Appendix C

Frank Miles/USFWS

Yellow-rumped warbler

Draft Habitat Management Plan

John Heinz National Wildlife Refuge at Tinicum
Draft Habitat Management Plan

January 2012

The National Wildlife Refuge System, managed by the U.S. Fish and Wildlife Service, is the world's premier system of public lands and waters set aside to conserve America's fish, wildlife and plants. Since the designation of the first wildlife refuge in 1903, the System has grown to encompass more than 150 million acres, over 550 national wildlife refuges and other units of the Refuge System, plus 37 wetland management districts

Table of Contents

List of Maps

List of Figures

List of Tables

Chapter 1.
Introduction

1.1 Scope and Rationale
1.2 Legal Mandates
1.3 Relation to Other Plans

1.1 Scope and Rationale

John Heinz National Wildlife Refuge at Tinicum (John Heinz NWR, the refuge) was created in 1972 for the purpose of preserving, restoring, and developing the natural area known as Tinicum Marsh. It was created to develop a wildlife interpretative center for the purpose of promoting environmental education and to afford visitors an opportunity to study wildlife in its natural habitat. The refuge protects approximately 200 acres of the remaining freshwater tidal marsh in Pennsylvania and represents an important migratory stopover along the Atlantic Flyway. It also provides protected breeding habitat for State-listed threatened and endangered species, as well as many neotropical migrants (Cohen and Johnson 2004).

John Heinz NWR is managed by the U.S. Fish and Wildlife Service (Service, we, our) as part of the National Wildlife Refuge System (Refuge System). The Refuge System maintains the biological integrity, diversity and environmental health of these natural resources for the benefit of present and future generations.

The refuge protects a variety of unique resources and also provides a unique opportunity for the education and outreach near the urban center of the city of Philadelphia, the nation's fifth largest metropolitan area. Sustaining and protecting these resources requires planning, active on-the-ground management, and partnerships with the surrounding communities of the Delaware Valley. This Habitat Management Plan (HMP) provides a long-term vision and specific guidance on managing the habitats for the identified resources of concern at John Heinz NWR. Once approved, the HMP will provide direction for the next 15 years. Interim reviews and use of adaptive management will assess and modify management activities as research, monitoring, and priorities require.

1.2 Legal Mandates

John Heinz NWR was created in 1972 for three primary purposes:

1. "Preserving, restoring, and developing the natural area known as Tinicum Marsh....a wildlife interpretative center for the purpose of promoting environmental education, and to afford visitors an opportunity for the study of wildlife in its natural habitat." (86 Stat. 891, dated June 30, 1972).

2. 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).

3. "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).

In 1997, Congress passed the National Wildlife Refuge System Improvement Act (Refuge Improvement Act), establishing a unifying mission for the Refuge System. The Refuge Improvement Act highlights six priority public uses that each refuge should evaluate for compatibility with its wildlife-first mandate. These six public uses include wildlife observation, interpretation, photography, environmental education, hunting, and fishing. The act requires that all refuges prepare a Comprehensive Conservation Plan (CCP) by 2012. John Heinz NWR began the CCP planning process in 2010.

1.3 Relation to Other Plans

Important guidance for wildlife habitat management at John Heinz NWR has already been provided by several important refuge, regional, and national plans.

Refuge Plans

Comprehensive Conservation Plan (CCP)
The Refuge Improvement Act requires that all refuges prepare a CCP by 2012. The CCP guides biological and public use actions on the refuge for a 15-year period. John Heinz NWR is scheduled to complete the CCP planning process in 2012. The goals and objectives developed as part of this HMP will be incorporated into the CCP.

Restoration Management Plan for the Lower Darby Creek with Recommendations for John Heinz National Wildlife Refuge at Tinicum, (Salas et al. 2006)
This Restoration Management Plan was developed in 2006 by the Delaware Riverkeeper Network under a Delaware Estuary Grant awarded to the Friends of the Heinz Refuge and funded by the National Fish and Wildlife Foundation. The purpose of this plan was to initiate an ecological restoration approach to habitat management at the refuge. This plan identified historic disturbances to the site, the ecological communities existing at the refuge, and provided recommendations for the restoration of the more natural ecological composition, structure, and function of these communities. The extensive field and GIS data, along with historic records and information compiled as part of this plan, were used extensively in the development of the HMP.

Pennsylvania Important Bird Area #73: Phase I Conservation Plan (Cohen and Johnson 2004)
John Heinz NWR is designated an Important Bird Area (IBA) by the National Audubon Society for its critical location within the Atlantic flyway and its complex of unique habitats. This Phase I Conservation Plan identifies habitat-based site boundaries, describes the birds and wildlife habitat which occur on the site with special reference to the species for which the site was selected as an IBA, identifies conservation issues and threats to the site, and provides recommendations for conservation actions. Its conservation recommendations are being considered with those of other refuges and regional plans.

Draft Deer Management Plan (D'Angelo 2011)
Refuge staff consulted with U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services to study the deer population present at John Heinz NWR and the effects of deer on refuge habitat, wildlife, and humans. The purpose of the deer management plan is to institute a sound biological program to efficiently manage the deer population within a sustainable and healthy balance within the habitat and objectives of the refuge.

Regional and National Plans

North Atlantic Landscape Conservation Cooperative Operations Plan, (USFWS 2009a)
The Service is developing a coordinated network of landscape conservation cooperatives (LCCs) across the United States, in part to address major environmental and human-related factors that limit fish and wildlife populations at the broadest of scales, including developing adaptation strategies in response to climate change. The LCC is utilizing principles of strategic habitat conservation (SHC) to develop and communicate landscape-scale scientific information to shape conservation across the northeastern United States. This initial plan outlines the regional threats to conservation, priority species and habitats, as well as active regional partnerships.

Mid-Atlantic Coast Bird Conservation Region 30 Implementation Plan (USFWS 2008a)
The Implementation Plan for the Bird Conservation Region (BCR) 30 combines regional plans, assessments, and research completed over the past two decades to develop continental-based bird conservation efforts. John Heinz NWR is located within the narrow portion of the Mid-Atlantic Coastal Plain located in southeastern

Pennsylvania. As such, this coastal zone is unique to the State of Pennsylvania and thus many of the priority species listed for BCR 30 are also species of concern listed within the Pennsylvania Wildlife Action Plan. These rankings and the recommendations of the inventory have been considered along with other local and regional conservation priorities.

A Natural Heritage Inventory of Philadelphia County, Pennsylvania, (PNHP 2008)
The Philadelphia County Natural Heritage Inventory was compiled by the Pennsylvania Department of Conservation and Natural Resource (PADCNR) Natural Heritage Program and the Western Pennsylvania Conservancy. It provides information on the general locations of rare, threatened, and endangered species, of the highest quality natural areas in the county, and identifies areas in need of restoration. The Pennsylvania Natural Heritage Program also provides State conservation rankings for each species of conservation concern in Pennsylvania. These rankings and the recommendations of the inventory have been considered along with other local and regional conservation priorities.

Pennsylvania Wildlife Action Plan, (PGC and PFBC 2005)
The State Wildlife Action plan was completed in 2005 and updated again in 2008 (Pennsylvania Game Commission (PGC) and Pennsylvania Fish and Boat Commission (PFBC) 2008). While creating a strategic focus for State fish and wildlife management agencies, this plan attempts to provide a Statewide perspective on conservation, presenting geographic, species, and habitat priorities. Considering John Heinz NWR's protection of habitats unique to the State of Pennsylvania, species of conservation priority were considered in development of the refuge's resources of concern.

Service Migratory Bird Program Strategic Plan, (USFWS 2004)
The Migratory Bird Program Strategic Plan provides direction for the Service's migratory bird management over the next decade (2004 to 2014). The plan contains a vision and recommendations for the Refuge System's place in bird conservation. It defines strategies for the Service, including the Refuge System, to actively support bird conservation through monitoring, conservation, consultation, and recreation. The refuge-specific HMP, to the extent it is practical, utilizes standard monitoring protocols, habitat assessment and management, and promotes nature-based recreation and education to forward the vision of the Migratory Bird Program Strategic Plan.

Service Birds of Conservation Concern, (USFWS 2008b)
This report identifies the migratory and nonmigratory bird species (beyond those already designated as federally threatened or endangered) that represent the Service's highest conservation priorities and draws attention to species in need of conservation action. The geographic scope includes the United States in its entirety, including island "territories" in the Pacific and Caribbean. Bird species considered for inclusion on lists in this report include nongame birds, gamebirds without hunting seasons, subsistence-hunted nongame birds in Alaska, Endangered Species Act candidates, proposed endangered or threatened, and recently delisted species. Assessment scores are based on several factors, including population trends, threats, distribution, abundance, and area importance.

Wildlife Habitat in Pennsylvania, Past, Present, and Future, (Goodrich et al. 2001)
Today, the PADCNR ranks coastal plain habitats as "impaired." The coastal plain region of Pennsylvania includes some of the last remaining habitats for certain wetland species in the State. The 2001 PADCNR report *Wildlife Habitat in Pennsylvania, Past, Present, and Future* (Goodrich et al. 2001), recommends that where possible, wetlands along the Delaware should be restored. Urban forest management is recommended to provide habitat for some tolerant forest wildlife. The reduction of runoff into streams and wetlands is also noted as a top priority, along with restoration of natural communities in undeveloped areas.

Bird Conservation Plan for the Mid-Atlantic Coastal Plain, (Physiographic Area 44), (PIF 1999)
Partners in Flight is a partnership of government agencies, private organizations, academic researchers, and private industry throughout North America focused on coordinating voluntary bird conservation efforts to benefit species at risk and their habitats. BCRs have been developed to guide management on a regional scale.

Version 1.0 of the Mid-Atlantic Coastal Plain BCR was completed in 1999. John Heinz Refuge is located within the Coastal Plain physiographic province and thus is considering the conservation priorities of this plan along with other conservation plans.

Delaware Estuary Comprehensive Conservation Management Plan, (DEP 1996)
The Delaware Estuary is faced with continuing threats from toxic substances, habitat loss and fragmentation, and human development. To help address these threats, the Delaware Estuary Program worked with many partners to develop the Comprehensive Conservation and Management Plan (CCMP) for the Delaware Estuary (DEP 1996). The CCMP is a comprehensive document describing the existing conditions of the Delaware Estuary and providing seven action plans (land management, water use management, habitat and living resources, toxics, education and involvement, and monitoring) and an implementation plan. While the Delaware Estuary Program has since merged with the Partnership for the Delaware Estuary, this reorganized entity is still active and is now responsible for addressing the various actions identified in the CCMP. We used this plan as a reference in developing habitat management and land protection planning objectives.

Refuge-specific Plans

In addition to these local, State, and regional plans, a number of other refuge program-specific plans have provided guidance either in their draft or final format, including but not limited to the following:

- Annual Habitat Work Plan (most recently completed in 2011, updated annually)
- Wildlife Disease Surveillance and Contingency Plan (completed 2006)
- Fire Management Plan (completed 2006)
- Public Use Plan (currently in draft form, to be completed in 2012)
- Law Enforcement Plan (currently in draft form, to be completed in 2012)
- Hurricane Action Plan (completed 2010)
- Energy Management Plan (completed 2003, updated annually)
- Safety Plan (completed 2010)
- Fishing Plan (to be completed within 3 years of CCP approval)

Chapter 2.
Background

2.1 Refuge Location and Description

The 1,200-acre John Heinz NWR is one of the most urban refuges managed by the Service. It is located within the City of Philadelphia and neighboring Tinicum Township in Philadelphia and Delaware Counties, about one-half mile north of Philadelphia International Airport (map C.1). The freshwater tidal marsh at the refuge now comprises approximately 80 percent of the State's coastal wetland. The refuge represents an important migratory stopover along the Atlantic Flyway that provides a mix of freshwater habitats. It also provides protected breeding habitat for State-listed threatened and endangered species, as well as many neotropical migrants (Cohen and Johnson 2004).

The refuge contains a variety of ecosystems unique to Pennsylvania and the Philadelphia metropolitan area including tidal and nontidal fresh water marsh, freshwater tidal creek, open impoundment waters, coastal plain and riparian forests, and early successional grasslands. Many of the refuge's ecosystems have been degraded, damaged, or (in some cases) destroyed as a result of the numerous historic impacts. However, many of these impacted ecosystems have the potential to be restored or enhanced through various management efforts. Some areas, including portions of the tidal marsh, contain healthy and intact ecological communities. These areas will require a more protection and monitoring-focused approach. Due to the refuge's location within the coastal plain (a small and unique physiographic region within Pennsylvania), many of its ecosystems contain unique plant communities or species of conservation concern.

2.2 Geographical Setting

Bird Conservation Region and Partners in Flight Physiographic Area

The regional planning efforts completed by the North American Bird Conservation Initiative (NABCI) and PIF created a series of regional conservation planning units at a national scale. NABCI efforts seek to unite all bird conservation efforts on a regional scale within Bird Conservation Regions. PIF's planning focus is conservation of landbirds within biologically based regions identified as BCRs. BCRs are generally larger in scale than PIF Physiographic Areas.

John Heinz NWR is located within BCR 30 (Mid-Atlantic Coast) and PIF Physiographic Area 44 (Mid-Atlantic Coastal Plain; see map C.2). Priority habitats identified in BCR 30 that are present at John Heinz NWR include mud flat, estuaries and bays, estuarine emergent wetlands, freshwater emergent wetlands, forested wetlands, rivers and streams, forested uplands, and grasslands. The Mid-Atlantic Coast BCR extends across Coastal Plain regions from northern New Jersey down through Pennsylvania, Delaware, Maryland, and into Virginia. Threats to priority habitats within BCR 30 are largely associated with human impacts as a result of the region being highly populated, first by Native Americans, and then over 300 years of European colonization (USFWS 2008a).

Atlantic Coast Flyway

Flyways are important units for managing waterfowl and other migratory bird populations as they help connect management of breeding, migration, and overwintering areas. The partnership includes 18 states and commonwealths and key Federal and regional habitat conservation agencies and organizations in the joint venture area. It was originally formed as a regional partnership focused on the conservation of waterfowl and wetlands under the North American Waterfowl Management Plan in 1988. Since then the focus has broadened to the conservation of habitats for all birds consistent with major national and continental bird conservation plans and the NABCI. John Heinz NWR is located in a unique landscape position along the Atlantic Coast Flyway. Its large open space and diverse habitats located along the Delaware River within a highly urbanized metropolitan area makes it a critical stop for many species.

Watershed Context

John Heinz NWR is located within the Delaware River Basin, which encompasses 13,600 square miles and stretches approximately 330 miles from headwaters in New York State to its confluence with the Atlantic

Ocean. The Delaware River watershed includes portions of Delaware, Maryland, New York, New Jersey, and Pennsylvania (DRBC 2004).

Within the Delaware watershed, the pre-industrial landscape was predominantly woods and wetlands, with expanses of farmland and nodes of human settlement. Decades of development and harvesting resulted in filled wetlands and a decrease in forests. By 1930, forests had been reduced to 32 percent and wetlands to 3 percent of the landscape. Between 1930 and 1996, urbanized land expanded from 3 to 14 percent (DRBC 2004).

Our project area (the refuge) is situated near the confluence of Darby Creek and the Delaware River located on the southwest boundary of the City of Philadelphia. Most of the 77 square miles of the Darby Creek watershed lies within Delaware County with additional portions found within surrounding Chester, Delaware, Montgomery, and Philadelphia Counties. The watershed is very urbanized, encompassing all (or parts) of 31 municipalities, which are home to approximately 500,000 people, with an average density of nearly 10 persons per acre (DCVA 2005).

Landscape Conservation Context

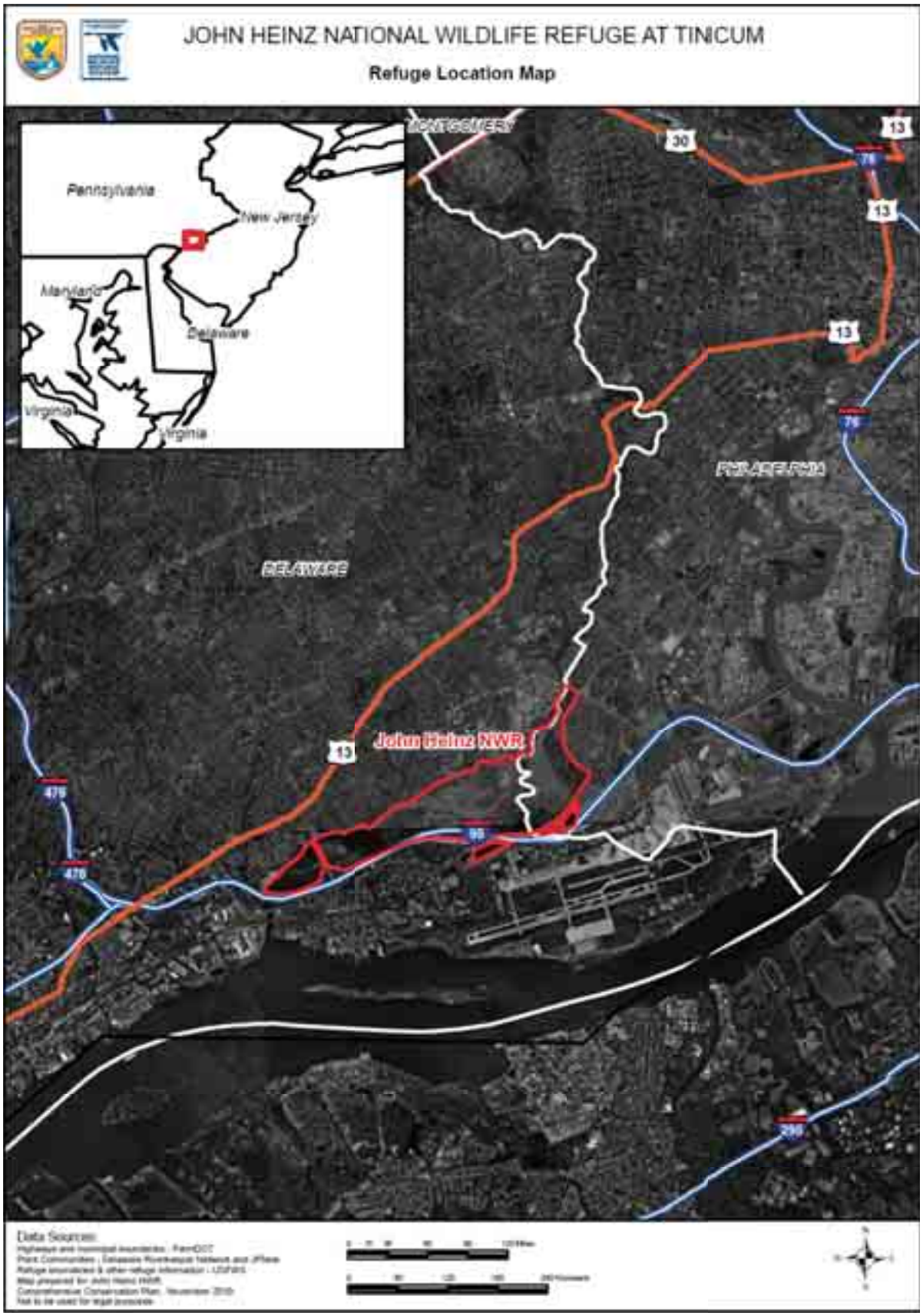
John Heinz NWR protects a variety of unique resources and also provides a unique opportunity for the education and outreach near the urban center of the City of Philadelphia, the nation's 5th largest metropolitan area (map C.1). Connecting children and families with nature is a very high priority national program of the Service. The urban interface of John Heinz NWR provides excellent opportunities for such environmental education and conservation outreach unlike any other refuge in the country. The ecosystems within John Heinz NWR, especially freshwater tidal marsh, support some of our nation's most biologically diverse assemblages of fish, wildlife, and plant species.

John Heinz NWR's location near the confluence of Darby Creek and the Delaware River also plays a significant role in the habitats and species utilizing the refuge. As one of only a few large freshwater marsh expanses along the Delaware River, the refuge provides an important stopover for many species during migration up the Delaware River flyway. The expanse of freshwater tidal marsh also provides critical spawning and nursery habitat for many riverine fish species.

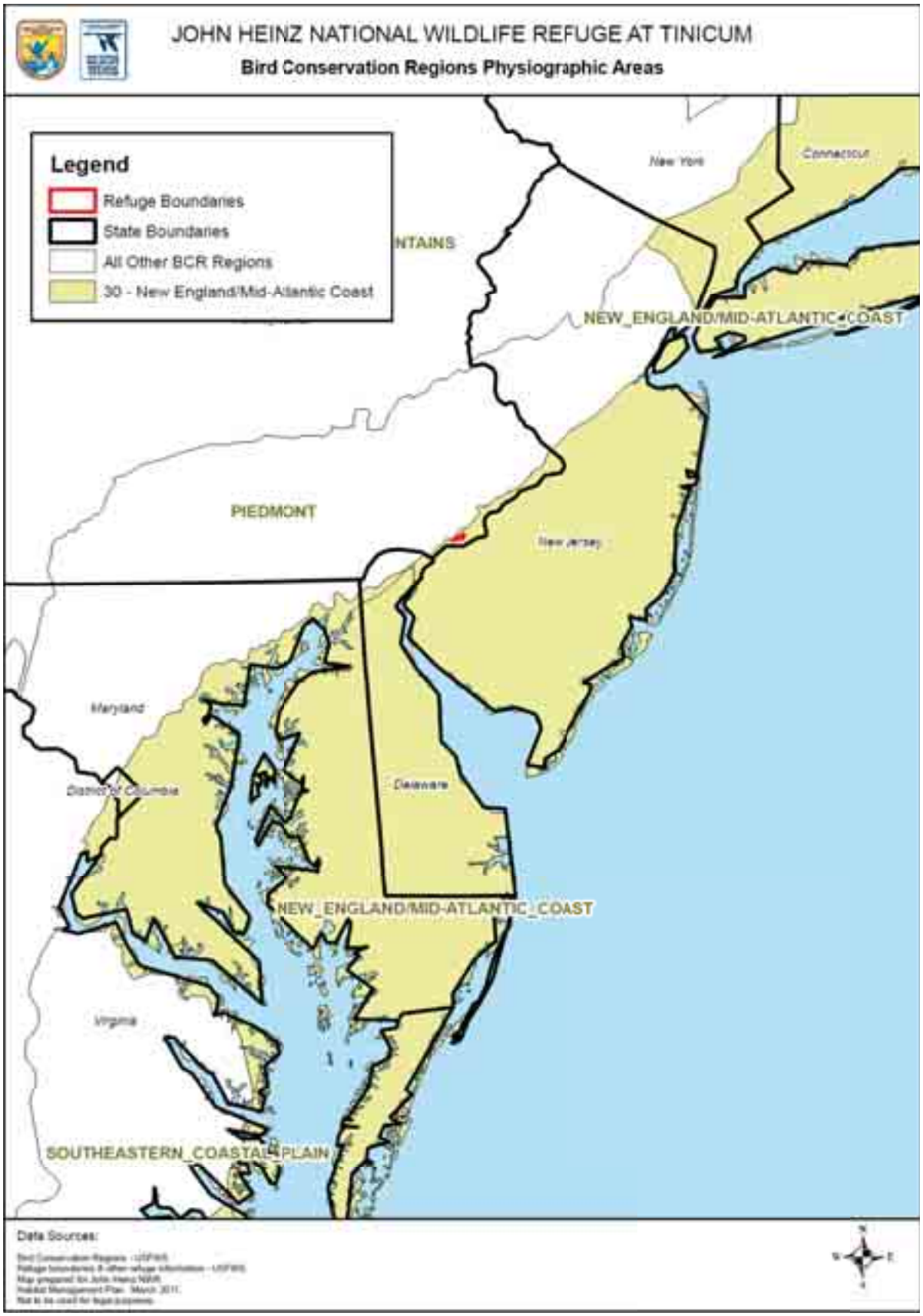
Much of the land surrounding the refuge is, and has been, urbanized for nearly 200 years. Major land use changes over the 20th century, however, brought major impacts to the refuge site and surrounding landscape like never seen before. Interstate highway, international airport, and expanded residential and industrial construction made John Heinz NWR a biological island contrasted amongst a highly urbanized landscape.

This position within a large urban area also provides many opportunities. More than 100,000 visitors from around the Delaware Valley and beyond visit the refuge each year. John Heinz NWR is in a unique position to foster greater community understanding of natural systems, species of conservation concern, the value of the refuge system, and the Service's mission in conserving and protecting those resources.

Map C.1. Location of John Heinz National Wildlife Refuge



Map C.2. Bird Conservation Regions in Relation to John Heinz National Wildlife Refuge



2.3 Historical Perspective

Geologic Development

John Heinz NWR is situated within Pennsylvania's southeastern most physiographic province, the Atlantic Coastal Plain (Low et al. 2002). This province extends from southern Delaware County up into Philadelphia County where it includes all of Philadelphia except the northwestern part. Outside of Pennsylvania, this province extends throughout areas along the Atlantic Ocean from Massachusetts to Florida, including all of southern New Jersey and most of Delaware.

This physiographic region is characteristically flat land with sandy soils. These soils are primarily composed of sand, silt, and gravel resulting from the weathering of very old Paleozoic and Precambrian metamorphic rocks. This rock, originally laid down as sediments 438 to1,600 million years ago, was altered by heat and pressure to form various metamorphic rocks, which in turn weather relatively easily. These rocks can be further described by the minerals they are composed of, the specific process that formed them, and their physical characteristics.

The area is influenced by the Delaware River and is in a different group. It is composed of sand and gravel laid down by periodic flooding over the last 1.6 million years with additional silt and clay deposits where finer material was able to settle. Alluvial sediments in areas along this reach of the Delaware River were deposited over the last 12,000 years (PNHP 2008). These finer alluvial sediments are those which naturally comprise much of the soils throughout the refuge. PADCNR has highlighted Tinicum Marsh as an Outstanding Scenic Geological Feature worth noting within this physiographic province (DCNR 2010).

Pre-European Settlement

The pre-settlement forest of southeastern Pennsylvania was a mixed-aged forest (Latham et al. 2005). In areas along the Delaware River, the coastal plain forest type covered a significant portion of the Philadelphia area. This community supported a suite of species common further south. This community developed in this region because of the sandy soils combined with the warm coastal air blown up from Delaware Bay. This forest type was dominated by sweet-gum (*Liquidambar styraciflua*) and oaks (*Quercus spp.*) intermixed with species such as American beech (*Fagus grandifolia*). The understory would have also included broadleaved evergreen species such as American holly (*Ilex opaca*) (PNHP 2008).

Floodplain forests were also found along many river systems in this part of the State. These forests would have been regularly flooded, for various durations, on an annual basis. In the most frequently flooded areas, fast-growing species such as sycamore (*Platanus occidentalis*), silver maple (*Acer saccharinum*), and American and slippery elm (*Ulmus americana and U. rubra* respectively) would dominate. Associated species would include eastern cottonwood (*Populus deltoides*), common hackberry (*Celtis occidentalis*), black walnut (*Juglans nigra*), butternut (*Juglans cinerea*), green ash (*Fraxinus pennsylvanica*), and box-elder (*Acer negundo*) interspersed among them. Permanently wet or saturated areas, such as backwaters and isolated oxbows, would have supported swamp white oak (*Quercus bicolor*), pin oak (*Quercus palustris*), and red maple (*Acer rubrum*).

Grasslands and native meadows were likely to be found throughout the Philadelphia area prior to colonization. However, it is unlikely that these were self-maintaining systems. Meadows were often managed by resident Native Americans who burned them on a periodic basis to prevent their succession back to forest partly in order to provide forage for game species such as grouse, turkey, deer, and elk (Latham et al. 2005).

The Pennsylvania Natural Heritage Program estimates that Philadelphia County at one time contained up to 10 to 20 square miles (6,400 to 12,800 acres) of freshwater tidal marsh. Historically, and as it is today, these wetlands provided an important breeding spot for many bird, mammal, fish, amphibian, reptile, and insect species. It was also a critical stopover site for migratory waterfowl and shorebirds during their annual migrations. Today, John Heinz NWR protects the 1/3 square mile of freshwater tidal marsh that remains in this part of the State (PNHP 2008).

Human occupation of the lower Delaware River drainage likely began as early as 16,000 years ago with the arrival of the ancestors of the Lenni-Lenape people, known to the English as the Delawares. This reach of the river was narrower and nontidal at that time, flowing through forested floodplain and freshwater marshes. Sea level rise had already been initiated by melting of the Wisconsin ice mass far to the north, and continued at a gradually slowing pace until about 5,000 years ago, by which time the local environment had stabilized as a tidal estuary with marshes comprising not only most of the current refuge land, but also a large part of the area now covered by Philadelphia International Airport.

European Settlement

As a result of the destruction caused by intensive historic period development, remarkably few archaeological sites dating from prior to European contact have been found in Philadelphia or its surrounding boroughs. The earliest recorded sites within the city date from approximately 5,000 years ago, although it is likely that earlier ones existed and some may still exist in small and scattered areas of undeveloped land.

Within Tinicum Township, the landscape of the refuge consists entirely of tidal marsh with a system of artificial dikes. Some of the dikes are wide enough to support trees and brush on their edges, but close examination of early maps and photographs reveal no natural islands. The only refuge areas suitable for Native American occupation prior to European contact consist of two narrow strips of terrace on the north side of Darby Creek in the town of Folcroft and a larger area within the Eastwick portion, containing the refuge headquarters and maintenance areas. These areas were farmland in the early 20th century but are now wooded. These areas may retain some archaeological potential, though the immediate vicinity of the refuge headquarters consists of deep and remarkably extensive modern fill.

Figure C.1. Historic Maps of Philadelphia Region (such as the example shown here) document the changes in land use and habitats around the refuge since European settlement (Scull 1752).

Soon after European settlement in the mid-17th century, farmers began to extensively dike and ditch tidal marsh to convert it to hayfields. Portions of the refuge dike system follow the trace of dikes dating from the mid-19th century, and likely considerably earlier. That earlier dike system was modified in the mid-20th century by installation of various water control structures, widening of virtually all dikes for construction of roads atop them, construction of interior dikes at some locations, and erosion of considerable lengths that fell out of use. The ditch system, poorly represented on historic maps but visible in early 20th century photographs, has almost completely vanished due to modern erosion and siltation. There are no standing historic structures on the refuge. The only dwelling sites recorded are two farmsteads established in the 1870s or earlier, both of which were obliterated by bridge construction and widening of South 84th Street in the 1970s.

20th Century Influences

Events that destroyed or highly altered what are now refuge lands over the 20th century are well documented in Two Studies of Tinicum Marsh (McCormick et al. 1970). One of the first impacts of the 20th century was the construction of the Philadelphia and Chester Railway Company, a trolley service that provided direct transit

between Chester and Philadelphia from 1901 to November 1946 (Schieck and Cox 1970). This former trolley bed runs parallel to the refuge's southern access road. While the trolley bed is not within the refuge boundary, its construction impacted current refuge lands with extensive cut and fill operations along its corridor. Aerial photos of the refuge area from 1928 document the presence of extensive marsh as well as several dike and road systems (figure C.2). It continues to affect the hydrology and drainage in the area of the impoundment.

Figure C.2. Aerial photograph of John Heinz National Wildlife Refuge lands in 1928 (prior to refuge establishment). Note the presence of extensive marsh and wetlands surrounded by agriculture.

The 1930s saw numerous, and expensive, repairs and alterations by the U.S. Army Corps of Engineers (ACOE). The Federal Works Program Administration, Pennsylvania legislature, and Delaware County all appointed funds to repair the dikes along the southern edge of Darby Creek. In 1935, a proposal for mosquito control led ACOE to construct a series of ditches throughout Tinicum Marsh. Some of these artificial channels are still visible today in the northern half of the freshwater tidal marsh. From the 1930s until the 1950s, several areas within and around Tinicum Marsh were utilized by ACOE for landfills of dredged material (McCormick et al. 1970).

The early 1970s saw the construction of Interstate 95 (I-95) and an interchange system with State Road 420. These major changes resulted in the dredging and filling of many marsh areas around the refuge. Today, these areas remain as permanent open water features where dredging occurred and as either degraded floodplain forest or wetlands dominated by common reed (*Phragmites australis*).

The Folcroft Landfill operated from the 1950s through the 1970s accepting municipal, demolition, and hospital waste. It was closed in 1973 as a result of permit violations and improper management. Closing activities included regrading of the landfill, reducing steep slopes along with covering and seeding the site (USEPA 2006).

In 1980, Congress authorized the purchase of the Folcroft Landfill to increase the size of the refuge. At this time, the U.S. Environmental Protection Agency (USEPA) remains in discussion with potentially responsible parties regarding investigation of the landfill's contamination (USEPA 2006). The refuge will facilitate the landfill cleanup efforts. In 1991, through a bill sponsored by Congressman Curt Weldon, the Tinicum Wildlife

Preserve officially became John Heinz National Wildlife Refuge at Tinicum in honor of the late Senator who was influential in the marsh's preservation.

In February 2000, a subsurface pipeline owned by Sun pipe Company and operated by Sunoco, Inc. ruptured, releasing 191,982 gallons of crude oil into the 145-acre impoundment in the refuge. At the time of the release, the impoundment contained a thick layer of ice that formed a natural barrier which prevented the oil from spreading throughout the impoundment. At its peak, the area affected by the oil spill encompassed approximately 1.6 acres. This included the oil slick floating under the ice and an area of shoreline adjacent to the slick containing emergent, scrub-shrub, and forested wetlands. Sunoco provided initial response personnel to secure the site and to begin the initial cleanup operation. More than 90 percent (173,799 gallons) of the spilled oil was recovered through the cleanup effort. In addition to the 1.6 acres directly impacted by oil contamination, another 1.25 acres were directly impacted by response vehicles and equipment.

Shortly after the oil leak was discovered and concurrent with the initial cleanup efforts, the Service, the PFBC, and the PADEP initiated a cooperative Natural Resource Damage Assessment (NRDA). Subsequently, the U.S. Environmental Protection Agency, Region III (USEPA) issued a Unilateral Administrative Order for the Abatement of Endangerment that required "restoring all areas, including soils and sediments, to the maximum extent possible, to their condition before the discharge of oil." Sunoco and the participating agencies developed a restoration plan. Restoration efforts were completed and a final report was submitted to the USEPA on June 3, 2005 (Entrix, Inc. 2005).

Habitat loss and degradation is the single greatest cause of loss or decline of species across the globe (and in Pennsylvania), threatening over 80 percent of rare and endangered species (Wilcove et al. 1998). Exotic, invasive species that compete with or reduce populations of native species is the second greatest cause of declines (affecting over 50 percent of terrestrial species). In Pennsylvania, an estimated one-third of all plants are nonnative, and 11 percent of all fish are exotics (Goodrich et al. 2001).

Maps of the refuge area dating back to the late 1700s show an area largely comprised of wetlands–likely freshwater tidal marsh, as it was historically present along the Delaware River. Over the following two centuries, agriculture and urbanization slowly encroached on these wetland areas. John Heinz NWR today is largely an island of habitat within its urban surroundings. As a result, large predators and other species that would have once inhabited the area are now gone.

PADCNR compiled an overall habitat quality rank by using estimates of habitat quality for streams, wetlands, forests, and grasslands index for each physiographic region throughout the State. This ranking highlights coastal plain habitats as the only "impaired" habitats within the State of Pennsylvania and highlights the coastal plain region as being home to some of the last remaining habitats for certain wetland species in the State. PADCNR recommends that where possible, wetlands along the Delaware should be restored (Goodrich et al. 2001). Urban forests could be focal points to provide habitat for some tolerant forest wildlife. Reduction of runoff into streams and wetlands should be top priority, along with restoration of natural communities in undeveloped areas (Goodrich et al. 2001).

The Refuge, the Land, and the People

The cultural history of the region reflects changing societal values in the United States. The Lenape and earlier indigenous people, along with European explorers and settlers, valued the marshes and adjacent uplands for agriculture, fishing, and hunting along with its strategic location for trade and transportation. Undoubtedly, this area's ongoing relationship with different cultures and land ethics throughout the centuries has had many impacts on the refuge as it is known today.

As the Tinicum region developed, the perceived value of marshes diminished for the public, which resulted in the fill or dredging of many acres of wetlands. The history of the refuge over the past 50 years reflects a renewed and refined sense of ecological value in respect to habitat protection and conservation.

2.4 Climate Influences and Natural and Anthropogenic Disturbances

The coastal climate of the Mid-Atlantic is characterized by seasonal variations from hot and humid summers to cold winters. The average summer temperature is around 75° Fahrenheit (F), while the average winter temperature is 33°F. Average precipitation totals around 46 inches per year, with an average annual snowfall of around 30 inches (NCDC 2006). July tends to be the warmest and wettest month with an average temperature around 85°F and average monthly rainfall around 4.38 inches. Along with the moderating effects of the coastal climate, hurricanes, tropical storms, and Nor'easters can provide extreme precipitation events (NCDC 2006). In recent years, these large events have caused flooding in and around the refuge.

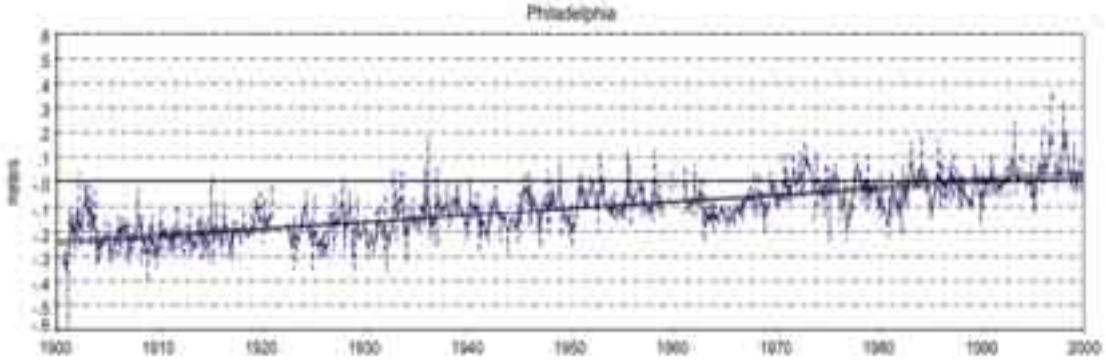
2.5 Current Refuge Conditions

Climate

The coastal climate of the Mid-Atlantic is characterized by seasonal variations from hot and humid summers to cold winters. Along with the moderating effects of the coastal climate, hurricanes, tropical storms, and Nor'easters can provide extreme precipitation events. In recent years, these large events have caused flooding in and around John Heinz NWR.

Like many areas throughout the world, the climate of southeastern Pennsylvania is changing. Over the past century a rise in mean annual temperature of 0.5°F has been recorded. Sea level, as measured by a tidal gauge at Philadelphia, has also risen nearly 1 foot over the past century as shown in figure C.3.

Figure C.3. Monitored sea levels at Philadelphia (1900–2000) displaying nearly a 1-foot rise in sea level over the past century (NOAA/NOS 1999).



Climate change and sea level rise projections for the region will potentially have major influences over the refuge's habitats and their management over the coming decades. The precise ecological impacts to the refuge as a result of a changing climate are largely unknown at this time. Detailed monitoring of habitat conditions and species utilization will be necessary to identify potential shifts in species assemblages or distribution across the refuge and region. However, reports and guidance documents published in recent years provide projections and estimates upon which the refuge can begin to build an understanding of how these potential impacts may manifest themselves and impact the refuge.

According to a recent report released by the Union of Concerned Scientists, temperature projections for the coming decades (2010 to 2039) may make eastern Pennsylvania's climate more closely resemble that of Maryland or northern Virginia as we know it today (UCS 2008). Philadelphia and other large cities already experience extreme heat and air pollution events. The Intergovernmental Panel on Climate Change (IPCC) projects that urban areas throughout North America will experience more severe and longer heat waves and increased impacts from air pollution (UCS 2008; Philadelphia AMS 2008). In their *Summary Report for*

Policymakers, the IPCC warns with "very high confidence" that these extreme temperature events may lead to increasing impacts on forests through disturbances from pests, diseases, and extended periods of high risks of fire. It is important to note that "very high confidence" is defined as a 9 in 10 likelihood of occurrence (IPCC 2007).

Recent sea level rise estimates by the IPCC for global sea level rise could have serious implications for the freshwater tidal marsh within John Heinz NWR. Conservative estimates project a rise between 7 and 14 inches over the next century, while higher estimates range between 10 and 23 inches (UCS 2008). Estimates by Najjar et al. (2000), project global sea level rise between 0.4 to 1.2 inches by 2030 and between 1.6 to 4.0 inches by 2095. Recent estimates compiled by the Climate Adaptation Working Group as part of the Partnership for the Delaware Estuary's report *Climate Change and the Delaware Estuary* (Najjar et al. 2010) indicate relative sea level rise (which accounts for mean sea level rise and land subsidence) may increase 2.6 to 5.6 feet (0.8 to 1.7 meters) by the end of the century.

Sea levels have fluctuated over many millennia. Tidal marshes (both salt and freshwater) typically respond to these fluctuations through two mechanisms: accretion of sediment across the marsh surface (e.g., a rising of the marsh surface elevation) or expansion into nearby (and topographically higher) riparian lands (e.g., conversion of surrounding lands) (Odum et al. 1984). Given the urbanization of the Darby Creek watershed and lands immediately surrounding the refuge, it is unclear which, if either, of these options may allow the necessary adjustment to rising sea levels.

In addition to the rise in water levels alone, the salt line of the Delaware River[1] has potential to shift upstream and into the zone encompassing the refuge. Currently, the refuge is less than 1 mile upstream from the salt line. The intrusion of salt water is problematic for freshwater tidal marshes and freshwater tidal swamps that cannot tolerate salinities greater than 0.5 milligrams per liter. Not only plants, but animal and microbial communities will be altered by salt intrusion (Weston et al. 2006, Craft 2007). As plants with a low salt tolerance become stressed, less productive and die, marsh communities shift to salt-tolerant species.

A major shift in the salinity of waters within the refuge could lead to a major shift in plant communities and species within areas containing freshwater tidal marsh today. Neither the effects of sea level rise on marsh elevations nor salinity levels are well understood within the Delaware Bay at this time, although preliminary analysis shows that the estuary has increased in salinity over time (Kreeger et al. 2010). Monitoring these influences over the coming years will be a major step in developing management options for the refuge in years to come.

In an effort to address the potential effects of sea level rise on United States national wildlife refuges, the Service contracted the application of the Sea Level Affecting Marshes Model (SLAMM) for most refuges in the Service's Northeast Region. This analysis was initiated to inform the decisionmaking process as part of CCP development for each refuge along with other long-term management plans. Changes in tidal marsh area and habitat type in response to sea level rise were modeled using the SLAMM 6.0. This model accounts for the dominant processes involved in wetland conversion and shoreline modifications during long-term sea level rise (Park et al. 1989; *http://www.warrenpinnacle.com/prof/SLAMM*; accessed January 2012).

For John Heinz NWR's analysis, SLAMM 6.0 was run using scenario A1B from the Special Report on Emissions Scenarios (SRES) – mean and maximum estimates (Warren Pinnacle Consulting, 2010). The A1 scenario assumes that the future includes very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Under the A1B scenario, the IPCC WGI Fourth Assessment Report (IPPC 2007) suggests a likely range of 0.7 to 1.6 feet (0.21 to 0.48 meters) of sea level rise by 2090 to 2099 "excluding future rapid dynamical changes in ice flow." The A1B-mean scenario that was run as a part of the refuge-specific analysis falls near the middle of this

[1] This is the zone where low-salinity freshwaters from the Delaware River watershed combine with high-salinity waters from Delaware Bay (characterized as having a concentration of 250 milligrams per liter (mg/L) sodium chloride).

estimated range, predicting 1.3 feet (0.40 meters) of global sea level rise by 2100. To allow for further analysis, SLAMM was also run assuming 1 meter, 1½ meters, and 2 meters of global sea level rise by the year 2100.

According to the SLAMM analysis conducted, John Heinz NWR is predicted to experience significant effects of sea level rise (Warren Pinnacle Consulting 2010). Undeveloped dry land, which makes up roughly one quarter of the refuge, is predicted to be lost at a rate between 24 percent and 54 percent (66 to 145 acres respectively) across the range of sea level rise scenarios. Tidal fresh marsh, which makes up roughly one third of the refuge, is predicted by to be lost at a rate of 9 percent to 84 percent (14 to 352 acres, respectively) once scenarios exceed 0.39 meters of global sea level rise (Warren Pinnacle Consulting 2010). According to these results, the refuge will begin to see the most drastic effects of sea level rise, once it exceeds 0.69 meters. These shifts in habitat type would result in major shifts in the habitat types and species composition across the refuge.

Another concern related to sea level rise is increasing salinity. Increasing sea levels will result in larger tidal volumes that carry more salt water higher up into the estuary. Sea level rise could increase the tidal range in the Delaware system (Walters 1992). Tidal range changes would also likely increase the salinity range over the tidal cycle (Kreeger et al. 2010). A preliminary analysis, completed by Najjar (2010), reviewed existing salinity measurements dating back to 1927 to document trends in salinity within the Delaware Estuary. His results suggest that salinity is increasing at a rate greater than can be explained by streamflow and models of the response of salinity to sea level. This phenomenon could be a result of other forces in the estuary, such as successive channel deepening events that occurred during the period of analysis, which could have also contributed to salinity intrusion due to larger tidal volumes and bathymetric changes (Kreeger et al. 2010). Due to such complexities involved in determining salinity migration at the upper end of the estuary, modeling of potential changes in salinity resulting from sea level rise could not be completed at the time of this writing.

Again, the IPCC warns with “high confidence” (or an 8 in 10 chance) that, “the resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbances (e.g. flooding, drought, wildfire, insects, ocean acidification) and other global change drivers…” (IPCC 2007). Heavy rain and snow events are anticipated for many parts of North America. For John Heinz NWR, being at the base of the Darby Creek watershed, already highly urbanized and experiencing frequent flooding, this prediction will only lead to more frequent flood events over the coming decades.

Over the last century, the annual average temperature in Pennsylvania increased by over 0.5°F (UCS 2008; NOAA 2008). This warming has resulted in many climate-related changes such as more frequent days with temperatures above 90°F, a longer growing season, increased heavy precipitation events, less winter precipitation in the form of snow and more as rain, and rising sea surface temperatures and sea level (Hayhoe et al. 2007).

Being located in a physiographic region where the ranges of many species overlap between northern and southern regions, the piedmont and coastal plain, plant, fish, and animal populations are diverse. These shifts in temperature and precipitation will likely impact the plant and animal populations adapted to the historic climate of the Mid-Atlantic. As summers are projected to become warmer across the Northeast, many plant species are likely to shift ranges northward (Iverson et al. 2008).

As outlined in earlier chapters, the refuge has acted as an ecological oasis within the highly urbanized lands surrounding Philadelphia. It has provided refuge for many species that use its habitats for migratory stopovers, nesting, spawning, and feeding. Habitat fragmentation has long been associated with reductions in habitat quality and resilience. This aspect of the refuge and its habitats will undoubtedly play a role in how they respond to a changing climate.

Hydrology and Geomorphology

John Heinz NWR is located at or slightly above sea level. Consequently, Darby Creek and the freshwater tidal marsh within the refuge contain a daily tidal fluctuation of around 6 feet Darby Creek flows through the refuge just upstream from its confluence with the Delaware River. Collectively, the Darby Creek and Cobbs Creek (a

major tributary of Darby Creek) watersheds drain approximately 74.1 square miles by the time they reach the refuge (USGS 2009).

As part of the *Restoration Management Plan for the Lower Darby Creek* (Salas et al. 2006), baseline geomorphic stream data was collected and analyzed for trends erosion and sinuosity from historic (1965 to 1990) and more recent (2000) aerial photographs along with topographic and other maps displaying the refuge area dating between (1757 and 2004). Darby Creek throughout much of the refuge is characterized by a braided stream channel with variable sinuosity. This channel type is common in coastal tidal streams near river deltas and tends be a relatively stable channel. However, major changes to the stream or watershed such as loss of vegetation, channel alterations, and urbanization, can affect stream morphology and cause the stream channel to adjust significantly (e.g., cause erosion and deposition) (Salas et al. 2006).

The basic geomorphic assessment of Darby Creek and other tributaries within the refuge generally reflect this inherent stability and response to major impacts. The majority of streams within the refuge have remained relatively stable over the past 40 years and longer. Analysis of historic aerial photographs and other maps show Hermesprota and Little Thoroughfare Creeks and portions of Darby Creek appearing relatively unchanged. However, major changes have been noted on Bow Creek and on other portions of Darby Creek.

Bow Creek, which historically connected Darby Creek and the Delaware River across what is now Philadelphia International Airport, is today completely isolated from Darby Creek. Darby Creek itself has displayed several signs of adjustment, most notably during the 1980s. Analysis of aerial photos from 1980 and 1990 show that the multi-channeled Darby's main channel cut through the center of Tinicum Marsh, shortening its total length by nearly half (from 8,400 linear feet to 4,800 linear feet). It is unclear what influenced this dramatic shift or whether the blockage of Bow Creek may have influenced this alteration of Darby Creek. The channel has remained relatively unchanged since this last adjustment period.

Many of the areas in and around the refuge were historically freshwater tidal marsh. As discussed previously, loss and alteration of wetlands dates back centuries, as early as the first Dutch settlements of the 1640s, when many marsh areas around the Tinicum region were diked for agriculture. More recent losses of tidal marsh occurred between the 1950s and early 1970s, when several areas of the refuge were filled or dredged. As a result of these large-scale disturbances, altered hydrology, invasive species introductions, and high levels of deer browse continually impact many of the natural communities within the refuge. As observed as part of the Delaware Riverkeeper Network's field surveys conducted in 2005, these areas are typically dominated by near monocultures of nonnative invasive species, contain fill and debris, un-natural amounts of open water habitat, and lack proper ecosystem structure (Salas et al. 2006).

The refuge also contains a 145-acre open water impoundment. For most visitors to the refuge, the impoundment is the focal point of their visit. Historically, the impoundment was managed as open water with periodic tidal fluctuation. In recent years, the Service has managed the water levels within the impoundment to benefit migratory waterfowl and shorebirds. This periodic drawing down of the impoundment and the presence of mud flats provide some of the best stopover habitat for migrating shorebirds in Pennsylvania. The area also serves as a wintering ground for over 20 species of waterfowl by providing stopover habitat for 1,100 to 1,400 individuals per day between September and March (Green et al. 2008).

Soils

The Soil Survey of Philadelphia County shows the lands of the refuge being comprised of marsh soils and urban land (e.g., organic and mixed fill) (NRCS 2009). As discussed in previous sections, the natural soil composition of most, if not all, of the refuge lands consisted of silty alluvial soils deposited over the last 12,000 years. However, significant soil disturbances that occurred during the 20th century altered the soil structure (and consequently the hydrology) of many areas in and around the refuge. Thus, most upland areas within the refuge are comprised of organic fill material. Despite this significant impact, many of the riparian forest communities that naturally occur within this region (coastal plain and floodplain forests) seemed to have established in many of these areas.

Water Pollution

The refuge is located within highly urbanized and industrial surroundings, making it vulnerable to many factors that could negatively affect ecosystem and wildlife health. Point source and nonpoint source pollution within the Darby Creek watershed and Delaware Estuary affects water quality and available food chain support for ecosystems providing habitat at the refuge.

Water quality in the refuge is the result of the inputs to three major streams: Darby Creek, Cobbs Creek (a major tributary to the Darby), and the Delaware River. For management purposes, the tidal portions of Delaware River tributaries are considered to be part of the river. Twice each day, river water enters the Darby system during high tide. In addition, various fish species freely move between Darby Creek and the Delaware River. Because of these factors, the tidal portion of Darby Creek is considered part of the Delaware River Basin Commission's Interstate Pollution Control Zone 4 (DRBC 2004). A zone-by-zone assessment of the attainment of designated water quality uses by the DRBC indicated that Zone 4 attained its recreational designated uses, but not its aquatic life uses (DRBC 2004). The contribution from each of these sources varies depending upon hydrologic, climatologic and anthropogenic conditions. Thus, the water quality found in the refuge is highly variable and complex. The status of water quality and aquatic life is determined by various chemical, physical and biological parameters.

Data for Darby and Cobbs Creeks have been collected by the Pennsylvania Department of Environmental Protection (PADEP), the U.S. Geological Survey (USGS), the Philadelphia Water Department (PWD), Darby Creek Valley Association (DCVA), the Academy of Natural Sciences (ANS), and others. Long-term monitoring of the tidal Delaware River occurs through the Delaware River Basin Commission (DRBC) with the Delaware Department of Natural Resources and Environmental Conservation (DNREC) conducting the sampling via contract from DRBC. The refuge is fortunate that a number of reports have been produced that describe the status of the Darby Creek watershed based on recent data: the Darby Creek Rivers Conservation Plan (DCVA 2005), Lower Darby Creek Area 33 EPA Facility Report (NOAA 2000), and PWD's Darby-Cobbs Characterization Report (PWD 2002).

During the early 20th century, the Delaware River in the vicinity of Philadelphia and Camden was the most polluted stretch of river in the United States, if not the world (Albert 1988). In September 1946, no dissolved oxygen was found in this reach of the river; a "dead zone" that extended for a distance of more than 20 miles. In the intervening years, a massive effort was made to clean up the Delaware Estuary. By the mid-1980s, major reductions in nutrient pollution resulted in needed water quality improvements. The reach where Darby Creek enters the Delaware has shown substantial improvement in this regard.

Fish data collected in recent years indicate that Darby Creek has greater species diversity including some pollution intolerant species. Biometric scores suggest that the downstream reach of Darby Creek is "good," although upstream locations were "fair" or "poor" (PWD 2002). Cobbs Creek fish metrics indicate only "fair" or "poor" (PWD 2002).

Environmental Contaminants

Environmental contaminants have a major impact on the health and fitness of wildlife present on the refuge. The Folcroft Landfill, which became part of the refuge in 1980, is part of the Lower Darby Creek Area Superfund Site. The Lower Darby Creek Area includes four other sites within a 2-mile stretch along Darby Creek (NOAA 2000). Of the five sites, only Folcroft Landfill is located on the refuge. Coordination with the EPA regarding contaminant remediation is ongoing. Ultimately, the Service will likely take the lead on completing restoration activities on this site.

Over the years, there have been widespread fish advisories in the river and various tidal tributaries, not including Darby Creek. These advisories are the result of contaminants found in fish, including polychlorinated biphenyls (PCBs). In 2003, Service staff collected 31 brown bullheads (*Ameiurus nebulosus*) as part of a habitat assessment related to Folcroft and Clearview Landfills with the main objective being to determine the prevalence of liver and skin tumors, preneoplastic lesions, and barbel abnormalities. Their findings reported a 26 percent prevalence of liver tumors and a 6 percent prevalence of skin tumors in brown bullheads (less than 260 mm in length) from Lower Darby Creek. Liver tumor prevalence is indicative of a contaminated habitat. Levels found were more than five times the Baumann (2002) criteria for distinguishing highly contaminated Areas of Concern from less contaminated Areas of Recovery (Pinkney et al. 2004).

A large crude oil spill in 2000 located on the refuge impacted the reproduction of resident turtle populations. Research was conducted to determine the effect of crude oil exposure on female snapping turtle and painted turtle fertility, reproductive output, and development of offspring (Bell 2005). There was no significant difference in egg fertility between female snapping turtles exposed to oil or control turtles. However, female snapping turtles had significantly lower fertility of eggs in 2002 compared to 2000. There was no difference in reproductive output between exposure groups or years for snapping turtles or painted turtles. Most snapping turtle embryos died early in development, and there were significantly more early deaths for oil exposed snapping turtles than controls. Control painted turtles not only had a higher incidence of abnormality than control snapping turtles, but malformations were more severe in the former than the latter. Oil exposure exacerbated developmental problems in snapping turtles, causing increased incidence and severity of deformity in embryos.

The study noted that both species exhibit high rates of embryonic and adult deformity and that although the refuge offers many advantages to the resident turtle populations, background pollution places a developmental burden on the life history of turtles that was exacerbated by exposure to crude oil. Despite the deformities documented in both oil-exposed and control turtles, exposure to crude oil did not appear to have significantly affected the fertility or relative clutch size of snapping turtles or painted turtles (Bell 2005).

Natural Community Types

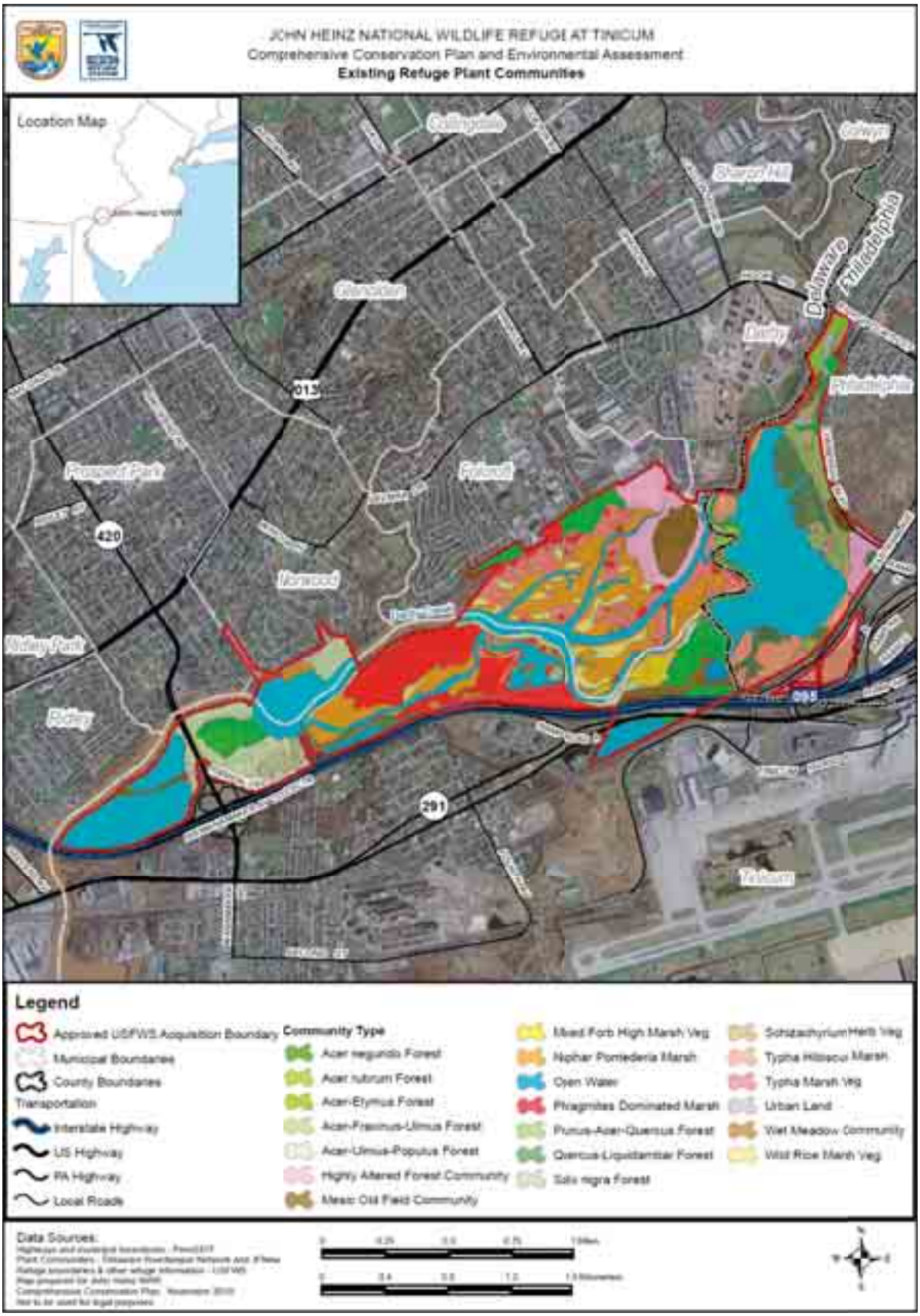
Refuge lands include a variety of ecosystems including open water, forests, grasslands, and tidal and nontidal wetlands. Many of the ecosystems (and the habitats they support) have been degraded, damaged, or destroyed as a result of the numerous impacts previously cited. Despite these alterations, many of these impacted ecosystems have the potential to be restored through various management actions and specific projects. Other areas, including portions of the freshwater tidal marsh, contain healthy and intact plant communities that will require a more protection-focused approach to management. Some ecosystems support plant communities or species of concern.

The Refuge System adopted the National Vegetation Classification System (NVCS) developed by the Nature Conservancy and the Natural Heritage Network as a standard for classifying plant communities. The classification contains hierarchical levels of community specificity. The narrowest level within the classification is the Association. The Restoration Management Plan for the Lower Darby Creek (Salas et al. 2006) included an inventory of the plant communities present at John Heinz NWR. Table C.1 lists the NVCS Associations found within the various broad-scale habitats of the refuge. Some communities were identified only down to the Alliance level, which is a broader category above Associations. Where possible, the conservation status rankings have been indicated as referenced by NatureServe Explorer and the Pennsylvania Natural Heritage Program. Conservation status rankings indicate the degree of imperilment of a species of community on either a global, national, or State level. The location and extent of these plant communities is displayed on map C.3.

Table C.1. Broad Habitat Types and National Vegetation Classification System Associations and Alliances Found Within John Heinz National Wildlife Refuge Based on the National Vegetation Classification System.

Broad Habitat Types	Natural Community Types (Association or Alliance)	Conservation Ranking (Global; State)
Freshwater Tidal Marsh	*Atlantic Coast Wild Rice Tidal Marsh*	*G4; S1*
	Freshwater Intertidal Mudflat	*G3/G4; S1*
	Freshwater Tidal Mixed Forbs High Marsh	*GNR; S1*
	Nuphar lutea Tidal Marsh	*GNR; SNR*
	Peltandra virginica - Pontederia cordata Tidal Herbaceous Vegetation	*G3/G4; S1*
	Phragmites Dominated Marsh	*GNR; SNR*
	Typha (angustifolia, latifolia) - (Schoenoplectus spp.) Eastern Herbaceous Vegetation	*G5; SNR*
Freshwater Nontidal Wetlands	*Phragmites Dominated Marsh*	*GNR; SNR*
	Typha angustifolia - Hibiscus moscheutos Herbaceous Vegetation	*GNR; SNR*
Open Water	*Freshwater Intertidal Mudflat*	*G3; S1*
Coastal Plain Forest	*Quercus palustris - Quercus bicolor - (Liquidambar styraciflua) Mixed Hardwood Forest*	*G3; S2*
Floodplain Forest	*Acer negundo Forest*	*GNR; SNR*
	Acer rubrum Forest	*GNR; SNR*
	Acer saccharinum - Acer negundo / (Elymus virginicus) Forest	*G4; SNR*
	Acer (rubrum, saccharinum) - Fraxinus spp. - Ulmus americana Forest	*G4; S1*
	Acer saccharinum - Ulmus americana - (Populus deltoides) Forest	*G4; S3*
	Salix nigra Temporarily Flooded Shrubland	*GNR; SNR*
	Prunus serotina - Acer rubrum - Amelanchier canadensis - Quercus spp. Forest Alliance	*GNR; SNR*

Map C.3. Plant Communities of John Heinz National Wildlife Refuge



These community types are described in more detail within chapter 2 of the draft CCP under development for the refuge.

Rare Plant Species and Exemplary Natural Communities

John Heinz NWR protects the last significant remnant of freshwater tidal marsh within the State of Pennsylvania. Several of the natural communities within the freshwater tidal marsh are ranked as S1 - critically imperiled within the State (typically 5 or fewer occurrences or very few remaining individuals or acres), or S3 - vulnerable in the State either because they are rare and uncommon, or found only in a restricted range, or because of other factors making them vulnerable to extirpation (typically 21 to 100 occurrences). The forested habitats of the refuge also contain communities of significant conservation status. Several coastal plain and floodplain forest communities identified on the refuge are ranked as S1 (critically imperiled), S2 (imperiled), or S3 (vulnerable).

Many of the plant species associated with the freshwater tidal marsh are also unique to Pennsylvania. Pennsylvania DCNR notes that portions of the freshwater tidal marsh support several State rare species such as waterhemp ragweed (*Amaranthus cannabinus)*, field dodder (*Cuscuta pentagona)*, Walter's barnyard-grass (*Echinochloa walteri)*, an unnamed eupatorium (*Eupatorium rotundifolium*), forked rush (*Juncus dichotomus)*, and shrubby camphor-weed (*Pluchea odorata)* (VanDervort-Sneed personal communication 2010).

Wildlife

John Heinz NWR was established in 1972 for the purpose of preserving, restoring, and developing the natural area known as Tinicum Marsh, to promote environmental education, and to afford visitors an opportunity to study wildlife in its natural habitat. The refuge is an important migratory stopover along the Atlantic Flyway. The diverse habitats support a variety of resident and migratory wildlife including 300 species of birds recorded since 1950, as well as many mammals, fish, amphibians, reptiles, insects, and plants. Refer to appendix A for the refuge's comprehensive list of species of conservation concern.

Birds

The refuge is a complex of critical habitats for birds in the highly urbanized landscape of greater Philadelphia. It has been designated as an Important Bird Area by the National Audubon Society. While most of the over 300 bird species identified at the refuge use it as a migratory stopover, more than 80 species have been recorded nesting on the refuge over the years. Several species are also State-listed threatened or endangered species or species of State or national management concern.

State endangered species such as the least bittern (*Ixobrychus exilis*) are known to breed at the refuge. Other Pennsylvania endangered species that have been observed at the site during migration, but are considered occasional or rare in abundance, include: yellow-crowned night-heron (*Nyctanassa violacea*), common tern (*Sterna hirundo*), black tern (*Chlidonias niger*), king rail (*Rallus elegans*), short-eared owl (*Asio flammeus*) and loggerhead shrike (*Lanius ludovicianus*). The king rail historically nested at the site (prior to 2000). The piping plover (*Charadrius melodus*) listed as extirpated in Pennsylvania, is an occasional "accidental" occurrence during migration.

Bald eagles (*Haliaeetus leucocephalus*), a former federally listed species, have historically used the refuge for hunting and roosting. The first known bald eagle nest on the refuge was built in 2009 with the first two refuge eaglets successfully hatched in 2010. The adult pair returned to breed on the refuge in 2011.

The peregrine falcon (*Falco peregrinus*), another former federally listed species, is often observed from the refuge during its migration. A number of active peregrine nests now occur in the Philadelphia area with these birds also potentially increasing their use of refuge habitats (Cohen and Johnson 2004).

The State–listed, threatened species, upland sandpiper (*Bartramia longicauda*) and yellow-bellied flycatcher (*Empidonax flaviventris*), have been observed at the site, but are considered rare or occasional in abundance, observed primarily during the migratory season. Ospreys (Pandion haliaetus) are present during migration and are frequently observed throughout summer. Two osprey platforms have been added to the refuge in hopes to lure in nesting birds. State species of special concern that utilize the refuge are

the black-crowned night-heron (*Nycticorax nycticorax*) and northern harrier (*Circus cyaneus*). The black-crowned night-heron nested (52 nests reported) at the site prior to 1996 but are now considered transient. Northern harrier is observed less frequently at the site since grassland buffer habitat has disappeared due to habitat successional changes and development. The green-winged teal (Anas crecca) and marsh wren (*Cistothorus palustris*) are State rare that nest at the refuge. The pied-billed grebe (*Podilymbus podiceps*), American coot (*Fulica americana*), Wilson's snipe (*Gallinago delicata*), Swainson's thrush (*Catharus ustulatus*), prothonotary warbler (*Protonotaria citrea*) and summer tanager (*Piranga rubra*) are other State candidate-rare species that have been observed at the refuge as well (Cohen and Johnson 2004).

Mammals
John Heinz NWR is one of 44 Important Mammal Areas designated by the Pennsylvania Wildlife Federation. The designation was awarded noting the refuge as supporting northern river otter use on occasion and being the last potential location for the marsh rice rat (*Oryzomys palustris*) in the State.

While no formal inventories have been conducted to date, numerous mammals are known to inhabit the refuge. Two nonnative species present include the Norway rat (*Rattus norvegicus*) and house mouse (*Mus musculus*). The gray squirrel (*Sciurus carolinensis*) is a common species found throughout upland habitats of the refuge, where it plays an important role in seed dispersal. Other common open space species supported by the refuge include the northern short-tailed shrew (*Blarina brevicauda*); the meadow vole (*Microtus pennsylvanicus*), white-footed mouse (*Peromyscus leucopus*) and several other rodent species, as well as raccoons (*Procyon lotor*), mink (*Mustela vison*), skunks (*Mephitis mephitis*), opossums (*Didelphis virginiana*), eastern cottontail rabbit (*Sylvilagus floridanus*) (PNHP 2008). Woodchuck (*Marmota monax*) and red fox (*Vulpes vulpes*) have been observed damaging the impoundment levee system as they attempt to burrow dens into dikes (Stolz, personal communication 2008). Feral domestic house cats pose a serious invasive mammalian predatory threat to all small native wildlife (birds, mammals, reptiles and amphibians) and need to be removed from the refuge when found.

Muskrat (*Ondatra zibethica*), long-tailed weasel (*Mustela frenata*), and least shrew (*Cryptotis parva*) are fairly common. Recent records also indicate beaver (*Castor canadensis*) and river otter (*Lontra canadensis*) occur occasionally on the refuge. It is also likely that the refuge sees occasional use by coyotes, which have been documented on adjacent property at Philadelphia International Airport (Stolz, personal communication 2008). Bats are frequently observed on the refuge during warmer seasons and a formal species diversity and population survey would provide valuable information with recent declines of these important creatures due to white nose syndrome and habitat disturbances.

White-tailed deer (*Odocoileus virginianus*) are another mammal species supported by the refuge. Refuge staff has conducted on-the-ground deer population surveys for several years. These surveys have been conducted by counting deer driven systematically from various portions of the refuge. Although this method does have potential for error, such as omitting or double counting individuals (McCullough 2001), the results of these surveys consistently record population numbers in the range of 200 to 240 deer per square mile. Given that the refuge currently covers approximately 1,000 acres (about 1.5 square miles) of marsh and upland ecosystems, the refuge's current density ranges between 133 to 160 deer per square mile. Density levels at which a deer population is considered "ecologically sustainable" varies depending on the habitat involved and the variables studied. A separate deer and songbird population relationship study in northwestern Pennsylvania concluded that the threshold level for negative effects on songbird richness was between 20 and 38 deer per square mile (deCalesta 1994). Additional research has shown a population density not exceeding 20 deer per square mile is optimal for forest regeneration (Rooney 2001). The Service and the U.S. Department of Agriculture Division of Wildlife Services have drafted a deer management plan. Once finalized, this plan will provide detailed guidance on management of the resident deer population based on observable impacts to (and recovery of) the refuge's habitats, not on a particular density target (D'Angelo personal communication 2009).

Reptiles and Amphibians
While no formal inventories have been conducted, there are eight turtle, three snake, and eight frog and toad species known to inhabit the refuge. Common frog and toad species such as bull frog (*Rana*

catesbeiana), green frog (*Rana clamitans melanota*), wood frog (*Rana sylvatica*), pickerel frog (*Rana palustris*), spring peeper (*Pseudacris crucifer*), American toad (*Bufo americanus*), and Fowler's toad (*Bufo woodhousei fowleri*) have all been heard calling during their respective breeding seasons. The State-endangered species, coastal plain leopard frog (*Rana sphenocephala* or *Rana utricularia*), is known to inhabit and breed at the refuge in shallow open water and isolated vernal pools.

The northern water snake (*Nerodia sipedon sipedon*), eastern garter snake (*Thamnophis sirtalis sirtalis*), and northern brown snake (*Storeria dekayi dekayi*) are all found at the refuge. These common species are generally associated with forested habitats and nearby open water.

Numerous turtles are known to use the open water habitats of the impoundment, freshwater tidal marsh, and Darby Creek. Species common to these habitats at the refuge include common musk turtle (*Sternothaerus odoratus*), eastern box turtle (*Terrapene c. carolina*), painted turtle (*Chrysemys picta x marginata*), common map turtle (*Graptemys geographica*), eastern spiny softshell turtle (*Apalone spinifera*) and the nonnative, invasive red-eared slider (*Trachemys scripta elegans*) (USFWS 2009b). The refuge also supports several rare species of turtle such as the formerly State endangered (now considered potenially extirpated in Pennsylvania) eastern mud turtle (*Kinosternon subrubrum*), the northern diamond-backed terrapin (*Malaclemys terrapin*), and a significant population of the State-threatened red-bellied turtle (*Pseudemys rubriventris*). These rare species are more commonly associated with the freshwater tidal marsh and open waters of Darby Creek. However, some of these have been known to move to and from the 145-acre impoundment as well.

Historically, the refuge and surrounding lands supported additional species of reptiles. The wood turtle (*Clemmys insculpta*) has been identified on lands adjacent to the refuge (Sunoco tank farms). Although considered extirpated in Pennsylvania, a gravid female eastern mud turtle was documented in nearby, from a road kill, in Bucks County in 2008. State surveys for the species were then conducted by East Stroudsburg State University including the refuge and two small populations of eastern mud turtles were found in nearby Bucks County with continued hopes that they may still or in the future be rediscovered on the refuge (Stolz, personal communication 2010)

A number of other reptile and amphibian species native to southeast Pennsylvania could potentially be discovered on the refuge where suitable habitat occurs within their native ranges. Such species include black rat snake, black racer, eastern ribbon snake, eastern Milk snake, five-lined skink, eastern fence swift, gray tree frog, eastern chorus frog, red-backed salamander, long-tailed salamander, dusky salamander, red salamander, and spotted salamander. Numerous nocturnal anuran vocalization surveys have been conducted as well as turtle mark-recapture studies with Drexel University and University of Philadelphia. At this time, a herpetological survey that includes terrestrial habitat and breeding areas to establish baseline data is necessary for long-term management of the refuge's reptile and amphibian fauna. Dr. Jim Spotila of Drexel University has indicated turtle nest predation on the refuge may be as high as 98 percent (most likely from raccoon, red fox, skunk and opossum) (Stolz personal communication 2009).

Fish

The refuge provides not only unique terrestrial habitat, but aquatic habitat as well. Freshwater tidal marshes, like Tinicum Marsh, are used by many aquatic species for spawning, year-round food and shelter, and as a nursery and rearing habitat (Mitch and Gosselink 1993). Freshwater tidal marshes are also a mixing zone for various groups of fish typically associated with certain habitats. Freshwater species, such as sunfish (*Lepomis spp.*) and catfish (*Ictalurus spp.*), estuarine species including killifishes (*Fundulus diaphanus*) and mummichogs (*Fundulus heteroclitus*), anadromous species including shad (*Dorosoma spp.*) and herrings (*Alosa spp.*), and the catadromous American eel (*Anguilla rostrata*) can all be found within Tinicum Marsh. A list of fish species observed on the refuge and in adjacent similar marsh areas around the Philadelphia International Airport can be found in table C.2 (Herpetological Associates 2001; NOAA 2000; Sweka and Mohler 2010).

Darby Creek and the open water areas of the freshwater tidal marsh may also provide suitable habitat for the federally and State-listed endangered shortnose sturgeon (*Acipenser brevirostrum*) and Atlantic

sturgeon (*Acipenser oxyrhynchus*) (PNHP 2008; PGC and PFBC 2005). While this species has not been confirmed within the refuge itself, it is known to occur in the nearby Delaware River, thus making protection of suitable habitat within the refuge a priority.

Invertebrates

While no invertebrate inventories have been conducted to date within the refuge or along Darby Creek, recent findings along the nearby Delaware River indicate that invertebrate conservation may be an added focus along Darby Creek. A series of mussel beds was identified in the stretch of river connected to the confluence with Darby Creek. Seven mussel species were identified within the Delaware River, including two species which were thought to be extirpated from Pennsylvania and New Jersey: the alewife floater (*Anodonta implicate*), and the tidewater mucket (*Leptodea ochracea*). Other species included two species considered critically imperiled: the pond mussel (*Ligumia nasuta*), and yellow lampmussel (*Lampsilis cariosa*), two species considered vulnerable: the creeper (Strophitus undulates) and the eastern floater (*Pyganodon cataracta*) and one common species the eastern elliptio (*Elliptio complana*).

Table C.2. Fish Species and Utilization of Lower Darby Creek and Freshwater Tidal Marsh Habitats (Herpetological Associates 2001; NOAA 2000; Sweka and Mohler 2010)

Species		Habitat Use			
Scientific Name	**Common Name**	**Spawning Area**	**Nursery Grounds**	**Shelter**	**Adult Forage**
Freshwater Species					
Ameirus catus	White catfish	~	~	~	~
Ameirus nebulosus	Brown bullhead	~	~	~	~
Catostomus commersoni	White sucker	~	~		~
Cyprinus carpio	Common carp	~	~		~
Etheostoma olmstedi	Tessellated darter	~	~	~	~
Gambusia holbrooki	Eastern mosquitofish	~	~	~	~
Hybognathus regius	Eastern silvery minnow	~	~	~	~
Ictalurus punctatus	Channel catfish	~	~	~	~
Lepomis cyanellus	Green sunfish	~	~		~
Lepomis gibbosus	Pumpkinseed	~	~		~
Lepomis macrochirus	Bluegill	~	~		~
Micropterus salmoides	Largemouth bass	~	~		~
Notemigonus crysoleucas	Golden shiner	~	~	~	~
Notropis hudsonius	Spottail shiner	~	~	~	~
Perca flavescens	Yellow perch	~	~		~
Pimephales notatus	Bluntnose minnow	~	~		~
Poxomis nigromaculatus	Black crappie	~	~		~
Umbra pygmaea	Eastern mudminnow	~	~	~	~
Estuarine-Marine Species					
Brevoortia tyrannus	Atlantic menhaden				~
Fundulus diaphanus	Banded killifish	~	~	~	~
Fundulus heteroclitus	Mummichog	~	~	~	~
Leiostomus xanthurus	Spot	~	~		~
Menedia beryllina	Inland silversides	~	~	~	~

Species		Habitat Use			
Scientific Name	**Common Name**	**Spawning Area**	**Nursery Grounds**	**Shelter**	**Adult Forage**
Estuarine-Marine Species (cont.)					
Micropogonias undulatus	Atlantic croaker	~	~		
Trinectes maculatus	Hogchocker		~	~	~
Anadramous Species					
Alosa aestivalis	Blueback herring	~	~	~	
Alosa mediocris	Hickory shad	~	~	~	
Alosa pseudoherangus	Alewife	~	~	~	
Dorosoma cepedianum	Gizzard shad	~	~		~
Morone saxatilis	Striped bass		~		~
Morone americana	White perch	~	~		~
Mugil cephalus	Striped mullet		~		
Catadromous Species					
Anguilla rostrata	American eel		~	~	~

Nonnative, Invasive Plants

Federal management of nonnative, invasive plant species is guided by the planning efforts outlined in Executive Order 13112 signed into law on February 3, 1999. The Executive Order requires that a Council of Departments dealing with invasive species be created and develop a National Invasive Species Management Plan every 2 years. The first such plan was released in January 2001, providing the basis for Federal management of invasive species. The Executive Order defines an invasive species as a species that is a) nonnative to the ecosystem under consideration and b) whose introduction causes (or is likely to cause) economic or environmental harm to human health.

The planning and inventory work completed as part of the Restoration Management Plan for the Lower Darby Creek in 2005 identified invasive plant species as one of the top impacts to refuge plant communities and a management priority for the coming years. The inventory identified nonnative invasive species present throughout John Heinz NWR and ranked their management priority based on (a) the extent to which the species is established on the refuge, (b) the potential ecological impact of the species on refuge plant communities, and (c) the degree of management difficulty involved in controlling the species. The results of this inventory and prioritization are included in table C.3 (Salas et al. 2006). Management prescriptions for identified invasive species are included in appendix B.

Recent Research and Monitoring Projects

Impoundment Management Study

From 2005 to 2007, John Heinz NWR participated in the Service's Region 3 and Region 5 Impoundment Management Study. The goal of this study was to determine the effects of timed water level management related to use by waterfowl, shorebirds, and wading birds. This study found that waterfowl were observed throughout the year, while shorebirds and waders were observed primarily between April and October. Shorebird frequencies peaked around the spring and fall migration periods, and wader frequencies peaked in mid-summer. Shorebird species composition was dominated by peeps (semipalmated sandpiper, unidentified peep, least sandpiper) in both the spring (approximately 80 percent of all shorebirds observed) and fall (approximately 90 percent). Waterfowl species most abundant during the spring migration period were ducks. Four species (northern shoveler, green-winged teal, mallard, northern pintail) accounted for less than 70 percent of the waterfowl during that period. Species composition was similar during the fall, with mallards and gadwall accounting for 47 percent of the waterfowl seen. Canada geese became the second-most abundant species during this same period. Great egrets and great blue herons dominated the waders observed during the breeding season (Green et al. 2008).

White-tailed Deer Research and Management Plan

In 2008, the Service contracted with the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services (APHIS-WS) to assist in studying the impacts of the deer population on plant communities within the refuge. Based on their analysis, they reported that the white-tailed deer population at John Heinz NWR was believed to surpass the carrying capacity of available habitat, causing severe ecological damage that negatively affected all other native species of plants and animals.

Table C.3. Invasive Species Identified at John Heinz National Wildlife Refuge and Their Associated Management Ranking.

Species	Ranking	Impact	Extent	Management Difficulty	Control Priority and Focus
Japanese knotweed *Polyganum cuspidatum*	1	●	○	●	**High** Prevent New Introductions and Eradicate Localized Occurrences
Porcelainberry *Ampelopsis brevipedunculata*	2	◉	○	◉	
Multiflora rose *Rosa multiflora*	3	◉	○	◉	
Reed canarygrass *Phalaris arundinacea*	4	◉	○	◉	
European privet *Ligustrum arvense*	5	○	○	○	
Common Reed *Phragmites australis*	6	●	◉	●	
Purple Loosestrife *Lythrum salicaria*	7	●	◉	●	
Mile-a-minute weed *Polyganum perfoliatum*	8	●	◉	○	**Medium** Eradicate Localized Occurrences and Reduce Size of Existing Populations
Japanese honeysuckle *Lonicera japonica*	9	●	◉	●	
Norway maple *Acer platanoides*	10	◉	◉	●	
Oriental bittersweet *Celastrus orbiculatus*	11	◉	◉	◉	
Tree-of-heaven *Ailanthus altissema*	12	◉	◉	◉	
Japanese hops *Humulus japonica*	13	◉	◉	◉	
Bush honeysuckle *Lonicera maackii*	14	◉	◉	◉	**Low** Focus Primarily on Areas of Conservation Significance
Japanese stiltgrass *Microstegium vimeneum*	15	●	●	◉	
Garlic mustard *Alliaria petiolata*	16	●	●	●	

● = High

◉ = Medium

○ = Low

Chapter 3.
Resources of Concern

3.1 Introduction

Resources of concern are the focal point of the HMP. The HMP policy (620 FW 1) defines "resources of concern" as: "All plant and/or animal species, species groups, or communities specifically identified in refuge purpose(s), [Refuge] System mission, or international, national, regional, state, or ecosystem conservation plans or acts. For example, waterfowl and shorebirds are a resource of concern on a refuge whose purpose is to protect "migrating waterfowl and shorebirds." Federal or state threatened and endangered species on that same refuge are also a resource of concern under terms of the respective endangered species acts."

The Service is entrusted by Congress to conserve and protect migratory birds, federally listed threatened and endangered species, interjurisdictional fish, and certain marine mammals (trust species). Each refuge also has its own specified purpose(s) for which it was created, which guide its management goals and objectives. Within these purposes, refuges support other elements of biological diversity such as locally rare plants, invertebrate and vertebrate species, natural communities, and the ecological processes that contribute to the biological integrity and environmental health at the refuge, ecosystem, and broader scales (USFWS 1999, 2003).

The first step in developing a habitat management strategy is to define a refuge's resources of concern in light of the multiple mandates, policies, purposes, and regional and national plans applicable to the particular refuge. The resources of concern need to be identified and prioritized in order to best focus the management objectives of the refuge. The following details the resources considered in development of John Heinz NWR resources of concern.

3.2 Potential Resources of Concern

There are many national, regional, State, and local plans and reports that have identified conservation concerns for areas in and around John Heinz NWR. The myriad of species and management recommendations provided in each plan was compiled into a list of potential resources of concern that cross referenced each plan and priority focus with a particular species noted of conservation significance. The final resources of concern were developed based on the priority species of greatest significance that were most likely to be impacted by management, and existing and future habitat at the refuge.

Refuge Purpose
John Heinz NWR was created in 1972 for three primary purposes:

1. "Preserving, restoring, and developing the natural area known as Tinicum Marsh....a wildlife interpretative center for the purpose of promoting environmental education, and to afford visitors an opportunity for the study of wildlife in its natural habitat." (86 Stat. 891, dated June 30, 1972).

2. 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).

3. "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).

The Service is mandated to manage John Heinz NWR to fulfill the purpose for which it was created. Thus, the resources of concern identified for the refuge must protect Tinicum Marsh, support the migratory bird management program, or protect fish and wildlife resources.

Service Trust Resources
While the refuge purpose is the foremost determinant of a particular refuge's management, managing trust resources is also a priority of refuges. Trust resources include:
Migratory Birds
A list of all species of migratory birds protected by the Migratory Bird Treaty Act (16 U.S.C. 703–711) and subject to the regulations on migratory birds are contained in subchapter B of title 50 CFR §10.13. The Service's Migratory Bird Program also maintains subsets of that list that provide priorities at the national, regional, and ecoregional (bird conservation region) scales. The primary sources of information that the refuge used to identify potential migratory birds species of concern included the following:

- Bird Conservation Region (BCR) 30, PIF Physiographic Area 44
- Continental and regional plans for landbirds, waterfowl, shorebirds, and marshbirds
- Rocky Mountain Bird Observatory Species Assessment Database
- Service Birds of Conservation Concern (USFWS 2008b)
- Status and trend information for refuge bird surveys and regional assessments

Interjurisdictional Fish
Interjusridictional fish include "populations that two or more states, nations, or Native American Tribal governments manage because of their geographic distribution or migratory patterns (710 FW 1.5H)." Examples include anadromous species of salmon and free-roaming species endemic to large river systems, such as paddlefish and sturgeon (Director's Order No. 132, 6[c]). The primary sources of information that the refuge used to identify potential aquatic habitats and fish species of concern included the following:

- Service Regional Fisheries Office List of Priority Fisheries
- National Fish Habitat Action Plan (Sportfishing and Boating Partnership Council 2006)

Wetlands
Wetlands provide habitat for approximately one-third of federally listed species and for migratory waterfowl. The Emergency Wetlands Resources Act of 1986 (Pub. L. 99–645 (100 Stat. 3582), approved November 10, 1986, authorizes the purchase of wetlands from Land and Water Conservation Fund. It requires the Secretary to establish a National Wetlands Priority Conservation Plan, which requires the states to include wetlands in their Comprehensive Outdoor Recreation Plans.

The refuge's wetlands are unique to Pennsylvania as they protect the last one-third square mile of freshwater tidal marsh remaining in the State (PNHP 2008).

Threatened and Endangered Species
The Endangered Species Act (16 U.S.C. 1531–1544, December 28, 1973, as amended 1976 to 1982, 1984 and 1988) states in Sec. 8A.(a) that:

> *"The Secretary of the Interior (hereinafter in this section referred to as the "Secretary") is designated as the Management Authority and the Scientific Authority for purposes of the Convention and the respective functions of each such Authority shall be carried out through the United States Fish and Wildlife Service."*

The act also requires all Federal departments and agencies to conserve endangered species and threatened species and that they shall utilize their authorities in furtherance of the purposes of this act.

To identify federally listed, threatened or endangered species of relevance to John Heinz NWR, we reviewed the following:

- The Federal List of Threatened and Endangered Species
- Recovery Plans for federally listed species in our region

3.3 Biological Integrity, Diversity, and Environmental Health

The Refuge Improvement Act states that, in administering the Refuge System, the Service shall "ensure that the biological integrity, diversity, and environmental health of the System are maintained…" (601 FW 3; also known as the "Integrity Policy"). The Service (2003) defines these terms as follows:

Biological Diversity	The variety of life and its processes, including the variety of living organisms, the genetic differences between them, and the communities and ecosystems in which they occur.
Biological Integrity	Biotic composition, structure, and functioning at genetic, organism, and community levels comparable with historic conditions, including the natural biological processes that shape genomes, organisms, and communities.
Environmental Health	Composition, structure, and functioning of soil, water, air, and other abiotic features comparable with historic conditions, including the natural abiotic processes that shape the environment.

Where possible, refuge management restores or mimics natural ecosystem processes or functions that support fish and wildlife and thereby maintain biological diversity, integrity, and environmental health (BIDEH). Given the continually changing environmental conditions and landscape patterns of the past and present (e.g., rapid development, climate change, sea level rise), relying on natural processes is not always feasible, nor always the best management strategy, for conserving wildlife resources. Uncertainty about the future requires that the refuge manage within a natural range of variability rather than emulating an arbitrary point in time. Rather than trying to maintain stability, we will maintain mechanisms that allow species, their genetic strains, and the natural communities they rely upon to evolve with changing conditions.

Meretsky et al. (2006) stated that the Integrity Policy directs refuges to assess their importance across landscape scales and "forge solutions to problems arising outside refuge boundaries." Regional land use problems include habitat fragmentation and lack of connectivity, high levels of contaminants, and incompatible development or recreational activities.

To manage the natural communities and the habitats they support within the natural range of variability, a review of maps, reports, and other resources was completed to assess historic, current, and future potential for the refuge. To assess the historical condition, site capability, current regional landscape conditions, biological diversity, and environmental health data pertinent to the refuge, the following resources were used:

- Maps and associated data on site history and capabilities:
  - Kuchler's (1964) potential natural vegetation
  - 1757 Map of Philadelphia and Parts Adjacent
  - 1850 Map of Philadelphia and Baltimore Railroad routes adjacent to current refuge lands
  - 1898 Topographic Map of Philadelphia and Delaware Counties
  - 1968 Vegetation Survey Map from *Two Studies of Tinicum Marsh* (McCormick et al. 1970)
- Maps of existing landscape conditions displaying watershed boundaries, habitat connectivity, as well as land use conditions and trends surrounding the refuge
- Maps of existing natural communities and invasive species distributions within the refuge
- Soil Survey of Philadelphia and Delaware Counties
- Global and regional trends in climate change and water quality
- Pennsylvania's Natural Heritage Program information on rare, declining, threatened, or endangered species, as well as unique natural communities
- Pennsylvania's Wildlife Action Plan (PGC and PFBC 2005)
- Status and trend information for potential species of concern as documented in regional and State assessments and reports.

Based on a review of the existing and historical data listed above, a list of habitats that contain naturally occurring elements of BIDEH was developed in order to determine those habitats that contain the most ecological and biological integrity (see table C.4).

Table C.4. Summary of Habitats that Represent Existing BIDEH for John Heinz National Wildlife Refuge.

Habitat Type (Plant communities that represent existing BIDEH)	Populations and Habitat Attributes	Natural Processes Responsible for These Conditions	Limiting Factors and Threats
Freshwater Tidal Marsh	Mix of several native herbaceous species dominated plant communities: *Atlantic Coast Wild Rice Tidal Marsh; Mixed Forbs High Marsh; Nuphar lutea Tidal Marsh; Peltandra virginica - Pontederia cordata Tidal Marsh; Typha (angustifolia, latifolia) - (Schoenoplectus spp.) Marsh* *Potential Conservation Species: supports a variety of fish, landbirds, waterbirds, waterfowl, and shorebirds.*	Tidal hydrology in combination with marsh surface elevation. Natural accretion of alluvial sediments across marsh surface. Developmentof natural channel morphology within marsh plain.	Altered hydrology; water quality degredation and contamination; invasive species; sea level rise.
Coastal Plain Forest	Pin oak *(Quercus palustris)*- Swamp white oak *(Quercus bicolor)* - sweetgum *(Liquidambar styraciflua)* Mixed Hardwood Forest. General characteristics include: Oaks occupy at least 25 percent of canopy. Shrub and vine species are variable and may include dogwoods (*Cornus spp.),* spicebush *(Lindera benzoin),* virginia creeper *(Parthenocissus quinquefolia),* and elderberry *(Sambucus canadensis)*. Herbaceous species vary but generally include a mix of sedges (*Carex* spp.), wild rye (*Elymus* spp.), bittercress (*Cardamine* spp.), mayapple (*Podophyllum* sp.), and other species. *Potential Conservation Species: American woodcock, northern oriole, wood thrush, coastal plain leopard frog.*	Seasonally wet or saturated silt and clay soils; regeneration of dominant canopy species through a combination of period fire of canopy openings.	Excessive deer browse prevent forest regeneration, reducing species diversity, and loss of native shrub layer; Invasive species outcompete remaining native species.

Habitat Type (Plant communities that represent existing BIDEH)	Populations and Habitat Attributes	Natural Processes Responsible for These Conditions	Limiting Factors and Threats
Floodplain Forest	Mix of multiple hardwood forest plant communities. General characteristics include: red and silver maple, and boxelder (*Acer rubrum, saccharinum* and *negundo*), green ash (*Fraxinus pensylvanica*), and willow (*Salix nigra*) canopy. Shrub species may include spicebush *(Lindera benzoin),* winterberry *(Ilex verticillata),* and elderberry *(Sambucus canadensis)*. Herbaceous species vary but generally include a mix of sedges (*Carex* spp.), wild rye (*Elymus* spp.), touch-me-not (*Impatiens* spp.), manna-grass (*Glyceria* sp.), and other species.	Seasonally flooded or saturated silt and clay soils; Regeneration of dominant canopy species through flood-induced canopy openings.	Excessive deer browse prevent forest regeneration, reducing species diversity, and loss of native shrub layer; Invasive species outcompete remaining native species.
	Potential Conservation Species: American woodcock, northern oriole, wood thrush, coastal plain leopard frog.		
Darby Creek	Open, tidal-influenced, flowing water; spawning habitat for estuarine and anadromous; provides fish passage to spawning areas in upper reaches of nontidal reaches of Darby Creek; provides forage for a variety of mammals, reptiles, amphibians, and birds.	Perennial tidal flows and periodic flooding. Open water with periodic mudflats.	Environmental contaminants; Degraded water quality; upstream migration barriers; sea level rise
	Potential Conservation Species: alewife, blueback herring, American eel		

Habitat Type (Plant communities that represent existing BIDEH)	Populations and Habitat Attributes	Natural Processes Responsible for These Conditions	Limiting Factors and Threats
Wet Meadows and Grasslands	Mix of native warm and cool season grasses and forbs including little bluestem (*Schizachyrium scoparium*), indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), wild rye (*Elymus* spp.), asters (*Symphyotrichum* spp.), goldenrods *(Soldago* spp.), bergamot (*Monarda fistulosum*), and other species.	Naturally maintained by periodic fire; contain seasonal saturation or flooding.	Loss of species and structure due to natural succession; invasive species outcompete native grass and forb species; patch size typically too small to provide nesting opportunities for grassland birds; requires intensive and regular maintenance
	Potential Conservation Species: American woodcock, sedge wren, short-eared owl		

3.4 Priority Resources of Concern

The potential resources of concern table (appendix C) contain a large number of species with a broad array of habitat needs. Prioritizing those species and their habitats is necessary in order to determine where to focus refuge management strategies. This process must consider to which species and habitats the refuge can make the greatest contribution in the context of the Refuge System, its surrounding landscape, and state, regional, and national priorities. To guide this process, the following concepts were considered:

- Achieving refuge purposes and managing for trust resources as well as biological diversity, integrity, and environmental health can be addressed through the habitat requirements of "focal species" or species that may represent guilds that are highly associated with important attributes or conditions within habitat types. The use of focal species is particularly valuable in addressing Service trust resources such as migratory birds.

- Indicator species can be used as a representative of biological integrity and environmental health (BIDEH). Indicator species presence, absence, abundance, or relative well-being in a given habitat niche serves as a marker of overall health of its required habitat type. For example, where the Delmarva Fox Squirrel served as an umbrella species for mixed hardwood forest habitats at Prime Hook NWR, the long-horned beetle (*Prionus laticollis*) can serve as an excellent indicator species of oak-dominated hardwood habitats as it is only found in healthy, mature oak stands with diverse mixed hardwood associates.

- Reference habitats and ecological communities can provide comparison data for habitat management where BIDEH parameters of refuge habitats have been degraded or severely impacted. Reference areas of freshwater tidal marsh (both on and off refuge) that contain intact BIDEH parameters can be utilized to compare both the degree of impacts to degraded marsh areas, as well as provide a measure of management success.

- BCR plans are increasing their effectiveness at ranking and prioritizing those migratory birds most in need of management of conservation focus. Although all species that make it to a ranked BCR priority list are in need of conservation attention, we selected focal species that ranked as High or Moderate in Continental Concern with a High to Moderate BCR Responsibility. See *www.abcbirds.org/nabci.com* for BCR rules used to rank birds.

- Focal species selected that were not birds (e.g. red-bellied turtle, American eel, Coastal Plain leopard frog) were identified as resources of concern due to concern over their population status range wide, because they are under review for inclusion on the Federal List of Endangered and Threatened Species, or because the Pennsylvania Wildlife Action Plan or Natural Heritage Program identified them as conservation priorities. Fish species were reviewed using regional and State conservation priorities and Federal trust species and trends.

- Habitat conditions on or around the refuge may limit its capability to support or manage for a potential species of concern. We evaluated the following site-specific factors:
  - Patch size requirements
  - Habitat connectivity
  - Incompatibility of surrounding land uses
  - Environmental conditions: soils, hydrology, disturbance patterns, contaminants, predation, invasive species
  - Specific life history needs

- The likelihood that a potential species of concern would have a positive reaction to management strategies.

- The ability to rely on natural processes to maintain habitat conditions within a natural range of variability suitable to the focal species.

- The ability to use adaptive management (flexibility and responsiveness of the refuge and the habitats) in the face of changing environmental conditions (e.g., climate change).

Table C.5 lists the priority resources of concern (and their primary focal species) for the refuge based on the information compiled and analyzed for this plan. Priority resources of concern are similar to "conservation targets" and the terms can be used interchangeably.

Table C.5. Priority Resources of Concern and Associated Focal Species for John Heinz National Wildlife Refuge.

Habitat	Species		Utilization By Species
Freshwater Tidal Marsh	Birds	American Bittern	B,M
		American Black Duck	B,M
		Black-bellied Plover	M
		Greater Yellowlegs	M
		King Rail	B,M
		Least Bittern	B,M
		Marsh Wren	B,M
		Sedge Wren	B,M
		Short-eared Owl	B,M
	Reptiles	Red-bellied Turtle	B,Y
Impoundment and Open Water	Birds	Black-crowned Night Heron	B,M
		Great Egret	B,M
		Least Tern	M
		Bald Eagle	M,W
	Reptiles	Red-bellied Turtle	B,Y
Coastal Plain and Floodplain Forests	Birds	American Woodcock	B,M
		Northern Oriole	B,M
		Prothonotary Warbler	M
		Wood Thrush	B,M
		Worm-eating Warbler	M
	Amphibian	Coastal Plain Leopard Frog	B,Y
Darby Creek	Birds	Bald Eagle	M,W
	Fish	Alewife	B, J
		Blueback Herring	B, J
		Striped Bass	B, J, Y
		American Eel	B, J

Utilization Codes:
B - Breeding
M - Migratory
W - Wintering
Y – Year-round
J - Juvenile or nursery habitat

3.5 Priority Habitat Types and Associated Focal Species

Refuge management most often focuses on restoring, managing, or maintaining habitats or certain habitat conditions to benefit a suite of focal species or a suite of plants and animals associated with a particular habitat. The priority habitats of John Heinz NWR were identified (table C.6) based on information compiled (e.g., site capability, historic condition, current vegetation, conservation needs of wildlife associates). As part of that process, we identified any limiting factors that affect the refuge's ability to maintain those habitats. Since all management activities cannot feasibly be undertaken at the same time, we have prioritized habitats (table C.7) based on the following ranking factors:

- Where management actions would provide the greatest conservation benefit to identified priority species
- Current habitat conditions and the urgency of needs for active management
- Landscape-level rankings for particular habitats

Although a habitat may be ranked as "moderate" priority, this should not be interpreted as meaning that the habitat type does not provide valuable habitat to a variety of species or contribute to the overall diversity, integrity, and health of the refuge. In some cases, habitats may not require active management by the refuge, or may represent an area where there is little management capability.

Table C.6. Focal Species, Associated Habitat Requirements, and Other Species Benefitting from Habitat Management at John Heinz National Wildlife Refuge.

Focal Species	Habitat Type	Habitat - Vegetation Structure
American Bittern	Freshwater Tidal Marsh	Platform nests constructed of reeds and grasses near the water. Found in marshes and wetland borders along lakes, ponds, rivers, and streams (Stewart and Robbins 1958, Swift 1987).
Black-bellied Plover		Breeding in northern tundra. Nonbreeding habitat includes mudflats, beaches, wet savanna, shores of ponds and lakes, wet meadows, flooded fields (Stiles and Skutch 1989). Feeds on insects and crustaceans (Terres 1980).
Greater Yellowlegs		Nonbreeding habitat includes marshes, ponds, lakes, stream margins and sand and gravel bars, lagoons, and coastal mudflats (AOU 1983, Stiles and Skutch 1989). Nests in muskeg country or at other wetlands near water.
King Rail		Nest is an elevated platform, often with a canopy and ramp, attached to plants in shallow water or waterside vegetation. Freshwater marshes, upland-wetland marsh edges (Harrison 1978, Meanley 1969).
Least Bittern		Nest is placed near open water in dense vegetation. Freshwater marshes with dense, grass-like vegetation (Palmer 1962, Kushlan 1973, Aniskowicz 1981, Weller 1961).
Marsh Wren		Nests in marsh vegetation. Found in freshwater marshes in cattails, bulrush, and reeds (AOU 1983).
Short-eared Owl		Nests on ground, generally in slight depression, often beside or beneath a bush or clump of grass. Many nests are near water but generally are on dry sites. Hunts in meadows, marshes and open lands (Bent 1938, Clark 1975, Terres 1980).
Sedge Wren		Nesting takes place among dense, tall growths of sedges and grasses in wet meadows/marshes. Breeding habitat includes marshes; moist meadows with scattered low bushes; upland margins of ponds and marshes (AOU 1983, Harrison 1978).
Red-bellied Turtle		Nests dug in soft soil in open areas near water, often in disturbed sites. Resides in relatively large deep bodies of water: creeks, rivers, marshes, ponds (USFWS 1981, DeGraaf and Rudis 1983, Ernst and Barbour 1972).

Focal Species	Habitat Type	Habitat - Vegetation Structure
American Black Duck	Impoundment and Open Water	Nest sites are very diverse; favors wooded swamps and marshes, shallow margins of lakes, streams, bays, mud flats, and open waters (Frazer et al. 1990a and 1990b, Merendino and Ankney 1994).
Bald Eagle		Nest is usually in mature trees near water. Feeds near water, e.g., lakes, reservoirs, large ponds, freshwater marshes, shorelines (Andrew and Mosher 1982, Green 1985, Campbell et al. 1990).
Black-crowned Night Heron		Marshes, swamps, wooded streams, shores of lakes, ponds, lagoons; freshwater situations. Nests in roosts with other heron species (AOU 1983).
Great Egret		Nests are found in adjacent trees or shrubby growth, preferably on islands. Usually in colonies with other heron species. Feeds in shallow rivers, streams, ponds, lakes, marshes (Spendelow and Patton 1988).
Least Tern		Beaches, bays, estuaries, lagoons, lakes, and rivers. Rests on sandy beaches, mudflats, and dikes (AOU 1983, Stiles and Skutch 1989).
Semipalmated Sandpiper		Breeds on grassy and shrubby tundra. Nonbreeding habitat includes mudflats, sandy beaches, shores of lakes and ponds, and wet meadows (AOU 1983). In spring at Delaware Bay, consumes large numbers of horseshoe crab eggs (Castro and Myers 1993, Botton et al. 1994).
Spotted Sandpiper		Nests near freshwater in both open and wooded areas, less frequently in open grassy areas away from water; on ground in growing herbage or low shrubby growth, or against log or plant tuft (Harrison 1978). In Minnesota, successful breeders usually returned to same area to breed the next year (Reed and Oring 1993).

Focal Species	Habitat Type	Habitat - Vegetation Structure
American Woodcock	Coastal Plain and Floodplain Forests	Nests in early and mid successional forests. In Virginia, it has been known to nest in mid-aged, open growth, mixed pine-hardwood forests on lowland flood plains (Roboski and Causey 1981). Nonbreeding habitat includes upper reaches of estuaries and occasionally coastal meadows (del Hoyo et al. 1996)
Northern Oriole		Nests near the outer edge of the tree canopy. Found in open woodland, deciduous forest edge, riparian woodland, partly open situations with scattered trees, shade trees (Stiles and Skutch 1989).
Prothonotary Warbler		Breeds in mature deciduous floodplain, river, and swamp forests; wet lowland forests. In migration, habitat includes dry woodland, scrub, thickets (Bushman and Therres 1988).
Wood Thrush	Coastal Plain and Floodplain Forests	Nests in bottomlands and other wet hardwood forests. Nests usually are placed in a crotch or are saddled on a branch of a shrub, sapling, or large tree (Bertin 1977, Roth 1987, Roth et al. 1996).
Worm-eating Warbler		Nests in well-drained oak forests, oak forests along river terraces, and drier islands of nontidal forested wetlands (Stasz 1996).
Coastal Plain Leopard Frog		Breeds in forested and mixed grassland vernal pools and shallow waters containing submerged plant stems or sticks. Rest of year spent in nearby moist vegetation (Ryan and Winne 2001).
American Eel	Darby Creek	Catadromous: lives in freshwater; spawns in ocean. Matures in freshwater and estuarine streams and rivers. Feeds on insects, worms, crayfish and other crustaceans, and small frogs and fishes (Haro and Krueger 1991, Feunteun et al. 2003).
Alewife		Marine populations spawn in quiet portions of rivers (fresh or brackish water) or in small streams. Juveniles leave freshwater and estuarine nursery areas generally in summer or fall (Fay et al. 1983).
Blueback Herring		Spawns spawns in shallow areas covered with vegetation within freshwater or brackish, tidally influenced portions of coastal rivers (Bozeman and Van Den Avyle 1989). Juveniles emigrate from freshwater in summer or fall (Fay et al. 1983).
Striped Bass		Uses rivers, tidally influenced fresh waters, and estuaries for spawning and nursery areas (Thomson et al. 1978). Young primarily consume zooplankton and other invertebrates; adults are predatory on fish and larger crustaceans (Hassler 1988).
American Woodcock	Wet Meadows and Grasslands	Nests in early and mid successional forests. In Virginia, it has been known to nest in mid-aged, open growth, mixed pine-hardwood forests on lowland flood plains (Roboski and Causey 1981). Nonbreeding habitat includes upper reaches of estuaries and occasionally coastal meadows (del Hoyo et al. 1996)
Northern Oriole		Nests near the outer edge of the tree canopy. Found in open woodland, deciduous forest edge, riparian woodland, partly open situations with scattered trees, shade trees (Stiles and Skutch 1989).
Coastal Plain Leopard Frog		Breeds in forested and mixed grassland vernal pools and shallow waters containing submerged plant stems or sticks. Rest of year spent in nearby moist vegetation (Ryan and Winne 2001).

Table C.7. Priority Habitats and Their Potential Limiting Factors at John Heinz National Wildlife Refuge.

Habitat Type	Reasons for Priority Ranking	Limiting Factors and Threats
Highest Priority Habitats		
Freshwater Tidal Marsh	Supports a globally rare and regionally endangered plant community (ranked S1/G3); supports Federal trust fish and wildlife species, State -listed endangered species as well as many other species labeled as high priority species in BCR 30 and State Wildlife Action Plan. Last intact example of unique remnant natural community in State of Pennsylvania. Supports wetlands, a Federal trust resource, and original purpose of the refuge.	Altered hydrology; water quality degradation and contamination; invasive species; sea level rise.
Coastal Plain Forest	Supports a globally rare and regionally endangered plant community (ranked S1/G3); Important habitat for species labeled as priority species in BCR 30. Supports wetlands, a Federal trust resource, and State-listed endangered species.	Excessive deer browse; invasive species;
Floodplain Forest	Important habitat for species labeled as priority species in BCR 30 and unique community (ranked S1/G3). Supports wetlands, a Federal trust resource, and State-listed endangered species.	Excessive deer browse; invasive species;
Impoundment/Open Water	Important habitat for species labeled as priority species in BCR 30 and as a foraging stopover along Atlantic flyway. Supports wetlands, a Federal trust resource, and original purpose of the refuge.	Requires intensive management and maintenance for optimal ecological benefits; invasive species; inadequate water control structure for water level manipulation
Medium Priority Habitats		
Darby Creek	Supports federally and State-listed endangered species as well as trust species. Requires little or no on-the-ground management at the refuge, but provides opportunities for protection and enhancement work with regional and watershed-based partnerships.	Degraded water quality and environmental contamination; upstream migration barriers; sea level rise
Grasslands	Isolated grassland habitat restorations provide habitat diversity and foraging habitat for landbird species, as well as provides additional habitat for State-listed amphibian and reptile species.	Succession; invasive species; requires regular maintenance

3.6 Conflicting Habitat Needs

Given the diversity of goals, purposes, mandates, and conservation priorities for the Refuge System, it is not uncommon to have conflicting management priorities at a refuge. Balancing the types and proportion of habitats (and their management) requires special consideration and process for determining the best course of action. John Heinz NWR contains habitat and management decisions that require such consideration.

Impoundment Management

The 145-acre impoundment was constructed in the early to middle part of the 20th century, while some portions of the dike system could potentially date back to the mid-17th century. The impoundment, due to its size, location, and potential for waterfowl and shorebird habitat make it the focal point of many refuge visitors. As such, this is an area that the refuge has spent considerable time and resources to determine its best use and appropriate management.

Until the past several years (since 2005), the 145-acre impoundment has largely been managed as an open water habitat for migrating and breeding waterfowl. Some tidal fluctuation occurs when water control structures allow bi-lateral flows in and out of the impoundment. There have been occasional water level drawdowns historically for maintenance purposes throughout this period. However, this type of management had limitations in its ecological benefits. Fish kills resulted from algal blooms and depleted oxygen levels. Management for waterfowl generally excluded potential benefits for other waterbirds and shorebirds. Invasive species such as purple loosestrife (*Lythrum salicaria*) and the native spadderdock (*Nuphar lutea*), have spread aggressively under the proper conditions. Control of these invasive species has largely been addressed through chemical application.

Starting in 2005, as part of their Region 3 and Region 5 Impoundment Management Study, the Service has managed the water levels within the impoundment to benefit migratory waterfowl and shorebirds. This periodic drawing down of the impoundment and the presence of mud flats have provided some of the best stopover habitat for migrating shorebirds in Pennsylvania. The area also has served as a wintering ground for over twenty species of waterfowl during this time documenting from 1,100 to 1,400 individuals per day between September and March (Green et al. 2008). This controlled water level management has also somewhat increased the prevalence of purple loosestrife, but has also increased the richness and diversity of fast-growing annual species on exposed mudflats. The potential for loosestrife colonization has been controlled with chemical application.

The results of the Region 3 and Region 5 Impoundment Management Study point to an increased diversity of plant species present and bird species utilizing the impoundment as a result of well-timed and managed water levels. Conflicting issues arise when trying to manage this 145-acre area for optimal and simultaneous use by shorebirds, waterbirds, and waterfowl. Conflicts between species can be resolved in part through timed water level management according to the migration times of various bird groups. Maintaining water levels to depths suitable for multiple groups during a given period also help reduce management conflicts between species and bird groups. Through continuing and improving this adaptive management started in recent years, the refuge can balance the needs of different species of concern within this area.

One limitation to the effective management of the impoundment appears to be the existing water control structure for the impoundment. Originally installed for periodic maintenance drawdowns, the capacity and elevation of the structure make it difficult to lower water levels quickly and to a level ideal for shorebird utilization. A secondary limitation to water level management would be the growth of invasive plant species such as purple loosestrife. If it cannot be controlled annually by chemical applications, it may require a year or two with no drawdown so it can be sprayed and then the root systems kept flooded to help control spread.

Coastal Plain, Floodplain, and Highly Altered Forests

Many of the areas surrounding the 145-acre impoundment and the freshwater tidal marsh contain floodplain forest communities. These habitats support several of the identified focal species listed as resources of

concern–mainly northern oriole, prothonotary warbler, wood thrush, worm-eating warbler, and coastal plain leopard frog. While management of invasive species and the excessive deer browse will improve habitat conditions for all of these species of concern, conflicts arise when considering large-scale restoration projects that have potential to shift the community type present.

One area within the floodplain forest located in the southeastern portion of the refuge is dominated by an exotic gray poplar (*Populus* x *canescens*). This 19-acre portion of forest also contains other exotic species including wineberry (*Rubus phoenicolasius*) and the invasive annual mile-a-minute vine (*Polygonum perfoliatum*). Regeneration within this portion of forest is dominated by new sprouts of gray poplar within canopy gaps. Despite the prevalence of nonnative and invasive species, this area does provide habitat utilized by short-eared owls (a focal resource of concern, a Pennsylvania endangered species, and Service trust species) for nesting as well as various warbler species. Under its direction by Congress, the refuge is required to manage for biological integrity, diversity, and environmental health of the entire system. In most cases, this approach will benefit the trust resources of the Service. Occasionally, this directive conflicts with short-term wildlife needs.

Under these circumstances, the refuge ultimately will seek to restore this 19-acre area to a combination of native floodplain or coastal plain forests replicating nearby natural communities. While evaluation of site conditions (soils, hydrology, existing species coverage and utilization), is necessary before large-scale restoration is undertaken, several other considerations will likely be made to balance current habitat needs with long-term ecosystem goals. To the extent feasible, the refuge can undertake a phased approach to removal of the exotic gray poplar and associated invasive species during off-peak utilization periods (ie. winter, summer). Phased clearing and planting will limit the amount of immediate habitat lost, while working toward long-term restoration goals. A full evaluation of species utilization and restoration options will be necessary prior to starting restoration efforts.

Another location where floodplain forest restoration may conflict with habitat management is in the degraded floodplain forest located adjacent to State Road 420 and Darby Creek in the eastern portions of the refuge. Approximately 57 acres of floodplain forest dominated by silver maple (*Acer saccharinum*), boxelder (*Acer negundo*), American elm (*Ulmus americana*), and eastern cottonwood (*Populus deltoides*) are located in this area. These communities were noted in the Lower Darby Restoration Management Plan (2005) as being severely degraded habitats due to excessive deer browse and invasive species, and the plan recommended a portion of this area be restored to freshwater tidal marsh. Historically, this area was freshwater tidal marsh until the early 1970s when the interchange for State Road 420 and Interstate 95 was constructed. The “Two Studies of Tinicum Marsh” documents the vegetation that was present in this area just prior to its alteration (McCormick et al. 1970).

Restoration of a portion of this area could pose a conflict between the management of species utilizing the floodplain forest habitat with those that would benefit from additional freshwater tidal marsh. When comparing habitat types, the number and types of species that would benefit from additional freshwater tidal marsh greatly outnumber those that utilize floodplain forests. Restoration of this site should utilize a combination of data from reference marsh vegetation, hydrology, and elevation, and channel morphology to restore a healthy and intact marsh. Some floodplain forest will likely need to remain due to existing pipeline right-of-ways and as sound and visual barriers. A preliminary estimate of the site indicates that up to 35 acres of freshwater tidal marsh could be restored in this area.

3.7 Adaptive Management

The priority resources of concern and their respective habitat attributes were used to develop specific habitat objectives. Refuge habitat management objectives must be achievable. Many factors, such as the lack of resources, existing habitat conditions, species response to habitat manipulations, climatic changes, and contaminants or invasive species, may reduce or eliminate the ability of the refuge to achieve objectives. Although these limiting factors were considered during the development of management objectives, conditions are likely to change over the next 15 years and beyond. The refuge will use adaptive management to respond to changing conditions that impair our ability to measure and achieve the habitat objectives. That will require the refuge to establish and maintain a monitoring program to ensure that changing conditions can be detected and responded to adequately and efficiently. The monitoring program will be developed in accordance with 701 FW 2 as a step-down plan.

Chapter 4.
Habitat Goals and Objectives

4.1 Background

The goals and objectives in this chapter were developed through collaboration among managers and biologists from John Heinz NWR and Region 5 of the Service. Prior to their development, John Heinz NWR staff and planners solicited input from a variety of government and nonprofit conservation organizations including the Service's Delaware Bay Ecological Services, NOAA Fisheries staff, USDA-APHIS Wildlife Services, Friends of the John Heinz Refuge, Partnership for the Delaware Estuary, and Delaware Riverkeeper Network. The goals written here are broad so that they may be incorporated into the CCP, which we began to draft in 2010. These goals and objectives will be reevaluated during the CCP process with additional public, State, university, and nongovernmental organization involvement. To develop habitat objectives, refuge staff conducted a comprehensive analysis of habitat requirements for each priority resource of concern (table C.5). To facilitate management, all priority resources of concern were grouped into habitat types, and further investigated reviewing limiting factors and threats to each habitat type (table C.6).

The Service requires habitat objectives be developed using the SMART criteria, specifically that objectives be Specific, Measurable, Achievable, Result-oriented, and Time-fixed. A rationale is provided for each habitat objective in order to summarize the scientific information, expert opinion, and professional judgment used to formulate each objective.

4.2 Habitat Goals and Objectives

GOAL 1 Protect, maintain, and restore where possible, the biological integrity, diversity, and environmental health of southeastern Pennsylvania coastal plain ecological communities that are unique to the refuge and sustain native plants and wildlife, including species of conservation concern.

Objective 1.1 Freshwater Tidal Marsh

Protect the existing 282 acres and restore or acquire an additional 173 acres of freshwater tidal marsh communities throughout the refuge within the next 15 years. Restored marsh would be dominated by native marsh vegetation including, but not limited to, wild rice (*Zizia aquatica*), spadderdock (*Nuphar lutea*), pickerelweed (Pontederia cordata), and tick-seed sunflower (*Bidens spp.*). Restored marshes will reestablish greater than 80 percent coverage of native marsh plant species and tidal hydrology that inundates greater than 90 percent of the marsh plain surface with shallow water (less than 1-foot maximum depth) at mean high tide and results in the development of natural channels across the marsh plain surface.

Rationale

The Pennsylvania Natural Heritage Program estimates that Philadelphia County at one time contained up to 10 to 20 square miles (6,400–12,800 acres) of freshwater tidal marsh. As it is today, historically, these wetlands provided an important breeding spot for many bird, mammal, fish, and insect species. It was also a critical stopover site for migratory waterfowl and shorebirds during their annual migrations. Today, John Heinz NWR protects the 1/3 square mile of freshwater tidal marsh that remains in this part of the State (PNHP 2008). Freshwater tidal marshes are some of the most biologically productive ecosystems in the world because they contain high plant diversity and support more bird use than any other wetland type (Mitch and Gosselink 1993). Coastal marshes (including freshwater tidal marshes) are among the highest priority habitats within BCR 30 due to pressures, rates of loss, or lack of information on present spatial distribution (USFWS 2008).

Although this remnant area of freshwater tidal marsh has been severely impacted over the years, it still supports a variety of species unique to the surrounding landscape and region. Nine of the 22 priority species of concern are primarily associated with this habitat type. At least another 8 of the 22 also utilize the marsh habitat. Vegetation structure, microhabitat conditions (elevations relative to mean high tide, presence of small channels across the marsh plain, occasional shrubs or small trees), and landscape context (surrounding land

use, size, and contiguousness) are more critical habitat components for species of concern, rather than specific plant species. However, the presence of high marsh, that is, portions of marsh that are at the upper extent of the high tide fluctuation and subject to shorter durations of inundation tend to support a greater variety of plant species and suitable nesting sites for species such as American bittern, least bittern, king rail, and marsh rice rat.

Due to recent reports on the effects of climate change, monitoring freshwater tidal and other coastal marshes is considered to be of high importance for their long-term conservation (USFWS 2008). Due to the unique landscape context of the refuge (within the Philadelphia metropolitan area, within a highly urbanized watershed, at the confluence of Darby Creek and the Delaware River, less than 1 mile upstream from the river's salt line) areas of freshwater tidal marsh are particularly vulnerable to changing sea levels. Alteration in the balance of marsh elevations, sediment accretion rates, sea levels, and salinity can potentially have major impacts on the existing marsh area. At this time, it is unclear to what extent sea levels will rise and how it might affect the refuge (UCS 2008). Due to this uncertainty, the refuge needs to create a marsh monitoring program to document and evaluate local trends in sedimentation rates, vegetative cover and species composition, as well as changes in percent of marsh surface as open water at low tide.

Two rare species listed as Pennsylvania-extirpated include the marsh rice rat and the eastern mud turtle. The eastern mud turtle has been identified at the refuge, but has not been confirmed by the Pennsylvania Natural Heritage Program. The marsh rice rat is believed to be extirpated from Pennsylvania (PNHP 2008). However, the freshwater tidal marsh at John Heinz NWR is the last potential habitat for this secretive small mammal. A series of presence or absence surveys throughout the marsh would provide data necessary to confirm the species presence within the State as well as its inclusion as a resource of concern for the refuge.

Chapter 2 documents the many impacts that have altered the extent and quality of freshwater tidal marsh existing today on the refuge. The Restoration Management Plan for Lower Darby Creek documented and mapped areas of historic tidal marsh that have been severely altered and their approximate date of impact (Salas et al. 2006). Some of these areas are suitable locations for restoration of tidal marsh habitat. Refuge staff has recently completed excavation work associated with restoration of tidal marsh to approximately 10 acres of land previously dominated by *Phragmites australis*.

Areas of freshwater tidal marsh less impacted by dredge and fill activities have been impacted by exotic, invasive species introductions. About 60 acres of tidal marsh are currently dominated by *Phragmites australis*. Many of these populations are smaller than 0.5 acres in size. Marsh vegetation and elevation surveys completed in 2005 documented the correlation between marsh plain elevations and species composition. *Phragmites* were found to generally inhabit the same zone as the highly diverse, Freshwater Tidal Mixed Forbs High Marsh ecological community component of the freshwater tidal marsh habitat. These areas of high marsh provide the most suitable nesting habitats for waterbirds associated with this habitat type.

Objective 1.2 Coastal Plain and Floodplain Forests

Over the next 15 years, acquire or restore up to 18 acres of coastal plain and floodplain forest, and manage the existing 34 acres of coastal plain forest and 261 acres of floodplain forest communities. These communities will provide healthy foraging and stopover habitat for migratory bird species and provide breeding habitat for the coastal plain leopard frog by: maintaining a canopy dominated by native trees, increasing native understory shrub and sapling cover by 10 percent, and at least a 15 percent reduction in areal coverage of herbaceous, invasive species as compared to levels inventoried in 2005. Also, we will restore at least 7.7 acres of existing cool-season grass meadows to at least 50 percent cover by native shrub or early successional coastal plain forest species near the 10-acre marsh restoration site and an additional 0.6 acres within the grasslands restored as part of the oil spill wetland mitigation site.

Rationale

Coastal plain and floodplain forests provide important habitat for migrating passerine species. The Mid-Atlantic Coastal Plain in Pennsylvania was historically found only in a 1 to 5 mile-wide strip along the lower 50 miles

of the State's Delaware River frontage. The coastal plain and floodplain forest types covered a significant portion of Philadelphia, supporting a suite of species common to forests further south (PNHP 2008). Focal species of concern identified for this habitat (northern oriole, prothonotary warbler, wood thrush, and worm-eating warbler), other associated species such as the Swainson's warbler, cerulean warbler, Kentucky warbler, Acadian flycatcher, and yellow-throated vireo, are all primarily associated with forested wetlands and have high concern scores within the Mid-Atlantic Coastal Plain (PIF 1999).

The prothonotary warbler and other landbirds utilize mature deciduous floodplain, riverine, and swamp forests primarily for migratory stopover and foraging habitat at the refuge (DeGraaf et al. 1980, Christman 1984). Although this species will utilize the drier portion of the forested wetland gradient, flooded habitats have been shown elsewhere to be preferred and of higher quality (Petit and Petit 1996). Prothonotary warblers are secondary cavity nesters and a good indicator species for permanently flooded forested wetlands. Prothonotary warblers are widespread throughout the extensive swamps and riverine forested wetlands within the Mid-Atlantic region (PIF 1999). However, these habitats are largely unrepresented in this portion of Pennsylvania and along the Delaware River.

Regional conservation plans developed by Partners in Flight and the Atlantic Coast Joint Venture both emphasize the need for inventory and monitoring of nesting sites for forested wetland nesting species such as prothonary warbler, wood thrush, and worm-eating warbler. While these species generally utilize the forest of John Heinz NWR for migratory stopover habitat, other species associated primarily with other habitats sometimes utilize forested areas for forage and nest sites. For example, bald eagles (primarily associated with the impoundment and Darby Creek) require forested areas for nesting sites. The short-eared owl (associated primarily with freshwater tidal marsh) is also known to nest in portions of the coastal and floodplain forests of John Heinz NWR. To better guide forest management at John Heinz NWR, an inventory of existing nesting sites and conditions will provide information to prevent potential damage to nest sites during restoration activities and enhance opportunities in other areas not yet suitable.

Most invasive plants reduce the availability and quality of native habitats, and these can have major impacts on priority bird species (USFWS 2008). The Restoration Management Plan for Lower Darby Creek documented extensive invasive species populations within the coastal plain and floodplain forest ecosystems. Multiflora rose *(Rosa multiflora)*, garlic mustard *(Alliaria petiolata)*, Japanese honeysuckle *(Lonicera japonica)*, Japanese stiltgrass *(Microstegium vimeneum)*, and mile-a-minute vine *(Polygonum perfoliatum)* are the most common invasive plant species found throughout forested habitats (Salas et al. 2006). An abundance of invasive species can result in reduced biodiversity and poor habitat quality. Some herbaceous and vine species (including garlic mustard, Japanese honeysuckle, Japanese stiltgrass, and mile-a-minute vine) can dominate the forest understory and prevent or inhibit tree and shrub regeneration. Many floodplain forest restoration projects in and around the Delaware Valley have resulted in significant degradation or loss as a result of competition with exotic, invasive species (PNHP 2008). Oriental bittersweet, Japanese hops, Japanese knotweed, Chinese wisteria, and bush honeysuckle are also major invasive species in this habitat at John Heinz NWR. In a few cases, some native birds of concern, including northern saw-whet owls, have benefited from the cover provided by entanglements of invasive vines, such as Oriental bittersweet (*Celastrus orbiculatus*) and Japanese honeysuckle (*Lonicera japonica*).

One of the most critical habitat components within forested ecosystems is a well-developed forest structure including canopy trees, sub-canopy trees, understory shrubs, and a diverse ground cover. These structural components provide numerous feeding opportunities as well as protective cover to escape predation. Much of this natural structure has been severely altered within John Heinz NWR as a result of excessive deer browse, as documented in the Restoration Management Plan for Lower Darby Creek (Salas et al. 2006). The impacts of deer on forest ecosystems and their habitat components has been well documented, including their status, trend, and impact within Pennsylvania (Latham et al. 2005). Long-term preservation of nesting habitat, conservation of high-quality habitat, and restoration of degraded areas will not be feasible with continued impacts of an unsustainable deer population.

Reduction of plant species diversity and richness is a commonly noted effect of deer overpopulation. On long affected sites, the establishment and dominance of browse resilient species often is the result. Consequently, deer browse can have a measured effect on the balance between native and introduced species. Studies have repeatedly shown that deer avoid invasive species such as garlic mustard, Eurasian honeysuckle *(Lonicera spp.)*, Japanese barberry *(Berberis japonica)*, and tree-of-heaven *(Ailanthus altissema)* if other sources of food are available (Latham et al. 2005). Deer abundance also alters ecosystem structure by reducing densities of understory trees and eliminating shrubs. Research in central Pennsylvania indicated that the occurrence of canopy gaps increased by 41 percent on lands where deer control efforts were prohibited as compared to State lands where control efforts were undertaken (Pederson and Wallis 2004).

The adverse effects of excessive deer browse are not limited to plant species. It can also alter ecosystems to the extent that they become unfavorable habitats for other wildlife. Gray squirrel, white-footed mouse, and some amphibian species have been shown to decline in areas highly browsed by deer (Elliot 1978; Nixon and Hanson 1987). Subsequently, predators of these species, owls, hawks and other carnivores, decline (Flowerdew and Elwood 2001). At a site in Virginia, a reduction in forest species densities also leads to increased nest predation and lower bird abundance (Leimgruber et al. 1994). These results were reinforced by a study of songbird/deer population relationships in British Columbia that found a 93 percent decrease in bird species dependent on understory vegetation (Allombert et al. 2005).

Refuge biologists have been conducting deer population inventories for more than 5 years. These surveys involve counting deer that are collectively driven systematically from various portions of the refuge. Although this method does have potential for error, such as omitting or double counting individuals (McCullough 2001), the results of these surveys have consistently recorded population numbers in the range of 200 to 240 deer per square mile. By comparison, a deer and songbird population relationship study in northwestern Pennsylvania concluded that the threshold level for negative effects on songbird richness was between 20 and 38 deer per square mile (deCalesta 1994).

Refuge biologists have completed a draft Deer Management Plan in partnership with the U.S. Department of Agriculture's Division of Wildlife Services. This plan will inventory and evaluate the level of deer browse pressure on the refuge habitats and develop a population management plan based on measurable results from browse surveys and vegetation transects. This plan will guide deer management based on its actual on-the-ground impacts to refuge habitats, rather than attempting to achieve an arbitrary density measurement (e.g., deer per square mile or set number of individuals) (D'Angelo and Stolz, personal communication, 2008).

As part of the Deer Management Plan, fenced vegetation plots that exclude white-tailed deer will be incorporated into monitoring. These plots will be used to gauge the potential for natural forest regeneration when browsing by deer is suppressed. Fenced plots will be paired with nearby unfenced plots. 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 fenced plots (D'Angelo personal communication 2009).

Highly altered forests of the refuge consist of existing forested habitats that either have not been completely inventoried to understand and delineate their NVCS community types due to access restrictions (in the case of Folcroft Landfill) or contain substantial variation from natural forest communities typical of the refuge and surrounding region. Management of these habitats focuses on inventory and identification of resources as well as restoration of areas where the need has been identified. As discussed in the prior section, the forests of the refuge are relatively young ecosystems having only been present for the past 20 to 30 years.

This early successional development to forest has led to the development of many coastal plain and floodplain forests typical of the Philadelphia area in most areas. One 19-acre area in particular has resulted in a forest dominated by the fast growing, exotic gray poplar. This portion of forest also contains other exotic species including wineberry (*Rubus phoenicolasius*) and the invasive annual mile-a-minute vine (*Polygonum perfoliatum*). Regeneration within this portion of forest is dominated by new sprouts of gray poplar within canopy gaps. Despite the prevalence of nonnative and invasive species, this area does provide habitat utilized by short-eared owls (a focal resource of concern, a Pennsylvania endangered species, and Service trust

species) for nesting as well as various warbler species.
Evaluation of site conditions (soils, hydrology, existing species coverage and utilization), will be necessary before large-scale restoration is undertaken. Considerations will need to be made to balance current habitat needs with long-term ecosystem goals related to nesting priority species of concern within this area. To the extent feasible, the refuge can undertake a phased approach to the removal of the exotic gray poplar and associated invasive species during off-peak utilization periods (i.e., winter and summer). Phased clearing and planting will limit the amount of immediate habitat lost, while working toward long-term restoration goals.

Objective 1.3 Darby Creek
Over the next 15 years, manage inputs to Darby Creek on the refuge to reduce contaminants, reduce stormwater impacts from the refuge, and provide spawning, nursery, foraging, and cover habitat for anadromous and catadromous fish populations and Federal trust fish and wildlife species, including American eel, striped bass, blueback herring, and alewife.

Rationale
Tidal portions of Darby Creek, in combination with freshwater tidal marsh, provide a unique and productive habitat for many fish species. Some estuarine species, such as killifishes and mummichogs (*Fundulus* spp.) complete their entire life cycle in estuarine portions of rivers, creek, and tidal marshes. Anadromous fish, such as the blueback herring and alewife, tidal streams, and rivers like Darby Creek and its side channels provide nursery habitat for juveniles (Odum et al. 1984). American eel, the only catadromous fish species in Atlantic Coast estuaries, spends most of its adult life in freshwater estuaries and are common in tidal creeks, rivers, and marsh channels (Lippson et al. 1979). Thus, improving water quality and restoring suitable channel morphology where possible is critical to maintaining healthy BIDEH parameters that support fish species.

The National Fish Habitat Action Plan (NFHAP) outlines several management strategies that can help guide aquatic habitat management on the refuge, as well as connecting habitats both up and downstream. Restoration efforts by local and regional organizations within the Darby Creek watershed support components of Strategy 2 (Restoring natural flow and habitat variability to streams and rivers). Dam removal and other fish barrier removal efforts along Darby Creek support Strategy 3 (Reconnecting fragmented river systems and spawning and nursery habitats). While these efforts are mainly located beyond the boundaries of John Heinz NWR, Strategy 3 can be supported at the refuge by freshwater tidal marsh restoration efforts that incorporate the development of shallow, sinuous, marsh surface channels that support spawning and nursery habitat for estuarine and freshwater fish species.

Water quality in the refuge is a highly variable and complex phenomenon resulting from inputs of three major streams: Darby Creek, Cobbs Creek (a major tributary to the Darby), and the Delaware River. The contribution from each of these sources at any given time varies depending upon tidal, hydrological, climatological, and anthropogenic conditions. The refuge is fortunate in that a number of reports have been produced recently that describe and summarize the status of the Darby Creek watershed based on recent data including the Darby Creek Rivers Conservation Plan (DCVA 2005), Lower Darby Creek Area 33 EPA Facility Report (NOAA 2000), and PWD's Darby-Cobbs Characterization Report (PWD 2002).

The Darby Creek watershed has numerous problems, most of which can be characterized as being derived from excessive urbanization. Cobbs Creek, a major tributary of Darby Creek has been found to be an area of significantly lower quality than Darby Creek (DCVA 2005). Urbanization has resulted in large amounts of impervious surface, which in turn is impacting the refuge through increasing stormwater runoff, introducing various toxic metals, resulting in algal-related impacts on in-stream oxygen resources, de-stabilizing stream banks, impairing and decreasing biological habitats, and decreasing stream base flows.

These impairments cause biological impacts. Fish data indicate that Darby Creek has greater species diversity including some pollution intolerant species. Biometric scores suggest that the downstream reach of Darby Creek is "good," although upstream locations were "fair" or "poor." Cobbs Creek fish metrics indicate only "fair"

or "poor" (PWD 2002). Research completed by the Service in 2004 found a significantly higher number (26 percent) of liver tumors and skin lesions in brown bullheads (*Ameiurus nebulosus*) collected from Darby Creek, as compared to those collected from nearby reference sites. The suspected source of this contamination is elevated levels of Polycyclic aromatic hydrocarbons (PAHs) in Darby Creek. According to the study authors, the EPA has identified 19 significant disposal or fill sites adjacent to Darby Creek from 1953 to 1983, including many sites that should still be considered significant potential sources of PAHs to Darby Creek (Pinkney et al. 2004).

The Folcroft Landfill, which became part of the refuge in 1980, is part of the Lower Darby Creek Area Superfund Site, which also includes the Clearview Landfill, located just upstream of the refuge, and four other sites within a 2-mile stretch along Darby Creek (NOAA 2000). Coordination with the EPA regarding contaminant remediation is ongoing. As a result, no restoration activities for the Folcroft Landfill are proposed in this plan. Ecological restoration plans will need to be coordinated with the EPA upon remediation of the contamination.

Due to the complexity and regional-scale of these water quality impacts, there is unfortunately little that can be done to alleviate these concerns through management on the refuge. However, the refuge can play an active role in coordination and technical assistance toward efforts that result in improved water quality on the refuge. The geographic location of the refuge at the base of the Darby Creek watershed and near the Delaware River make it an ideal location for bringing together all parties involved in protection and restoration efforts.

GOAL 2 Contribute to the enhancement of native species diversity in the Delaware Estuary, including migratory birds and other species of conservation concern, within the refuge's managed open waters and grasslands.

Objective 2.1 Impoundment and Nontidal Open Water

Restore about half (78 acres) of the 145-acre impoundment to freshwater tidal marsh and manage the remaining 66.6-acre impoundment and 56.4-acres of nontidal open water to enhance habitat available for shorebirds, waterfowl, and wading birds during their peak spring and fall migration periods while maintaining essential habitat for other freshwater species of management concern, such as red-bellied turtles, through a combination of water level management, wetland restoration, and invasive species control.

To the extent practicable, these measures will include the following:

1. Annually support migratory shorebirds through a mix of shallow water (less than 6 inches water depth), mudflat with sparse vegetation (less than 10 percent cover), and mudflats with no vegetation, at times of peak migration (spring: May, and fall: mid-August through September).

2. Annually support migratory waterfowl through a mix of shallow (6 to 24 inches water depth) flooded vegetation (*Carex* ssp.*, Polygonum* ssp.*, Peltandra* ssp.) at times of peak migration (spring: late March, and fall: late October).

3. Annually support migratory wading birds through a mix of shallow remnant pools (6 to 12 inches water depth) at times of peak migration (spring: late March, and fall: late August).

4. Sustain State-threatened red-bellied turtle through protection of hibernation, foraging, basking, and nesting habitat.

Rationale

Dikes around the refuge are believed to have been built as early as the 1640s by either the Swedes or the Dutch in order to create areas suitable for agriculture. The 145-acre impoundment as we know it today was likely constructed sometime during the 1940s or 1950s. The periodic drawing down of the impoundment and the presence of tidal mud flats provide some of the best stopover habitat for migrating shorebirds in

Pennsylvania (Cohen and Johnson 2004). In addition, many waterfowl, wading birds, waterbirds, and landbirds utilize the impoundment as well. The area serves as a wintering ground for over 20 species of waterfowl with 1,100 to 1,400 individuals per day between September and March (Green et al. 2008).

Historically, the impoundment was fed by a combination of groundwater and diversions from Darby Creek and managed as open water with periodic tidal fluctuation. Two former water control structures are still in place along portions of the impoundment dike. However, these structures became unusable as Darby Creek's channel pattern shifted further away from the dike in these locations during the early 1980s–causing the structures to become silted in. Today, the refuge contains an active water control structure in the northeast corner of the impoundment. Over the past several years, the Service has managed the water levels within the impoundment to benefit migratory waterfowl, wading birds, and shorebirds with successful results (Green et al. 2008; Phillips personal communication 2008).

This recent management was completed in conjunction with 23 other national wildlife refuges across the Service's Regions 3 and 5 as part of a 3-year management experiment. Management prescriptions for the timing of water manipulation in impoundments involved drawdowns to coincide with either spring or fall shorebird migration. The effects of this timing on waterbird communities, invertebrate communities, and vegetation communities, throughout the annual wetland cycle, were monitored. In addition to evaluating the effects of traditional habitat management practices on attaining objectives for a suite of trust species, this study provides monitoring protocols, databases, and analytical methods that can be used by refuge staff after the study ends for adaptive management of their impoundments (Lyons et al. 2005).

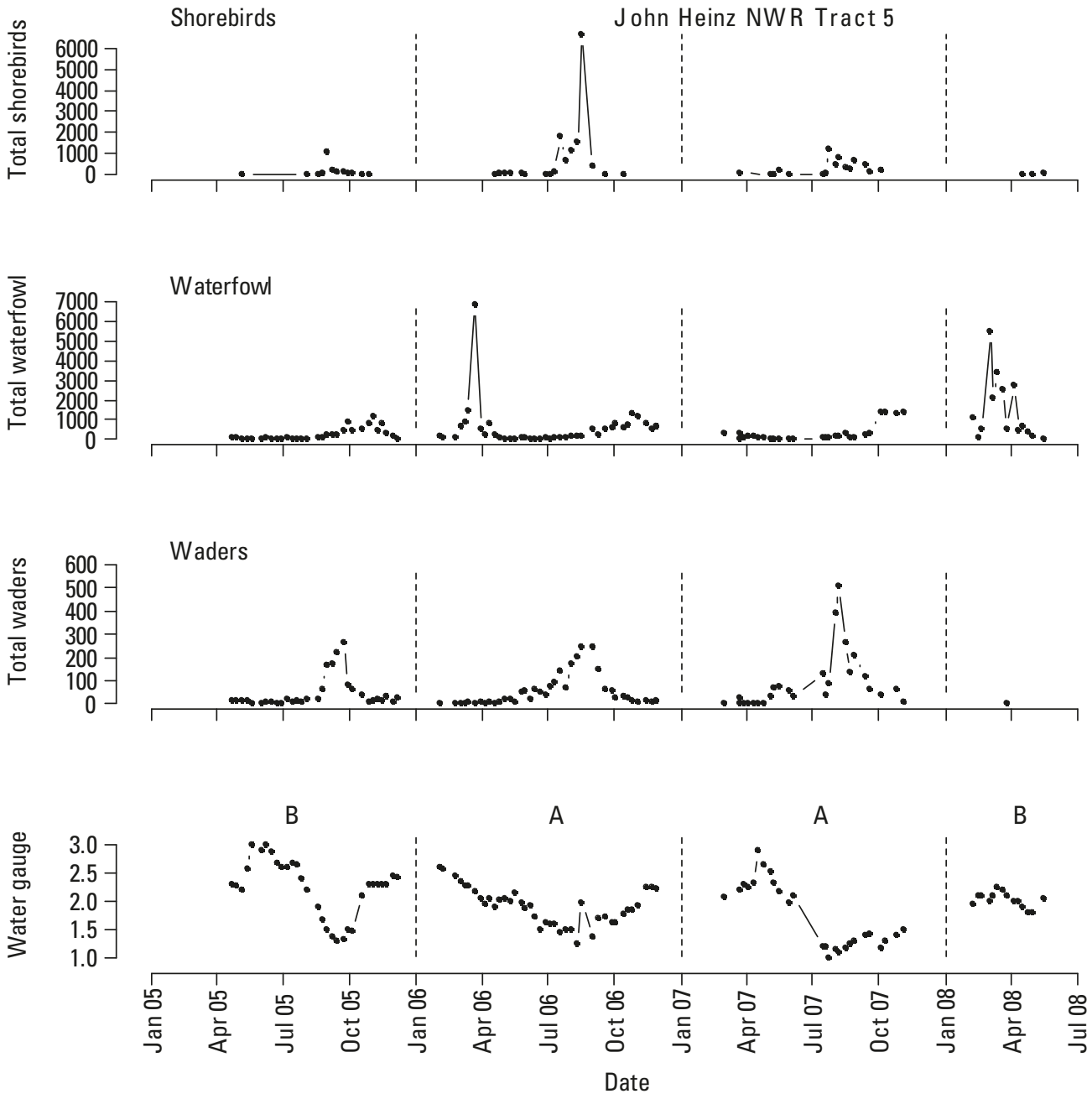
The impoundment study results are completed in draft form at the time of this writing. At this time, it appears that the timed management developed as part of the study has been successful in supporting diverse bird population use of the impoundment area (Green et al. 2008; Phillips personal communication 2008). Draft results indicate that this management should be continued.

These timed drawdowns are focused on providing the most optimal habitat available within the impoundment for various bird groups during their peak migration stopovers in both the spring and fall (figure C.4). The results of this study indicate that the following variations in mean water levels and vegetation composition provide the most benefits for migrating groups. The impoundment area also provides secondary and hibernation habitat use by the State-listed endangered turtle species generally associated with the freshwater tidal marsh and Darby Creek (Stolz personal communication 2005). Management considerations must be made to sustain the use by and protection of these nonbird focal species as well.

Table C.8. Bird Groups and Optimal Conditions for Migratory Stopover and Forage Enhancement within the Impoundment (Based on Results of the Region 3 and Region 5 Impoundment Study).

Bird Groups	Water Depth (inches)	Vegetation Composition and Areal Coverage	Time of Year
Shorebirds	0.0 – 6.0	Mudflats containing less than10 percent vegetative cover.	Spring: May Fall: Mid-August to September
Waterfowl	6.0 – 24.0	Less than10 percent cover of shallow marsh and emergent aquatic species (including *Carex, Polygonum,* and *Peltandra*)	Spring: Late March Fall: Late October
Wading Birds	6.0 – 12.0	Open water containing less than 10 percent vegetative cover.	Spring: Late March Fall: Late August

Figure C.4. Shorebird, waterfowl, and wader abundance (adjusted for partial observability) and water gauge levels within the 145-acre impoundment at John Heinz National Wildlife Refuge (from Green et al. 2008).



Management of the impoundment requires an adaptive approach to reduce, control, or eliminate undesirable plant species such as the invasive, exotic purple loosestrife and the aggressive, native spadderdock, while at the same time promoting the germination of seed producing vegetation such as smartweeds and mudflats

for benthic invertebrates. In some years, it is anticipated that the annual water level management objectives will likely require some variation from the timing most adaptable for migratory birds. To maintain extensive mudflats, annual vegetation, and shallow pools, the impoundment will occasionally require extensive inundation to prevent long-term establishment of perennial invasive species, such as purple loosestrife. Extended inundation periods should be employed when the presence of invasive species becomes larger than feasible for control through herbicide applications. The threshold for this type of management action would be when the impoundment begins to support approximately 10 acres (7 percent) coverage of a nearly monotypic population of invasive exotic species.

Prior to construction, the lands inundated by the 145-acre impoundment were historically freshwater tidal marsh. The Restoration Management Plan for Lower Darby Creek outlined portions of the impoundment for potential tidal marsh restoration opportunities. Refuge staff has been interested in restoring portions of the impoundment to enlarge the total area of freshwater tidal marsh and to improve public accessibility to this unique habitat (Stolz and Woodward personal communication 2009).

Objective 2.2 Wet Meadows, Grasslands, and Early Successional Habitats

Manage up to 64 acres to create a mix of native grasses and flowering plants, within components including early successional shrubs and trees to sustain stopover foraging and cover for migratory landbirds. Specifically,

1. Annually, manage habitat around Frog Pond and Hoy's Pond fringe as native-species dominated wet meadow to contain less than 15 percent areal coverage of tree and shrub species, and no greater than 5 percent bare ground, and so that at least 90 percent of the total areal cover is comprised of native species.

2. Within 10 years of plan approval, restore biological diversity to the existing 7.1 acres of grasslands surrounding the visitor center and refuge entrance, so that at least 90 percent of the total areal cover is comprised of native species and support a minimum of 7 species of native grasses, and 7 species of native flowering plants.

Rationale

Fewer grasslands are available to birds throughout the Mid-Atlantic region as agricultural lands have been lost to commercial and residential development as well as natural succession. Today, grassland dependent birds within the Mid-Atlantic region depend upon agricultural landscapes and other artificial habitats to maintain populations. Military installations, airports, golf courses, parks, recreational fields and other man-made and maintained grasslands provide some modified types of this habitat today. The New England and Mid Atlantic Coast BCR 30 recommends that opportunities to affect large grassland communities should be implemented, when practical (USFWS 2008).

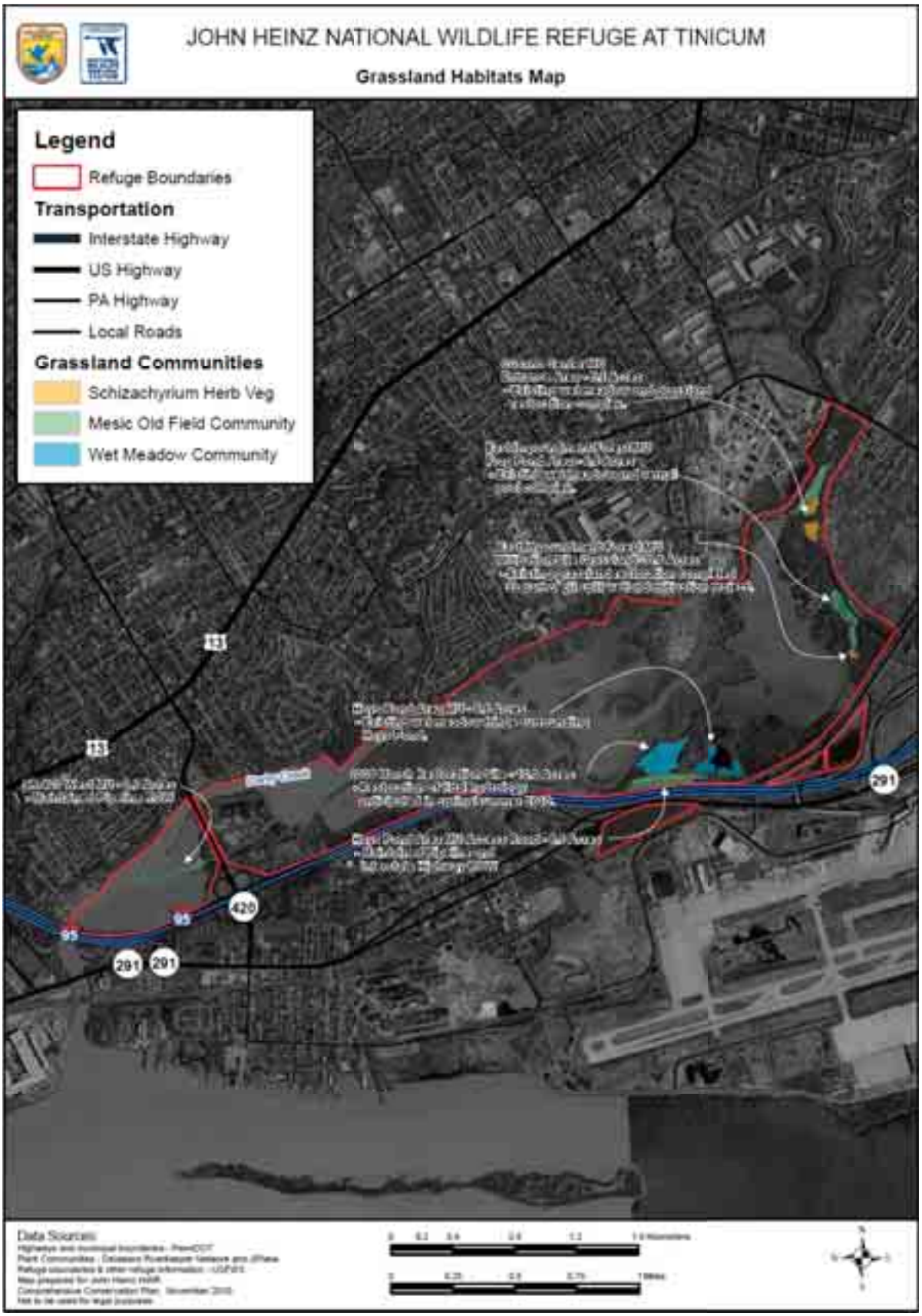
Grasslands and native meadows likely covered a substantial proportion of the Philadelphia area prior to European colonization. It is unlikely that these were self-sustaining ecosystems in this area. There is extensive evidence that meadows were managed by resident Native Americans who burned them on a periodic basis to prevent their succession back to forest and provide foraging areas for game species such as grouse, turkey, deer, and elk (Latham et al. 2005). These systems supported plant species that are generally common to the extensive grasslands found in Midwestern States despite their diminutive size. As availability of grassland habitats has decreased, these species have experienced population declines and are now considered among the most threatened species within the Mid-Atlantic region (PIF 1999). Several remnant native meadows exist within Philadelphia with active restoration plans. Active management of these areas typically includes the removal of nonnative invasive species, replanting of lost native species, and control of woody species (PNHP 2008).

Until the past few decades, the upland habitats of the refuge were comprised of a substantially greater amount of grasslands than today (McCormick et al. 1970; McMennamin personal communication 2008). The Restoration Management Plan for Lower Darby Creek compared habitat coverages between those documented in the Two Studies of Tinicum Marsh and those identified as part of field inventories conducted in 2005. Many forested areas along the existing dike system and within areas east and south of the 145-acre impoundment contained scattered trees (less than 10 percent cover) and “old field” vegetation in 1968, making the forested habitats of the refuge a relatively recent cover type (Salas et al. 2006).

While the grasslands of John Heinz NWR are generally too small to support nesting of priority grassland species within the region (see map C.4), some grassland areas can provide suitable migratory support habitat. Additionally, these grasslands provide important habitat for focal species of concern such as the short-eared owl, sedge wren, marsh wren, and the Coastal Plain leopard frog. The Coastal Plain leopard frog in particular is known to breed in some of the shallow permanent water and vernal pool habitats found within wet meadow grasslands (Phillips and McMennamin, personal communication 2008).

Despite these benefits, grasslands, being an early successional community type, require significant maintenance and time inputs to be maintained over a long-term period. In some areas, it will be more economically and ecologically beneficial to manage existing grassland habitats in a successional trajectory toward coastal or floodplain forest. Each individual grassland patch will require evaluation based on existing and potential habitat benefits, educational and research value, regulatory requirements (in the case of utility and highway right-of-ways), as well as aesthetic and visitor service goals for grasslands found near the refuge entrance and visitor center. An overview of the grasslands of John Heinz NWR is provided in figure 4.1. Management Units used to describe locations are specified in section 5.1.

Map C.4. Existing Grassland Habitats at John Heinz National Wildlife Refuge



Chapter 5.
Management Strategies and Prescriptions

5.1 Development of Management Strategies and Prescriptions

This chapter outlines management strategies and prescriptions to address the habitat management goals and objectives outlined in chapter 4. Management strategies identify the tools and techniques (e.g. mowing, water level manipulation, chemical application, etc.) utilized to achieve the habitat objectives. Prescriptions provide the details behind the specific means by which the strategies will be implemented (e.g. timing, frequency, duration, and location). A review of available literature related to potential strategies and prescription was incorporated during their development. The identified treatments were selected in consultation with other refuge biologists, managers, and practitioners to ensure their effectiveness. Many environmental factors including wildlife populations, weather, seasonal variations, and habitat conditions affect the selected prescriptions and their ability to achieve objectives from year to year. As such, many of the details of prescriptions will be identified in the Annual Habitat Work Plan. Prescriptions outlined herein are discussed on a conceptual level.

The natural world contains a myriad of extremely complex and dynamic systems. This is especially true in biological refuges such as John Heinz NWR, which contain an array of different habitats that support hundreds of plant, fish, and wildlife species in a relatively small area. It is important to understand as land stewards and habitat managers, that one can never fully understand each aspect of these continually changing systems. Despite the extensive planning efforts undertaken within this HMP, there will undoubtedly be additional need to address changes to physical, ecological, social, political, and financial factors that influence biodiversity and its conservation.

The work outlined within this habitat management plan is intended to be feasible, yet extensive, given the available workload of refuge staff and community support. As such, additions of biological technicians and other staff may help in achieving these management objectives over the next several years. The management prescriptions outlined here represents a comprehensive effort to guide management primarily over the next 5 years. However, it is impossible to predict the full suite of management strategies and prescriptions required over this period. Some additional strategies may need to be added, others listed here may not be utilized at John Heinz NWR.

5.2 Management Units

In order to implement management prescriptions, the refuge is divided into a series of Habitat Management Units (map C.5). These habitat management units were developed as a result of the major habitat types identified throughout the habitat management planning process.

The refuge was first divided into management units in the early 1980s as part of the refuge Master Plan. These management units were created based on projected management and land use for the refuge. While still referenced to some degree, the alpha-numeric identification system tends not to be referenced in day-to-day management.

In 2005, as part of the *Restoration Management Plan for the Lower Darby Creek*, the Delaware Riverkeeper Network and refuge staff also developed a system of 14 management units for the refuge. These units were delineated based on several factors, such as geographic size, location, landscape influences, and existing in-formal designations currently in use by refuge staff. These management units were then subdivided into sub-units based on the ecological community identified for a particular component of that area. While this system aided in dividing portions of the refuge into distinct units for on-the-ground management, actual management conducted by staff is conducted on a more localized and habitat-based scale (Phillips, personal communication 2009).

No single system of management units is likely to capture all the complexities and requirements for planning and management of the refuge. The habitat management units developed under this plan are intended to coincide with these previous efforts as applicable. Table C.9 is provided as a cross-reference between the HMP management units and those others previously developed for John Heinz NWR.

Map C.5. Habitat Management Units as Defined by the Habitat Management Plan

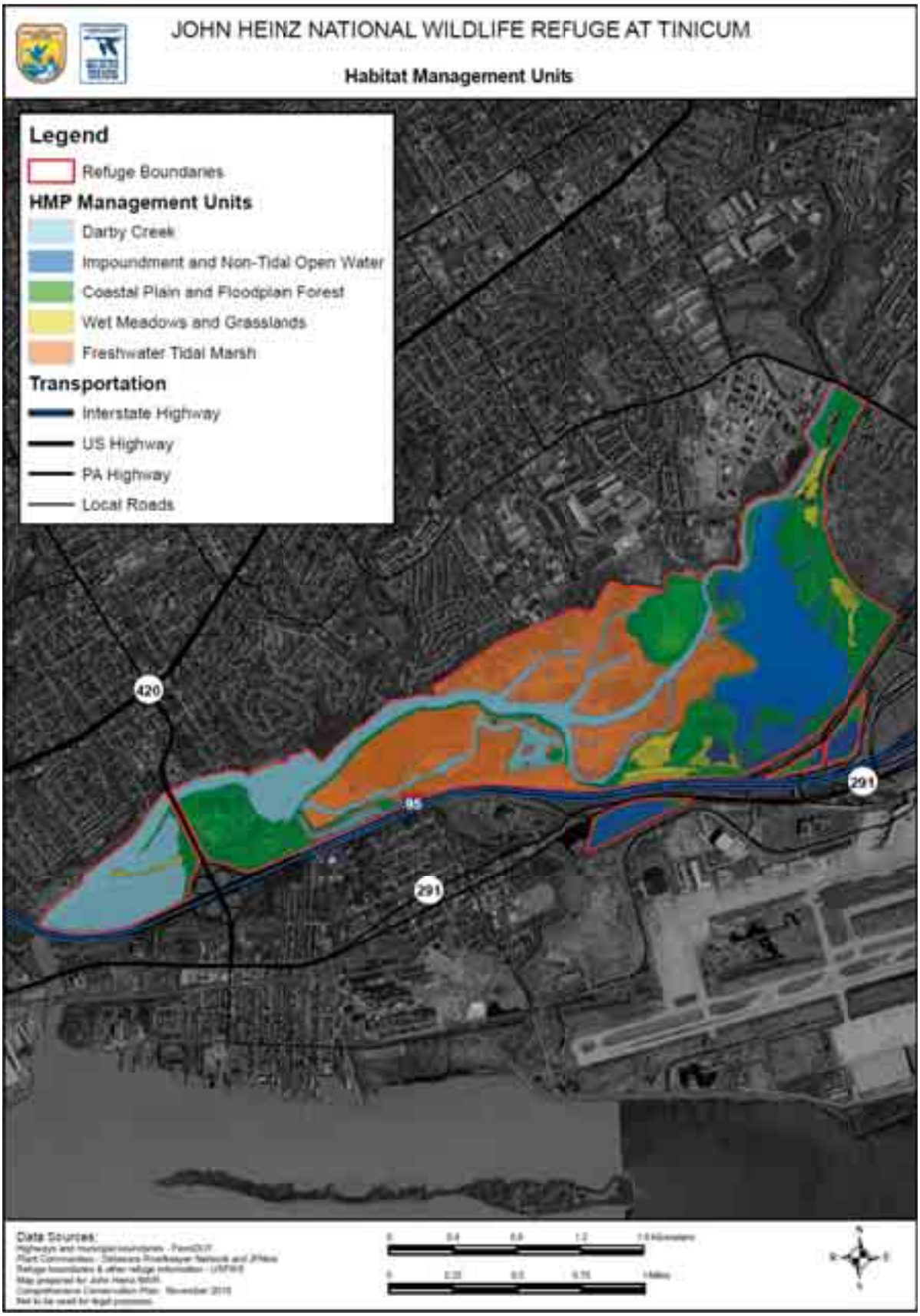


Table C.9. Management Units at John Heinz National Wildlife Refuge (see map 5.1 for locations).

Management Unit (Lower Darby Creek Restoration Plan[1])	Resource Planning Unit (Refuge Master Plan[2])	Treatment Sub-Units (USFWS[3])	HMP Habitat Unit
Cusano Area	FL-1	Lindbergh Berm Woods	Floodplain Forest
		5-Acre Field	Grassland
		CEEC Back Meadow	Grassland
		CEEC Frog Pond Woods	Floodplain Forest
		Frog Pond	Wet Meadow
		Maint/Creek Woods	Floodplain Forest
		Maint/Lindbergh Woods	Floodplain Forest
		Parking Area Meadow	Grassland
East Impoundment Forest	NL-1	Lower Impoundment Woods	Coastal Plain Forest
		Warbler Woods/Middle Impoundment Woods	Coastal Plain Forest
		Spill Site Meadow	Wet Meadow
		Spill Site Restoration Area	Wet Meadow
		Poplar Woods	Floodplain Forest
		Upper Impoundment Woods	Coastal Plain Forest
Impoundment and Dike	MW-1	Creekside of Dike	Darby Creek
		Impoundment	Impoundment and Nontidal Open Water
		Little Horseshoe	Impoundment and Nontidal Open Water
	MM-1	Big Horseshoe	Impoundment and Nontidal Open Water
South Impoundment Forest	FL-2	Trolly Bed Pond	Impoundment and Nontidal Open Water
		Trolly Bed / Bartram Woods	Floodplain Forest
	MM-2	Oak Island	Coastal Plain Forest
		Oak Island Marsh	Coastal Plain Forest
Henderson Dike and Marsh	FL-4	Henderson Trail	Floodplain Forest
		Penn Dot Property	Freshwater Tidal Marsh
		Mitigation Site 2 (Airport Mitigation Site)	Freshwater Tidal Marsh
		Mitigation Site 1 (Blue Route Mitigation Site) Phrag. Islands	Freshwater Tidal Marsh
	TW-2	Mitigation Site 1 Western Tidal Marsh	Freshwater Tidal Marsh

Management Unit (Lower Darby Creek Restoration Plan[1])	Resource Planning Unit (Refuge Master Plan[2])	Treatment Sub-Units (USFWS[3])	HMP Habitat Unit
Darby Creek	TC-1	Darby Creek	Darby Creek
	MW-2	Long Hook Creek	Darby Creek
	TL-1	Eastern 420 Lagoon	Darby Creek
	TW-3		
	TL-2	Northern 420 Lagoon	Darby Creek
	TL-3	Southern 420 Lagoon	Darby Creek
	TW-4	Un-named Area	Darby Creek
Hoys Pond Area	FL-3	Hoys Pond	Impoundment and Nontidal Open Water
		Corps Property	Wet Meadow
		Blue Route Spoils Site	Wet Meadow
		I-95 Underpass	Floodplain Forest
		Cross-Dike Field	Wet Meadow
		Hoy's Pond Area Woods	Floodplain Forest
		Corps Property Woods	Floodplain Forest
I-95 Outliers	MW-1	16-Acre Pond	Impoundment and Nontidal Open Water
	FL-2	Bob's Refuge	Floodplain Forest
North Tidal Marsh	TW-1	North Tidal Marsh	Freshwater Tidal Marsh
South Tidal Marsh		South Tidal Marsh	Freshwater Tidal Marsh
SR 420 East	OF-1	420 woods (Westinghouse Property)	Floodplain Forest
SR 420 West	Un-named	420 Split	Floodplain Forest
Folcroft Landfill	SW-1	Folcroft Landfill	Floodplain Forest and Grassland
		Annex	Floodplain Forest

[1]Salas, D., D.M. Williams, and R.C. Albert. 2006. Restoration management plan for the Lower Darby Creek. Delaware Riverkeeper Network.

[2]U.S. Fish and Wildlife Service. 1980. John Heinz National Wildlife Refuge at Tinicum Master Plan.

[3]Phillips, B. 2009. Personal communication regarding refuge management units. U.S. Fish and Wildlife Service.

5.3 Management Strategies and Prescriptions by Habitat Objective

Objective 1.1 Freshwater Tidal Marsh

Protect the existing 282 acres and restore or acquire an additional 173 acres of freshwater tidal marsh communities throughout the refuge within the next 15 years. Restored marsh would be dominated by native marsh vegetation including, but not limited to, wild rice (*Zizia aquatica*), spadderdock (*Nuphar lutea*), pickerelweed (*Pontederia cordata*), and tick-seed sunflower (*Bidens* spp.). Restored marshes will reestablish greater than 80 percent coverage of native marsh plant species and tidal hydrology that inundates greater than 90 percent of the marsh plain surface with shallow water (less than 1-foot maximum depth) at mean high tide and results in the development of natural channels across the marsh plain surface.

Management Strategies

Continue to:

- Provide technical support to regional corridors and restoration efforts upon request and to targeted projects, such as:
  - Tinicum Township and Long Hook Creek wildlife and riparian corridor restoration
  - Philadelphia International Airport marsh mitigation and restoration
- Utilize existing biological datasets to guide species and habitat management restoration.
- Control nonnative, invasive species focused primarily on phragmites and purple loosestrife through a combination of aerial herbicide application, and spot treatments throughout the growing season when populations exceed greater than 5 percent (10 acres) areal coverage across the existing 284.5 acres of freshwater tidal marsh.
- Pursue the completion of additional marsh restoration projects as funding allows.

Within 2 years of plan approval:

- Utilize partnerships with local universities and regional researchers to define a baseline monitoring plan that continues monitoring of variables related to climate change impacts within the existing marsh. Utilize partners to evaluate monitoring data to verify accuracy of previous and current model results.

Within 5 years of plan approval:

- Work with the Service's Delaware Bay Estuary Project office to complete the restoration of a 55-acre wetland area dominated by phragmites to freshwater tidal marsh subject to daily fluctuation in tidal hydrology and dominated by a mix of native species such as pickerelweed, spadderdock, and wild rice. Restored marshes will contain a network of channels across the marsh surface that resemble the pattern, dimension, and profile of channels within reference marsh areas in order to provide aquatic habitat for nursery and juvenile fish.

Within 15 years of plan approval:

- Implement the restoration of a 27.0-acre wetland area dominated by degraded floodplain forest.
- Evaluate restoration of approximately 78 acres of the impoundment to freshwater tidal marsh subject to daily fluctuation in tidal hydrology and dominated by a mix of native species, such as pickerelweed, spadderdock, and wild rice.

Monitoring Components

Continue to:

- Support ongoing research related to sea level rise, marsh accretion rates, and nitrogen removal capacity within tidal marsh by Academy of Natural Sciences.
- Participate in Spill Prevention, Control, and Countermeasure Plans or other environmental emergency action plans as related to the protection of Darby Creek, open water and tidal wetlands on refuge lands.

Within 5 years of plan approval:

- Monitor and adapt marsh restoration projects to climate change impacts to the extent practical.

Within 10 years of plan approval:

- Within 10 years of plan approval, we would begin to reevaluate the refuge's acquisition boundary through the Service's Preliminary Project Proposal process to address rising sea level caused by climate change, as much of what is currently within the refuge boundaries could be under water in the next 50 to 100 years.

Objective 1.2 Coastal Plain and Floodplain Forests

Over the next 15 years, acquire or restore up to 18 acres of coastal plain and floodplain forest, and manage the existing 34 acres of coastal plain forest and 261 acres of floodplain forest communities. These communities will provide healthy foraging and stopover habitat for migratory bird species and provide breeding habitat for the coastal plain leopard frog by: maintaining a canopy dominated by native trees, increasing native understory shrub and sapling cover by 10 percent, and at least a 15 percent reduction in areal coverage of herbaceous, invasive species as compared to levels inventoried in 2005. Also, restore at least 7.7 acres of existing cool-season grass meadows to at least 50 percent cover by native shrub or early successional coastal plain forest species near the 10-acre marsh restoration site and an additional 0.6 acres within the grasslands restored as part of the oil spill wetland mitigation site.

Management Strategies and Prescriptions

Continue to:

- Control exotic, invasive species impacting forested habitats, including Norway maple (Acer platanoides), tree-of-heaven (Ailanthus altissima), garlic mustard (Alliaria petiolata), porcelainberry (Ampelopsis brevipedunculata), Oriental bittersweet (Cephalanthus orbiculatus), Japanese honeysuckle (Lonicera japonica), bush honeysuckle (Lonicera maackii), Japanese stiltgrass (Microstegium vimeneum), and multiflora rose (Rosa multiflora) through a combination of herbicide application, biological controls, hand pulling and cutting, and cut-stump treatments where applicable.

- Maintain existing stands of nonnative poplar. Attempt reforestation of native species in canopy gaps as they develop.

- Install occasional tree plantings to close canopy gaps and supplement poor regeneration due to deer browse pressure. Protect saplings with individual tree exclosures to minimize browse and decrease associated tree mortality.

- Finalize the Deer Management Plan originally drafted by USDA Division of Wildlife Services staff in 2009. No deer management control actions would be implemented, but ongoing evaluation of impacts would continue.

- Restrict public access to eagle nesting areas during the breeding season and limit public access to areas utilized by other rare species during their breeding seasons.

Within 5 years of plan approval:

- Reduce and then maintain resident deer populations through the use of wildlife control specialists, based on recommendations of the finalized deer management plan, in order to reduce deer population densities, improve the available deer habitat, improve tree regeneration, and reduce the relative effects on human populations. Monitor regeneration in plant richness and diversity within established monitoring plots.

- Adapt long-term management plan for forest habitats to create mixed-age stands of hardwood species identified as primary components of coastal plain and floodplain target communities.

Within 10 years of plan approval:

- Initiate restoration actions on 15 acres of nonnative poplar-dominated forest to establish a successional trajectory towards coastal plain and floodplain forest communities containing biological diversity and integrity similar to other forest habitats existing on the refuge.

Monitoring Components

Continue to:

- Complete deer browse impact monitoring using established USDA Division of Wildlife Services protocols including the review of deer population densities, deer habitat characterization, tree regeneration analysis, and relative effects on human populations.

- Conduct annual population monitoring (flushing surveys) to evaluate deer population trends on the refuge. Utilize FLiR counts completed in January 2009 and 2010 to evaluate population levels and trends of flushing surveys.

Within 3 years of CCP approval:

- By fall 2011, establish vegetation monitoring plots and record baseline data in order to track long-term richness and diversity of tree, shrub, and herbaceous vegetation and monitor impacts of management activities on biological integrity and diversity.

- By 2013, conduct an ecological inventory and assessment of the floodplain forest parcel identified within the State Highway 420 East Management Unit to assess the ecological cost and benefit of restoring some or all of the area to freshwater tidal marsh.

Within 10 years of CCP approval:

- By 2020, evaluate effectiveness of sustained reductions in deer populations and the recovery ability of plant communities in order to determine where to supplement with native plant reintroductions, if at all.

Objective 1.3 Darby Creek

Over the next 15 years, manage inputs to Darby Creek on the refuge in order to reduce contaminants, reduce stormwater impacts from the refuge, and provide spawning, nursery, foraging, and cover habitat for anadromous and catadromous fish populations and Federal trust fish and wildlife species, including American eel, striped bass, blueback herring, and alewife.

Management Strategies and Prescriptions

Continue to:

- Maintain existing partnerships to assess and manage for water quality improvements impacting the refuge.

- Annually, review and refresh staff in spill response protocols and emergency protection measures.

- Coordinate with EPA and other stakeholders to close Folcroft and Clearview Landfills and minimize environmental health impacts related to contaminants associated with these sites.

- Assist Delaware Bay Estuary Project Office in coordinating and providing technical assistance to fish passage, stream, and riparian restoration projects within the Darby Creek watershed that have potential to increase available habitat for species utilizing the refuge or improvements to water quality.

Monitoring Components

Continue to:

- Support volunteer-based water quality monitoring along Darby Creek on the refuge as resources allow.

- Support of occasional and ongoing research to evaluate fish tissue surveys, contaminant level accumulation, and other environmental impacts of environmental hazards.

- Complete installation of a water quality monitoring unit along Darby Creek on the refuge to implement long-term and continuous monitoring.

Within 5 years of plan approval:

- Install a network of water quality monitoring equipment along Darby Creek on the refuge to implement long-term and continuous monitoring of salinity, dissolved oxygen, pH, temperature, flow rate, and other parameters.

Objective 2.1 Impoundment and Nontidal Open Water

Restore about half (78 acres) of the 145-acre impoundment to freshwater tidal marsh and manage the remaining 66.6-acre impoundment and 56.4 acres of nontidal open water to enhance habitat available for shorebirds, waterfowl, and wading birds during their peak spring and fall migration periods. Meanwhile, maintain essential habitat for other freshwater species of management concern, such as red-bellied turtles, through a combination of water level management, wetland restoration, and invasive species control.

To the extent practicable, these measures will include the following:

- Annually support migratory shorebirds through a mix of shallow water (less than 6 inches water depth), mudflat with sparse vegetation (less than 10 percent cover), and mudflats with no vegetation, at times of peak migration (spring: May, and fall: mid-August through September).

- Annually support migratory waterfowl through a mix of shallow (6 to 24 inches water depth) flooded vegetation (Carex spp., Polygonum spp., Peltandra spp.) at times of peak migration (spring: late March, and fall: late October).

- Annually support migratory wading birds through a mix of shallow remnant pools (6 to 12 inches water depth) at times of peak migration (spring: late March, and fall: late August).

- Sustain State-threatened red-bellied turtles through protection of hibernation, foraging, basking, and nesting habitat.

Management Strategies and Prescriptions

Continue to:

- Control invasive species impacting the impoundment and nearby open water habitats as feasible. Purple loosestrife (Lythrum salicaria) and phragmites when they spread over 5 percent (7 acres) of areal coverage across the impoundment and the aggressive native species, spadderdock (Nuphar lutea) when it spreads across greater than 10 percent (14 acres) of areal coverage. Control through a combination of herbicide application, mechanical controls, and water level manipulation treatments where feasible.

- Attempt management of impoundment water levels as conditions allow in order to maximize benefits to migrating shorebirds, waterfowl, waterbirds, and wading birds during each groups' peak migration periods. Adjust drawdown timing and duration to control nonnative, invasive species when herbicide applications become a less cost-effective option against larger populations.

- Enhance and maintain existing dike system to prevent and minimize structural damage sustained to access roads and dikes by flood events and muskrat nesting burrows.

- Close the water control structure into the impoundment during forecasted storm events to minimize stormwater runoff and pollution inputs.

- Partner with Tinicum Township to manage stormwater inputs into the impoundment and open waters along Long Hook Creek.

Within 5 years of plan approval:

- Conduct a series of inventory surveys or reviews of species and habitat use of the 145-acre impoundment and freshwater tidal marsh to evaluate benefits to wildlife of open water, managed mudflat, and tidal marsh habitats.

- Complete a study and restoration plan to determine the optimal size, location, and components for restoration of part of the 145-acre impoundment to freshwater tidal marsh and provide improved water control management and habitat enhancement of the remaining impoundment area.

- Evaluate water quality inputs from neighboring stormwater drainage discharging onto refuge lands and initiate development of improvement measures, such as redirecting stormwater inputs from Philadelphia International Airport to Long Hook Creek.

Within 15 years of plan approval:

- Restore approximately half of the 145-acre impoundment to freshwater tidal marsh, actual area and restoration plan will be based on the study recommendations.

Monitoring Components

Continue to:

- Support annual volunteer frog monitoring.

- Monitor water quality (temperature, pH, and dissolved oxygen) and water level fluctuations within the impoundment throughout the year.

- Conduct weekly inventories and monitoring of shorebirds, waterfowl, waterbirds, and wading birds use and abundance within the impoundment during spring and fall migrations. Use data to document the ongoing effectiveness of water level management activities and adjust management protocols as necessary.

- Conduct migratory bird surveys for landbirds, waterbirds, and waterfowl.

- Complete fisheries inventory of isolated ponds on refuge lands.

Within 10 years of plan approval:

- Assess potential changes in flood elevations of existing dikes and facilities on and adjacent to the refuge and evaluate adaptation to changes in flood elevations.

- Conduct baseline red-bellied turtle inventory surveys and create a long-term monitoring program within the impoundment, open water areas, and the freshwater tidal marsh to determine forage, hibernaculum, and nesting sites. Where feasible, complete inventories in partnership with local universities and State agencies.

Objective 2.2 Wet Meadows, Grasslands, and Early Successional Habitats

Manage up to 64 acres to create a mix of native grasses and flowering plants, within components including early successional shrubs and trees to sustain stopover foraging and cover for migratory landbirds. Specifically,

1. Annually, manage habitat around Frog Pond and Hoy's Pond fringe as native-species dominated wet meadow to contain less than 15 percent areal coverage of tree and shrub species, and no greater than 5 percent bare ground, and so that at least 90 percent of the total areal cover is comprised of native species.

2. Within 10 years of plan approval, restore biological diversity to the existing 7.1 acres of grasslands surrounding the visitor center and refuge entrance, so that at least 90 percent of the total areal cover is comprised of native species and support a minimum of 7 species of native grasses, and 7 species of native flowering plants.

Management Strategies and Prescriptions

Continue to:

- Annually mow to maintain the existing 72 acres of wet meadow, grassland, and forest opening habitats for wildlife, environmental education, and interpretive purposes.

- Control exotic, invasive species impacting wet meadow and grassland habitats, including Oriental bittersweet, Japanese hops, Japanese honeysuckle, purple loosestrife, phragmites, mile-a-minute vine, and multiflora rose through a combination of herbicide application, hand pulling, and mowing.

- Maintain and create vernal pools and wet meadows for amphibian breeding and grassland bird stopover habitat.

- Promote warm-season grass establishment in areas previously dominated by cool-season grasses.

Within 5 years of plan approval:

- Cease annual mowing of 8 acres of existing grasslands targeted for successional transition into a scrub-shrub dominated habitat type.

- Install supplemental plantings within the grasslands surrounding the visitor center to enhance species diversity to levels targeted.

Within 15 years of plan approval:

- Complete habitat management, compatible use, and public use planning of Folcroft Landfill site within 2 years of site remediation and release.

Monitoring Components

Continue to:

- Annually conduct anuran call surveys of known vernal pools to monitor species and their use of areas for breeding sites. Utilize data to document sensitive breeding areas and long-term effectiveness of management activities in order to adjust management protocols as necessary.

Literature Cited

Albert, R.C. 1988. The Historical Context of Water Quality Management for the Delaware Estuary. Estuaries, Vol. 11, No. 2. Estuarine Research Federation.

Allombert, S., A.J. Gaston, J. Martin. 2005. A natural experiment on the impact of overabundant deer on songbird populations. Biological Conservation. 126: pp. 1–13.

American Ornithologists' Union (AOU). 1983. Check-list of North American Birds, 6th edition. Allen Press, Inc., Lawrence, Kansas. 877 pp.

Andrew, J.M. and J.A. Mosher. 1982. Bald eagle nest site selection and nesting habitat in Maryland. J. Wildlife Management 46:382-390.

Aniskowicz, B.T. 1981. Behavior of a male least bittern I*xobrychus exilis* after loss of mate. Wilson Bulletin 93:395-397.

Barnes, J.H., and Sevon, W.D. 2002. The Geological Story of Pennsylvania (3rd ed.): Pennsylvania Geological Survey, 4th ser., Educational Series 4, 44 p.

Baumann, P.C. 2002. Beneficial use impairment #4: Fish tumors and other deformities. In: Workshop on delisting criteria on the Detroit River Area of Concern. 2002. Proceedings of a workshop held at the University of Windsor, April 26-27, 2002. Environment Canada, Burlington, Ontario. 124 p.

Bell, B.A. 2005. The Effects of Crude Oil on the Reproduction of Freshwater Turtles. Doctor of Philosophy Thesis. Submitted June 2005. Drexel University. 129 p.

Bent, A.C. 1938. Life histories of North American birds of prey. Part 2. U.S. Nat. Mus. Bull. 170. 482 pp., 92 pls.

Bertin, R.I. 1977. Breeding habitats of the Wood Thrush and Veery. The Condor. 79:303-11.

Botton, M.L., R.E. Loveland, and T.R. Jacobsen. 1994. Site selection by migratory shorebirds in Delaware Bay, and its relationship to beach characteristics and abundance of horseshoe crab (*Limulus polyphemus*) eggs. Auk 111:605-616.

Bozeman, E.L.,Jr., and M.J. Van Den Avyle. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (South Atlantic)--alewife and blueback herring. USFWS. Biol. Rep. 82(11.111). 17 pp.

Bushman, E.S., and G.D. Therres. 1988. Habitat management guidelines for forest interior breeding birds of coastal Maryland. Maryland Dept. Natural Resources, Wildlife Tech. Publ. 88-1. 50 pp.

Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, and M.C. McNall. 1990. The birds of British Columbia. Volume 2. Nonpasserines: diurnal birds of prey through woodpeckers. University of British Columbia Press, Vancouver, B.C. 636 pp.

Castro, G., and J.P. Myers. 1993. Shorebird predation on eggs of horseshoe crabs during spring stopover on Delaware Bay. Auk 110:927-930.

Christman, S.P. 1984. Breeding bird response to greentree reservoir management. Journal of Wildlife Management 48:1164-1172.

City of Philadelphia. 2008. Philadelphia's Air Quality Report. Department of Public Health Air Management Services. 44 pp. [Online version available at <*http://www.phila.gov/health/airmanagement/*>]

Clark, R.J. 1975. A field study of the short-eared owl (*Asio flammeus*) Pontoppidan in North America. Wildlife Monographs 47:1-67.

Cohen, M. and J. Johnson. 2004. Pennsylvania Important Bird Area #73: John Heinz National Wildlife Refuge at Tinicum Phase 1 Report. Audubon Society.

Craft, C. 2007. Freshwater input structures soil properties, vertical accretion, and nutrient accumulation of Georgia and U.S. tidal marshes. Limnology and Oceanography. 52(3):1220-1230.

D'Angelo, G.J. 2011. Draft White-tailed Deer Management Plan for John Heinz National Wildlife Refuge at Tinicum, Philadelphia, Pennsylvania. USDA-APHIS. 76 pp.

D'Angelo, G.J. 2009. Personal Communication.

Darby Creek Valley Association (DCVA). 2005. Darby Creek Watershed Comprehensive Plan. [Online version available at <*http:// www.dcva.org*>]

deCalesta, D.S. 1994. Impact of white-tailed deer on songbirds within managed forests in Pennsylvania. Journal of Wildlife Management 58: 711-718.

DeGraaf, R.M., G.M. Whitman, J.W. Lanier, B.J. Hill, and J.M. Keriston. 1980. Forest habitat for birds of the northeast. United States Forest Service, Northeast Forest Experiment Station, 598 pp.

DeGraaf, R.M., and D.D. Rudis. 1983. Amphibians and reptiles of New England. Habitats and natural history. Univ. Massachusetts Press. vii + 83 pp.

Delaware Estuary Program (DEP). 1996. Comprehensive Conservation and Management Plan for the Delaware Estuary. Wilmington, Delaware. 470 pp.

Delaware River Basin Commission (DRBC). 2004. 2004 Delaware River and Bay Surface Water Quality Assessment Report for 2000 – 2002.

del Hoyo, J., A. Elliot, and J. Sargatal. 1996. Handbook of the birds of the world. Volume 3. Lynx Editions. Barcelona. 821 pp.

Elliot, L. 1978. Social biology and foraging ecology of the eastern chipmunk (*Tamias striatus*) in the Adirondack Mountains. Smithsonian Contributions to Zoology. 265: 1-107.

Entrix, Inc. 2005. Final Report: Sunoco Pipeline Release Incident at John Heinz National Wildlife Refuge, Philadelphia, PA. Prepared for Sunoco, Inc. (R&M) and Sun Pipeline Company, Philadelphia, PA. June 3, 2005. Project No.: 7089309.

Ernst, C.H., and R.W. Barbour. 1972. Turtles of the United States. Univ. Press of Kentucky, Lexington.

Fay, C.W., R.J. Neves, and G.B. Pardue. 1983. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Mid-Atlantic): alewife/blueback herring. FWS/OBS-82/11.9.

Feunteun, E., P. Laffaille, T. Robinet, C. Briand, A. Baisez, J.M. Olivier, and A. Acou. 2003. A review of upstream migration and movements in inland waters by anguillid eels: toward a general theory. Pages 191-213 in K. Aida, K. Tsukamoto, and K. Yamauchi, editors. Eel Biology. Springer, Tokyo.

Flowerdew, J.R. and S.A. Elwood. 2001. Impact of woodland deer on small mammal ecology. Forestry. 74: 277-287.

Frazer, C., J.R. Longcore, and D.G. McAuley. 1990a. Habitat use by postfledging American black ducks in Maine and New Brunswick. Journal of Wildlife Management 54:451-459.

----. 1990b. Home range and movements of postfledging American black ducks in eastern Maine. Canadian Journal of Zoology. 68:1288-1291.

Goodrich, L., Brittingham, M., Bishop, J., Barber, P. 2001. Wildlife Habitat in Pennsylvania: Past, Present, and Future. Pennsylvania Department of Conservation and Natural Resources. Harrisburg, Pennsylvania. [Online version available at <*http://www.dcnr.state.pa.us/wlhabitat/commonwealth.aspx*>]

Green A.W., W.L. Kendall, H.P. Laskowski, J.E. Lyons , L. Socheata, and M.C. Runge. 2008. Draft version of the USFWS R3/R5 Regional Impoundment Study. U. S. Fish and Wildlife Service.

Green, N. 1985. The Bald Eagle. Pp 508-531 in R.L. DiSilvestro, ed., Audubon Wildlife Report 1985. National Audubon Society, New York.

Haro, A.J., and W.H. Krueger. 1991. Pigmentation, otolith rings, and upstream migration of juvenile American eels (*Anguilla rostrata*) in a coastal Rhode Island stream. Canadian Journal of Zoology. 69:812-814.

Harrison, C. 1978. A Field Guide to the Nests, Eggs and Nestlings of North American Birds. Collins, Cleveland, Ohio.

Hassler, T.J. 1988. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest)--striped bass. USFWS Biol. Rep. 83(11.82). U.S. Army Corps of Engineers, TR EL-82-4. 29 pp.

Hayhoe, K., C.P. Wake, T.G. Huntington, L. Luo, M.D. Schwartz, J. Sheffield, E. Wood, B. Anderson, J. Bradbury, A. DeGaetano, T.J. Troy, and D. Wolfe. 2007. Past and future changes in climate and hydrological indicators in the U.S. Northeast. Climate Dynamics, 28(4), 381-407.

Herpetological Associates. 2001a. Endangered and Threatened Wildlife Species Surveys in Wetlands throughout Philadelphia International Airport, Delaware and Philadelphia Counties, Pennsylvania.

----. 2001b. Master Plan Technical Report No. 2: A Survey of Fishes of the Philadelphia International Airport and the Adjacent Delaware River Estuary.

Intergovernmental Panel on Climate Change (IPCC). 2007. Summary for Policymakers of the Synthesis Report of the IPCC Fourth Assessment Report. Valencia, Spain. [Online version available at <*http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf*]>

Iverson, L., A. Prasad, and S. Matthews. 2008. Potential changes in suitable habitat for 134 tree species in the northeastern United States. Mitigation and Adaptation Strategies for Global Change, 13(5-6), 487-516.

Kreeger, D., J. Adkins, P. Cole, R. Najjar, D. Velinsky, P. Conolly, and J. Kraeuter. 2010. Climate Change and the Delaware Estuary: Three Case Studies in Vulnerability Assessment and Adaptation Planning. June 2010. Partnership for the Delaware Estuary, PDE Report No. 10-01. 117 pp.

Kuchler, A.W. 1964. Potential Natural Vegetation of the Conterminous United States. American Geographical Society. Special Publication No. 36.

Kushlan, J. A. 1973. Least bittern nesting colonially. Auk 90:685-686.

Latham, R.E., J. Beyea, M. Benner, C.A. Dunn, M.A. Fajvan, R.R. Freed, M. Grund, S.B. Horsley, A.F. Rhoads and B.P. Shissler. 2005. Managing White-tailed Deer in Forest Habitat From an Ecosystem Perspective: Pennsylvania Case Study. Report by the Deer Management Forum for Audubon Pennsylvania and Pennsylvania Habitat Alliance, Harrisburg. xix + 340 pp.

Leimgruber, P., W.J. McShea and J. Rappole. 1994. Predation on artificial nests in large forest blocks. Journal of Wildlife Management. 58: 254-260.

Lippson, M.A.J., M.S. Haire, A.F. Holland, F. Jacobs, J. Jensen, R.L. Moran-Johnson, T.T. Polgar, and W.A. Richkus. 1979. Environmental Atlas of the Potomac Estuary. Williams and Heintz Map Corp. Washington D.C.

Low, D.J., D.J Hippe, and D. Yannacci. 2002. Geohydrology of Southeastern Pennsylvania. U.S. Geological Survey. U.S. Department of the Interior. New Cumberland, PA. Water-Resources Investigations Report 00-4166. 361 pp.

Lyons, J.E., Runge, M.C., Kendall, W.L., Laskowski, H., Lor, S. 2005. Timing of Impoundment Drawdowns and Impact on Waterbird, Invertebrate, and Vegetation Communities within Managed Wetlands. USGS Refuge Cooperative Research Program. Laurel, MD.

McCormick, J., R. Grant and R. Patrick. 1970. Two Studies of Tinicum Marsh. The Conservation Foundation.124 pp.

McCullough, D.R. 2001. Male harvest in relation to female removals in a black-tailed deer population. Journal of Wildlife Management 65: 46-58.

McMenamin, M. 2008. Facility manager, John Heinz National Wildlife Refuge at Tinicum. Personal Communication.

Meanley, B. 1969. Natural history of the king rail. North American Fauna 67:1-108.

Merendino, M.T., and C.D. Ankney. 1994. Habitat use by mallards and American black ducks breeding in central Ontario. Condor 96:411-421.

Meretsky, V., R. Fischman, J. Karr, D. Ashe, J. Scott, R. Noss, and R. Schroeder. 2006. New directions in conservation for the National Wildlife Refuge System. BioScience. 56(2):135–143.

Mitch, W.G. and J.G. Gosselink. 1993. Wetlands. Second Edition. J. Wiley and Sons Press. pp. 267-291.

Najjar, R.G. 2010. Potential impact of climate change on salinity of the Delaware Estuary. A Report for the Partnership of the Delaware Estuary. 2010. Appendix A i*n* Kreeger, D., J. Adkins, P. Cole, R. Najjar, D. Velinsky, P. Conolly, and J. Kraeuter. June 2010. Climate Change and the Delaware Estuary: Three Case Studies in Vulnerability Assessment and Adaptation Planning. Partnership for the Delaware Estuary, PDE Report No. 10-01. 117 pp.

Najjar, R.G., H.A. Walker, P.J. Anderson, E.J. Barron, R.J. Bord, J.R. Gibson, V.S. Kennedy, C.G. Knight, J.P. Megonigal, R.E. O'Connor, C.D. Polsky, N.P. Psuty, B.A. Richards, L.G. Sorenson, E.M. Steele, and R.S. Swanson. 2000. The Potential Impacts of Climate Change on the Mid-Atlantic Coastal Region. Climate Research. 14:219–233.

National Oceanic and Atmospheric Administration (NOAA). 2000. Lower Darby Creek Area 33 Report for EPA Facility ID: PASFN0305521.

----. 2008. National Oceanic and Atmospheric Administration, Satellite and Information Service. 2008. United States Historical Climatology Network (USHCN). Data from National Climate Data Center. [Online version available at <*http://lwf.ncdc.noaa.gov/oa/climate/research/ushcn/ushcn.html*>]

Natural Resource Conservation Service (NRCS). 2009. National Cooperative Survey Data for Delaware County, Pennsylvania. Web Soil Survey, Version 1.0. Accessed February 2009. [Online version available at <*http://websoilsurvey.nrcs.usda.gov/app/*>]

Nixon, C.M. and L.P. Hansen. 1987. Managing forests to maintain populations of gray and fox squirrels. Illinois Department of Conservation Technical Bulletin No. 5. Springfield. 35 pp.

Odum, W.E., T.J. Smith III, J.K. Hoover, and C.C. McIvor. 1984. The Ecology of Freshwater Tidal Marshes of the United States East Coast: A Community Profile. U. S. Fish and Wildlife Service. FWS/OBS-87/17. Washington D.C. 177 pp.

Park, R.A., M.S. Trehan, P.W. Mausel, and R.C. Howe. 1989. The Effects of Sea Level Rise on U.S. Coastal Wetlands. Pp 1-1 to 1-55. in J. B. Smith and D. A. Tirpak, eds. The Potential Effects of Global Climate Change on the United States, Appendix B - Sea Level Rise. U.S. Environmental Protection Agency, Washington, D.C.

Palmer, R.S. (editor). 1962. Handbook of North American birds. Vol. 1. Loons through flamingos. Yale University Press, New Haven. 567 pp.

Partners in Flight (PIF). 1999. Bird Conservation Plan For the Mid-Atlantic Coastal Plain (Physiographic Area 44), April 1999. Version 1.0. American Bird Conservancy. Williamsburg, Virginia.

Pederson, B.S. and A.M. Wallis. 2004. Effects of white-tailed deer herbivory on forest gap dynamics in a wildlife preserve, Pennsylvania, U.S.A. Natural Areas Journal. 24: 82-94.

Pennsylvania Game Commission (PGC) and Pennsylvania Fish and Boat Commission (PFBC). 2005. Pennsylvania's Wildlife Habitat Action Plan, Version 1.0a. Harrisburg, Pennsylvania. [Online version available at <*http://www.pgc.state.pa.us/pgc/cwp/view.asp?a=496&q=162067*>]

Pennsylvania Natural Heritage Program (PNHP). 2008. A Natural Heritage Inventory of Philadelphia County. Western Pennsylvania Conservancy. Middletown, PA.

Petit, L.J. and D.R. Petit. 1996. Factors governing habitat selection by Prothonotary Warblers: Field tests of the Fretwell-Lucas models. Ecological Monographs. 66:367-387.

Philadelphia Water Department (PWD). 2002 and July 2004 update. Darby-Cobbs Watershed Comprehensive Characterization Report. (Updated 2004).

Phillips, B. 2008. Refuge biologist, John Heinz National Wildlife Refuge at Tinicum. Personal Communication.

Pinkney, A.E., Harshbarger, J.C., Roberts, M.R. 2004. Tumor Prevalence in Brown Bullheads (Ameiurus nebulosus) from Darby Creek, John Heinz National Wildlife Refuge at Tinicum, Philadelphia, PA. CBFO-C04-03 and PAFO-C04-02. 37 pp.

Reed, J.M., and L.W. Oring. 1993. Philopatry, site fidelity, dispersal, and survival of Spotted Sandpipers. Auk 110:541-551.

Roboski, J.C. and M.K. Causey. 1981. Incidence, habitat use, and chronology of woodcock nesting in Alabama. Journal of Wildlife Management 45:793-797.

Rooney, T.P. 2001. Deer impacts on forest ecosystems: a North American perspective. Forestry 74: 201-208.

Roth, R.R. 1987. Assessment of habitat quality for Wood Thrush in a residential area. Pp. 139-49 in L.W. Adams and D.L. Leedy (editors). Integrating man and nature in the metropolitan environment. Proceedings of the National Symposium on Urban Wildlife, Chevy Chase, Maryland, 4-7 November, 1986. National Institute for Urban Wildlife, Columbia, Maryland.

Roth, R.R., M.S. Johnson, and T.J. Underwood. 1996. Wood Thrush (*Hylocichla mustelina*). In A. Poole and F. Gill, editors, The Birds of North America, No. 246. Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, DC. 28 pp.

Ryan, T.J., and C.T. Winne. 2001. Effects of hydroperiod on metamorphosis in *Rana sphenocephala*. American Midland Naturalist 145:46-53.

Salas, D., D.M. Williams, and R.C. Albert. 2006. Restoration Management Plan for the Lower Darby Creek. Delaware Riverkeeper Network. 101 pp.

Schieck, P. and H.E Cox. 1970. Trolleys of Lower Delaware Valley Pennsylvania. Harold and Cox. 86pp.

Scull, N. and Heap, G. 1752. A Map of Philadelphia and Parts Adjacent: With A Perspective View Of The State-House. Library of Congress Geography and Map Division Washington, D.C. [Online version available at <*http://hdl.loc.gov/loc.gmd/g3824p.ct000294*>]

Spendelow, J.A. and S.R. Patton. 1988. National Atlas of Coastal Waterbird Colonies in the Contiguous United States: 1976-1982. U.S. Fish and Wildlife Service, Biological Report 88(5). 326 pp.

Sportfishing and Boating Partnership Council. 2006. National Fish Habitat Action Plan. 28 p.

Stasz, J.L. 1996. Worm-eating Warbler (*Helmitheros vermivorus*). Pp 352-353 in C.S. Robbins and E.A.T. Blom, editors. Atlas of the breeding birds of Maryland and the District of Columbia. University of Pittsburgh Press, Pittsburgh.

Stewart, R.E., and C.S. Robbins. 1958. Birds of Maryland and the District of Columbia. North American Fauna No. 62. U.S. Govt. Printing Office, Washington, D.C.

Stevens, S. 1964. Pennsylvania, Birthplace of a Nation. Random House. New York. pp. 5-26.

Stiles, F.G. and A.F. Skutch. 1989. A guide to the birds of Costa Rica. Cornell University Press, Ithaca, New York, USA. 511 pp.

Stolz, G. 2009. Refuge manager, John Heinz National Wildlife Refuge at Tinicum. Personal Communication

Sweka, J. and J. Mohler. 2010. Fish Species Richness on the John Heinz National Wildlife Refuge at Tinicum. USFWS-Northeast Fishery Center.

Swift, B.L. 1987. An analysis of avian breeding habitats in Hudson river tidal marshes. New York State Department of Environmental Conservation, Division of Fish and Wildlife, Delmar, New York. Unpublished report. 62 pp.

Terres, J.K. 1980. The Audubon Society encyclopedia of North American birds. Alfred A. Knopf, New York.

Thomson, K.S., W.H. Weed III, A.G. Taruski, and D.E. Simanek. 1978. Saltwater fishes of Connecticut. 2nd edition. State Geological and Natural History Survey of Connecticut, Department of Environmental Conservation, Bulletin 105. viii + 186 pp.

Union of Concerned Scientists (UCS). 2008. Climate Change in Pennsylvania: Impacts and Solutions for the Keystone State. UCS Publications. Cambridge, MA. [Online version available at <*http://www.climatechoices.org/pa*>]

U.S. Environmental Protection Agency (USEPA). 2006. USEPA Region 3. Lower Darby Creek Current Site Information. [Online version available at <*http://www.epa.gov/reg3hwmd/npl/PASFN0305521.htm/*>]

U.S. Fish and Wildlife Service (USFWS). 1999. Fulfilling the promise: the national wildlife refuge system. U.S. Fish and Wildlife Service. Arlington, Virginia.

----. 2003. Biological integrity, diversity, and environmental health. USFWS Policy 601 FW3. U.S. Fish and Wildlife Service. Arlington, Virginia.

----. 2004. A Blueprint for the Future of Migratory Birds, Migratory Bird Program Strategic Plan 2004-2014. U.S. Fish and Wildlife Service, Migratory Birds and State Programs. Arlington, Virginia. 27pp.

----. 2008a. New England Mid-Atlantic Coast Bird Conservation Region (BCR 30) Implementation Plan. Atlantic Coast Joint Venture, Hadley, MA: Region 5, Fish and Wildlife Service, U.S. Department of the Interior. [Online version available at <*http://www.acjv.org/BCR_30/BCR30_June_23_2008_final.pdf>]*

----. 2008b. Birds of Conservation Concern 2008. U.S. Department of Interior, U.S. Fish and Wildlife Service, December 2008. Division of Migratory Bird Management. Arlington, Virginia. 85 pp. [Online version available at <*http://www.fws.gov/migratorybirds/>*]

----. 2009a. North Atlantic Landscape Conservation Cooperative Development and Operations Plan. December 2009. U.S. Department of Interior, U.S. Fish and Wildlife Service, Northeast Region. Hadley, MA. 38 pp.

----. 2009b. John Heinz National Wildlife Refuge Web site. Accessed April 2009 [Online version available at <*http://www.fws.gov/northeast/heinz/>*].

U.S. Geological Survey (USGS). 2009. Pennsylvania StreamStats Data Obtained for Darby Creek within the John Heinz National Wildlife Refuge at Tinicum location. Accessed on April 2009. [Online version available at <*http://water.usgs.gov/osw/streamstats/pennsylvania.html*>]

Warren Pinnacle Consulting, Inc. 2010. Application of the Sea Level Affect Marshes Model (SLAMM 6) to John Heinz National Wildlife Refuge. Prepared for U.S. Fish and Wildlife Service, National Wildlife Refuge System, Arlington VA. December 2010.

Weller, M.W. 1961. Breeding biology of the least bittern. Wilson Bulletin. 73:11-35.

Weston, N.B., R.E. Dixon, and S.B. Joye. 2006. Ramifications of increased salinity in tidal freshwater sediments: Geochemistry and microbial pathways of organic matter mineralization. Journal of Geophysical Research 111, G01009.

Wilcove, D.S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. BioScience. 48:607–617.

Woodward, L. 2009. Former Deputy Refuge Manager at John Heinz National Wildlife Refuge. Personal Communication.

Appendix A.
Plan Development Team

Lead Author

Dan Salas
Ecologist, ESA Certified
JFNew

Contributing Authors and Cooperators

Gary M. Stolz
Refuge Manager
John Heinz NWR

Brendalee Phillips
Refuge Biologist
John Heinz NWR

Larry A. Woodward
Deputy Refuge Manager
John Heinz NWR

Mike McMennamin
Maintenance Specialist
John Heinz NWR

Rob Allen
Contaminants Biologist
John Heinz NWR

Beth Goldstein
Refuge Planner
Northeast Region 5

Nicole Staskowski
Regional Manager
JFNew

Gino D'Angelo
Wildlife Biologist
USDA APHIS Wildlife Services

Jan Taylor
Regional Biologist
Northeast Region 5

Hal Laskowski (retired)
Regional Biologist
Northeast Region 5

Appendix B.
Potential Habitat Management Strategies

This section identifies potential management tools or strategies that are available to land managers to achieve desired habitat objectives. These strategies were identified through successful refuge application, literature review and in consultation with other land managers.

Invasive Species Management

Controlling and managing invasive species is a strategy for maintaining the biological integrity and diversity of all habitats. The Fulfilling the Promise National Invasive Species Management Strategy Team developed a national strategy for management of invasive species for the Refuge System in 2002. The strategy recommends the following priority order of action for invasive species management:

1. Prevent invasion of potential invaders.
2. Eradicate new or small infestations.
3. Control and contain large established infestations.

Potential management strategies for preventing invasive species, prioritizing control efforts for established invasive species, and controlling invasive species are described in detail below. Prior to the initiation of invasive species control efforts, the refuge manager must understand the biology of the species to be controlled. A number of resources are available on the internet to assist refuge managers with invasive species management. This is a partial list of helpful Web sites.

- Service Managing Invasive Plants Modules: *http://www.fws.gov/invasives/staffTrainingModule/index.html* (accessed January 2012)
- National Invasive Species Information Center: *http://invasivespeciesinfo.gov/index.shtml* (accessed January 2012)
- National Biological Information Infrastructure Invasive Species Information Node: *http://invasivespecies.nbii.gov/* (accessed January 2012)
- The Global Invasive Species Initiative: *http://tncinvasives.ucdavis.edu/* (accessed January 2012)
- USGS Invasive Species Program: *http://biology.usgs.gov/invasive/* (accessed January 2012)
- Mid-Atlantic Exotic Pest Plant Council (MA-EPPC): *http://www.ma-eppc.org/* (accessed January 2012)
- Weeds Gone Wild: *http://www.nps.gov/plants/alien/index.htm* (accessed January 2012)

Refuge managers should conduct appropriate and applicable pest detection, environmental surveillance, and monitoring before, during, and after any management activity to determine whether pest management goals are achieved and whether the activity caused any significant unanticipated effects. The lowest risk, most targeted approach for managing invasive species should always be utilized (Department of Interior 2007).

Work with Partners

Working with partners is the most effective way to manage invasive species on a refuge. Control efforts on the refuge will have little long-term impact if the surrounding lands and waters are infested with invasive species.

Incorporate Invasive Species Prevention in All Facilities and Construction Projects

Minimize ground disturbance and restore disturbed areas. Require mulch, sand, gravel, dirt, and other construction materials to be certified as free of noxious weed seeds. Avoid stockpiles of weed-infested materials.

To prevent the spread of invasives along transportation corridors, maintain invasive species-free zones along trails, around parking lots and boat launches, and at other related facilities. Inspect these areas often and control new infestations immediately. Minimize the number and size of roads on the refuge.

Remove all mud, dirt, and plant parts from all equipment between projects or when equipment is moved from one location to another.

Incorporate Invasive Species Prevention in Impoundment Design and Management
Minimize infrastructure development in managed wetland units to reduce unnecessary dikes, waterways, and access roads. These often are sources of infestation and pathways to spread invasive species.

Plant a native cool-season grass mix that will establish quickly to stabilize banks and dikes and to prevent the establishment of invasive species. Consider one of the following mixes recommended by the Natural Resources Conservation Service for New York State:

1. Canada wild rye (*Elymus canadensis*) (5 lb. per acre), riverbank wild rye (*E. riparius*) (3 lb. per acre), and Eastern bottlebrush grass (*E. hystrix*) (2 lb. per acre); or
2. Canada wild rye (4 lb. per acre), riverbank wild rye (4 lb. per acre), Virginia wild rye (*E. virginicus*) (4 lb. per acre), and rough bentgrass (*Agrostis scabra*) (1 lb. per acre)

For either mix, consider adding a cover crop of seed oats (*Avena sativa*) or triticale (*Triticale hexaploide*) so bare soil is not exposed to erosion or to invasive plant seeds and rhizomes. This nonnative plant will establish quickly and then drop out of the mix after 1 to 2 years.

Time water manipulation activities, such as flooding and drawdowns, to minimize the germination and spread of invasive plant seeds and to encourage the growth of native species. Flooding can also be used to stunt the growth of some invasive species as described below under water level management.

Early Detection and Rapid Response
Where prevention is not possible, early detection and rapid response is the next best strategy. Success will depend, in part, on participation by all refuge staff, contractors, volunteers, and visitors in efforts to report and respond to invasions. The refuge manager must have access to up-to-date reliable scientific and management information on species that are likely to invade. The following sources for State and regional invasive species information and updates provide an initial list of potential invasive species present within the region:

- PA Invasive Species Council: *http://www.invasivespeciescouncil.com/default.aspx* (accessed January 2012)
- Mid-Atlantic Exotic Pest Plant Council (MA-EPPC): *www.ma-eppc.org* (accessed January 2012)
- WeedUS Natural Area Weed Database of the US: *http://www.invasive.org/weedus/index.html* (accessed January 2012)

These lists, along with identification information for each species, should be distributed amongst refuge staff and volunteers and posted in refuge facilities. In addition to these lists, a list of experts should be maintained by the refuge manager to facilitate rapid and accurate species identification for species that are particularly difficult to identify. The refuge manager should communicate with the PA Invasive Species Council and Mid-Atlantic Exotic Pest Plant Council regarding the status of early detection species in the region.

When small infestations are spotted, they should be eradicated as soon as possible. The site must then be monitored for several years to ensure the control was effective.

Prioritizing Invasive Species Control Efforts
The first step in prioritizing invasive species control efforts is to determine the abundance and distribution of invasive species on the refuge or management unit. However, control efforts should not be delayed to collect statistically rigorous survey data. Baseline data regarding the location of many invasives on the refuge already may be available via observations of staff, volunteers, contractors, and refuge visitors. These observations should be documented and mapped. If a more formalized mapping procedure is desired the North American

Weed Management Association (*http://www.nawma.org;* accessed January 2012) has information on mapping procedures.

There are a number of ranking tools to assist land managers with the daunting task of prioritizing their invasive plant control efforts. The Fulfilling the Promise National Invasive Species Management Strategy Team recommends using the following order of priority to determine appropriate actions:

1. Smallest scale of infestation
2. Poses greatest threat to land management objectives
3. Greatest ease of control.

Table C.3 provides a prioritization summary of known invasive exotic species occurring at John Heinz NWR. The prioritization of species within that table follows the prioritization rankings listed above. Keep in mind that the prioritization in table C.3 is considered for invasive species across the entire refuge. Some species listed as "medium" priority across the refuge, may be a "high" priority for a particular habitat (such as *Phragmites* for the freshwater tidal marsh). This prioritization should be periodically reviewed and updated as necessary to reflect changes in species, distribution, and effectiveness of management.

When limited resources prevent the treatment of entire populations, the following order of priority is recommended:

1. Treat the smallest infestations (satellite populations).
2. Treat infestations on pathways of spread.
3. Treat the perimeter and advancing front of large infestations.

The following ranking systems are available for prioritizing invasive plant species control:

- Morse, L.E., J.M. Randall, N. Benton, R. Hiebert, and S. Lu. 2004. An Invasive Species Assessment Protocol: Evaluating Nonnative Plants for Their Impact on Biodiversity. Version 1. NatureServe, Arlington, Virginia. Web site: *http://www.natureserve.org/getData/plantData.jsp* (accessed January 2012)
- R. D. Hiebert and J. Stubbendieck, Handbook for Ranking Exotic Plants for Management and Control (Natural Resources Report NPS/NRMWRO/NRR-93/08), U.S. National Park Service, Midwest Regional Office, Omaha, Nebraska, 1993.
- APRS Implementation Team. 2000. Alien plants ranking system version 5.1. Jamestown, ND: Northern Prairie Wildlife Research Center Online. (Version 30SEP2002). Web site: *http://www.npwrc.usgs.gov/resource/literatr/aprs (accessed January 2012)*

Restore Altered Habitats and Reintroduce Native Plants

Restoration is critically important because the conditions responsible for the initial invasion will expose the site to a resurgence of the invasive species, as well as a secondary invasion of one or more different species. Furthermore, restoration of a disturbed area before the initial invasion may preclude the need for further control efforts. The goal is to conserve and promote natural processes that will inherently suppress potential pest populations (Department of the Interior 2007).

If funding or personnel are not available to restore highly disturbed areas in a timely manner, consider planting a cover crop for several years to stabilize the site prior to reintroducing native plants. This will prevent more invasive seeds from entering the environment until the site can be restored. Native plants can then be established by direct seeding or planting with less competition from invasive species in the seed bank. When practical, local genotypes of native species should be used.

Biological Control

Biological control is the use of animals or disease organisms that feed upon or parasitize the invasive species target. Usually, the control agent is imported from the invasive species' home country, and artificially high numbers of the control agent are fostered and maintained. There are also "conservation" or "augmentation"

biological control methods where populations of biological agents already in the environment (usually native) are maintained or enhanced to target an invasive species. The advantages of this method are that it avoids the use of chemicals and can provide relatively inexpensive and permanent control over large areas. Appropriate control agents do not exist for all invasive species. Petitions must be submitted to, and approved by, the USDA Technical Advisory Group on weed biological control before any proposed biological control agent can be released in the United States.

Sometime around 2000, John Heinz NWR participated in USDA APHIS programs that resulted in a release of the purple loosestrife biological control *Galerucella* beetle at two sites within the refuge. The first release site, around Hoy's Pond, has resulted in reduction of loosestrife in this area. The second release within the Impoundment was not as successful due to water levels historically present within the impoundment. At this time, no plan exists to re-release new populations of *Galerucella*, but it should be explored in the near future in combination with potential biological controls for other invasive species (Phillips personal communication 2009).

The refuge biologist and manager should evaluate various biological control agents as they become available for field application for the invasive species documented across the refuge. Discussions with USDA APHIS staff may help provide an overview of available research, development of biological control agents, and potential for application of species-specific controls.

Manual and Mechanical Control

Mechanical removal of invasive organisms can be effective against some herbaceous plants, shrubs and saplings, and aquatic organisms. This is particularly effective for plants that are annuals or have a taproot. Care should be taken to minimize soil disturbance to prevent creating conditions ideal for weed seed germination. Repeated cutting over a growing period is needed for effective control of many invasive plant species. Care should be taken to properly remove and dispose of any plant parts that can re-sprout. Treatments should be timed to prevent seed set and re-sprouting. The following methods are available: hand-pulling, pulling with hand tools (weed wrench, etc.), mowing, brush-hogging, weed-eating, stabbing (cutting roots while leaving in place), girdling (removing cambium layer), mulching, tilling, smothering (black plastic or other), and flooding.

The advantages of mechanical treatment are low cost for equipment and supplies and minimal damage to neighboring plants and the environment. The disadvantages are higher costs for labor and inability to control large areas. For many invasive species, mechanical treatments alone are not effective, especially for mature plants or well-established plants. For some invasive plants, mechanical treatments alone exacerbate the problem by causing vigorous suckering. Mechanical treatments are most effective when combined with herbicide treatments (e.g. girdle and herbicide treatment).

Water Level Management in Impoundments

Water level management is also used to control invasive species and promote desirable plants. Robust plants such as *Phragmites* require air pockets (carbon dioxide) to survive. Flooding of impoundments throughout all (or part) of a growing season, inhibits or prohibits vegetative growth of robust vegetation, particularly after mowing or chemical application. Subsequent drawdown will allow for germination of moist-soil plants preferred by waterfowl. Timing and speed of drawdown affects species diversity, density, and seed production. Slow drawdown (4 to 8 weeks) early in the season creates greater species diversity, while fast drawdown (a few days to less than 2 weeks) results in lush extensive stands of similar vegetation. Late in the season, however, slow drawdown promotes greater diversity and density, whereas fast drawdown promotes undesirable plant composition (Lane and Jensen 1999). Flooding also promotes robust perennial control by muskrats.

Winter drawdowns are also possible, but should be avoided as they have detrimental effects on species overwintering in the impoundments such as invertebrates, reptiles, amphibians, and muskrats. Winter drawdowns have been shown to help control undesirable overpopulations of white water lily and carp, but managers should weigh this benefit with the potential costs before undertaking a winter drawdown.

Deer Control

As discussed in chapters 2 and 3, invasive plant problems often are exacerbated by white-tailed deer overbrowsing native species, and when deer numbers rise above the carrying capacity, biodiversity declines (NY State Department of Environmental Conservation 2007).

John Heinz NWR's proximity to high density residential neighborhoods, Philadelphia International Airport, Interstate 95, regional railways, and other public roads make public hunting a difficult option for control of deer populations at the refuge. Public hunting may be used to reduce the deer population only if it is logistically feasible, provides appropriate public safety and screening procedures, and is biologically efficient. An alternative for John Heinz NWR may be use of wildlife control specialists. While this prohibits the opportunity for a combination of public use and deer population management, it does ensure appropriate safety measures are taken. Wildlife control specialists in other highly urbanized settings around Philadelphia have been successful in controlling pest species. A combination of both approaches may be another consideration depending on resources available, public interest, and population targets. Deer control must be conducted in combination with other invasive plant control measures as deer control alone will not be effective if the invasive plants are already established.

Deer exclosures should be considered only in small highly sensitive areas (e.g., where invasive plants are out-competing rare plants and the rare plants will be extirpated without intervention). This method is labor intensive and costly to employ and should only be used on a very limited basis until the native community is firmly established and the invasive species are controlled.

Herbicides

There are a wide variety of chemicals that are toxic to plant and animal species. They may work in different ways and be very target specific, or affect a wide range of species. Herbicides may be "pre-emergent," that is, applied prior to germination to prevent germination or kill the seedling, or "post-emergent" and may have various modes of action (auxin mimic, amino acid inhibitor, mitosis inhibitor, photosynthesis inhibitor, lipid biosynthesis inhibitor). Products may come in granular, pelleted, dust, or liquid forms. Liquid herbicides are commonly diluted to an appropriate formula and mixed with other chemicals that facilitate mixing, application, or efficacy. Common application methods include foliar spray, basal bark, hack and squirt, injection, and cut stump. The timing of applications is critical to achieve good control, as the growth stage at which an organism will be most effectively controlled varies with different species.

The advantages are that the right chemicals, applied correctly, can produce desired results over a large area for a reasonable cost. The disadvantages are that the chemicals may affect nontarget species at the site (including the applicator) or contaminate surface or groundwater. Proper planning includes using the most target-specific, least hazardous (to both humans and the environment), and most effective chemical for the job. Additionally, one should research minimum effective dosage, as the chemical labels often give higher than necessary concentrations. Herbicides often are most effective when used in combination with mechanical methods described above.

Attention to protective gear, licensing requirements and other regulations is essential. In the Service, all pesticide and other chemical applications (including adjuvants designed to enhance effectiveness) are covered by Service and departmental regulations, and a Pesticide Use Proposal (PUP) is required for all pesticide applications.

Control of Overabundant or Nonnative Waterfowl Populations

Controlling invasive or overabundant waterfowl, such as mute swans, snow geese, and resident population Canada geese is a strategy used to protect native waterbirds and fisheries, and prevent the destruction of wetland habitats on refuges. Control methods include: harassment, egg shaking, sterilization, and removal.

The Atlantic Flyway Council outlines the coordination of state and Federal wildlife agencies "to reduce mute swan populations in the Atlantic Flyway to levels that will minimize negative ecological impacts to wetland habitats and native migratory waterfowl and to prevent further range expansion into unoccupied areas." Target populations of mute swans vary by state and range from 0 to 500 free-flying birds (Atlantic Flyway Council 2003).

In the fall of 2005, the Service completed an Environmental Impact Statement that included a multifaceted approach for managing resident Canada geese. At the recommendation of the Atlantic Flyway Council, the Service approved the use of special regulations beginning in 2007 to help curb the growth of these geese in the Eastern United States included in this approach was the expansion of hunting methods during September seasons (USFWS 2005).

While neither mute swans nor resident Canada geese have been nuisances at John Heinz NWR, control options should be considered if at some point overabundant waterfowl begin to pose impacts to other species of conservation concern or components of BIDEH. The refuge manager should consider implementing appropriate population control measures as necessary.

Protecting Nesting Birds
The seasonal closure of nesting and foraging areas may be necessary to protect sensitive nesting bird species and habitats on the refuge, such as the bald eagle. Posting “no disturbance” or “area closed” signs near bird nesting areas, nesting islands, or individual nest locations, is one way to help prevent disturbance caused by humans and boats. Signs are placed in the appropriate areas as soon as possible in the spring and are maintained throughout the nesting season. If disturbance is noted by refuge staff, additional areas may be posted as well.

Impoundment Management

Water Level Manipulation
Water level management (timed drawdown and flooding) is a strategy used to mimic the dynamic water regime of some natural wetlands, and is typically timed to benefit shorebirds, wading birds, and/or waterfowl. During a draw down, mudflats and shallow waters areas are created to provide foraging habitat for shorebirds, while at the same time concentrating food for wading birds. Some waterfowl (e.g., teal) will also take advantage of the concentrated and more accessible food resources. Eventually, the soils in these mudflat areas begin to oxidize and warm up. This in turn causes moist-soil vegetation to germinate. If the water is removed early in the growing season, moist-soil vegetation will outcompete most perennial emergent vegetation, which requires warmer soil temperatures for germination. When water is removed later in the growing season, perennial emergent vegetation usually dominates. This is often an undesirable outcome of a drawdown and is usually avoided. As moist-soil annual vegetation grows, shallow (not to exceed 1/3 plant height) flooding can be used to irrigate growing vegetation, create shallow water foraging habitat for waterfowl or discourage growth of perennial or invasive plants. Water levels are usually returned to the desired management level prior to fall migration, or the following spring migration if water is not available in the fall. Generally, slow (over several weeks) drawdowns will provide a greater diversity of moist-soil plants than faster (over a few days) drawdowns (Frederickson and Taylor 1982).

Alternatively, drawdowns may occur in fall to provide foraging habitat for fall migrating shorebirds and some waterfowl. Winter drawdowns are also possible, but should be avoided as they have detrimental effects on species overwintering in the impoundments such as invertebrates, reptiles, amphibians, and muskrats. Winter drawdowns have been shown to help control undesirable overpopulations of white water lily, but managers should weigh this benefit with the potential costs before undertaking a winter drawdown.

Water may also be held in an impoundment over the growing season, or several growing seasons, to provide breeding habitat for waterfowl and marsh birds. This is usually done in areas where a healthy perennial emergent component exists in the wetland. Over time, water stress or muskrat activity will often reduce the amount of emergent vegetation until it is no longer a significant component of the impoundment. At this point the impoundment has little value to breeding waterfowl and marsh birds and another drawdown should be considered.

Vegetation Management
Plants that occur in an impoundment can be either desirable or undesirable based on their value to wildlife. Generally, plants that provide cover, energy, or nutritional value for objective wildlife are desirable. Plants that quickly develop monocultures and impede foraging by wildlife are undesirable. Whether a plant is desirable or

not also depends on why the impoundment is being managed. For example, cattail is undesirable to shorebirds and waterfowl because it forms dense monotypic stands, and reduces foraging habitat (mudflats and moist-soil vegetation) of shorebirds and waterfowl. In contrast, it provides cover and breeding habitat for marsh birds, and therefore is desirable if managing for those species. The challenge of impoundment management is balancing the needs of various wildlife guilds. In addition to the water level manipulation techniques listed in the previous paragraphs, below are available strategies for promoting desirable vegetation and controlling undesirable or invasive plants.

Muskrat Population Management
Muskrats are efficient at reducing the cover of robust perennial vegetation. The impoundment should be held high for at least 1 year, and muskrat trapping in the impoundment interior should be prohibited when the cover of robust perennial vegetation needs to be decreased. However, if perennial vegetative cover is lower than desired, muskrat control should be conducted. Muskrat trapping also should be employed when muskrat numbers are high enough to damage impoundment dikes or water control structures. Trapping of muskrats takes place during the fall and winter, during State-established trapping seasons. Muskrat trapping follows State regulations and refuge-specific regulations and is issued through a special use permit. See the refuge trapping plan for more information.

Mowing
Mowing can be used to reduce plant height and deplete energy reserves of invasive and robust plants. Repeated mowing within a growing season is often necessary to successfully control invasive plants. This can be logistically difficult in a habitat that is managed for various resources of concern. However, mowing can be effective when combined with other strategies, such as chemical treatment, spring flooding, and disking. Timing of mowing should be scheduled to occur when the undesirable plants are at maximum above ground energy reserve and have little potential for seed dispersal. This is usually the point between flowering and seed setting. Mowing may also increase plant diversity by creating space (light) for other species to germinate.

Due to the unconsolidated nature of sediments deposited within the bed of the impoundment, mowing is not a likely option for vegetation management in most cases. However, there may be occasional opportunities for mowing and cutting in portions of the impoundment fringe. Accessibility and stability should be carefully considered prior to mowing treatments.

Herbicide
The most commonly used herbicide for controlling invasive and robust vegetation in impoundments is glyphosate. Methods of application include spot-treatment using backpack or ATV mounted sprayer, or aerial application. Spot-treatment is more targeted (avoiding neighboring plants), but can be very labor intensive when treating large areas. Aerial application is less labor-intensive, but is not as target-specific, and requires extensive planning to execute. Herbicides are applied during flowering and prior to seed set to maximize effectiveness.

Seeding and Planting
Most impoundments contain abundant stock of moist-soil plant seeds native to a locality, therefore making seeding and planting unnecessary (Frederickson and Taylor 1982). These seeds may remain viable in the soil for many years, and germinate under suitable environmental conditions (Lane and Jensen 1999). In extreme circumstances, past human activities (such as extensive herbicide use, prolonged flooding, and promoting monotypic plants for many years) may have altered site conditions such that the soil seed bank is inadequate or nonexistent (Weller 1990). In these situations, the seed bank may need to be augmented through planting of seeds, rhizomes, or seedlings to ensure growth of desirable plants. Only native species should be used for seeding and planting. Whenever possible, seeds and other plant material should be obtained from a local reference site, either through direct seed harvest or transplant, or from a nursery that procured their stock locally.

Beaver Control
Because beavers are part of the natural landscape, and can be beneficial in terms of creating wetland habitats, harvest of nuisance beavers will only be conducted when negative impacts are determined to be excessive. Beavers interfere with impoundment management by damaging or clogging water control structures and

altering water levels on surrounding lands so impoundments either cannot be filled or cannot be drained. Whenever possible, water control structures and drainage pipes should be fitted with guards to prevent beavers from clogging the pipes or damaging the structures. Trapping is the most effective method of removing problem beavers and may be conducted either during fur season or by nuisance trappers during other times of the year.

Impoundment Improvement Through Depression Creation

Impoundments are created when an ecological system has been altered and the hydrology has been modified and cannot be restored by other means due to surrounding land uses. Impoundments are managed to mimic natural hydroperiods or to provide the best possible habitat for high-priority wildlife species. Impoundments that do not provide high quality habitat, should be modified to achieve the refuge's highest priority habitat goals and objectives.

Annual and perennial wetland vegetation establishment within impoundments is dependent on site elevation relative to hydrology (inundation or saturation levels). In impoundments with little or no change in bathymetric elevation, enhancing the gradient of elevation changes may be a suitable technique for habitat enhancement. Due to the degree of habitat degradation and the lack of wildlife use, it is beneficial to create depressions to restore these areas to high-quality wetland habitat. Depressions will create a mix of emergent marsh and open water habitat that will improve biological diversity and productivity.

Depressions should be created by physically removing material. Other methods that leave the material onsite create temporary openings that fill in as the displaced muck slumps back in and cattails re-invade. Material should be removed to create open water areas and channels in an irregular pattern. The irregular pattern visually attracts wildlife and creates more edge and interspersion between open water and emergent vegetation. The finished bottom of all excavations should be 6 to 36 inches lower than the managed water level of the rest of the impoundment. A meandering channel should connect the newly created depressions to the rest of the impoundment, thus permitting water flow and water level management by the same structures used to control water levels in the surrounding impoundment. A minimum of 50 percent of the side slopes of the depressions should be at a grade of 6:1 (6 horizontal to 1 vertical) or flatter. Slopes as flat as 10:1 are preferable if possible. The remaining side slope area should have a grade of 3:1 or flatter. The connecting ditches should have side slopes of 2:1 or flatter. Excavated muck should be spread over a nearby upland area on the refuge (Sheila Hess, personal communication, October 2005; USDA-NRCS 2006a).

Construction should be planned for the winter when the ground is frozen or the summer following a spring drawdown when earth moving equipment is least likely to sink in the unconsolidated muck. At John Heinz NWR, the soft substrate of the impoundment bed has prohibited access by most equipment. Additionally, portions of the impoundment are used by red-bellied turtles for winter hibernation. Consideration of these sites needs to be incorporated into any enhancement plan.

Forest Management

Silvicultural Prescriptions

Active management generally has not historically been necessary to maintain forest communities in John Heinz NWR. However, communities such as the coastal plain forest, dominated by oak and sweetgum, may require occasional clearing and thinning in order to promote regeneration of these shade-intolerant canopy species.

If a forested tract is degraded and not meeting habitat objectives, then a silvicultural prescription may be needed. A silvicultural prescription is a detailed set of written instructions for the treatment of a forested property and should be developed prior to the treatment of forested tracts other than invasive species treatments (Adams and Dwyer 2012). A forester should be consulted to develop a prescription based on the site conditions and habitat objectives identified in the HMP.

Forest Establishment and Reforestation

Patch size and distribution on the landscape are important considerations in planning and managing habitats. Forest restoration at John Heinz NWR, as outlined in the HMP should be focused on conversion of existing grassland areas, or exotic species-dominated forest, to a coastal plain forest community. Forest restoration to

a floodplain forest community is also appropriate along rivers and open water as riparian forest corridors are often more diverse than adjacent upland areas despite occupying a small area. These areas should be chosen based on their juxtaposition to currently existing forested tracts.

In grassland and meadow areas, forests may be established by allowing the area to succeed naturally; seeding herbaceous, shrub, and tree species; planting shrub and tree seedlings or saplings; or by a combination of these methods. Shade-tolerant herbaceous species may need to be seeded or planted after a canopy is established as they may not survive full sun conditions. The plants in the surrounding landscape should be surveyed to determine the seed stock. If desirable species are in the surrounding landscape and the invasive species load is low, then natural succession should be allowed to proceed. Invasive or other undesirable species can be selected out with herbicides. It may be desirable to plant only those species that are not already present in the surrounding landscape.

If the area is surrounded by invasive species, then allowing natural succession without seeding or planting natives likely will not be successful. Planting seeds of native species is less expensive than planting seedlings or saplings, but it will take longer for these to become established. A combination of seeding and planting may be the best strategy to "flood" the site with natives to outcompete surrounding invasives. The seedlings and saplings will produce seeds and provide shade more quickly, and the planted seeds will provide competition for invasive seeds already present in the soil. The site must be monitored, and invasive species must be controlled before they become well-established. The invasives in the surrounding landscape also should be controlled as resources permit.

Whenever nursery shrubs and trees are planted, they should be protected from deer and other herbivores. Selection of species and ecotypes is a critical step in seeding and restoration. Using local seed and plant materials is important in restoration as plants have wide genetic diversity across geographic space.

Grassland Management

As noted within the HMP, John Heinz NWR does not have grasslands of large enough size to support breeding sites for many grassland birds. Instead, these habitats tend to provide stopover foraging habitat. Refuge grasslands consist of both cool-season and warm-season grasses. Cool-season grasses start growing in spring as soon as the snow melts and the days start to warm up. They grow best in spring and fall and tend to stop growing during the hot dry days of summer. They are usually relatively short and do not grow as dense as many warm-season grasses. Conversely, warm-season grasses do not start growing until late spring and grow best during the hot dry summer months. They generally grow taller and denser than cool-season grasses.

Currently, most cool-season grasses within John Heinz NWR are exotic species brought over from Europe as forage for livestock. Most warm-season grasses are native to the North American prairie. Some varieties are native to Pennsylvania's historic grasslands and the Northeast as well. Exotic cool-season and native warm-season grasses are readily available from seed companies across the country. Some seed companies are beginning to propagate native cool-season grasses, making them more available for planting, but still at a relatively high price.

Many species of grassland birds require relatively large blocks of habitat for nesting areas. Some species, such as upland sandpiper and Henslow's sparrow are not likely to be found in grassland patches of less than 75 acres. Other species patch size requirements are smaller, but grasslands of less than 25 acres generally do not meet the requirements for most grassland nesting birds and may be better suited to a different habitat type (e.g., shrubland) (Mitchell et al. 2000).

Historically, most of the Northeast was forested, except for a period following European settlement when much of the region was cleared for agriculture and subsequently grasslands and open fields became abundant. In pre-settlement times, permanent, large openings were uncommon, except for selected coastal areas. Scattered openings occurred along large river floodplains, around beaver flowages, in coastal heathlands and in other areas of regular disturbance. Large grasslands are now in decline and the region is becoming more forested (Rothbart and Capel 2006).

Populations of grassland birds are declining as grassland habitats and other agricultural conditions diminish. Norment (2002) notes that despite the relatively recent (last 200 years) rise and fall of grassland habitats and associated birds in New England, the region may still be important for these species given their continental decline and habitat loss in the core of their ranges in the Midwest. While grasslands of John Heinz NWR are not sizable enough to provide suitable breeding habitat, they can be managed to improve their BIDEH and provide quality habitat for species migrating through the refuge.

Mowing

Mowing (or cutting) is very effective at controlling broad leaf forbs and woody species, provided it occurs during the growing season of these plants. Mowing is especially effective in supporting weed control efforts associated with new grassland seeding and establishment. Cutting should be delayed until after the nesting season of most grassland birds (usually mid-July) but should be done as soon as possible after this date to allow for maximum stress on invading forbs and shrubs. Depending on the amount of forb and shrub invasion, some grassland fields may require repeated cutting during any one season. Cutting should be done often enough to keep the grassland in the intended state. Occasionally it is possible to selectively mow small sections of forb and tree encroachment within larger grassland fields, thus saving the refuge resources and reducing disturbance to the grassland as a whole.

Prescribed Fire

If used properly, fire can be a useful tool for maintaining grasslands. Generally, prescribed fire is suitable for controlling woody species and to a lesser extent broad leaf forbs in warm-season grasslands. Cool-season grasslands are difficult to maintain with prescribed fire. To achieve effective control of woody species, fire must be applied late enough in the growing season to allow these species to leaf out, but early enough to ensure that sprouting warm-season grasses are not damaged. Due to the early season growth habits of cool-season grasses, they are often too green to allow a fire during the time when woody plants have leafed out.

Due to health constraints related to urban air quality, as well as safety concerns for Philadelphia International Airport, Interstate 95, and regional rail, fire is an unlikely management tool for applications at John Heinz NWR. Despite these constraints, the refuge manager should have an understanding of fire ecology and its place within the habitats of the refuge and suitable alternatives for management.

Herbicides

Woody plants or broadleaf forbs can be sprayed with herbicide during the growing season to control their spread within grassland habitat. Herbicides can either be specific to a certain type of plant (e.g., dicamba for broad leaf plants) or general (e.g., glyphosate). Herbicides can also be sprayed on individual plants, such as from a backpack sprayer, or broadcast across the grassland, such as from a boom sprayer. The species being controlled and the amount of invasion into the grassland will determine which herbicide is used and how it is applied.

The sensitive nature of many refuge habitats and species dictate that herbicides are used with extreme care. It is illegal to use an herbicide in a manner inconsistent with the label, but refuges should strive to be even more restrictive with their use. Nonchemical management techniques should be considered before deciding to use herbicides. Unfortunately, chemical control is often the only effective control technique available for certain plants, particularly many invasive species. Refuges should select the most benign chemical available to effectively do the job and apply it at the minimum necessary rate.

Grassland Establishment

As stated above, patch size and distribution on the landscape are important considerations in planning and managing habitats. Some cool-season grass dominated meadows of John Heinz NWR can be enhanced through establishment of native warm-season grasslands.

Seeding and planting desirable plants can be used to enhance existing grasslands, in restoration of degraded grasslands, or in conversion of croplands. Selection of species and ecotypes is a critical step in seeding and restoration. While many species are commercially available for grassland restoration, few are native to the Northeast. Using local seed and plant materials is important in restoration as plants have wide genetic diversity across geographic space.

Initial seedbed preparation to decrease the weed seed bank is critical to successful grassland establishment. Former agricultural fields are ideal sites for grassland establishment if weed problems are already under control. The field should only need to be disked or sprayed with herbicide in spring prior to seeding as soon as the soil is dry enough.

In fallow fields, a controlled burn the summer or fall prior to seeding decreases surface weed seeds and litter. By the following March or April, spring disking or tilling will reduce the number of winter-growing weeds which set seed. The area should be left fallow during summer and tilled or sprayed with herbicide (glyphosate or pre-emergent herbicide), as necessary, to eliminate late-germinating weeds. One advantage of this spring-summer fallow technique is that deep soil moisture is conserved for the following fall planting. Finally, seedbed preparation may require smoothing with a land plane or scraper and roller if soil clods are large. Rolling with a ring roller provides compaction that will maintain good soil moisture following the first rains.

Broadcast seeding followed by shallow harrowing and cultipacking is very effective, especially on well-prepared soil. A small flexible tine harrow (Fuerst) can be pulled by a standard ATV to easily and rapidly harrow soil to cover the broadcast seed. In small or inaccessible areas, four pronged cultivator rakes can be used to agitate the soil and cover the seed. The preferred method of seeding warm-season grasses is with a no-till drill. When using a drill in recently tilled seedbeds, it is best to cultipack the tilled soil before seeding. Whether drilling or broadcasting on tilled soil, it is essential to cultipack after seeding. It is further recommended to cultipack twice after broadcasting, with the second cultipacking 90 degrees from the first (USDA- NRCS 2006b).

Because warm-season grasses are slow to germinate and have less seedling vigor than cool-season grasses, weed and sod control, both before and after planting, is much more critical than when establishing cool-season grasses. For establishing warm-season grasses, weed control throughout the growing season is just as critical as it is before planting. It usually takes at least two growing seasons to establish a warm-season grass stand which makes weed control during the first growing season critical. Because warm-season grasses are not shade-tolerant, weed canopies will reduce seedling vigor. Moisture competition from weeds and cool-season grasses may also further reduce seedling vigor (NRCS-USDA 2006).

To establish warm-season grasses, weeds are usually controlled by clipping with a sicklebar mower set at a height where only the leaf tips of the warm-season grass seedlings are cut, and the growing point is not damaged. This will reduce the shading competition but not hurt the emerging seedlings. Mowing weeds before flowering will prevent seed production. Mowing two to three times may be necessary during the establishment year; however, if clipped too frequently, weeds may “stool out” (grow out instead of up) (NRCS-USDA 2006).

Appendix B References

Adams, J. and J. Dwyer. Silvicultural Prescriptions. Handouts for Master Tree Farmer II Session 2, Talk 1. Southern Regional Extension Forestry. Accessed January 2012. [Online version available at <*http://www.sref.info/courses/mtf2/mtf2-2-1.pdf*>].

Anonymous, Montana Weed Mapping Handbook: Montana Noxious Weed Survey and Mapping System (Version 2.0), undated.

Atlantic Flyway Council. 2003. Atlantic Flyway Mute Swan Management Plan 2003-2013. Accessed January 2012. [Online version available at <*http://www.michigan.gov/documents/dnr/AFC_mute_swan_plan1_364878_7.pdf*>]

Baldassarre, G.A. and E.G. Bolen. 1994. Waterfowl Ecology and Management. John Wiley and Sons, Inc., New York, NY.

Department of the Interior. 2007. Departmental Manual; Environmental Quality Programs; Part 517: Pesticides: Chapter 1: Integrated Pest Management Policy. Office of Environmental Policy and Compliance, Washington D.C.

Frederickson, L.H. and D.L. Batema. Greentree Reservoir Management Handbook. Gaylord Memorial Laboratory. The School of Natural Resources, University of Missouri-Columbia, Puxico, MO.

Fredrickson, L.H. and T.S. Taylor. 1982. Management of seasonally flooded impoundments for wildlife. U.S. Fish and Wildlife Service Resource Publication.

Fulfilling the Promise National Invasive Species Management Strategy Team. 2002. The National strategy for management of invasive species. National Wildlife Refuge System.

Gruchy, J.P. and C.A. Harper. 2006. When is the best time to disk native warm-season grasses for wildlife? In Proceedings of the Fifth Eastern Native Grass Symposium (Matt Sanderson ed.) Omnipress, Madison, WI.

Hess, S. 2005. Personal communication.

Lane, J.J. and K.C. Jensen. 1999. Moist-soil impoundments for wetland wildlife. U.S. Army Corps of Engineers Technical Report EL-99-11.

Lowry, D.J. 1990. Restoration and creation of palustrine wetlands associated with riverine systems of the glaciated northeast. In Wetland Creation and Restoration: The Status of Science (J. A. Kusler and M. E. Kentula, eds.). Island Press, Washington, D.C.

Mitchell, L.R., C.R. Smith, and R.A. Malecki. 2000. Ecology of Grassland Breeding Birds in the Northeastern United States- A Literature Review with Recommendations for Management. US Geological Survey, New York Cooperative Research Unit, Department of Natural Resources, Cornell University.

Mitchell, W.A. and C.J. Newling. 1986. Greentree Reservoirs: Section 5.5.3, US Army corps of Engineers Wildlife Resources Management Manual. Department of the Army, Vicksburg, MS.

New York State Department of Environmental Conservation. 2007. New York hunting and trapping 2007-08 official regulations guide. NY State Department of Environmental Conservation, Albany, NY.

Niering, W.A. and R.H. Goodwin. 1974. Creation of Relatively stable shrublands with herbicides: arresting “succession” on rights-of-way and pastureland. Ecology 55:784-795.

Norment, C.J. 2002. On grassland bird conservation in the Northeast. Auk 119:271–279.

Rothbart, P. and S. Capel. 2006. Maintaining and Restoring Grasslands. In Managing grasslands, shrublands, and young forest habitats for wildlife. A guide for the northeast (J.D. Ohler, D.F. Covell, S. Capel, and B. Long, eds.). The Northeast Upland Habitat Technical Committee. Massachusetts Division of Fisheries and Wildlife

Sample, D.W. and M.J. Mossman. 1997. Managing habitat for grassland birds: a guide for Wisconsin. Wisconsin Department of Natural Resources Publication No. SS-925-97.

Sepik, G.F., R.B. Owen, and M.W. Coulter. 1981. A Landowner’s Guide to Woodcock Management in the Northeast. Misc. Report No. 253. University of Maine, Orono, ME.

USDA-NRCS. 1999. Natural Resources Conservation Service Conservation Practice Standard: Pothole. New York.

USDA-NRCS. 2006a. Natural Resources Conservation Service Wetland Restoration – 774 Pothole. New York.

----. 2006b. Warm-season Grasses in Pennsylvania. Harrisburg, PA.

U.S. Fish and Wildlife Service (USFWS). 2005. Final Environmental Impact Statement: Resident Canada Goose Management. Accessed January 2012. [Online version available at <*http://www.fws.gov/migratorybirds/CurrentBirdIssues/Management/cangeese/finaleis.>]*

Weller, M.W. 1990. Waterfowl management techniques for wetland enhancement, restoration and creation useful in mitigation procedures. In Wetland creation and restoration: The status of the science. (J.A. Kusler and M.E. Kentula, eds.). Island Press, Washington, D.C.

Williams, R.K. Construction, maintenance, and water control structures of tidal impoundments. In Waterfowl Habitat Restoration Enhancement and Management in the Atlantic Flyway (W. R. Whitman, T. Strange, L. Widjeskog, R. Whittemore, P. Kehoe, and L. Roberts eds.). Delaware Department of Natural Resources and Environmental Control, Dover, DE.

Zimmerman, J.L. 1988. Breeding season habitat selection by the Henslow's sparrow in Kansas. Wilson Bulletin 100(1):17-24.

Appendix C.
Resources of Concern for John Heinz National Wildlife Refuge

Species	Seasons/Abundance at John Heinz NWR[1]				Nesting[1]	Federal T&E[2]	PA T&E[3]	BCR 30[4]	PIF 44[5]	USFWS North Atlantic LCC Priority List[6]	USFWS Birds of Conserv. Concern[7]	Federal Trust Fish	PA SWAP Priority[8]	North Atlantic Shorebird Plan[9]	North American Waterbird Plan[10]	Watefowl Management Plan[11]
	Spr	Sum	Fall	Win												
Waterbirds																
American Bittern	c	r	o	r	Y		PE	M	2		X		HC			
American Coot	c	o	c	o	Y								MC			
Black Tern	o	r	o												M	
Black-crowned Night Heron	a	a	a	o	Y		PE	M					V		M	
Bonaparte's Gull	o	r	o	r											M	
Caspian Tern	o	r	o						5						L	
Cattle Egret	o	o	r												NR	
Common Gallinule	u	u	u	r	Y				5				MC			
Common Tern	r	r	r					M					V		L	
Double-crested Cormorant	c	r	c	r											NR	
Forster's Tern	r	o	c						5						M	
Glaucous Gull	r		r	r											NR	
Glossy Ibis	o	o	o					H	5						L	
Great Blue Heron	a	c	a	c					5				MC		NR	
Great Egret	a	a	a	r	Y		PE		5				V		NR	
Gull-billed Tern			r					HH	2	X	X				H	
Herring Gull	c	o	c	c											L	
Horned Grebe	r		r	r				H			X					
Iceland Gull	r		r	r											L	
King Rail	o	o	o	r	Y		PE	M	1B				V			
Laughing Gull	o	o	c	r											NR	
Least Bittern	o	c	o		Y		PE		2		X		V			
Least Tern	r	r	r					H	2		X				H	
Little Blue Heron	o	c	c					M	5						H	
Northern Gannet			r	r				H							NR	
Pied-billed Grebe	c	r	c	o	Y				5		X		MC			

Species	Seasons/Abundance at John Heinz NWR[1]				Nesting[1]	Federal T&E[2]	PA T&E[3]	BCR 30[4]	PIF 4[5]	USFWS North Atlantic LCC Priority List[6]	USFWS Birds of Conserv. Concern[7]	Federal Trust Fish	PA SWAP Priority[8]	North Atlantic Shorebird Plan[9]	North American Waterbird Plan[10]	Watefowl Management Plan[11]
	Spr	Sum	Fall	Win												
Red-throated Loon			r	r				HH			X					
Ring-billed Gull	c	o	c	c											NR	
Royal Tern			r					M	5						M	
Snowy Egret	a	a	a		Y			M			X				H	
Sora	o	o	o	r	Y			M					MC			
Tricolored Heron	o	o	o					M	5						H	
Virginia Rail	o	o	o	r	Y								HC			
White Ibis	r		r												M	
Yellow-crowned Night Heron	r	r	r				PE	M	5				V		M	
Waterfowl																
American Black Duck	a	c	a	c	Y			HH	1B	X			MC			D
American Wigeon	o		o	o				M								I
Blue-winged Teal	c	c	c	r	Y											I
Brant	r		r	r						X						
Bufflehead	o		o	r				H								I
Canada Goose	a	a	a	c	Y					X						
Canvasback	o		o	r				H								I
Common Goldeneye	r	r	r	r				M								
Common Merganser	o		o	o												I
Gadwall	o	r	o	o				M								I
Greater Scaup	c	r	o	o				H								I
Green-winged Teal	c	o	a	c	Y			M					V			I
Hooded Merganser	o	r	o	r	Y			M								I
Lesser Scaup	o		o	o				H								D
Mallard	a	a	a	c	Y			H								NT
Northern Pintail	c	o	c	c	Y			M								D

Species	Seasons/Abundance at John Heinz NWR[1]				Nesting[1]	Federal T&E[2]	PA T&E[3]	BCR 30[4]	PIF 44[5]	USFWS North Atlantic LCC Priority List[6]	USFWS Birds of Conserv. Concern[7]	Federal Trust Fish	PA SWAP Priority[8]	North Atlantic Shorebird Plan[9]	North American Waterbird Plan[10]	Watefowl Management Plan[11]
	Spr	Sum	Fall	Win												
Northern Shoveler	c	r	c	o	Y											I
Red-breasted Merganser	o		r	r				M								I
Redhead	r	r	r	r												NT
Ring-necked Duck	o	r	o	o												I
Ruddy Duck	c	o	c	c				M					MC			I
Tundra Swan	r		r	r				H					R			
Wood Duck	a	c	a	o	Y			M								I
Landbirds																
Acadian Flycatcher	r	r	u						1B				MC			
Alder Flycatcher	o	o	u		Y								MC			
American Kestrel	c	c	c	c	Y				2							
Bald Eagle	u	r	u	u			PT	M	5		X		HC			
Bank Swallow	c	o	c						5				MC			
Barn Owl	c	c	c	c	Y		CR		2				MC			
Barred Owl	r	r	r	r					5							
Bay-breasted Warbler	c	r	c					H		X	X					
Black-and-white Warbler	c	r	c	r				H								
Black-billed Cuckoo	o	o	o		Y								MC			
Blackburnian Warbler	c	r	c					M					MC			
Blackpoll Warbler	c	r	c										V			
Black-throated Blue Warbler	c	r	c										MC			
Black-throated Green Warbler	c	r	c										MC			
Blue-winged Warbler	o	o	o					HH	1B	X	X		R			
Bobolink	o	r	c						5							
Brewer's Blackbird			r	r												

Species	Seasons/Abundance at John Heinz NWR[1]				Nesting[1]	Federal T&E[2]	PA T&E[3]	BCR 30[4]	PIF 44[5]	USFWS North Atlantic LCC Priority List[6]	USFWS Birds of Conserv. Concern[7]	Federal Trust Fish	PA SWAP Priority[8]	North Atlantic Shorebird Plan[9]	North American Waterbird Plan[10]	Watefowl Management Plan[11]
	Spr	Sum	Fall	Win												
Broad-winged Hawk	o	o	c	r				H					MC			
Brown Creeper	c		c	c												
Brown Thrasher	c	c	c	o	Y			H	2				MC			
Canada Warbler	c	r	c					M		X	X		MC			
Cerulean Warbler	r	r	r					M	1B		X		HC			
Chimney Swift	c	c	c					H	2				MC			
Cliff Swallow	o	r	o						5							
Common Nighthawk	c	o	c										MC			
Cooper's Hawk	o	r	o	o					5							
Dickcissel	r	r	r	r					3				HC			
Eastern Kingbird	c	c	c		Y			H								
Eastern Meadowlark	o	r	o	r									MC			
Eastern Wood Pewee	o	r	o						1B							
Field Sparrow	c	o	c	c	Y			H	2							
Golden Eagle	r		r	r									V			
Golden-winged Warbler	r	r	r					M			X		HC			
Grasshopper Sparrow	r		r					M					MC			
Gray Catbird	c	c	c	o	Y			M	2							
Great Crested Flycatcher	o	r	o		Y			H								
Henslow's Sparrow	r		r						1B		X		HC			
Kentucky Warbler	r	r	u					H	1B		X		MC			
Loggerhead Shrike	r	r	r	r					5		X		IC			
Long-eared Owl	r		r	r			PU						HC			
Louisiana Waterthrush	r	r	u					H	1B				R			
Marsh Wren	c	c	c	r	Y		CR	H					HC			

Species	Seasons/Abundance at John Heinz NWR[1]				Nesting[1]	Federal T&E[2]	PA T&E[3]	BCR 30[4]	PIF 44[5]	USFWS North Atlantic LCC Priority List[6]	USFWS Birds of Conserv. Concern[7]	Federal Trust Fish	PA SWAP Priority[8]	North Atlantic Shorebird Plan[9]	North American Waterbird Plan[10]	Watefowl Management Plan[11]
	Spr	Sum	Fall	Win												
Northern Bobwhite	r	r	r	r				H	2				IC			
Northern Flicker	c	c	c	o	Y			H								
Northern Goshawk	r		r	r									V			
Northern Harrier	c	o	c	c	Y		CA		5				HC			
Northern Oriole	c	o	c	r	Y			H								
Olive-sided Flycatcher	r		u								X		IC			
Osprey	o	o	o				PT		5				V			
Peregrine Falcon	r	r	r	r			PE		5		X		HC			
Pine Siskin	r	r	o	o									V			
Prairie Warbler	c	r	c					HH	1B	X	X		MC			
Prothonotary Warbler	r	r	u					H	1B				HC			
Red Crossbill				r									V			
Red-headed Woodpecker	r	r	r					M	2		X					
Red-shouldered Hawk	o	r	o	o					5				MC			
Rusty Blackbird	c	r	c	o				H			X					
Savannah Sparrow	c	r	c	r	Y				5							
Scarlet Tanager	c	r	c					H	2				R			
Sedge Wren	r	r	r		Y		PE	M	1B		X		IC			
Sharp-shinned Hawk	o	r	o	r									MC			
Short-eared Owl	o		o	o			PE	M	5		X		IC			
Summer Tanager	r	r	r										HC			
Swainson's Thrush	c	o	c								X		V			

Species	Seasons/Abundance at John Heinz NWR[1]				Nesting[1]	Federal T&E[2]	PA T&E[3]	BCR 30[4]	PIF 44[5]	USFWS North Atlantic LCC Priority List[6]	USFWS Birds of Conserv. Concern[7]	Federal Trust Fish	PA SWAP Priority[8]	North Atlantic Shorebird Plan[9]	North American Waterbird Plan[10]	Watefowl Management Plan[11]
	Spr	Sum	Fall	Win												
Vesper Sparrow	c	o	o	o					5							
Whip-poor-will	r	r	r					H			X		MC			
White-eyed Vireo	c	c	c		Y				1B							
Willow Flycatcher	c	c	u		Y								MC			
Winter Wren	o		c	r									MC			
Wood Thrush	c	c	c	r	Y			HH	1B	X	X		R			
Worm-eating Warbler	r	r	u					H	1B		X		R			
Yellow-bellied Flycatcher	r	r	u										V			
Yellow-breasted Chat	c	c	c	r	Y				2				MC			
Yellow-throated Vireo	o	r	o					H	1B				MC			
Shorebirds																
American Woodcock	c	c	c	r	Y			HH		X			MC	X		
Black-bellied Plover	o	r	c	r				H								
Buff-breasted Sandpiper			r					H			X					
Common Snipe	c	r	c	o				M								
Dunlin	o		o	r				H								
Greater Yellowlegs	c	o	c	r				H								
Hudsonian Godwit			o					H			X					
Killdeer	a	a	a	o	Y			M								
Least Sandpiper	o	o	o	r				M								
Lesser Yellowlegs	o	o	0	r				M			X					
Marbled Godwit			r					H			X					
Piping Plover	r		r			E		HH	1A	X				X		

Species	Seasons/Abundance at John Heinz NWR[1]				Nesting[1]	Federal T&E[2]	PA T&E[3]	BCR 30[4]	PIF 44[5]	USFWS North Atlantic LCC Priority List[6]	USFWS Birds of Conserv. Concern[7]	Federal Trust Fish	PA SWAP Priority[8]	North Atlantic Shorebird Plan[9]	North American Waterbird Plan[10]	Watefowl Management Plan[11]
	Spr	Sum	Fall	Win												
Red Knot	r		r					HH		X	X			X		
Red-necked Phalorope	r		r							X						
Ruddy Turnstone	r	r	r					HH								
Sanderling	r		r					HH		X						
Semipalmated Plover	c	r	c					M								
Semipalmated Sandpiper	c	o	c	r				H		X	X					
Short-billed Dowitcher	o	r	o	r				H			X					
Solitary Sandpiper	c	o	c								X		MC			
Spotted Sandpiper	c	c	c		Y			M								
Upland Sandpiper	r	r	r				PT	M	1B		X		IC			
Western Sandpiper		r	o	r				M								
Whimbrel	r		r					HH		X	X			X		
White-rumped Sandpiper	o	o	o					H								
Willet	r		r					H	3							
Wilson's Phalarope	r	r	r					H								
Mammals																
Marsh rice rat	nc	nc	nc	nc			SX									
Northern river otter	nc	nc	nc	nc			CA						MC			
Amphibians																
Coastal plain leopard frog	c	c	c	c	Y		PE						V			
Reptiles																
Eastern mud turtle	nc	nc	nc	nc	Y		PX									
Red-bellied turtle	u	u	u	u	Y		PT						HC			

Species	Seasons/Abundance at John Heinz NWR[1]				Nesting[1]	Federal T&E[2]	PA T&E[3]	BCR 30[4]	PIF 44[5]	USFWS North Atlantic LCC Priority List[6]	USFWS Birds of Conserv. Concern[7]	Federal Trust Fish	PA SWAP Priority[8]	North Atlantic Shorebird Plan[9]	North American Waterbird Plan[10]	Watefowl Management Plan[11]
	Spr	Sum	Fall	Win												
Fish																
American eel	p	p	p	p								X	MC			
Alewife	p	p	p	p						X		X				
Blueback Herring	p	p	p	p								X				
Eastern mudminnow	p	p	p	p			CR									
Hickory shad	p	p	p	p			PE					X				
Striped Bass	p	p	p	p						X		X				
Shortnose sturgeon	nc	nc	nc	nc		E	PE			X		X	IC			
Plants																
Waterhemp Ragweed	p	p	p	p			PR					X	MC			
Field Dodder	p	p	p	p			PT									
Walter's Barnyard-grass	p	p	p	p			PE									
A Eupatorium	p	p	p	p												
Forked Rush	p	p	p	p			PT									
Shrubby Camphor-weed	p	p	p	p						X		X				

Sources

[1] U.S. Fish and Wildlife Service. John Heinz NWR at Tinicum Web site. Available online at: *http://www.fws.gov/heinz/index.html*; accessed January 2012. a - abundant; c- common; u - uncommon; o - occasional; r - rare; nc - not confirmed on refuge, but potential habitat; p - present (from surveys) but seasonal abundance unknown

[2] U.S. Fish and Wildlife Service. Endangered Species Program Web site. Available online at: *http://ecos.fws.gov/tess_public/pub/listedAnimals.jsp*; accessed January 2012. E - Endangered; T - Threatened; R - Rare

[3] Pennsylvania Natural Heritage Program. Pennsylvania Natural Heritage Program Web site. Available online at: *http://www.naturalheritage.state.pa.us/;* accessed January 2012. PE - Endangered; PT - Threatened; PR - Rare; PX/SX - Extripated; CA - Candidate at Risk; CR - C

[4] U.S Fish and Wildlife Service. 2008. New England Mid-Atlantic Coast Bird Conservation Region (BCR 30) Implementation Plan. Atlantic Coast Joint Venture, Hadley, MA: Regoin 5, Fish and Wildlife Service, U.S. Department of the Interior. *http://www.acjv.org/BCR_30/BCR30_June_23_2008_final.pdf*; accessed January 2012. HH - Highest Priority; H - High Priority; M - Moderate Priority

[5] Partners in Flight. April 1999. Partners in Flight: Mid-Atlantic Coastal Plain Bird Conservation Plan (Physiographic Area #44) Version 1.0. Williamsburg, VA. Prioritization Rankings = 1 (Highest) - 5 (Lowest).

[6] U.S. Fish and Wildlife Service. December 2009. North Atlantic Landscape Conservation Cooperative Development and Operations Plan. U.S. Department of Interior, U.S. Fish and Wildlife Service, Northeast Region. Hadley, MA. 38 pp.

[7] U.S. Fish and Wildlife Service. 2008. Birds of conservation concern 2008. Division of Migratory Bird Management, Arlington, Virginia. 93 pp. Online version available at: *http://www.fws.gov/migratorybirds/NewReportsPublications/SpecialTopics/BCC2008/BCC2008.pdf*; accessed January 2012.

[8] Pennsylvania Game Commission/Pennsylvania Fish and Boat Commission. Accessed December 2008. State Wildlife Action Plan. Available online at *http://www.portal.state.pa.us/portal/server.pt?open=514&objID=622722&mode=2*; accessed January 2012. IC - Immediate Concern (Tier 1); HC - High Level Concern (Tier 2); R - Responsibility Species (Tier 3); V- Vulnerable Species (Tier 4); MC - Maintenance Concern (Tier 5)

[9] Clark and Niles. 2000. North American Shorebird Conservation Plan. Atlantic Flyway Priorities. Woodbine, NJ.

[10] James A. Kushlan, Melanie J. Steinkamp, Katharine C. Parsons, Jack Capp, Martin Acosta Cruz, Malcolm Coulter, Ian Davidson, Loney Dickson, Naomi Edelson, Richard Elliot, R. Michael Erwin, Scott Hatch, Stephen Kress, Robert Milko, Steve Miller, Kyra Mills, Richard Paul, Roberto Phillips, Jorge E. Saliva, Bill Sydeman, John Trapp, Jennifer Wheeler, and Kent Wohl. 2002. Waterbird Conservation for the Americas: The North American Waterbird Conservation Plan, Version 1. Waterbird Conservation for the Americas. Washington, DC. Online version available at: *http://www.waterbirdconservation.org/pdfs/plan_files/complete.pdf*; accessed January 2012.

[11] Atlantic Coast Joint Venture. February 2007. North American Waterfowl Management Plan: Continental Progress Assessment. Population Trend Data = I - Increasing; D - Decreasing; NT - No Trend.

Appendix D.
Known Vegetation of John Heinz National Wildlife Refuge

Known vegetation data is compiled from meander surveys conducted throughout John Heinz NWR in summer and fall of 2005. It is not intended as an exhaustive list or survey of the refuge, but provided for informational purposes.

Species identified as “invasive” are those listed as such by Pennsylvania Department of Conservation and Natural Resources. Additional species listed as “nonnative” may be ecologically aggressive and may require management.

Scientific Name	Common Name	Native/Nonnative/Invasive
Acer negundo	boxelder	Native
Acer platanoides	Norway maple	Invasive
Acer rubrum	red maple	Native
Acer rubrum	red maple	Native
Acer saccharinum	silver maple	Native
Acer saccharinum	silver maple	Native
Aesclepius syriaca	common milkweed	Native
Aesclepius incarnata	swamp milkweed	Native
Ailanthus altissema	tree-of-heaven	Invasive
Alliaria petiolata	garlic mustard	Invasive
Ambrosia artimisiifolia	common ragweed	Native
Amorpha frutescens	wild false indigo	Native
Ampelopsis brevipedunculata	porcelainberry	Invasive
Andropogon gerardii	big bluestem	Native
Andropogon virginicus	broomsedge	Native
Apocynum cannabinum	dogbane	Native
Artemisia vulgaris	mugwort	Nonnative
Aster divaricatus	white wood aster	Native
Aster novae-angliae	New England aster	Native
Baccharis halmifolia	groundsel-tree	Native
Bidens laevis	tickseed sunflower	Native
Boehmeria cylindrica	false nettle	Native
Calamagrostis canadensis	bottlebrush grass	Native
Carex stricta	tussock sedge	Native
Carex. spp.	unidentified sedge species	Native
Celtis occidentalis	hackberry	Native
Cephalanthus occidentalis	buttonbush	Native
Celastrus orbiculatus	Oriental bittersweet	Invasive
Cirsium vulgare	bull thistle	Invasive
Clematis spp.	unidentified clematis species	Unknown
Commelina communis	Asiatic dayflower	Nonnative
Conyza canadensis	horseweed	Native

Scientific Name	Common Name	Native/Nonnative/Invasive
Cornus amomum	silky dogwood	Native
Crategus spp.	hawthorn	Native
Dactylis glomerata	orchardgrass	Nonnative
Daucus carota	Queen Anne's lace	Nonnative
Digitaria sanguinalis	crabgrass	Nonnative
Echinacea purpurea	purple coneflower	Native
Elymus riparius	riparian rye	Native
Elymus virginicus	Virginia wild rye	Native
Erigeron spp.	daisy fleabane	Native
Eupatorium rugosum	white snakeroot	Native
Gleditsia triacanthus	honey locust	Native
Helianthus giganteus	swamp sunflower	Native
Heteranthera spp.	unidentified mud-plantain	Native
Hibiscus moscheutos	hibiscus	Native
Humulus japonica	Japanese hops	Invasive
Ilex verticillata	winterberry	Native
Iris versicolor	blue flag iris	Native
Juglans nigra	black walnut	Native
Juncus effusus	dark green bulrush	Native
Juncus tenuis	path rush	Native
Lamium amplexicaule	henbit	Nonnative
Ligustrum vulgare	Chinese privet	Invasive
Lindera benzoin	spicebush	Native
Liquidambar styraciflua	sweetgum	Native
Liriodendron tulipfera	tulip poplar	Native
Lonicera maackii or tartarica	shrub honeysuckle	Invasive
Lonicera japonica	Japanese honeysuckle	Invasive
Ludwigia palustris	marsh-purslane	Native
Lythrum salicaria	purple loosestrife	Invasive
Malus spp.	unidentified crabapple species	Unknown
Microstegium vinemeum	Japanese stiltgrass	Invasive
Monarda fistulosum	wild bergamot	Native
Morus alba	white mulberry	Nonnative
Morus papyrifera	paper mulberry	Nonnative
Nuphar lutea	spadderdock	Native
Nyssa sylvatica	blackgum	Native
Onoclea sensibilis	sensitive fern	Native
Panicum virgatum	switchgrass	Native
Parthenosis quinquifolia	Virginia creeper	Native
Paulownia tomentosa	Paulownia tree	Nonnative
Phytolacca americana	pokeweed	Native

Scientific Name	Common Name	Native/Nonnative/Invasive
Pinus strobus	eastern white pine	Native
Platanus occidentalis	American sycamore	Native
Pluchea odorata	marsh fleabane	Native
Polyganum cespitosum	long-bristled smartweed	Native
Polyganum cuspidatum	Japanese knotweed	Invasive
Polyganum lapthifolium	white smartweed	Native
Polyganum perfoliatum	mile-a-minute vine	Invasive
Polyganum sagittatum	arrow-leaved tearthumb	Native
Pontederia cordata	pickerelweed	Native
Populus canescans	gray poplar	Nonnative
Populus deltoides	eastern cottonwood	Native
Populus grandidentata	big-toothed aspen	Native
Prunus serotina	black cherry	Native
Quercus alba	white oak	Native
Quercus palustris	pin oak	Native
Quercus phellos	willow oak	Native
Rhus glabra	smooth sumac	Native
Robinia pseudoacacia	black locust	Native
Rosa multiflora	multiflora rose	Invasive
Rubus allegheniensis	blackberry	Native
Rubus occidentalis	raspberry	Native
Rubus phoenicolasius	wineberry	Nonnative
Rudbeckia triloba	gray-headed coneflower	Native
Salix fragilis	crack willow	Nonnative
Salix nigra	black willow	Native
Sambucus canadensis	elderberry	Native
Sassafras albidum	sassafras	Native
Scirpus cyperinus	woolgrass	Native
Setaria spp.	unidentified foxtail species	Nonnative
Solidago spp.	unidentified goldenrod species	Native
Sonchus oleraceus	sow thistle	Nonnative
Sorghastrum nutans	Indiangrass	Native
Toxidendron radicans	Poison ivy	Native
Typha angustifolia	narrow leaved cattail	Native
Typha latifolia	broad leaved cattail	Native
Ulmus americana	American elm	Native
Urtica dioica	common nettle	Native
Viburnum dentatum	arrowwood viburnum	Native
Vicia spp.	crown vetch	Nonnative

Scientific Name	Common Name	Native/Nonnative/Invasive
Vinca minor	periwinkle	Nonnative
Vitis spp.	unidentified grape species	Native
Wisteria floribunda	Chinese wisteria	Nonnative
Ziziania aquatica	wildrice	Native

Composition of Species	Number	Percent
Native	82	67
Nonnative	17	14
Invasive	15	12

Appendix E.
Nonbird Animal Species of John Heinz NWR

Species included in this list are those observed onsite by refuge staff and volunteers as well as additional species found commonly throughout Philadelphia County according to the Pennsylvania Natural Heritage Program.

Scientific Name	Common Name
Reptiles	
Thamnophis sirtalis	eastern garter snake
Chrysemys picta	painted turtle
Chelydra serpentina	snapping turtle
Sternotherus odoratus	stinkpot turtle
Pseudemys rubriventris	red-bellied turtle
Trachemys scripta elegans	red-eared slider
Kinosternon subrubrum	eastern mud turtle
Terrapene c. carolina	eastern box turtle
Malaclemys t. terrapin	northern diamond-backed terrapin
Storeria dekayi dekayi	northern brown snake
Nerodia sipedon	northern water snake
Amphibians	
Lithobates catesbeianus	bullfrog
Lithobates clamitans	green frog
Plethodon cinereus	red-backed salamander
Anaxyrus americanus	American toad
Pseudacris crucifer	spring peeper
Anaxyrus fowleri	Fowler's toad
Lithobates palustris	pickerel frog
Lithobates sphenocephalus	Coastal Plain (southern) leopard frog
Mammals	
Blarina brevicauda	northern short-tailed shrew
Castor canadensis	beaver
Cryptotis parva	least shrew
Didelphis virginiana	opossum
Lontra canadensis	northern river otter
Marmota monax	Woodchuck or groundhog
Mephitis mephitis	skunk
Microtus pennsylvanicus	meadow vole
Mus musculus	house mouse
Mustela frenata	long-tailed weasel
Odocoileus virginianus	white-tailed deer
Ondatra zibethicus	muskrat
Peromyscus leucopus	white-footed mouse

Scientific Name	Common Name
Procyon lotor	raccoon
Rattus norvegicus	Norway rat
Sciurus carolinensis	gray squirrel
Sylvilagus floridanus	eastern cottontail
Tamias striatus	eastern chipmunk
Vulpes vulpes	red fox