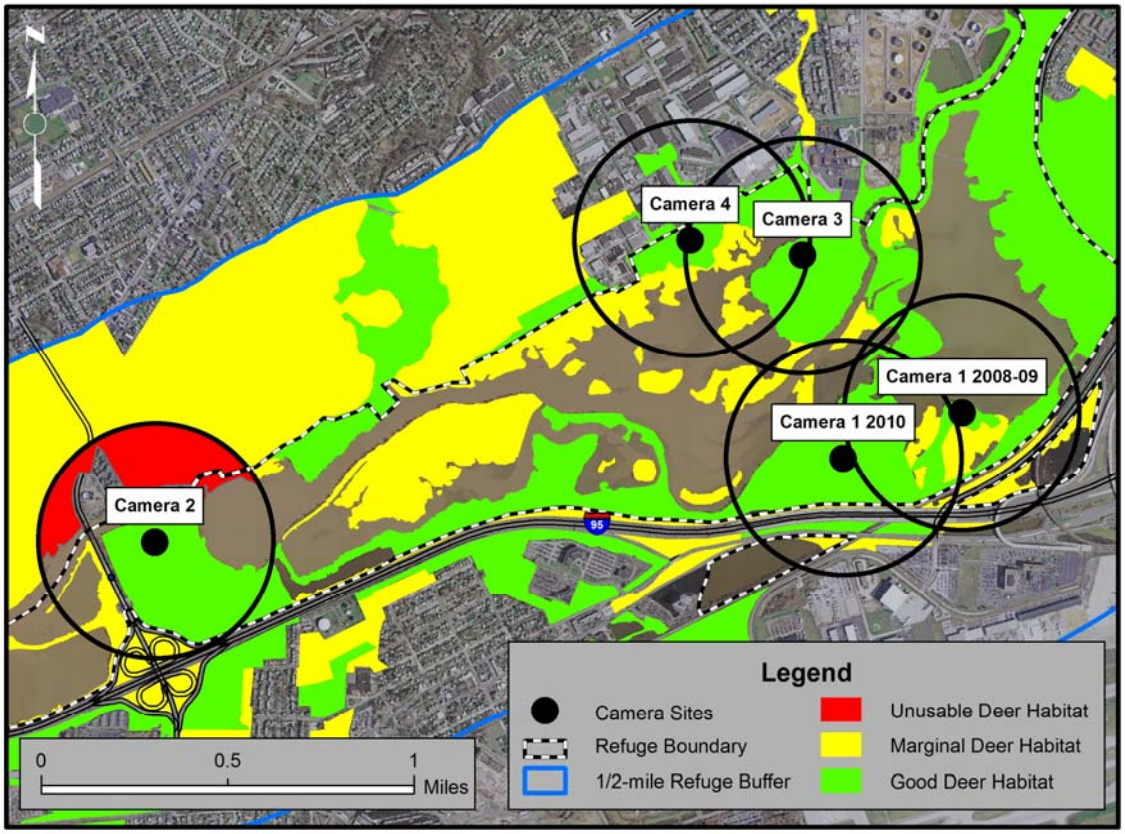
Deer Population Dynamics.–Adult doe to buck ratios observed averaged 4.7:1 (SE = 1.2) during roving surveys and 1.5:1 during baited surveys. Bucks have a tendency to dominate bait sites, and a lesser doe to buck ratio for baited surveys was expected. It appears that sport hunting has had a minimal impact on the deer population. Compared to other deer populations that are exposed to consistent hunting pressure, JHNWR has a relatively high number of adult bucks utilizing the property. Bucks are naturally pre-disposed to greater mortality than does because they range farther, are more sought after by hunters, and are more susceptible to deer-vehicle collisions when searching for mates during the fall breeding season. Many deer populations regulated by sport hunting display doe to buck ratios in excess of 10:1. Still, bringing the balance of does to bucks on JHNWR nearer to 1:1 would provide benefits. When males are in sufficient abundance to breed the available females during their first estrous cycle for the year, the length of the breeding season is reduced. A shorter breeding season decreases physiological stress on individual deer making them less susceptible to disease and starvation. Also, deer are required to travel less in search of mates, which may minimize the incidence of deer-vehicle collisions common during breeding season.

Table 2. Estimates of deer abundance via baited infrared camera surveys conducted by USDA APHIS WS on JHNWR, Philadelphia and Delaware Counties, Pennsylvania during December of 2008, 2009, and 2010.

	2008	2009	2010
Estimated total no. deer	68	84	93
Estimated no. bucks	24	23	26
Estimated no. does	36	40	36
Estimated no. fawns	8	21	31
Acres per deer	5.2	4.2	3.9
Acres surveyed	356	356	372

[a] The location of camera 1 was changed for 2010 from the location used during 2008 and 2009 to minimize disturbance to an active American bald eagle nest.

Figure 18. Characterization of available habitat for white-tailed deer during baited infrared camera surveys conducted by USDA APHIS WS on JHNWR, Philadelphia and Delaware Counties, Pennsylvania during December of 2008, 2009, and 2010. The amount of area serviced by each baited infrared camera was analyzed relative to the useable habitat available to deer (yellow and green shaded areas) in a 200-acre circle centered on the baited infrared camera site. The red shading within the circle for Camera 2 indicates habitat that would be useable to deer, but was inaccessible to deer from the area of Camera 2. The location of Camera 1 was changed for 2010 from the location used during 2008 and 2009 to minimize disturbance to an active American bald eagle nest.



Fawns tend to be under-represented in baited surveys since they are socially subordinate to adult does and bucks and their presence on bait sites is suppressed. The average fawn to doe ratio was 1.17:1 (SE = 0.2) for roving surveys and 0.54:1 (SE = 0.2) during baited surveys. The likelihood of observing the different age and sex classes of deer during roving surveys is assumed to be directly related to their proportion in the population. Therefore, it appears that greater than one fawn per doe is being recruited into the population annually. Given that at least one-third of the deer population is composed of adult females, the population has the potential to grow at a rate of greater than 33 percent per year. This is consistent with previous studies of deer population growth (McDonald et al. 2006).

The deer densities derived during this study may be considered a conservative estimate of deer abundance on JHNWR since over 2 months of sport hunting for deer had occurred outside of the refuge boundary by the beginning of the surveys and the majority of deer-vehicle collisions had already occurred for the annual population cycle. Despite this, deer density

estimates for JHNWR during this study were a minimum of six times greater than recommendations by WS for minimization of deer-human conflicts in suburban habitats (10 deer per square mile). Likewise, the density of deer observed on JHNWR was high relative to deer densities recommended for maintaining plant diversity in forested areas (6 deer per square mile, Alverson et al. 1988).

Deer Herd Health Check

Biological Indices.–Deer collection for the herd health check was conducted on 22 December 2010 between 20:45 and 22:00 hours. There was no disturbance or safety risk to the public. Deer were removed whole from the environment and taken to a central processing facility for examination. Following examination, the eviscerated deer carcasses were donated to a local needy family as per the direction of the district wildlife conservation officer.

Three adult females were collected on JHNWR (Table 3). Each deer was in fair physical condition with no evidence of disease. Deer 1 had signs of trauma from a past accident. The right rear leg was healed with obvious calcification. The injury appeared to cause no affliction to the deer. With live body weights $\geq$120 pounds, all three deer were normal in size for adult females relative to other deer herds observed by WS in the urban Philadelphia region (D'Angelo, unpublished data). Likewise, the relationship between chest girth and live body weight for deer collected on JHNWR was similar a scale developed by the Pennsylvania State University Department of Dairy and Animal Science and The Pennsylvania Game Commission for deer across Pennsylvania. (http://www.portal.state.pa.us/portal/server.pt/community/deer/11949) (Figure 19). This suggests that deer on JHNWR were in physical condition similar to those used to develop this scale.

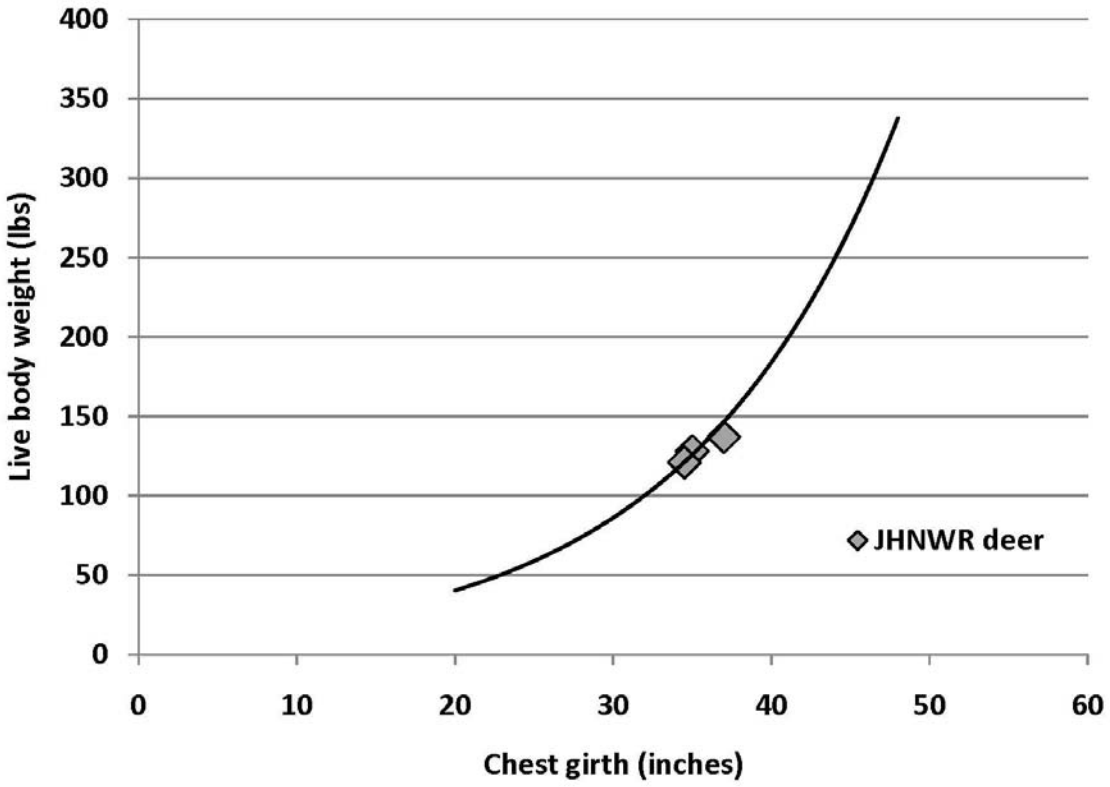
Because fat is deposited internally first, low to moderate Tail Fat Scores (1 to 2) suggested that these individuals were able to build enough internal fat reserves to also achieve supplemental fat subcutaneously. Since subcutaneous fat was not utilized by the time of collection in late-December, food resources were not extremely limited on JHNWR despite relatively high deer densities. Kidney Fat Indices $\geq$30 percent of the weight of the kidney corroborate that deer on JHNWR obtained sufficient food during fall to generate good fat reserves. In very poor habitats with high deer densities and limited forage, some deer may not produce a full complement of body fat because of caloric demands for physical maintenance and reproduction. However, in excellent habitats with deer herds in balance with the ecosystem, kidney fat reserves may be $\geq$3 times those observed on JHNWR.

Reproduction in the female deer collected on JHNWR was less than expected for deer in southeastern Pennsylvania. Most adult does produce twins. However, only one doe in this sample conceived twins, one conceived a single fawn, and the third doe was not yet pregnant. While later in the breeding season, the third doe may have conceived in a subsequent estrous cycle if she was not collected. The estimated dates of conception and parturition for the two does carrying fetuses were typical of deer in this region.

Table 3. Indices of physical condition for three adult female white-tailed deer collected for a herd health check by USDA APHIS WS on 22 December 2010 as part of a study examining the ecology of white-tailed deer on JHNWR, Philadelphia and Delaware Counties, Pennsylvania.

Variable	Deer 1	Deer 2	Deer 3
Sex	Female	Female	Female
Age (years)	4.5	5.5	5.5
Live weight (lbs.)	121	128	137
Chest girth (inches)	34.5	35.0	37.0
Kidney fat index	30.8	63.2	61.9
Tail fat index	1	1	2
No. of fetuses	1	2	0
Estimated date of conception	01 November	29 October	—
Estimated date of parturition	29 May	26 May	—

Figure 19. Relationship between chest girth and body weight of white-tailed deer from across Pennsylvania observed by the Pennsylvania State University Department of Dairy and Animal Science and The Pennsylvania Game Commission (black trend line) as compared to the relationship between chest girth and body weight for three adult female white-tailed deer (silver diamonds) collected by USDA APHIS WS on 22 December 2010 as part of a study examining the ecology of white-tailed deer on JHNWR, Philadelphia and Delaware Counties, Pennsylvania.



Contaminants Testing.–Mineral concentrations in the deer collected on JHNWR were within or near the limits of ranges known to be normal for white-tailed deer for most elements in liver tissues (Table 4). While normal trace element levels for muscle tissue in white-tailed deer have not been established, concentrations of most elements would be expected to be less in muscle versus liver tissue because the liver functions to filter the blood coming from the digestive tract and thus collects more minerals. Most notably from this sample, levels of lead were negligible in the liver and muscle of all three deer examined. Deer 1 had a level of iron in the liver tissue that was slightly higher than the normal range, however the concentration of iron in the muscle tissue was normal. Based on this sample of adult female white-tailed deer collected on JHNWR, there appeared to be no concerns for human consumption of venison from this herd. Although contamination of venison is unlikely, to minimize risk of toxins, people should avoid consuming internal organs (i.e., liver) of deer harvested on JHNWR.

Table 4. Concentrations of trace elements contained in liver and muscle tissues of white-tailed deer collected for a herd health check by USDA APHIS WS on 22 December 2010 on JHNWR, Philadelphia and Delaware Counties, Pennsylvania. Asterisks indicate values outside of known normal ranges for individual elements.

Mineral	Sample	Normal range (ppm)[a]	Deer 1 (ppm)	Deer 2 (ppm)	Deer 3 (ppm)
Arsenic	Muscle	—	<0.1	<0.1	<0.1
	Liver	<0.5	<0.1	<0.1	<0.1
Cadmium	Muscle	—	<0.03	<0.03	<0.03
	Liver	<0.001-6.5[b]	<0.03	0.21	0.13
Calcium	Muscle	—	36.2	31.0	32.1
	Liver	25-60	42.1	44.2	61.3*
Cobalt	Muscle	—	<0.03	<0.03	<0.03
	Liver	0.0-2.2[c]	<0.03	0.07	0.09
Copper	Muscle	—	1.10	1.4	2.0
	Liver	0.0-456[b]	0.68	16.9	5.2
Iron	Muscle	—	42.4	32.2	42.9
	Liver	70-300[d]	370*	122	75.1
Lead	Muscle	—	<0.1	<0.1	<0.1
	Liver	<1.0	<0.1	<0.1	<0.1
Magnesium	Muscle	—	262	283	281
	Liver	23-422[b]	183	177	145
Manganese	Muscle	—	<0.3	<0.3	1.1
	Liver	1.9-37[b]	0.30*	2.82	2.7
Molybdenum	Muscle	—	<0.03	<0.03	<0.03
	Liver	0.6-1.3[e]	0.04*	0.95	0.71
Selenium	Muscle	—	0.29	0.21	0.32
	Liver	0.2-1.1	0.57	0.98	0.71
Thallium	Muscle	—	<0.1	<0.1	<0.1
	Liver	—	<0.1	<0.1	<0.1
Zinc	Muscle	—	17.4	15.8	16.5
	Liver	30-110	32.3	44.6	33.9

[a] Unless specified, trace element levels in the normal range were reported as adequate in liver samples for adult white-tailed, black-tailed, and mule deer (ppm wet weight) by the Pennsylvania Animal Diagnostic Laboratory System. Results outside of these ranges do not necessarily indicate deficits or toxicity.

[b] Normal range of trace element levels derived from those reported as normal by Pennsylvania Animal Diagnostic Laboratory System and observed by Woolf et al. (1982) and not specified as abnormal in the publication.

[c] Normal range of trace element levels derived from those observed by Woolf et al. (1982) and not specified as abnormal in the publication.

[d] Normal range of trace element levels derived from those observed by Lewis et al. (2001) and not specified as abnormal in the publication.

[e] Normal range of trace element levels derived from those observed by Eisler (1989) and not specified as abnormal in the publication.

Other Related Indices

Deer-vehicle Collisions.–The direct effects of overabundant deer often are not reliably quantifiable. Surprisingly, in requesting data from local municipalities in the area of JHNWR, WS found that few deer-vehicle collisions were reported from 2004 to 2009 (Table 5). However, since none of the municipalities recorded information specifically identifying accidents as being related to deer, rates of deer-vehicle collisions were the impression of the respondent rather than recorded data. Since most sources did not specifically record data about deer-vehicle collisions and no reliable source of information was available for the area of JHNWR, no additional data were solicited in 2010 to 2011.

Table 5. Information about rates of deer-vehicle collisions (DVCs) in municipalities in the area of JHNWR, Philadelphia and Delaware Counties, Pennsylvania. Interviews of Police Department officials and Road Department supervisors to obtain deer-vehicle collision data were conducted by USDA APHIS WS during September 2009 as part of a study examining the ecology of white-tailed deer on the Refuge.

Municipality	Data Recording Specific to Deer-vehicle Collisions	Comments
Darby Township	No	Probably 5 to 10 DVCs annually.
Folcroft Borough	No	Probably several DVCs annually.
Norwood Borough	No	No data available.
Prospect Park Borough	No	About 2 DVCs on Rt. 420 in last 5 years.
Ridley Park Borough	No	Accident investigator felt that no DVCs occurred.
Tinicum Township	No	Few DVCs.

Additionally, few incidents of deer-vehicle collisions in the area were recorded by the Pennsylvania Game Commission and Pennsylvania Department of Transportation. The Pennsylvania Game Commission responded that generating reports on deer-vehicle collisions was problematic since they were in hard copy format from the contractor responsible for removing reported deer carcasses from State roadways. A search of records for Tinicum Township, the largest municipality sharing a border with JHNWR, yielded one deer carcass removed from a roadway during 2008.

Pennsylvania Department of Transportation maintains a detailed crash reporting system for State-controlled roadways. From 2004 to 2008, four deer-vehicle collisions were documented within one mile of JHNWR. These data from all resources polled, suggest that deer-vehicle collisions are rare in the area. Still, accidents involving deer are an important issue

causing human death, property damage, and waste of deer as a resource. During each roving survey and during day time visits to JHNWR, WS observed deer fleeing along the corridor of Interstate 95 in response to the vehicles or pedestrians on the Refuge. This presents a potentially dangerous situation on a daily basis.

Lyme Disease.–Philadelphia County requires the reporting of confirmed cases of Lyme Disease, however suspected locations of infection are not specified (Table 6). Information from Delaware County could not be obtained. Lyme Disease was consistently the number one reportable vector-borne illness and within the top 10 reportable diseases in Philadelphia County. JHNWR receives visitors from a broad geographic area, even other States and Countries. Neighbors of the Refuge may become infected near their homes or at locations where they may have traveled. Undoubtedly, people likely were infected with Lyme Disease by black-legged ticks on and near the Refuge, but tracking the rate of infection is difficult.

Table 6. Confirmed cases of Lyme Disease in Philadelphia County as reported by the Philadelphia Department of Public Health Division of Disease Control Annual Reports from 1996 to 2009. Data after 2010 were not yet available.

Year	Confirmed cases of Lyme Disease	Year	Confirmed cases of Lyme Disease
1996	225	2003	164
1997	184	2004	182
1998	179	2005	172
1999	220	2006	139
2000	165	2007	172
2001	99	2008	281
2002	179	2009	236

White-tailed deer are reservoir hosts of the adult black-legged tick and rates of Lyme Disease are prevalent where deer become overabundant. However, results of studies differ on the relationship between tick abundance and prevalence of Lyme Disease in areas with different deer densities. Rand et al. (2003) found that tick abundance increased directly with deer densities and few ticks were collected in areas with deer densities less than 18 deer per square mile. Jordan et al. (2007) found that an active deer culling operation in which 47 percent of deer were removed resulted in no apparent effect on tick abundance over three years after deer were reduced. However, deer densities in this study were still $\geq$60 deer per square mile. Also, Rand et al. (2004) found that after complete removal of deer from an offshore island tick abundance and prevalence of Lyme Disease initially increased before crashing several years after deer removal. While the exact relationship between deer densities and Lyme Disease infection rates are not clearly understood, evidence is sufficient to support justification of managing deer at lower densities to reduce the risk of Lyme Disease to the public.

Recommendations

Deer Management.–To reduce the negative effects of overabundant deer on Refuge habitats, deer densities on JHNWR should be reduced to a point where acceptable levels of damage by deer are aligned with the desire of the public to appreciate deer in a natural state and in balance with their habitat. For urban habitats such as JHNWR, deer densities less than 10 deer per square mile are appropriate. Likewise, to reduce overbrowsing by deer in forested ecosystems, densities of less than 10 deer per square mile are recommended.

Given that many of the deer utilizing JHNWR have home ranges overlapping adjacent private lands and depend on wetland areas for subsistence, deer density objectives should not be solely based on 324 acres of upland habitat under Refuge control. Rather, it should be assumed that the local deer population has access to approximately 3.3 square miles of suitable habitat as estimated by WS analyses. Therefore, with 3.3 square miles of available habitat and a deer density goal of less than 10 deer per square mile, annual post-harvest deer abundance should not exceed 33 deer at a near even sex ratio of does to bucks. Based on deer abundance data at the time of this study, prior to fawning in spring 2011, a reduction of approximately 241 deer would be required to achieve this objective. Once the desired herd condition is achieved, the deer population must be maintained through persistent annual harvest. Most deer populations require approximately 30 percent harvest annually to maintain desired deer densities. Correspondingly, fawn to doe ratios on JHNWR suggest that annual population growth may be 30 percent. After population goals are met, harvest of approximately 10 deer annually will be required on JHNWR.

Desirable conditions resulting from such lowered deer densities would likely include: 1) a healthy deer population below biological and social carrying capacities, 2) a reduction in human health and safety risks (e.g., Lyme Disease), 3) reduced damage to native vegetation, 5) improved habitat conditions for other wildlife including songbirds, reptiles, and amphibians, and 6) possible recreational opportunities for sport-hunters to help maintain desired deer population levels. Deer population densities relative to the goals of JHNWR should continue to be monitored. Deer management strategies should be adapted annually to maintain deer densities consistent with the goals of JHNWR.

The methods by which the deer population is reduced and maintained are at the discretion of JHNWR within the guidelines set forth by the Pennsylvania Game Commission. WS recommends establishment of a controlled public sport-hunting program with archery equipment as part of the management regime. Controlled sport-hunting would aid in reducing and maintaining deer densities. Given the limitations of archery equipment, space limitations for situating hunters safely across the Refuge, financial and logistical costs for the number of days hunting can occur on the Refuge, it is likely that supplemental removal of deer will be necessary to align deer numbers with objectives of the Refuge. Therefore, professional deer removal via wildlife control specialists should be utilized to reduce and maintain deer densities in areas where sport hunting cannot be conducted safely, legally, or efficiently.

Forest Management.–In anticipation of lowered deer densities and the proliferation of vegetation with reduced browse pressure, silvicultural treatments should be initiated as soon as feasible to substantially reduce non-native tree and herbaceous species. Nonnative trees should be culled, and desirable individual trees should be protected during timbering operations. Treatment of the understory by mechanical means, herbicide, or fire will be required to reduce

the abundance of exotic weeds and competition for tree seedlings. Seeding to reduce erosion or for habitat creation should utilize desired native species. Even at reduced deer densities, establishment of tree seedlings may be challenging due to limited forage. Therefore, multiple large deer exclosures (i.e., >10 acres) should be created where non-native plant species may be intensively removed and desired vegetation will be protected. At minimum, the forest regeneration plots established for this study should be maintained to gauge the potential for establishment of forest regeneration when browsing by deer is suppressed. Forest regeneration will be deemed within acceptable limits when the number and viability of individuals of desired plant species in unfenced plots is at least 50 percent of those in fenced plots.

SECTION 5: PROPOSED DEER POPULATION MANAGEMENT PROGRAM

Introduction

Based on the information collected during the study of deer ecology on JHNWR, a deer management program was developed to balance deer with the habitat for the health of deer and the ecosystem, and to reduce health and safety risks to the public. The proposed deer management program emphasizes reducing and maintaining the deer population to stimulate desired growth of native plants. It may provide a high-quality recreational opportunity to the sport-hunting public in the future.

Conformance with Statutory Authorities

Several laws and a recent executive order apply to hunting on national wildlife refuges. They are summarized below.

The National Wildlife Refuge System Administration Act of 1966.–The National Wildlife Refuge System Administration Act of 1966, as amended by the National Wildlife Refuge System Improvement Act of 1997 consolidated the various categories of lands administered by the Secretary of the Interior (Secretary) through the Service into a single Refuge System. The Act establishes a unifying mission for the Refuge System, a process for determining compatible uses of refuges, and a requirement for preparing comprehensive conservation plans. This Act states first and foremost that the mission of the Refuge System is to be focused singularly on wildlife conservation. This Act identifies six priority wildlife-depending recreation uses (hunting, fishing, wildlife observation and photography, and environmental education and interpretation), clarifies the Secretary's authority to accept donations of money for land acquisition and places restrictions on the transfer, exchange or other disposal of lands within the Refuge System. Most importantly, this Act reinforces and expands the "compatibility standard" of the Refuge Recreation Act. The Refuge Administration Act authorizes the Secretary, under such regulation as he/she may prescribe, to "permit the use of any area within the System for any purpose, including but not limited to hunting, fishing, public recreation and accommodation, and access whenever he/she determines that such uses are compatible with the major purposes for which such areas were established".

Executive Order 12996 (March 25, 1996).–This Executive Order, entitled "Management and General Public Use of the National Wildlife Refuge System," contains a directive to: "...recognize compatible wildlife-dependent recreational activities involving hunting, fishing, wildlife observation and photography, and environmental education and interpretation as priority general public uses of the Refuge System..."

National Wildlife Refuge System Centennial Act.–The Centennial Act was passed as part of Public Law 106-408 on November 21, 2000. The purpose of the legislation was to: (1) establish a commission to promote awareness by the public; (2) develop a long-term plan to meet the priority needs; (3) require an annual report on the needs of the System; and (4) improve public use programs and facilities.

Refuge Recreation Act of 1962.–This Act (16 U.S.C. 460k) authorizes the Secretary of the Interior to administer such areas for public recreation as an appropriate incidental or secondary use only to the extent that it is practicable and not inconsistent with the primary objectives for which the area was established. In addition, the Refuge Recreation Act requires that funds are available for the development, operation, and maintenance of the permitted forms of recreation.

Endangered Species Act of 1973.–The Endangered Species Act of 1973, as amended, did not specifically address the Refuge System but it does directly affect management activities within the Refuge System. The Act directed Federal agencies to take actions that would further the purposes of the Act and to ensure that actions they carry out, authorize or fund do not jeopardize endangered species or their critical habitat.

Code of Federal Regulations (CFR), Title 50.–Section 31.1 Determination of surplus wildlife populations states that the population and requirements of wildlife species on wildlife refuge areas shall be determined by population census, habitat evaluation, and other means of ecological study.

Section 31.2 Methods of surplus wildlife population control states that upon a determination that wildlife are surplus to a balanced conservation program on any wildlife refuge area, the surplus may be reduced or utilized in accordance with Federal and State law and regulation by:

(a) Donation or loan to public agencies and institutions.
(d) Official wildlife control operations.
(e) Public hunting or fishing.

Section 31.11 Donation and loan of wildlife specimens states that wildlife specimens may be donated or loaned to public institutions for specific purposes. Donations or loans of resident species of wildlife will not be made unless the recipient has secured the approval of the State.

Section 31.14 Official animal control operations states.

(a) Animal species which are surplus or detrimental to the management program of a wildlife refuge area may be taken in accordance with Federal and State laws and regulations by Federal or State personnel or by permit issued to private individuals.
(b) Animal species which are damaging or destroying Federal property within a wildlife refuge area may be taken or destroyed by Federal personnel.

Section 31.15 states that the privilege of hunting may be extended to the general public.

Section 32.1 states that the opening of a wildlife refuge area to hunting will be dependent upon the provisions of law applicable to the area and upon a determination by the Secretary of the Interior that the opening of the area to the hunting of migratory game birds, upland game, or big game will be compatible with the principles of sound wildlife management and will otherwise be in the public interest.

Section 32.2 has provisions applicable to each person engaged in public hunting on a wildlife refuge area.

Section 32.3 explains the procedure for publication of special regulations.

Deer Management Purpose

The purpose of the white-tailed deer management program is to balance the deer population on the Refuge relative to the objectives of JHNWR. It may also provide the public with an opportunity for high quality deer hunting after additional National Environmental Policy Act (NEPA) analysis and public review and comment. The deer management program will benefit habitat management objectives of the Refuge, specifically in controlling the deer population and improving stands of native vegetation capable of supporting a greater diversity of wildlife.

The National Wildlife Refuge System Improvement Act (Refuge Improvement Act) establishes as the policy of Service that wildlife-dependent recreation, when compatible with refuge purposes and the mission of the Refuge System, is a legitimate and appropriate public use of the Refuge System, through which the American public can develop an appreciation for fish and wildlife. The Refuge Improvement Act directs the Service to facilitate such recreation, including hunting (50 CFR Part 32, Page 46346, Sept. 4, 2001). In addition, the Service policy on hunting as stated in the *Refuge Manual* (8RM 5.1) is: "....to permit hunting on any Refuge within the Refuge System upon a determination that hunting is compatible with the major purposes for which such areas are established." In addition to a compatibility determination, the Refuge Recreation Act requires verification that funds are available for the development, operation and maintenance of the hunting program.

The Service has long recognized that deer management through wildlife control specialists and/or controlled refuge hunts are an integral part of a comprehensive wildlife management program. Such deer control programs are also recognized as acceptable management tools to effectively manipulate wildlife population levels.

Objectives

- Improve vegetative conditions for the benefit of Federal trust species such as migratory birds and threatened and endangered species;
- Conform to the State deer damage management policy;
- Reduce damage to forested areas within 5 years of project implementation;
- Utilize wildlife control specialists to rapidly achieve deer density goals;
- Evaluate potential to open the refuge to a limited deer hunt (e.g., youth hunt, hunters with disabilities) to provide additional recreational opportunities for the public and to aid in reducing and maintaining deer density goals on an annual basis;

- Perform all deer population control activities in a manner safe for participants, neighbors, the public, and Refuge employees.

Initial reduction and maintenance of the white-tailed deer population will be with wildlife control specialists. Pre-harvest deer density estimates will be conducted annually in the fall to prescribe the number of deer to be removed to regulate deer abundance to less than 10 deer per square mile.

Once population goals are achieved, annual deer population management will potentially be a combination of wildlife control specialists. If warranted in the future, JHNWR will partner with PGC to evaluate in detail a proposal to provide opportunities for deer hunting on the refuge consistent with State and local regulations and laws. Other alternatives, including no action (i.e., no hunting) would be considered in this evaluation, and there would be additional opportunities for public involvement before a final decision would be made.

Prior to opening any refuge to hunting, the Service must complete several steps. First, we must meet the requirements of NEPA including involving the public and preparing the appropriate NEPA document (an environmental assessment or environmental impact statement) to evaluate a reasonable range of alternatives and the associated effects on the human environment. Next, we must prepare the NEPA decision document which documents the alternative (or combination of alternatives) we are choosing to implement. As part of this process, we must complete an evaluation of effects on federally listed species under section 7 of the Endangered Species Act. We must also prepare a news release, an outreach plan, a hunt plan, a compatibility determination, and revise the Code of Federal Regulations (50 CFR) as needed. If implemented, all future public archery hunting on JHNWR would be in accordance with State, Federal and Refuge Regulations. The Refuge would likely institute a permit system, weapons restrictions, safety zones, and similar special conditions for safety and wildlife management purposes at that time. If any portions of the Refuge are opened for hunting in the future, they would be designated by signs and/or shown on permits or maps. Special regulations and maps would then be available to the public.

Relationship of Deer Management Program to Goals and Purposes.– Potential negative effects of using wildlife control specialists to control the deer population on the Refuge are discussed in this document and in the John Heinz NWR at Tinicum Draft Comprehensive Conservation Plan and Environmental Assessment (USFWS 2012). As mentioned previously, any effects of implementing a public deer hunt on the refuge would need to be addressed in a subsequent NEPA document (i.e., an environmental assessment or environmental impact statement). Additional information on effects of white-tailed deer management on Pennsylvania deer populations are available in the environmental assessment prepared by USDA APHIS (2003).

Relationship to Other Plans and Documents.– All Refuges are required to develop a Comprehensive Conservation Plan (CCP) that will provide long-range guidance and management to achieve Refuge purposes; help fulfill the Refuge System mission; maintain and, where appropriate, restore the ecological integrity of each Refuge and the Refuge System and help meet other mandates. Currently, JHNWR is completing a CCP concurrent with this Deer Management Plan. The CCP encompasses management activities on the refuge. The deer

management plan is a "step-down" management plan of the CCP. This plan has been incorporated and amended as necessary for the completion of the CCP.

Assessment

An assessment of Refuge resources can be found in the JHNWR Draft CCP and Environmental Assessment (USFWS 2012). As mentioned previously, before the Refuge could be opened to public hunting, a separate hunt environmental assessment would need to be prepared, as well as a hunt plan, outreach plan, Refuge-specific regulations (if any) and a compatibility determination. These documents address environmental impacts of implementing a public hunt program.

Guidelines for Wildlife Control Specialist Deer Population Management

Supplemental deer removal will be conducted by WS, private contractors, or other agents of JHNWR under the guidelines of a Deer Control Permit through the Pennsylvania Game Commission. Professional deer removal operators could be permitted to use specialized equipment and methods such as baiting, high-powered rifles fitted with suppressors to minimize noise; infrared and night vision technologies for identification of safe shooting opportunities and to increase the ability to locate deer; and shooting at night, from vehicles, and in close proximity to buildings. Deer harvested by professional operators will provide venison for charitable donation.

Description of Possible Deer Management Program with Hunting

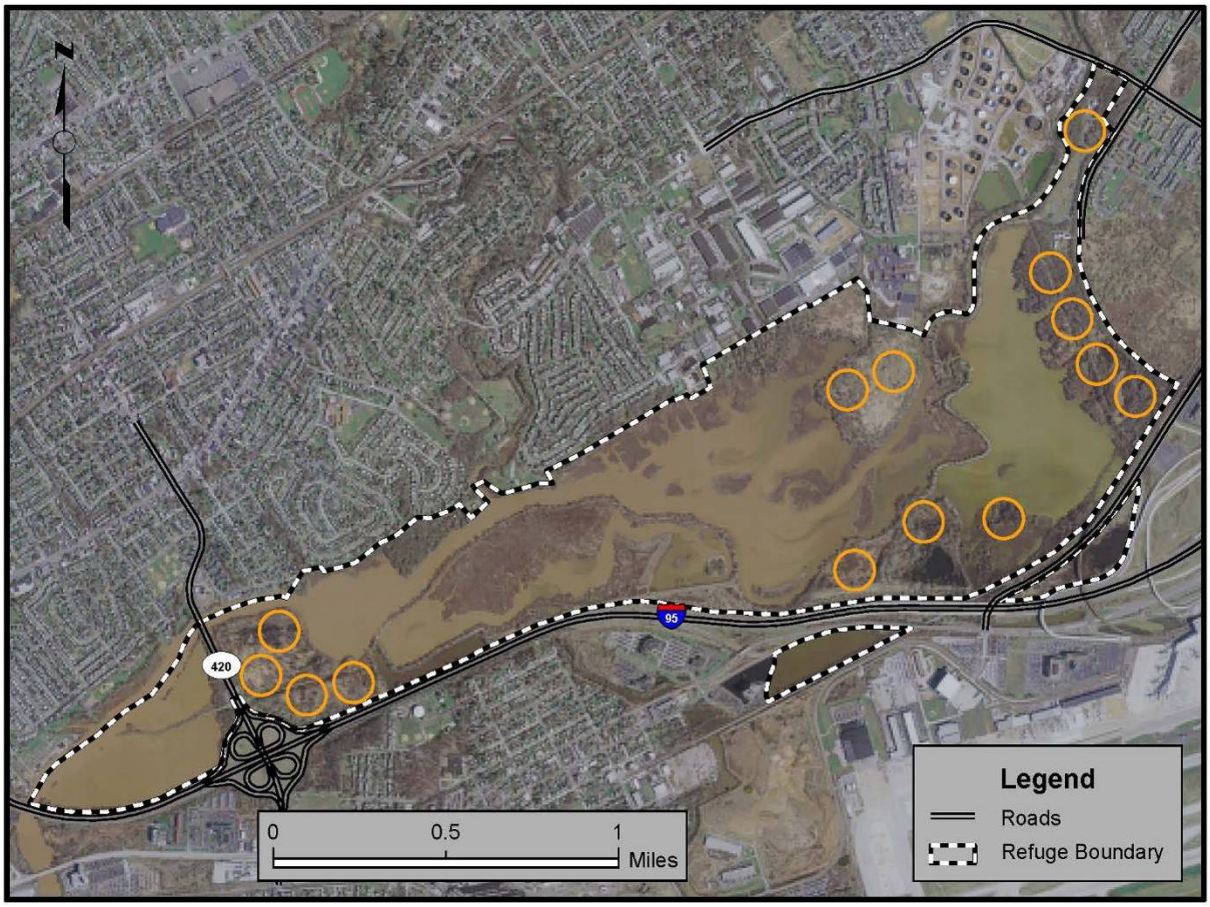
Guidelines for Future Archery Hunt Program.– The following administrative procedures for refuge hunting programs can be found in the Service *Refuge Manual* (8 RM 5.5):

> *"Refuge hunting programs should be planned, supervised, conducted, and evaluated to promote positive hunting values and hunter ethics such as fair chase and sportsmanship. In general, hunting on Refuges should be superior to that available on other public or private lands and should provide participants with reasonable harvest opportunities, uncrowded conditions, limited interference from or dependence on mechanized aspects of the sport. This may require zoning the hunt unit and limiting the number of participants. Good planning will minimize the controls and regimentation needed to achieve hunting objectives."*

If Areas are Opened to Archery Hunting.–For reasons of safety, preventing disturbance among hunters and from the public, and for best controlling harvest of deer in key areas of the Refuge (see Figure 20), WS recommends the following guidelines if areas are opened to archery hunting: 1) Refuge staff should install elevated hunting stands with access by ladder in areas determined to be used regularly by deer; are posted to restrict access by the public; and are minimum 400 yards from other hunter stand locations, 200 yards from Refuge boundaries, and 200 yards from Refuge roads and paths; 2) hunters should be required to utilize approved safety harnesses while in elevated stands; 3) hunters should be directed to stand locations by Refuge staff and required to remain in the immediate area of the stand for the hunt duration; 4) stand

locations should be moved between hunts as necessary to most effectively control hunting effort. Initial recommendations would achieve approximate hunter densities of approximately 23 acres per hunter.

Figure 20. Recommended elevated stand locations with 400-yard buffers (orange circles encompass stand locations and 400-yard buffer) around each stand for archery sport-hunters if the refuge is opened to limited hunts for white-tailed deer on JHNWR located in Philadelphia and Delaware Counties, Pennsylvania. USDA APHIS WS recommends buffering stand locations to ensure safety; provide quality hunting experiences; and contain deer harvest locations away from other hunters, public areas, and roadways.



Accommodations may be made for disabled hunters involved in the controlled archery sport-hunting program. Limited vehicular access that may include ATVs could be made available on an as needed basis at approved areas and times. Construction of a temporary hunting blind with wheelchair accessibility could be available and those hunters recognized by Pennsylvania Game Commission as disabled would have preference regarding such use.

> PA Title 34 Game and Wildlife Code, Sec. 2504(a) "*It is unlawful for any person to shoot at any game or wildlife while it is on a public highway or on a highway open to use or used by the public or to shoot across a public highway or a highway or roadway open to use or used by the public unless the line of fire is high enough above the elevation of the*

highway to preclude any danger to the users of the highway. It shall be unlawful for any person, after alighting from a motor vehicle being driven on or stopped on or along a public highway or road open to public travel, to shoot at any wild bird or wild animal while the person doing the shooting is within 25 yards of the traveled portion of the public highway or road open to public travel."

Species to be Taken.–As defined by the Service's *Refuge Manual*, hunting on refuges may be allowed for migratory game birds and resident game species, which are generally sub-divided into big game and upland (small) game categories. Only archery hunting for white-tailed deer (big game) is recommended on JHNWR. The take of white-tailed deer should be in accordance with State bag limits and seasons, although antlerless deer should be targeted, with the goal of reducing deer overabundance. The refuge manager should determine the ratio of antlerless to antlered deer to be taken prior to the hunting season. This determination should be based on the Refuge's habitat management objectives and the annual deer surveys. The hunt should occur within dates established by the refuge manager within guidelines of the Pennsylvania Game Commission.

Justification for Requiring Refuge Special Use Hunt Permits.–All archery hunters should be required to apply for and obtain a bow hunting special use permit to hunt on JHNWR. This system would enable the Refuge to ensure control over the quality and safety of the hunt. Permits should be awarded on a name-drawn lottery basis to fairly distribute archery access while balancing the number of hunters with available acreage and projected annual harvest. An application fee should be assessed each applicant, which should be used to offset the hunt's administrative costs. This fee should be non-transferable, and non-refundable. Maps delineating hunt zones should be part of the permit package. The permit should inform hunters of current refuge regulations, assignment of hunt units, and other pertinent information for the current year's hunt. It should be given to hunters at the mandatory hunter orientation program prior to the hunt. When bow hunting on JHNWR, hunters should be required to have in their possession the Refuge special use permit at all times.

The entire perimeter of JHNWR is posted with appropriate boundary and/or closed area signs, therefore the signed hunting permit would comply with the State general trespass law which states in Pennsylvania that the land owner must assert their rights to enforce trespass.

Procedures for Consultation and Coordination with the State.–The development of the Deer Management Plan was done in consultation with the Pennsylvania Game Commission. If we propose a public hunt program on the refuge, a letter of concurrence should be obtained from the Pennsylvania Game Commission. JHNWR should consult with Pennsylvania Game Commission, annually, or on an as-needed basis, to discuss archery hunt issues and the management of wildlife control specialists. Aspects in which Refuge regulations may be more restrictive than State regulations are: 1) in the number of days of the hunt-the refuge should have fewer days due to the administrative constraints imposed by limited available staff and the desire to minimize disturbance to non-target species; 2) to continue to provide the other priority wildlife-dependent public uses which include environmental education, wildlife photography, and interpretation; and 3) methods of take.

Methods of Control and Enforcement in Archery Hunt, if Implemented.–The Refuge special use permit system should be used to control hunter placement, density, and safety. Enforcement of State and Federal regulations should be maintained through check-in and check-out stations and spot checks of hunters in the field by State and Service law enforcement officials should occur, as available. A check-in station should be established where hunters will check-in for the day and be assigned a specific hunting location.

Staffing and Funds to Facilitate Potential Future Archery Hunt.–The initial startup cost of implementing an archery hunt is expected to be $4,000 for boundary posting, flyers, public notices, posters, maps, etc. The annual cost of running this program is expected to be $9,000 which includes a substantial portion of overtime for law enforcement personnel. Refuge staff would need to prepare the annual Refuge hunting regulations leaflet, make changes to the hunt plan and regulations as needed, prepare annual output reports, and respond to public inquiries about the hunt program. Refuge staff should collaborate with and receive assistance from the Pennsylvania Game Commission and WS in checking hunters in and out and collecting biological information from harvested deer.

In addition to general staffing, Service and/or other authorized law enforcement personnel at the Federal, State, County and local levels should be requested to assist during each day of the hunt. Service law enforcement assistance would need to be authorized by the Regional Office to ensure the involvement of a minimum of one additional refuge officer to assist with the hunt. In addition to staff expenses, the refuge would incur costs for signs, vehicle maintenance, leaflet printing, and miscellaneous supplies.

Initial Costs:

Boundary posting (materials):	$1,000
Production of hunt flyers, public notices, posters, etc:	$1,500
Design hunter orientation course and target qualifications:	$1,500
Total	$4,000

Additional Staffing Need:

Detailed GS-9 Law Enforcement Officer:	$5,000

Annual (recurring costs):

Hunt staff administration (reservations, check-in/out, deer check):	$2,000
Law Enforcement Officer (over time):	$5,000
Printing:	$1,000
Miscellaneous (signs, equipment, vehicle, etc.)	$1,000
Total	$9,000

Measures Taken to Avoid Conflicts with Other Management Objectives

Biological Conflict.–The proposed deer management program will cause few biological conflicts with other wildlife species. Some disturbance of other animals is unavoidable when sport-hunters and wildlife control specialists are on the Refuge and when they are using firearms. However, disturbance will be minimized because many spring and summer nesting forest songbirds will have migrated south and reptiles, amphibians, and some mammals will have entered a dormant stage prior to either portion of the deer management program. If an archery hunt is implemented, disturbance to resident wildlife or winter migrants is not anticipated given the low density of hunters recommended (i.e., 1 bow hunter per 23 acres of the Refuge's 324 acres of upland habitat) and archery hunting is recommended on fewer than half of the days allotted for the Pennsylvania hunting season.

JHNWR is within the range of American bald eagle and these majestic birds are fairly regular users of the refuge for nesting and roosting areas along the Delaware River. Although the hunting season would coincide with the time of year that eagles are potentially present, it is not expected that the proposed archery hunt would affect bald eagles. Hunters would primarily use the Refuge upland habitat, while the wetland areas and open water are those more often occupied by eagles and they could not be possibly be confused with any legal game species (deer only) on the Refuge.

To ensure sound wildlife management, the Refuge should monitor the deer population, both through a continuation of the annual deer survey and the collection of age, sex, and weight information from harvested deer. Some of this information would be necessary if a hunt program is implemented and has been included in the cost of administering the hunts.

Public Use Conflicts.–The Refuge is sensitive to the proximity of its neighbors and is committed to ensure their safety. For this reason, the Refuge should establish safety zones adjacent to residential areas (i.e., a 500-foot, no-shooting zone around the Refuge's perimeter). Other Refuge uses consist of individuals hiking the nature trails and canoeists/kayakers paddling the Darby Creek and Tinicum Marsh. Use of the nature trails is variable during the fall and light during January. However, to ensure visitor safety and a quality experience for all Refuge visitors, nature trails should be closed to the public on hunt days. JHNWR should post signs at the main creek access points (i.e., canoe launch and west end at lagoons) to notify the public that a deer hunt is in progress. JHNWR should coordinate with the local marinas to ensure that they are aware of the hunt season on the refuge and that they notify their customers. JHNWR should further instruct hunters that they are not authorized to shoot across waterways; this should be reinforced by using appropriately defining hunt zone boundaries.

Administrative Conflicts.–No administrative conflicts are anticipated.

Potential Implementation of Archery Hunt

Federal Regulations.–Archery hunting on the Refuge would be contingent on specific regulations enacted by the Service for refuges in general and JHNWR in particular. These are in addition to State regulations, and would take precedence where they are more restrictive than the State regulations. General stipulations for refuge hunting as contained in the Code of Federal Regulations (50 CFR Part 32) state that hunters must have a valid State license, comply with all

current Federal hunting regulations including the migratory bird regulations (50 CFR Part 20), and comply with all state hunting and safety regulations. Additionally, hunters would be required to comply with the terms and conditions established by JHNWR for access to the Refuge itself and for the Refuge's site-specific archery hunting program. Some of the more pertinent Federal regulations for hunting on a national wildlife refuge follow:

1. Each person shall secure and possess the required State license.

2. Each person shall comply with the applicable provisions of the laws and regulations of the State.

3. Each person shall comply with the terms and conditions authorizing access and/or use of national wildlife refuges.

4. Each person must comply with the provisions of any refuge-specific regulations. Regulations, special conditions, and maps of the hunting areas for a particular wildlife refuge are available at Refuge office. Information concerning hunter orientation is available by phoning the Refuge office.

5. The use of any drug on any arrow for bow hunting on national wildlife refuges is prohibited. Archers may not have arrows employing such drugs in their possession.

6. The unauthorized distribution of bait and hunting over bait is prohibited.

7. The use of nails, wire, screws or bolts to attach a stand to a tree, or hunting from a tree into which a metal object has been driven to support a hunter is prohibited.

8. The use or possession of alcoholic beverages while hunting is prohibited.

State Regulations.–All State regulations would apply to hunting on the Refuge, including weapons restrictions and hunting hours. The applicable State hunting license and deer tags would be required.

Refuge-specific Archery Hunting Regulations.–Hunting on the Refuge should be contingent on specific regulations enacted by the Service for refuges in general and JHNWR in particular. These are in addition to State regulations, and would take precedence where they are more restrictive than the State regulations. The regulations listed below should govern the hunting program on JHNWR.

1. Refuge should be closed to hunting between February 1 and September 14 of each year, with specific "open" archery hunting dates between September 15 and January 31 established by annual rule.

2. Only white-tailed deer should be taken on the Refuge and by archery only. Hunters should be required to first take at least one antlerless deer before taking an antlered deer.

Total refuge archery special use permits and deer gender ratios for harvest should be set annually by refuge manager based on annual deer surveys.

3. Hunters should be required to have in their possession a valid JHNWR hunting special use permit and photo identification on their person while hunting Refuge property. Hunters would obtain permits from the Refuge.

4. Hunters should be required to possess proof of completion of a State archery hunter education course, any Refuge-specific orientation program and target qualification upon daily check-in at the designated Refuge location(s).

5. Hunters should be limited to driving on open public access roads and parking in public areas as noted on a map with the JHNWR Hunting Regulations. Hunters requiring additional accommodations for disability access should contact refuge manager in advance to make such arrangements as needed.

6. Parking permits distributed by the Refuge should be displayed face-up on the vehicle dashboard while hunting.

7. Hunters should be required to check in and be at assigned parking area as noted on Refuge permit and hunters must check out by designated time on Refuge permit.

8. Use of dogs to hunt or pursue game should be prohibited.

9. Only Pennsylvania licensed hunters with valid Refuge special use permit and photo ID should be allowed to carry archery equipment on the refuge and only within refuge bow season and hours. No firearms or ammunition should be permitted on the Refuge except by law enforcement officers and Refuge permitted wildlife control specialists during times of official operations.

10. Shots should only be taken from assigned stands.

11. No person should kill or cripple any deer without making reasonable effort to retrieve the deer and retain it in his/her actual custody. Hunters should be required to notify Refuge staff prior to pursuing wounded deer outside of their assigned hunt zone.

12. Refuge installed stands or blinds should be the only type permitted on the Refuge.

13. Hunters should be required to utilize approved safety harnesses while in elevated stands.

14. Deer hunters should be required to wear a minimum of 250 square inches of hunter orange clothing, visible on head, chest, and back during Refuge archery season. Camouflage orange should not qualify.

15. Screw in steps, bolts, or other screw in materials for attachment to trees should be prohibited.

16. Hunters should be required to report all accidents and injuries to Refuge personnel as soon as possible and no later than departure from the Refuge.

17. Failure to comply with Federal, State, and/or Refuge regulations should lead to dismissal from the Refuge and participation in future hunts.

18. Refuge hunting regulations, as listed on the archery hunting special use permit should be in effect.

19. Use or possession of alcohol should be prohibited.

20. Use of any bait, salt or enticement would be prohibited.

21. Junior hunters selected should be required to be accompanied by a non-hunting adult who has a valid Pennsylvania State hunting license.

22. Use of flagging or reflective trail markers should be prohibited.

23. Scouting should only be allowed during designated times and days as noted in the Refuge hunting regulations.

Anticipated Public Reaction.–Currently, most local residents support a deer management program because of personal property damage to landscaping and forested areas. However, deer management hunts elsewhere have met with opposition in recent years.

There may be negative reactions to the deer hunt by anti-hunting groups. Response to any potential demonstrations or protests would be coordinated through the Northeast Regional Office of the Service, and may require assistance from Refuges who have dealt with these situations in the past. If necessary, State and local law enforcement officials may be asked to assist.

Recommended Hunter Selection Process.–Based on the size of available upland habitats and intention of providing a safe and quality hunt, the daily number of hunters on the 324 acres of refuge uplands should not exceed 14, for a density of 1 hunter per 23 acres. Additional limits should be placed on the number of hunters permitted in each area by assigning hunters to a designated hunt zone (one hunter per hunt zone). The number of archery sport-hunters permitted per day of hunting could be adjusted annually based on population surveys, data collected from deer assessed at check-in stations, the response of forest vegetation to browsing, and safety considerations. All hunters should be required to check-in at the Refuge headquarters and should be assigned to a hunt zone. At that time they should sign and retain a copy of the Refuge Hunting Permit.

Hunter Application and Registration Procedures if Implemented.–All persons interested in hunting on the Refuge would be required to possess a valid State hunting license and necessary deer tag(s) prior to submitting their application and the non-refundable application fee to the Refuge. Hunters should be selected by a random drawing. Selected hunters should be

required to attend a State archery hunter education course, a scheduled Refuge hunter orientation program if available, and refuge archery target qualification in order to hunt on the Refuge.

Upon arriving at the Refuge for the hunt, hunters should be required to display the following items to Refuge Personnel to participate in the hunt: State hunting license and tags, valid Refuge archery hunting special use permit, proof of hunter education course, Refuge archery hunt orientation and target qualification (if applicable), and the appropriate hunter orange. Hunters should be required to check out at the designated Refuge location prior to leaving the Refuge at the end of the day.

Hunter numbers should be modified in the future if necessary to promote safety, relieve hunter congestion or public use conflicts, increase harvest, or ensure compatibility with other Refuge objectives. Procedures for hunter selection may need to be modified as improvements to the system are necessary.

Recommended Media Selection for Announcing and Publicizing Hunts.– If the Refuge implements a public hunt, staff should prepare an annual news release announcing the availability of permit applications and provide a summary of the hunting program for that year. The public should be informed of Refuge hunting regulations and seasons through news releases to local and widely distributed media outlets, as well as through the Refuge Hunting Regulations Permit. Hunt days should also be posted at the Refuge headquarters and information kiosk, as well as on the Refuge's Web site (*http://www.fws.gov/heinz/index.html*). The Refuge Manager could also announce the hunt to Refuge neighbors and other interested parties by letter. The Refuge's contact information (address and phone number) should be included in the Pennsylvania Game Commission hunting brochures. An annual program update should be filed each year as required, outlining any changes in the current hunt program. Rules and regulations should be published in the *Federal Register* as required.

Conclusion

The proposed deer management program will be an integrated approach to balancing deer with the habitat for the good of the ecosystem, public users of the Refuge, and the health of the deer population. The management program will be driven by regular collection of site-specific data on the Refuge to adapt the program to fulfill the objectives of the Refuge.

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APPENDIX A. Summary table derived from studies which examined effort required to remove white-tailed deer by various methods.

Deer Removal Method	Hours per deer removed
Sharpshooting from stands over bait[a]	4.1
Sharpshooting from stands over bait[b]	2.2
Sharpshooting from vehicles at night[a]	1.1
Sharpshooting from stands over bait and Sharpshooting from vehicles at night-simultaneous effort in same area[c]	1.2
Opportunistic sharpshooting by conservation officers on patrol[b]	5.1
Controlled archery hunt[d]	97.3
Archery hunting during combined shotgun-archery controlled hunt[e]	38.0
Shotgun hunting during combined shotgun-archery controlled hunt[e]	23.5
Controlled shotgun hunt[b]	33.7
Controlled hunt with assigned stands (weapons not specified-probably shotguns with slugs)[f]	6.8

[a] Butfiloski, J. W., D. I. Hall, D. H. Hoffman, and D. L. Forster. 1999. White-tailed deer management in a coastal Georgia residential community. Wildlife Society Bulletin 25:491-495. Note: Data averaged for 3 years of study.

APPENDIX A. Continued.

[b] Doerr, M. L., J. B. McAninch, and E. P. Wiggers. 2001. Comparison of four methods to reduce white-tailed deer abundance in an urban community. Wildlife Society Bulletin 29:1105-1113. Note: Data averaged for 3 years of study. Sharpshooting from a stand over bait includes sharpshooting effort by police and park rangers.

[c] DeNicola, A. J., S. J. Weber, C. A. Bridges, and J. L. Stokes. 1997. Nontraditional techniques for management of overabundant deer populations. Wildlife Society Bulletin 25:496-499.

[d] Kilpatrick, H. J., and W. D. Walter. 1999. A controlled archery deer hunt in a residential community: cost, effectiveness, and deer recovery rates. Note: Based on total effort of 1,848 person-hours by archery hunters and 19 deer recovered.

[e] Kilpatrick, H. J., A. M. LaBonte, and J. T. Seymour. 2002. A shotgun-archery hunt in a residential community: evaluation of hunt strategies and effectiveness. Wildlife Society Bulletin 30:478-486. Note: Actual hours hunted per day were not reported. Data presented were based on assumption of 5 hours hunted per individual hunter per day.

[f] Kilpatrick, H. J., S. M. Spohr, and G. G. Chasko. 1997. A controlled deer hunt on a state-owned coastal reserve in Connecticut: controversies, strategies, and results. Wildlife Society Bulletin 25:451-456.

Please note: All estimates of effort for deer control methods do not include time for planning, law enforcement, or venison processing. This compilation represents studies of deer herds with differing densities and management histories in a variety of habitats and hunt structures.

APPENDIX B. Spatial dynamics of white-tailed deer in suburban habitats.

Foreword on Deer Spatial Dynamics:

Data on the spatial dynamics of suburban white-tailed deer are limited by individual study design. The information presented below represents a compilation from the primary literature. Data collection, ages of deer studied, and methods of home range size calculation differed among studies. Also, home ranges of female white-tailed deer may vary in different habitats, latitudes, and deer population densities. However, data from these studies suggested that home ranges for female white-tailed deer in suburban habitats ranged between approximately 50 to 1,974 acres with most averaging less than 640 acres (1 square miles). In general, the authors of these studies indicated that home range sizes of suburban deer were less than deer in rural forested and agricultural habitats.

Dispersal from their natal range by female white-tailed deer occurs at a very low rate regardless of habitat. Correspondingly, descriptions of dispersal rates of female white-tailed deer are rare in the literature. Only one study (Porter et al. 2004) described dispersal of female white-tailed deer in a suburban habitat. This suggests that immigration and emigration of female white-tailed deer has negligible effects on the change in abundance of deer populations. This is especially true for suburban habitats.

Please Note: Comparative table on following page.

APPENDIX B. Continued. Home ranges of female white-tailed deer in suburban habitats.

Location	Home Range Size (acres) [a]	Study
Irondequoit, New York	53[b]	Porter et al. (2004)
Chicago, Illinois	150	Piccolo et al. (2000)
Valley Forge, Pennsylvania	235[c]	Lovallo and Tzilkowski (2003)
Bloomington, Minnesota	355[d]	Grund et al. (2002)
Northeastern Massachusetts	1,050	Gaughan and DeStefano (2005)
Northwestern Massachusetts	1,974	Gaughan and DeStefano (2005)
Groton, Connecticut (control area, no reduction)[e]	84	Kilpatrick et al. (2001)
Groton, Connecticut (treatment area, pre-reduction)[e]	241	Kilpatrick et al. (2001)
Groton, Connecticut (treatment area, post-reduction)[e]	93	Kilpatrick et al. (2001)
Hilton Head Island, South Carolina (control area, no reduction)[f]	80	Henderson et al. (2000)
Hilton Head Island, South Carolina (treatment area, pre-reduction)[f]	108	Henderson et al. (2000)
Hilton Head Island, South Carolina (treatment area, post-reduction)[f]	130	Henderson et al. (2000)

[a] Home ranges were calculated for locations collected over an annual period unless otherwise noted.

[b] Represents average summer home range size for female white-tailed deer in several locales in Irondequoit, New York. Deer in this population exhibit winter migration.

[c] Pooled average for adult female white-tailed deer for years 1997, 1998, and 1999.

[d] Average seasonal home range size for spring. Other seasonal home ranges were less: winter = 211 acres, summer = 124 acres, and fall = 230 acres.

[e] Kilpatrick et al. (2001) illustrates the effects of an experimental population reduction on home range size of female white-tailed deer. They reported a decrease in home range size from pre-reduction to post-reduction on the treatment area. Since no change in home range size was

APPENDIX B. Continued.

observed for deer in the control area, the home range size presented in the table represents an average for the years 1995, 1996, and 1997. The pre-reduction home range size on the treatment area represents an average for the years 1994 and 1995. The post-reduction home range size on the treatment area represents an average for the years 1996 and 1997.

[f] Henderson et al. (2000) illustrates the effects on home range size of female white-tailed deer exposed to an experimental 50 percent population reduction. They reported an increase in home range size from pre-reduction to post-reduction on the treatment area. Since no change in home range size was observed for deer in the control area, the home range size presented in the table represents an average for the winter season for years 1996 and 1997. For the treatment area, the pre-reduction home range size is for the winter of 1996 and post-reduction home range size is for the winter of 1997.

APPENDIX C. Species and diameter at breast height (DBH) of individual overstory trees with stems within 40 feet of the center of 5 forest regeneration survey plots on John Heinz National Wildlife Refuge at Tinicum, Philadelphia and Delaware Counties, Pennsylvania in the early growing season of May and June 2009.

	Canopy Tree Species / DBH		
Plot 1	White mulberry/12”	Paulownia/8”/4.5”	Choke cherry/4.5”
Plot 2	Red maple/4”/6”/7”	Black cherry/8”/9”/12”	–
Plot 3	American elm/27”	White mulberry/5”/19”	Tree of Heaven/6”
Plot 4	Pin oak/26”	–	–
Plot 5	Boxelder/5”	–	–

APPENDIX D. Average measures of the composition of the forest understory for 5 survey plots, each with 5 unfenced subplots (UF) and 4 fenced subplots (F) to exclude white-tailed deer browsing of vegetation, on John Heinz National Wildlife Refuge at Tinicum, Philadelphia and Delaware Counties, Pennsylvania in the early growing season of May and June of 2009 and 2010. Fencing was installed in Spring 2009. Note: percentages may not add to 100 percent due to averaging.

Early Growing Season

	Plot 1				Plot 2				Plot 3				Plot 4				Plot 5			
	2009		2010		2009		2010		2009		2010		2009		2010[a]		2009		2010	
	UF	F	UF	F	UF	F	UF	F	UF	F	UF	F	UF	F	UF	F	UF	F	UF	F
Percent aerial ground cover																				
Bare	33	28	22	15	97	98	99	76	13	45	50	4	78	82	—	—	34	34	16	22
Forb	63	50	60	60	3	2	1	5	87	33	40	76	12	8	—	—	4	3	0	1
Grass	0	2	18	5	0	0	0	0	0	2	10	0	0	0	—	—	62	43	84	58
Percent vertical plant cover																				
0-2 feet	20	25	32	41	0	0	0	0	10	9	42	56	21	5	—	—	9	8	23	14
2-4 feet	0	0	0	1	0	0	2	0	0	0	2	17	10	0	—	—	0	0	0	0
4-6 feet	0	0	4	0	0	0	24	1	0	0	0	0	0	0	—	—	0	0	0	0
No. woody seedlings	0	0	0	1	1	0	0	2	1	0	0	0	0	0	—	—	0	0	0	1
Percent forest canopy cover	85		92		88		77		69		65		98		—		88		54	

[a] Plot 4 was not accessed during the early growing season of 2010 to minimize disturbance to an active American bald eagle nest.

APPENDIX E. Average measures of the composition of the forest understory for 5 survey plots, each with 5 unfenced subplots (UF) and 4 fenced subplots (F) to exclude white-tailed deer browsing of vegetation, on John Heinz National Wildlife Refuge at Tinicum, Philadelphia and Delaware Counties, Pennsylvania in the late growing season of August of 2009 and 2010. Fencing was installed in Spring 2009. Note: percentages may not add to 100 percent due to averaging.

Late Growing Season

	Plot 1				Plot 2				Plot 3				Plot 4				Plot 5			
	2009		2010		2009		2010		2009		2010		2009		2010		2009		2010	
	UF	F	UF	F	UF	F	UF	F	UF	F	UF	F	UF	F	UF	F	UF	F	UF	F
Percent aerial ground cover																				
Bare	62	50	50	25	98	80	99	79	39	42	52	27	70	53	64	36	39	32	27	27
Forb	38	30	47	54	1	1	1	1	61	36	30	53	30	15	6	6	0	1	0	0
Grass	0	0	3	0	1	0	0	0	0	0	0	0	0	12	30	38	61	47	73	53
Percent vertical plant cover																				
0-2 feet	3	10	27	23	1	0	0	0	61	12	90	59	35	42	31	34	9	16	10	12
2-4 feet	0	0	0	0	2	10	0	0	3	0	38	12	18	10	2	0	0	0	0	0
4-6 feet	24	4	7	0	2	2	9	0	0	0	4	5	2	25	0	0	0	0	0	0
No. woody seedlings	0	0	1	2	0	0	0	3	0	0	1	0	0	0	0	0	0	0	0	4
Percent forest canopy cover	92		89		96		92		74		85		70		66		89		85	

APPENDIX F. Dominant herbaceous plant composition of the forest understory for 5 survey plots, each with 5 unfenced subplots (UF) and 4 fenced subplots (F) to exclude white-tailed deer browsing of vegetation, on John Heinz National Wildlife Refuge at Tinicum, Philadelphia and Delaware Counties, Pennsylvania in early growing season of May and June 2009 and 2010. Fencing was installed in Spring 2009. Shading indicates that a dominant plant was non-native. Plot 4 was not accessed during the early growing season of 2010 to minimize disturbance to an active American bald eagle nest.

	Early Growing Season						Late Growing Season					
	2009			2010			2009			2010		
	Dominant Plant 1	**Dominant Plant 2**	**Dominant Plant 3**	**Dominant Plant 1**	**Dominant Plant 2**	**Dominant Plant 3**	**Dominant Plant 1**	**Dominant Plant 2**	**Dominant Plant 3**	**Dominant Plant 1**	**Dominant Plant 2**	**Dominant Plant 3**
Plot 1 Unfenced	Stinging nettle	Garlic mustard	Japanese honey.	Garlic mustard	Stinging nettle	Japanese honey.	Garlic mustard	Stinging nettle	—	Stinging nettle	Japanese honey.	Purpletop grass
Plot 2 Unfenced	Poison ivy	—	—	Japanese honey.	—	—	Poison ivy	Japanese stiltgrass	—	Poison ivy	—	—
Plot 3 Unfenced	Garlic mustard	Indian strawberry	Virginia creeper	Garlic mustard	Japanese honey.	Wine raspberry	Stinging nettle	Garlic mustard	Indian strawberry	Poison ivy	Stinging nettle	Indian strawberry
Plot 4 Unfenced	Japanese stiltgrass	Stinging nettle	Mile-a-minute vine	—	—	—	Mile-a-minute vine	Smartweed	—	Mile-a-minute vine	Smartweed	Stinging nettle
Plot 5 Unfenced	Japanese stiltgrass	Wild rose	—	Japanese stiltgrass	Phragmites	—	Japanese stiltgrass	Purpletop grass	—	Japanese stiltgrass	Purpletop grass	Phragmites
% non-native		60			100			70			53	
Plot 1 Fenced	Stinging nettle	Garlic mustard	Setaria grass	Garlic mustard	Stinging nettle	Desmodium	Garlic mustard	Stinging nettle	Japanese honey.	Stinging nettle	Garlic mustard	—
Plot 2 Fenced	Virginia creeper	Wild rose	—	Poison ivy	Virginia creeper	—	Virginia creeper	Poison ivy	—	Virginia creeper	—	—
Plot 3 Fenced	Indian strawberry	Virginia creeper	Garlic mustard	Garlic mustard	Stinging nettle	Virginia creeper	Garlic mustard	Virginia creeper	Japanese honeysuckle	Virginia creeper	Garlic mustard	Indian strawberry
Plot 4 Fenced	Japanese stiltgrass	Stinging nettle	Mile-a-minute vine	—	—	—	Japanese stiltgrass	Mile-a-minute vine	Virginia creeper	Japanese stiltgrass	Virginia creeper	Smartweed
Plot 5 Fenced	Japanese stiltgrass	Phragmites	Purpletop grass	Japanese stiltgrass	Phragmites	—	Japanese stiltgrass	—	—	Japanese stiltgrass	—	—
% non-native		60			42			67			60	

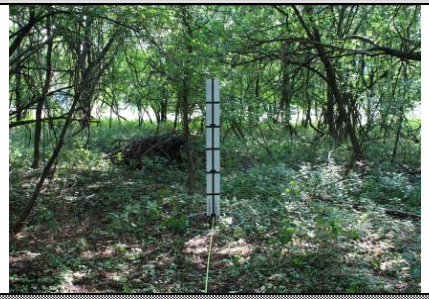
APPENDIX G.1. Reference photographs for unfenced and fenced subplots of forest regeneration Plot 1 on John Heinz National Wildlife Refuge at Tinicum, Philadelphia and Delaware Counties, Pennsylvania in the early growing season of May and June 2009. Data on forest regeneration were collected by USDA APHIS Wildlife Services as part of a study examining white-tailed deer ecology on the Refuge. Cross-hatched headings indicate subplots to be fenced in June 2009 after photographs were taken.

Plot 1. Early Growing Season 2009.

Northwest	North	Northeast
		
West	**Central**	**East**
		
Southwest	**South**	**Southeast**
		

APPENDIX G.2. Reference photographs for unfenced and fenced subplots of forest regeneration Plot 1 on John Heinz National Wildlife Refuge at Tinicum, Philadelphia and Delaware Counties, Pennsylvania in the late growing season of August 2009. Data on forest regeneration were collected by USDA APHIS Wildlife Services as part of a study examining white-tailed deer ecology on the Refuge. Cross-hatched headings indicate subplots that were fenced in June 2009.

Plot 1. Late Growing Season 2009.

Northwest	North	Northeast
		
West	**Central**	**East**
		
Southwest	**South**	**Southeast**
		

APPENDIX H.1. Reference photographs for unfenced and fenced subplots of forest regeneration Plot 2 on John Heinz National Wildlife Refuge at Tinicum, Philadelphia and Delaware Counties, Pennsylvania in the early growing season of May and June 2009. Data on forest regeneration were collected by USDA APHIS Wildlife Services as part of a study examining white-tailed deer ecology on the Refuge. Cross-hatched headings indicate subplots to be fenced in June 2009 after photographs were taken.

Plot 2. Early Growing Season.

Northwest	North	Northeast
		
West	**Central**	**East**
		
Southwest	**South**	**Southeast**
		

APPENDIX H.2. Reference photographs for unfenced and fenced subplots of forest regeneration Plot 2 on John Heinz National Wildlife Refuge at Tinicum, Philadelphia and Delaware Counties, Pennsylvania in the late growing season of August 2009. Data on forest regeneration were collected by USDA APHIS Wildlife Services as part of a study examining white-tailed deer ecology on the Refuge. Cross-hatched headings indicate subplots that were fenced in June 2009.

Plot 2. Late Growing Season.

Northwest	North	Northeast
		
West	**Central**	**East**
		
Southwest	**South**	**Southeast**
		

APPENDIX I.1. Reference photographs for unfenced and fenced subplots of forest regeneration Plot 3 on John Heinz National Wildlife Refuge at Tinicum, Philadelphia and Delaware Counties, Pennsylvania in the early growing season of May and June 2009. Data on forest regeneration were collected by USDA APHIS Wildlife Services as part of a study examining white-tailed deer ecology on the Refuge. Cross-hatched headings indicate subplots to be fenced in June 2009 after photographs were taken.

Plot 3. Early Growing Season.

Northwest	North	Northeast
		
West	**Central**	**East**
		
Southwest	**South**	**Southeast**
		

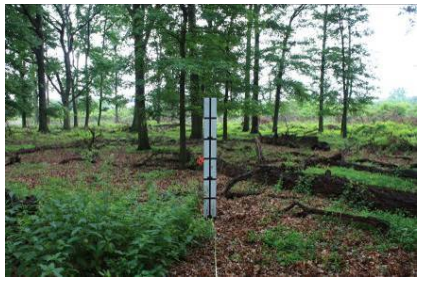
APPENDIX I.2. Reference photographs for unfenced and fenced subplots of forest regeneration Plot 3 on John Heinz National Wildlife Refuge at Tinicum, Philadelphia and Delaware Counties, Pennsylvania in the late growing season of August 2009. Data on forest regeneration were collected by USDA APHIS Wildlife Services as part of a study examining white-tailed deer ecology on the Refuge. Cross-hatched headings indicate subplots that were fenced in June 2009.

Plot 3. Late Growing Season.

Northwest	North	Northeast
		
West	**Central**	**East**
		
Southwest	**South**	**Southeast**
		

APPENDIX J.1. Reference photographs for unfenced and fenced subplots of forest regeneration Plot 4 on John Heinz National Wildlife Refuge at Tinicum, Philadelphia and Delaware Counties, Pennsylvania in the early growing season of May and June 2009. Data on forest regeneration were collected by USDA APHIS Wildlife Services as part of a study examining white-tailed deer ecology on the Refuge. Cross-hatched headings indicate subplots to be fenced in June 2009 after photographs were taken.

Plot 4. Early Growing Season.

Northwest	North	Northeast
		
West	**Central**	**East**
		
Southwest	**South**	**Southeast**
		

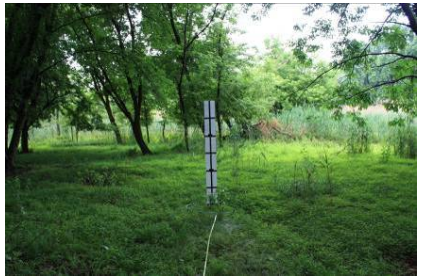
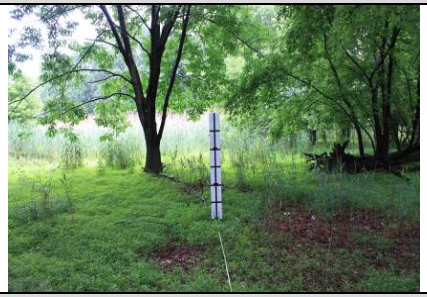
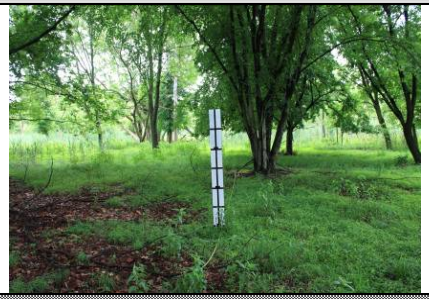
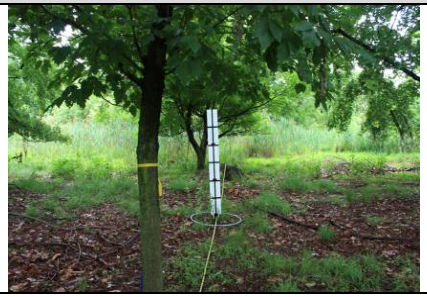
APPENDIX J.2. Reference photographs for unfenced and fenced subplots of forest regeneration Plot 4 on John Heinz National Wildlife Refuge at Tinicum, Philadelphia and Delaware Counties, Pennsylvania in the late growing season of August 2009. Data on forest regeneration were collected by USDA APHIS Wildlife Services as part of a study examining white-tailed deer ecology on the Refuge. Cross-hatched headings indicate subplots that were fenced in June 2009.

Plot 4. Late Growing Season.

Northwest	North	Northeast
		
West	**Central**	**East**
		
Southwest	**South**	**Southeast**
		

APPENDIX K.1. Reference photographs for unfenced and fenced subplots of forest regeneration Plot 5 on John Heinz National Wildlife Refuge at Tinicum, Philadelphia and Delaware Counties, Pennsylvania in the early growing season of May and June 2009. Data on forest regeneration were collected by USDA APHIS Wildlife Services as part of a study examining white-tailed deer ecology on the Refuge. Cross-hatched headings indicate subplots to be fenced in June 2009 after photographs were taken.

Plot 5. Early Growing Season.

Northwest	North	Northeast
		
West	**Central**	**East**
		
Southwest	**South**	**Southeast**
		

APPENDIX K.2. Reference photographs for unfenced and fenced subplots of forest regeneration Plot 5 on John Heinz National Wildlife Refuge at Tinicum, Philadelphia and Delaware Counties, Pennsylvania in the late growing season of August 2009. Data on forest regeneration were collected by USDA APHIS Wildlife Services as part of a study examining white-tailed deer ecology on the Refuge. Cross-hatched headings indicate subplots that were fenced in June 2009.

Plot 5. Late Growing Season.

Northwest	North	Northeast
		
West	**Central**	**East**
		
Southwest	**South**	**Southeast**
		

APPENDIX L. Summary of eighteen roving white-tailed deer density surveys completed by USDA APHIS Wildlife Services on John Heinz National Wildlife Refuge at Tinicum, Philadelphia and Delaware Counties, Pennsylvania during November, December and January of 2008-2011.

Date of survey	# deer observed	Approximate area observed (acres)	Deer density estimate (deer/square mile)
20 Nov. 2008	75	147	58
25 Nov. 2008	82	142	66
04 Dec. 2008	82	156	60
15 Dec. 2008	84	170	57
05 Jan. 2009	85	151	64
08 Jan. 2009	55	104	60
23 Nov. 2009	47	94	57
24 Nov. 2009	58	95	70
21 Dec. 2009	40	137	33
22 Dec. 2009	39	86	52
26 Jan. 2010	46	97	54
27 Jan. 2010	44	64	78
22 Nov. 2010	74	107	79
23 Nov. 2010	60	72	95
21 Dec. 2010	83	115	82
22 Dec. 2010	77	116	76
19 Jan. 2011	72	115	71
20 Jan. 2011	85	101	96