Chapter 2

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Great egrets within the 145-acre impoundment at John Heinz NWR

Affected Environment

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2.1 Introduction

This chapter describes the current and historic physical, biological, and socioeconomic landscape of John Heinz NWR. Included are descriptions of the physical landscape, the regional context and its history, and the refuge environment, including its history, current administration, programs, and specific refuge resources. Much of the information included herein was originally compiled in the Draft Habitat Management Plan (appendix B). Since then, several new studies and reports related to aspects of climate change, biological management, and socioeconomic demographics have been released. Those reports have been reviewed by the planning team and incorporated into the summary provided here.

2.2 The Physical Landscape

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 small areas of human settlement. Decades of development and harvesting resulted in filled wetlands and a decrease of forests (DRBC 2004).

The refuge is located 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).

Geologic Development

John Heinz NWR is situated within Pennsylvania's southeastern most physiographic province, the Atlantic Coastal Plain (Low et al. 2010). 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 to 1,600 million years ago, was altered by heat and pressure to form various metamorphic rocks, which in turn weather relatively easily.

The refuge is influenced by the Delaware River and its soils are in a different group. Soils on the refuge are 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. DCNR (2010) has highlighted Tinicum Marsh as an Outstanding Scenic Geological Feature worth noting within this physiographic province.

2.3 The Cultural Landscape Setting and Land Use History

Pre-European Habitat

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 farther 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).

PNHP estimates that Philadelphia County at one time contained 10 to 20 square miles (6,400to12, 800 acres) of freshwater tidal marsh (PNHP 2008). 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 over 1/3 square miles (282 acres) of the freshwater tidal marsh that remains in this part of the State (PNHP 2008).

Pre-European Settlement

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 nontidalat 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 this 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.

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 the Tinicum Township, the landscape of the refuge consists entirely of tidal marsh overlaid by a system of dikes. Some of the dikes are wide enough to support trees and brush on their edges, but close examinations of early maps and photographs reveal no natural islands. The only refuge areas suitable for pre-Contact Native American occupation consist of two narrow strips of terrace on the north side of Darby Creek in 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 forested. These areas may retain some archaeological potential, though the immediate vicinity of the refuge headquarters consists of a deep and remarkably extensive modern fill.

European Settlement

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 on top of 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 2.2). It continues to affect the hydrology and drainage in the area of the impoundment.

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 projects 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 phragmites.

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).

Figure 2.1. 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.

In 1980, Congress authorized the purchase of the Folcroft Landfill to increase the size of the refuge. At this time, a potentially responsible party (PRP) group is conducting a remedial investigation of the landfill pursuant to an administrative order on consent with the U.S. Environmental Protection Agency (USEPA) (USEPA 2006). Refuge staff is working with USEPA to 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).

Additional information on the history and cultural resources of the refuge and surrounding lands are identified in the Phase I Archaeological Survey Report developed for the Clearview Landfill, part of the Lower Darby Creek Area Site (Kim and Teamerson 2011). This report is available online at the EPA's Lower Darby Creek summary Web site.

Wildlife and Habitat Changes

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). Invasive species that compete with or reduce populations of native species are 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 nonnative (Goodrich 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.

The Pennsylvania Department of Conservation and Natural Resources 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 Pennsylvania and highlights the coastal plain region as being home to 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*, recommends that where possible, wetlands along the Delaware should be restored. 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 2001).

The Refuge, the Land, and the People

The cultural history of the region reflects changing societal values in the U.S. 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.

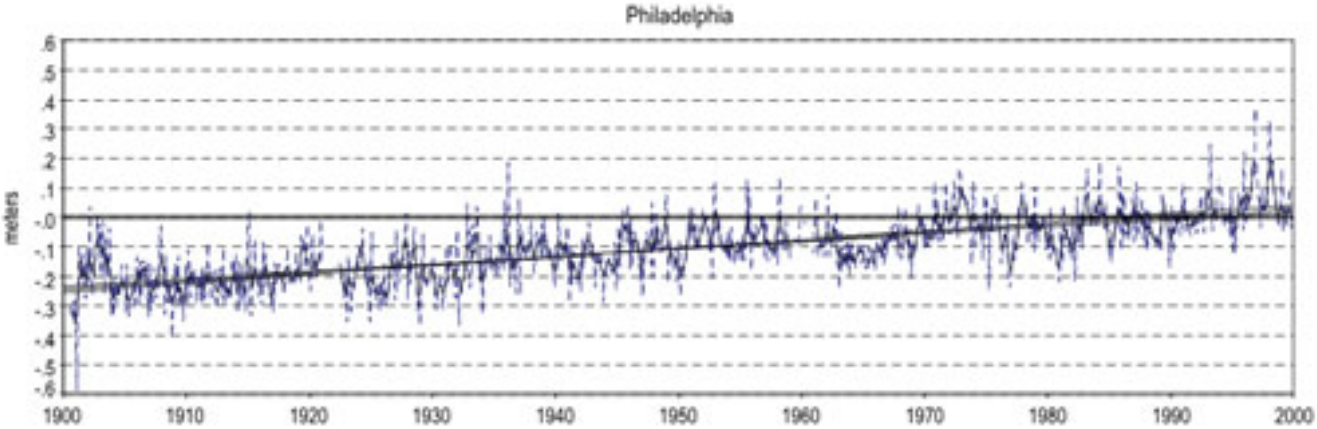
2.4 The Current Climate and Potential Effects of Climate Change

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 (NRCC 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 (NRCC 2006). In recent years, these large events have caused flooding in and around the refuge.

Like many areas throughout the world, the climate of southeastern Pennsylvania is changing. Over the past century mean annual temperature has risen 0.5°F (UCS 2008). Sea level, as measured by a tidal gauge at Philadelphia, has also risen nearly 1 foot over the past century as shown in figure 2.2 (NOAA/NOS 1999).

Figure 2.2. Monitored Sea Levels at Philadelphia, Pennsylvania (1900–2000). Note the nearly 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 habitats of John Heinz NWR and their management over the coming decades. As with other areas throughout the world, the precise ecological impacts to John Heinz NWR from 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 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). Najjar et al. (2000) estimate global sea level rise between 0.4 to 1.2 inches by 2030 and between 1.6 to 4.0 inches by 2095. Another recent estimate shows relative sea level rise (which accounts for mean sea level rise and land subsidence) may increase 2.6 to 5.6 feet by the end of the century (Kreeger et al. 2010).

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 (i.e., a rising of the marsh surface elevation) or expansion into nearby (and topographically higher) riparian lands (i.e., conversion of surrounding lands) (Odum et al. 1984). Due to the unique landscape context of John Heinz NWR being situated within the Philadelphia metropolitan area, at the base of a highly urbanized watershed and at the confluence of Darby Creek with the Delaware River, the refuge's freshwater tidal marsh is particularly vulnerable to changing sea levels. Given this level of urbanization in the Darby Creek watershed, 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 et al. 2008). 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 John Heinz NWR could lead to a major shift in plant communities and species within areas which are currently freshwater tidal marsh. 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 into the future.

In an effort to address the potential effects of sea level rise on United States national wildlife refuges, the Service's Northeast Region contracted the application of the Sea Level Affecting Marshes Model (SLAMM) for most of its refuges with tidal waters. 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; Warren Pinnacle 2011).

[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).

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. 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 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 3.3 feet (1 meter), 4.9 feet (1.5 meters), and 6.6 feet (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. 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 freshwater 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 (approximately 14 to 352 acres respectively) once scenarios exceed 1.3 feet (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 2.3 feet (0.69 meters). These levels of sea level rise would result in major shifts in the habitat types and species composition across the refuge (table 2.1). Appendix J provides more information on the SLAMM analysis and the predicted impacts of sea level rise on John Heinz NWR.

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 Dr. Najjar of Pennsylvania State University, 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 2010). Due to such complexities 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 which is already highly urbanized and experiencing frequent flooding, this prediction would likely lead to more frequent flood events over the coming decades.

Table 2.1. Predicted Net Loss of Habitat Types at John Heinz NWR Using a Simulated Scenario of a 2.3 feet of Sea Level Rise through 2100.

	Predicted Acreage by Habitat Type				
Habitat Type	**Initial**	**2025**	**2050**	**2075**	**2100**
Tidal Fresh Marsh	419.7	406.7	401.2	395.7	381.2
Undeveloped Dry Land	268.0	217.5	209.8	200.4	176.2
Inland Open Water	184.6	164.5	164.6	164.4	163.9
Riverine Tidal	145.0	68.9	67.6	60.7	59.6
Inland Fresh Marsh	66.5	62.5	62.5	62.3	47.3
Tidal Swamp	61.6	58.7	58.0	56.6	54.8
Developed Dry Land	41.6	36.3	35.4	34.2	32.6
Inland Shore	7.8	6.7	5.5	4.2	3.2
Estuarine Open Water	0.0	97.6	104.9	123.3	140.2
Tidal Flat	0.0	0.0	28.6	23.9	20.1
Regularly Flooded Marsh	0.0	55.2	25.9	33.5	38.1
Transitional Salt Marsh	0.0	18.1	22.2	26.0	60.0
Irregularly Flooded Marsh	0.0	1.9	8.6	9.6	17.7
Total Acreage (including water)	**1194.7**	**1194.7**	**1194.7**	**1194.7**	**1194.7**

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 (the piedmont and coastal plain) where the ranges of many species overlap between northern and southern regions, the area's 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 using its habitats for migratory stopovers, nesting, spawning, and feeding. Unfortunately, the isolation of the refuge from other natural areas will limit the ability of refuge habitats to respond to the predicted impacts of climate change. For example, marsh habitat will be unable to shift inland because of the urban development surrounding the refuge.

2.5 Air Quality

The Philadelphia Department of Public Health, Air Management Services (AMS), the local air pollution control agency for the city of Philadelphia, is responsible for the prevention, abatement, and control of air pollution and air pollution nuisances, achieving and maintaining Federal National Ambient Air Quality Standards (NAAQS) in Philadelphia, and protecting the health and quality of life of the Philadelphia community from the adverse effects of air contaminants and noise (Philadelphia AMS 2010).

Philadelphia and its surrounding communities face many of the same air pollution challenges as other urban areas, mainly as emissions from vehicles and industries. The city of Philadelphia maintains a network of ten air monitoring sites located throughout the city. Many of the monitoring sites measure in "real time" the criteria principal pollutants: ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter (PM10 and PM2.5), and lead (Pb). Five of the sites also measure toxics, such as 1, 3-butadiene, benzene and carbon tetrachloride.

Areas of Pennsylvania where air pollution levels consistently stay below these standards are designated "attainment." Areas where air pollution levels persistently exceed these standards are designated "nonattainment" (PADEP 2011). According to the Pennsylvania DEP Bureau of Air Quality, Delaware and Philadelphia Counties are rated as moderate for attainment of the 1997 8-hour ozone standard of 0.08 ppm. These counties are also rated as "nonattainment" for standards related to particulate matter. Philadelphia County is also considered "nonattainment" for carbon monoxide standards (PADEP 2011).

Based on a preview of the results to State and local air agencies, air toxins in Philadelphia that show an excess lifetime cancer risk of greater than one in a million are: formaldehyde, benzene (including benzene from gasoline), acetaldehyde, 1,3-butadiene, carbon tetrachloride, naphthalene, chromium compounds, arsenic compounds (inorganic including arsine), PAHs and polyoxymethylene (POM), tetrachloroethylene (perchloroethylene), and ethylene oxide.

In Philadelphia, motor vehicles account for up to 60 percent of the total air pollution, according to the EPA (Clean Air Council 2011). According to the Delaware Valley Regional Planning Commission (DVRPC), I-95 immediately adjacent to and south of the refuge carries approximately 80,000 vehicles per day through Delaware County and South Philadelphia, and reaches a peak of 150,000 vehicles per day through Center City Philadelphia (DVRPC 2009). Bartram Avenue adjacent to the eastern refuge boundary carries about 20,000 vehicles per day (DVRPC 2005).

The Philadelphia AMS maintains the area Air Quality Index (AQI). The AQI is based on the five criteria air pollutants: ground level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. Each pollutant is scored using formulas developed by the EPA. Based on the AQI, the number of days with good air quality in Philadelphia steadily increased from 1990 until 1999 and then decreased until 2002 before again increasing and subsequently leveling

off around 2005. In the same timeframe, the number of days with moderate air quality increased and leveled off (Philadelphia AMS 2010). Over the period from 1990 through 1998, the annual number of days with unhealthy air quality dramatically decreased and has remained about the same, roughly 23 days per year for each year since 2008 (Philadelphia AMS 2010). According to Philadelphia AMS, these improvements can be attributed mainly to emission reductions from gasoline markets, including vapor recovery at retail gasoline stations, and companies shutting down pollution producing processes (Philadelphia AMS 2010).

2.6 Soils

The Soil Survey of Philadelphia County shows the lands of John Heinz NWR being comprised of marsh soils and urban land (i.e., 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.

2.7 Hydrology and Water Quality

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 experience 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 74.1square miles by the time they reach the refuge (USGS 2009).

As part of the Delaware Riverkeeper Network plan completed in 2005, baseline geomorphic stream data was collected and analyzed for trends in 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. 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 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, unnatural amounts of open water habitat, and lack proper ecosystem structure (Salas et al. 2006).

The refuge also contains a 145-acre open water impoundment. The impoundment as we know it today was likely constructed sometime during the 1940s or 1950s. Historically, the impoundment was managed as open water with periodic tidal fluctuation. Two 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. This caused the structures to become silted in. Today, the refuge maintains one active water control structure in the northwest corner of the impoundment.

Water Quality

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 waterways: Darby Creek, Cobbs Creeks (a major tributary to the Darby) and the Delaware River. 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. 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 Creek 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).

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 the 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 U.S., 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 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's species diversity has increased over previous levels, including some pollution intolerant species. Environmental health metric scores based on fish populations 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" environmental health scores (PWD 2002).

Environmental Contaminants

Environmental contaminants have an impact on 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. EPA currently maintains authority over the remediation of the site. The Service currently owns this property and will ultimately take on management of it once the legal cases are settled and site closure is completed.

Over the years, aquatic life uses, as determined by PADEP and the Pennsylvania Fish and Boat Commission were not attained because of 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, staff from the Service's Chesapeake Bay Ecological Services Field Office, assisted by the Pennsylvania Ecological Services Office, collected 31 brown bullheads (*Ameiurus nebulosus*) as part of a study on the effects of polycyclic aromatic hydrocarbons (PAHs) in urbanized watersheds. The main objective was to determine the prevalence of liver and skin tumors, lesions that precede tumor development, and barbel abnormalities. Their findings reported a 26 percent prevalence of liver tumors and a six 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 of liver tumors 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. 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 oilexposed 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).

2.8 Noise and Soundscapes

John Heinz NWR is northwest of the Philadelphia International Airport (PHL) and is separated from the airport by I-95, a Southeastern Philadelphia Transportation Authority (SEPTA) rail line, and Bartram Avenue. The refuge is not aligned with any existing runway and is not on the direct approach or departure track for any of the existing runways. The noise analysis completed for a runway expansion project environmental impact statement (EIS) demonstrated that the refuge experiences noise levels between 45 and 60 decibels (dB) based on the Day-Night Average Sound Level (DNL) recorded near the refuge. A noise monitoring site on Lindberg Boulevard south of the refuge showed an average DNL of 50 dB. This is calculated to increase to 55.4 dB in 2007 and 56.5 dB in 2015 with the runway expansion project (PHL 2005).

These noise levels are considered compatible with the outdoor recreational use of the refuge in accordance with Federal Aviation Regulations Part 150 criteria for compatible land use (PHL 2005). However, we and other conservation partners are concerned about the ongoing impact of noise on wildlife present on the refuge. Noise generated from I-95 and Philadelphia International Airport, may adversely affect foraging of some species dependent on echolocation, including songbirds, bats, and frogs (Cohen and Johnson 2004, Siemers and Schaub 2010).

Noise impacts on wildlife are variable depending on the intensity and duration of the noise, as well as the auditory range of the animal itself. A study of wintering bald eagles found that human activities such as boating and fishing disturb eagles (especially adults). Normally occurring sounds were not particularly disturbing, although acute noise (such as gunshots) elicited escape behavior (Stalmaster and Newman 1978). Another study of bald eagles found human pedestrian activity was more disturbing than overflights by aircraft (Grubb and King 1991). At a study (Burger and Gochfeld 1998) conducted on a national wildlife refuge in Florida, researchers found that waterbirds such as the sora rail, glossy ibis, little blue heron and Louisiana heron were disturbed by the presence of visitors and that loudness was as significant of a disturbance as the number of people in this effect.

Highway noise has varied impacts, depending on species, tolerance to disturbance, and species preference. A study of impact of highways measured forest breeding birds in transects extending 1,200 feet (400 meters) from the edge of I-95 in Maine and found that four species were less abundant near the road while another six became more abundant near the roadway (Ferris 1979). Species that became less abundant near the road include the bay-breasted warbler, blue jay, Blackburnian warblers, and winter wrens. The six species that became more abundant near the road included the chestnut sided warbler, white-throated sparrow, wood thrush, common yellowthroat, robin, and Tennessee warbler.

Noise impacts can influence amphibians as well. The vocalizations of closely related anuran species, or even local populations of those with disjunctive

distributions, are known to differ in frequencies, harmonics, duration and rate of repetition of individual calls, as well as trill or pulsation rates (Bogert 1960). Decibels (dB) are routinely used as a measure of sound intensity. Griffin and Hopkins (1974) measured sound levels of bullfrog (*Rana catesbieana*) choruses and noted that the sound of calls travels unpredictably across a site depending on landscape and other ambient sounds. To be effective, the sound serving as the stimulus (i.e. frog calls) probably must be within relatively narrow limits of variation to be identified by that individual species (Bogert 1960). As documented in these studies, some amphibian calls occur within a narrow frequency bandwidth. In relation to the refuge, calls at these lower decibel ranges may easily be overpowered by ambient noise, depending on the location within the refuge, based on the existing average DNL of 50 dB measured near Lindberg Boulevard. As such, noise associated with I-95 and the airport likely prevents effective communication by impeding these calls because the dB levels overlap with the dB levels of the amphibian calls.

Road noise has been documented to adversely impact amphibians. For instance, when exposed to motorcycle sounds up to 95 dB, estivating spadefoot toads (Scaphiopus couchi) responded by emerging from their burrows (Brattstrom and Bondello 1983). Emerging prematurely may cause stress on the toads because estivation has exacerbated dehydration and depleted energy reserves. While this species is not located on the refuge, the research implications provide concern for the less-researched amphibian species found on the refuge. If intense sounds, such as low-altitude aircraft, cause the toads in the refuge to emerge at a time when food and water are not available, chances are likely they will not survive, let alone be able to reproduce.

Even though the refuge is an undeveloped area within a highly urbanized landscape, some elements of the natural landscape are maintained. Emerging science on natural soundscapes shows the importance of recognizing and documenting local, natural soundscapes. These soundscapes are considered to be an essential part of a landscape, its representative and "vocal" wildlife, and one's personal experience in the wild, whether in a park, wilderness, refuge, or similar form of natural landscape. As with other regions in North America, natural soundscapes have suffered greatly, mostly within the last 20 years. There are two main contributors to these changes: habitat destruction and an increase in human noise due to aircraft and land-based machinery, the impact of which is observed miles from the source (Krause 1999). There is no specific information on the soundscape of John Heinz NWR but there are clearly the sounds and noises of an urbanized landscape, in addition to the natural sounds normally associated with refuges. Traffic, airplanes, heavy equipment operation, industrial and commercial operations, and building and road construction all contribute to community noise and disturbance in varying degrees. These disturbances can be a feature of a degraded environment, and impacts due to human-induced noise need to be mitigated wherever possible.

2.9 Socioeconomic Landscape

Socioeconomic Setting of the Philadelphia Area and Refuge Surroundings

The refuge is located in southeastern Pennsylvania within Delaware and Philadelphia counties. Between 2000 and 2010, the population of Delaware County increased 1.5 percent and the population of Philadelphia County increased 0.6 percent (U.S. Census Bureau 2011). This is compared to a 3.4 percent increase across the State of Pennsylvania and 9.7 percent for the country as a whole (U.S. Census Bureau 2011). In 2009, the median household income in Delaware County was $61,848 and for Philadelphia County was $36,959, compared to $49,501 for the State and $50,221 for the United States overall. Between 2005 and 2009, unemployment was estimated at 3.7 percent in Delaware County, 12.1 percent in Philadelphia County, and 6.8 percent for the State of Pennsylvania (U.S. Census Bureau 2011).

According to the Delaware Valley Regional Planning Commission, 6 percent of the region's population is 5 years old or younger; 22 percent is between 5 and 19 years; 59 percent is between 20 and 64 years; and 13 percent is considered elderly, age 65 and older. One of the greatest challenges facing the region in coming years will be the continued aging of the population, particularly in the suburbs, as nearly nine percent of the population is between the ages of 55 and 64 years (considered "near elderly"). In particular, many of the neighborhoods immediately adjacent to the refuge are estimated to have over 15 percent of their residents 65 years or older (DVRPC 2009).

The surrounding landscape is demographically diverse. The percentage of the non-white and/or Hispanic population in surrounding neighborhoods ranges from less than 8 to over 30 percent. The average household income ranges from $27,000 to 51,800 in surrounding portions of Philadelphia County and $27,000 to 63,300 in neighboring portions of Delaware County. Single parents with children under 17 years of age comprise over ten percent of households in most surrounding neighborhoods. From a transportation perspective, some neighboring communities in Philadelphia County have up to 47 percent of carless households—relying solely on public transportation or other means of transportation. While in surrounding Delaware County, carless households range from 8 to 30 percent (DVRPC 2009).

Population trends forecasted for Philadelphia over the period between 2000 and 2020 anticipate a slight loss in overall population. The surrounding population will continue to have a large percent of elderly residents, with some areas forecasted to have over 15 percent of its population be 65 years or older (DVRPC 2009). Minority populations in the region will continue to increase. Philadelphia is a "majority-minority" city, with 61 percent of its population being of minority race and/or Hispanic as of 2006. The percentage of minorities increased in every county in the region between 2000 and 2006, with 2006 percentages in the region's suburban counties ranging from 36 percent in Camden County to 11 percent in Bucks County. Much of this growth in the minority population is attributable to growth in the numbers of Asians and Hispanics (DVRPC 2009).

Refuge Contribution to the Local Economy

The economic contribution of the refuge was evaluated as part of a nationwide survey and analysis conducted in 2006. In that year, the refuge recorded 106,491 visits. Ninety-eight percent of visits were for non-consumptive purposes such as hiking, wildlife observation, and photography. The majority of the visits (approximately 72 percent) were by nearby residents.

Total visitor expenditures related to recreation on the refuge estimated a total of about $1.1 million in FY 2006. Non-residents spent 67 percent of all visitor expenditures (about $719,500). Based on the analysis conducted by the evaluation final demand associated with refuge visitor recreational spending totaled $1.7 million. This represents the total dollars generated to the local economy as the result of refuge visits. This demand resulted in 14 jobs, which generated $536,300 in income and $241,400 in tax revenue. Non-resident visitors generated $1.1 million in economic stimulus to the local economy (Carver and Caudell 2007).

In context, the 36 million visitors to the Greater Philadelphia area spent $5 billion in 2009 (Tourism Economics 2009). Tourism is a significant part of the economy in the region and 83,664 jobs were sustained by visitors in 2009 with a total income of $2.6 billion (GPTMC 2010). The Greater Philadelphia Tourism Marketing Corporation estimates that tourism generated $1.2 billion in taxes in 2009 and that 5 percent of all jobs in the region are sustained by tourism.

2.10 Refuge Administration

Staffing

John Heinz NWR is managed by staff dedicated specifically to the refuge and its programs. This refuge currently has ten permanent staff: a refuge manager, deputy refuge manager, refuge wildlife biologist, a supervisory park ranger, one park ranger/law enforcement officer, a park ranger (vistor services), two outdoor recreation planners, facilities manager, and a maintenance worker. Seasonal staff positions, including a temporary biological technician, currently vary between one and five each year.

Budget

Operational funding includes salaries, supplies, utilities, fuel, and all other operational activities (wildlife and habitat surveys and management) that are not funded by special projects. Base maintenance funds, used to repair vehicles, equipment, and facilities, generally have been stable over the past 5 years. The replacement of vehicles, larger pieces of equipment (e.g., tractor, backhoe), or larger facilities (buildings) are funded as projects.

Our annual funding fluctuates according to the number and size of special projects funded that year (e.g., vehicle or equipment replacement, visitor service enhancements, and facility improvements). In 2010, the refuge operated on a budget of approximately $1.2 million. This level of funding is relatively consistent with prior years: $1.1 million in 2008, $1.3 million in 2009.

Acquisition

Map 1.3 depicts the refuge ownership boundary as of December 30, 2010. Table 2.2 below summarizes the land acquisition history of the refuge by year. The refuge currently owns 993 acres within its 1,200 acre approved acquisition boundary. There are eight existing right-of-way easements for pipeline, utility, and transportation infrastructure located within lands owned in fee by the refuge.

Table 2.2. Land Acquisition History of John Heinz National Wildlife Refuge at Tinicum.

Acquisition Date	Funding Source	Acres
1910	MBCF, NONE	167.59
1973	NONE	145.33
1978	LWCF, NONE	147.56
1979	LWCF, NONE	139.93
1980	LWCF, NONE	318.76
1986	OTHER	0.00
1995	NONE	18.30
1996	LWCF	55.70
	Total Acreage =	**993.2**

LWCF—Land and Water Conservation Fund.—funding sources include revenues from the sale of surplus Federal real property, motorboat fuel taxes, fees for recreation on Federal lands, and receipts from mineral leases on the outer continental shelf.

MBCF—Migratory Bird Conservation Fund.—the funding source is receipts from the sale of Federal Migratory Bird Hunting and Conservation Stamps.

Distributing Refuge Revenue Sharing Payments

Since 1935, the Service has made refuge revenue sharing payments to local municipalities containing lands under its administration. The actual amount of the payments is determined by formulas specified in the Revenue Sharing Act (16 U.S.C. 715s) and annual funding appropriated by Congress. The formulas used to determine payments to local municipalities are based on the number of acres in each municipality and the appraised value of refuge lands in their jurisdiction. Currently for John Heinz NWR, we make revenue sharing payments to Delaware County, the townships of Darby, Folcroft, and Tinicum, the Interboro School District, and the city of Philadelphia. Between fiscal years 2005 and 2009, combined payments to all municipalities have averaged about $38,000 per year.

2.11 Refuge Natural Resources

John Heinz NWR 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 2.1). The freshwater tidal marsh at the refuge now comprises approximately 80 percent of the State's coastal wetland (Cohen 2004; PNHP 2008). 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 2004).

The refuge contains a variety of ecosystems unique within Pennsylvania and the Philadelphia metropolitan area including tidal and nontidal freshwater 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 anthropogenic 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. Because of 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.

Regional Conservation Context

Being situated within a highly urbanized landscape, the refuge is geographically isolated from many other conservation lands in the region (see map 1.2). The largest (over 1,000 acres) and closest natural areas near the refuge consist of freshwater tidal marsh located across the Delaware River in New Jersey (less than 5 miles away), as well as the forested habitats of Fairmount Park, Ridley Creek State Park, and Valley Forge National Historic Park (all within 25 miles of the refuge).

As a result, the refuge has limited biological connectivity to adjacent conservation lands. Aside from a single 100-acre parcel of forested land abutting the eastern refuge boundary, there is little other terrestrial habitat available directly outside of the refuge boundary. Aquatic resources remain connected between the tidal Darby Creek and the Delaware River. Nontidal portions of Darby Creek do contain several low-head dams impeding upstream movement of fish and limiting available spawning habitat.

The refuge is the only Federal conservation land located in Delaware and Philadelphia Counties. The nearest national wildlife refuge, Supawna Meadows NWR, is located approximately an hour's drive south of the refuge near Salem, New Jersey. The recently authorized Cherry Valley NWR will be located approximately a 1 to 2 hour's drive north the refuge.

2.12 Refuge Biological Resources

Natural Community Types

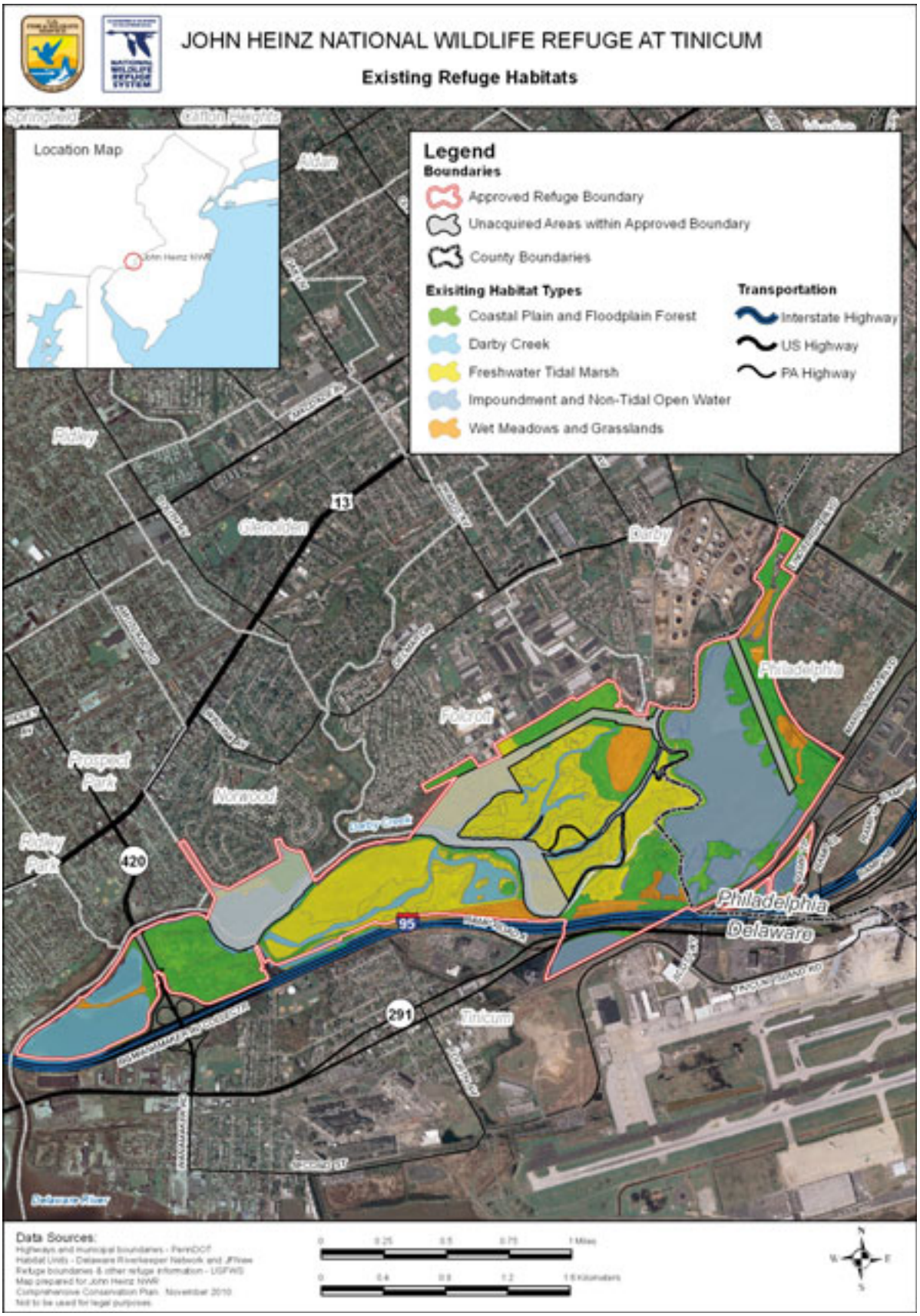
Refuge lands include a variety of ecosystems including open water, forests, grasslands, and tidal and nontidal wetlands. Many of the ecosystems (and the habitats they support) have been degraded, damaged, or destroyed as a result of the numerous impacts previously cited. Despite these alterations, many 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. Some ecosystems support plant communities or species of concern.

The Refuge System has 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 broader habitat categories that are comprised of these communities are displayed on map 2.1. The location and extent of the individual plant communities are displayed on map 2.2.

Bill Thompson

Bald eagle

Map 2.1. Habitats of John Heinz National Wildlife Refuge at Tinicum



Map 2.2. Plant Communities of John Heinz National Wildlife Refuge at Tinicum

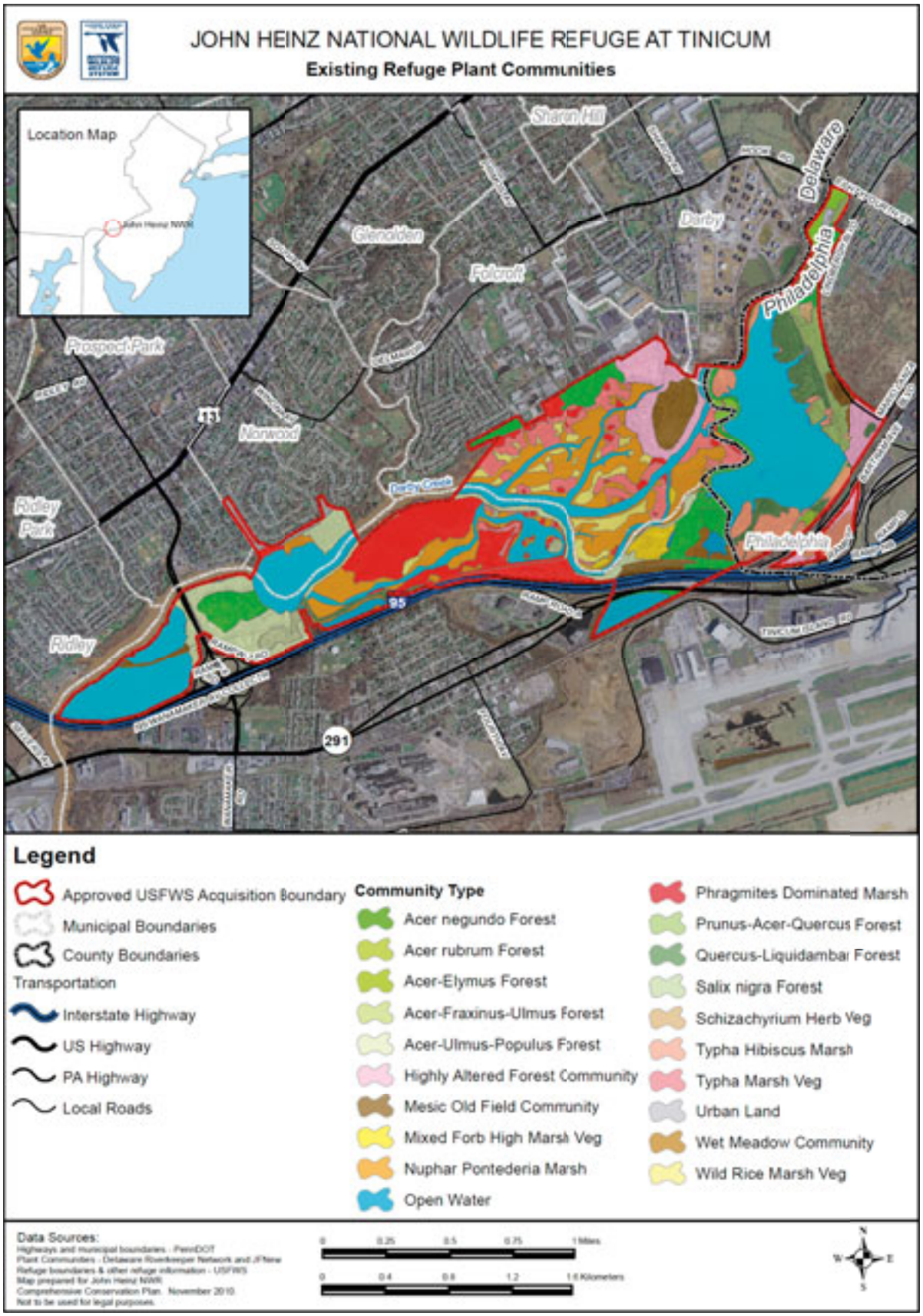


Table 2.3 lists the NVCS Associations found within the various broad scale habitats of the refuge. Where possible, the conservation status rankings have been indicated as referenced by NatureServe Explorer and the Pennsylvania Natural Heritage Program. Conservation status rankings indicate how imperiled a species or community is on either a global, national, or state level. "S" identifies state rankings, where "G" designates global rankings. A scale of 1 through 5 is applied to denote the conservation significance of a particular habitat on each scale. A 1 identifies the habitat as "critically imperiled," a 3 indicates the habitat as "vulnerable," while a rank of 5 notes an occurrence as "secure."

Table 2.3. Broad Habitat Types and National Vegetation Classification System Associations and Alliances Found within John Heinz National Wildlife Refuge at Tinicum.

Broad Habitat Types	Natural Community Types	Conservation Ranking (Global; State) (NatureServe; PNHP)
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
	Spadderdock Tidal Marsh	GNR; SNR
	Arrowhead – Pickerelweed Tidal Herbaceous Vegetation	G3/G4; S1
	Phragmites Dominated Marsh	GNR; SNR
	Cattail – Bulrush Eastern Herbaceous Vegetation	G5; SNR
Freshwater Nontidal Wetlands	Phragmites Dominated Marsh	GNR; SNR
	Narrow-leaved Cattail – Swamp Rose Mallow Herbaceous Vegetation	GNR; SNR
Open Water	Freshwater Intertidal Mudflat	G3; S1
Coastal Plain Forest	Pin oak – Swamp White Oak – Sweetgum Mixed Hardwood Forest	G3; S2
Floodplain Forest	Boxelder Forest	GNR; SNR
	Red Maple Forest	GNR; SNR
	Silver Maple - Boxelder / Virginia Wild Rye Forest	G4; SNR
	Maple (Red, Silver) – Ash – American Elm Forest	G4; S1
	Silver Maple – American Elm – (Cottonwood) Forest	G4; S3
	Black Willow Temporarily Flooded Shrubland	GNR; SNR
	Black Cherry – Red Maple – Serviceberry – Oak Forest Alliance	GNR; SNR

Freshwater Tidal Wetlands

Freshwater tidal wetlands comprise approximately one-third of the refuge. Protection of this habitat is one of the primary purposes outlined in the refuge's mandated purposes. The marsh contains some ecological communities considered State critically imperiled (S1) and globally rare (G3) and occurrences of State/federally rare, threatened, and endangered plant and animal species

(NatureServe 2005; PNHP 2008). These wetlands are subject to a range of tidal fluctuation on a daily basis of approximately 6 feet between mean high tide and mean low tide. Vegetation is diverse, with species and plant communities directly influenced by the relative elevation of mean high tide.

Most freshwater tidal marsh is dominated by pickerelweed, arrowhead, spadderdock, or wild rice. However, PADCNR notes that portions of this marsh support several State rare species such as waterhemp ragweed (*Amaranthus cannabinus)*, field dodder (*Cuscuta pentagona)*, Walter's barnyard-grass (*Echinochloa walteri)*, an un-named eupatorium (*Eupatorium rotundifolium*), forked rush (*Juncus dichotomus)*, and shrubby camphor-weed (*Pluchea odorata)* (VanDervort-Sneed personal communication 2010).

Coastal Plain and Floodplain Forests

Coastal plain and floodplain forests are the habitat type that is considered to be the late-successional forest community typical of the Pennsylvania Coastal Plain region. Coastal plain and floodplain forests provide important habitat for migrating passerine species. The 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).

Coastal plain forests are noted as a rare habitat type within Pennsylvania (PNHP 2008). These forests are dominated by a canopy mix of oak and sweetgum. Under reference conditions, oaks should typically comprise at least 25 percent of the dominance in a stand. Other typical canopy associates may dominate, including sweetgum, blackgum, and swamp white oak. Other wetland hardwood species can occur, including silver maple, river birch, and northern red oak. Native shrub and vine species are variable and may include dogwoods, spicebush, Virginia creeper, and elderberry (NatureServe 2005; Westervelt 2006).

Intactness of this forest type varies between stands; however, most are impacted by excessive deer browse and invasive species colonization. Garlic mustard, Japanese honeysuckle, and Japanese stiltgrass dominate much of the groundlayer while vines such as Oriental bittersweet are also frequent. Mile-a-minute vine is widespread in many canopy gaps and appears to be preventing canopy tree regeneration. Additional invasive species found within the canopy include Norway maple and tree-of-heaven. A portion of the floodplain forest located in the southeastern portion of the refuge is dominated by a hybridized, nonnative gray poplar (*Populus x canescens or alba*) (Salas et al. 2006), see "Highly Altered Habitats" later in this section for additional information.

Darby Creek

The tidal portion of Darby Creek and its side channels flows through the refuge and tidal marsh. Since this represents an aquatic habitat, the ranking system used for the terrestrial habitats does not apply. Despite a lack of ranking, Darby Creek is known to support a diversity of estuarine fish species described in more detail in the next section.

The geomorphology, water quality, and influences of Darby Creek are discussed in more detail in section 2.6 above.

Impoundment and Nontidal Open Waters

The refuge contains several small open water features and a managed impoundment (table 2.4).

Eastern box turtle

USFWS

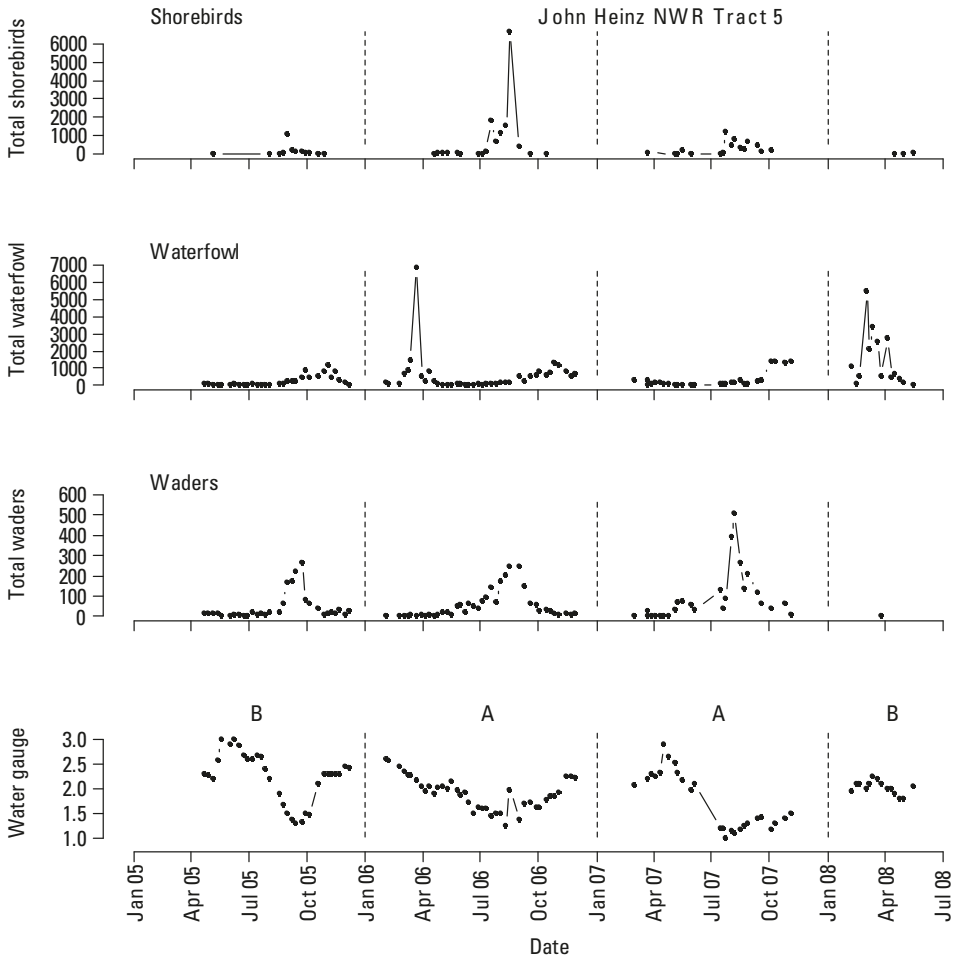
Table 2.4. Summary of Existing Open Water Features at John Heinz National Wildlife Refuge at Tinicum.

Name	Size (Acres)	Features
145-acre Impoundment	145	Managed impoundment for open water and mudflat.
Impoundment Fringe	34.1	Open water and marsh areas surrounding Impoundment.
Frog Pond	<0.5	Shallow water area near visitor center.
Hoys Pond	5	Deep water pond near I-95.
16-acre Pond	16	Open water bounded by Bartram Ave and I-95.

The 145-acre impoundment and nearby nontidal open water habitats of the refuge provide stopover habitat for a variety of waterbirds, waterfowl, and shorebirds. 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 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 the refuges after the study ends for adaptive management of their impoundments (Lyons et al. 2005).

The recently completed impoundment study included timed drawdowns. These timed drawdowns focused on providing the optimal habitat available within the impoundment for various bird groups during their peak migration stopovers in both spring and fall (figure 2.3).

Figure 2.3. 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).



The two treatments noted were an early season drawdown timed to coincide with spring shorebird migration (Treatment A), and a late season drawdown coinciding with summer/fall shorebird migration (Treatment B). Timing of each treatment (as displayed above) includes 2005, Treatment B; 2006–2007, Treatment A; 2008, Treatment B. Dashed vertical lines indicate the beginning of a year.

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). Based on the draft results of this study, variations in mean water levels and vegetation composition provide the most benefits for migrating groups are presented in table 2.5.

Table 2.5. Bird Groups and Optimal Conditions for Migratory Stopover and Forage Enhancement Within the Impoundment (based on results of the R3/5 Impoundment Study).

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

Portions of the impoundment also contain numerous nesting boxes. These boxes (primarily for swallow, but also for wood ducks) have been installed and maintained by a combination of refuge staff and volunteers. These boxes were initially installed to provide opportunities for wildlife observation and interpretation, including how visitors can benefit wildlife in their own backyard.

The impoundment and open waters also provide support for reptile and landbird breeding habitat. Bald eagles have nested successfully in forested areas adjacent to the impoundment. The impoundment area also provides secondary habitat for the State-listed coastal plain leopard frog and breeding, feeding, and hibernation habitat for the State-listed red-bellied turtle (Stolz personal communication 2005). Management considerations must be made to sustain the use by and protection of these non-bird focal species as well.

There are several impediments to effectively managing the 145-acre impoundment. The mean bed surface of the impoundment is approximately 1 foot below that of the mean low flow elevation of Darby Creek. Additionally, the impoundment receives uncontrolled stormwater from neighboring lands in which is a source of pollution and added water volume during rain events. Increasingly, the impoundment also becomes flooded out during high flow events resulting from more frequent and extreme precipitation. These excessive water levels have breached or caused substantial damage to the dike and access road system around the impoundment on at least four occasions over the past 10 years (Stolz personal communication 2010).

Another issue with impoundment management is ongoing maintenance of the dike and access road along the north and western edge of the impoundment. Burrowing mammals may potentially excavate small holes and tunnels into the sides of dike roads. These burrows can lead to dike weakening and collapse over time if unaddressed. To minimize or repair the damage from burrowing mammals, the refuge occasionally adds stone rip rap or fill to portions of dikes washed out by high water. To date, burrowing has not resulted in any major dike failures, however refuge staff continue to evaluate the potential for this management concern.

The remaining 56 acres of nontidal open waters owned by the refuge include a series of deeper ponds near or adjacent to I-95. Hoy's Pond is a 5 acre pond with maximum depths between 6 and 10 feet. The water is relatively clear with large mats of duckweed (*Lemna* spp.) covering much of the water surface around the edge of the pond. Hoy's Pond is a popular fishing site, where anglers pursue largemouth bass (*Miropertus salmoides*) and sunfish (*Lepomis* spp.) species. In

the past, refuge staff has added discarded Christmas trees to the pond to serve as cover for fish species.

Another open water habitat area is known as 16-acre pond. It is located along Route 291 and Bartram Avenue. It is shallow with depths generally less than 3 or 4 feet with some spadderdock coverage. This pond receives stormwater inputs from surrounding industrial and commercial lands. Its location between several roads and highways with heavy traffic makes it not only biologically isolated, but also difficult to access for management. As a result of the low habitat values observed and isolation from other nearby waters (Sweka and Mohler 2010), we do not actively manage the 16-acre pond. The water of 16-acre pond is highly eutrophic (Sweka and Mohler 2010). This pond contains a mix of common, pollution-tolerant, warm-water fish species such as bluegill.

Grasslands and Wet Meadows

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).

Prior to the past few decades, John Heinz NWR had a substantially greater amount of grasslands than today (McCormick et al. 1970, McMenamin personal communication 2008). Currently, many of these historic grasslands are covered by coastal plain or floodplain forest community types. The Restoration Management Plan for Lower Darby Creek compared habitat coverage between those documented in the Two Studies of Tinicum Marsh (McCormick et al. 1970) and those identified as part of field inventories conducted in 2005 (Salas et al. 2006). 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. Additionally, historic aerial photographs reviewed as part of that plan documented a greater extent of grasslands east of the existing impoundment (Salas et al. 2006). Due to this relatively isolated and small (less than 100 acres) component of grassland, it is unlikely that the refuge ever had significant regional populations of priority grassland birds.

Several meadow and grassland communities at the refuge provide stopover habitat for neo-tropical migrant birds, raptors, amphibians, reptiles, and mammal species. 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 the refuge's wet meadow grasslands (Phillips and McMenamin personal communication 2008).

Most of the grasslands existing on the refuge today are the result of managed utility right-of-ways that intersect portions of the refuge. Utility corridors transporting oil, gas, potable water, wastewater, and electricity all pass through the refuge. Due to the disturbed nature of these communities, none contain the

species composition to make them identifiable with known grassland associations by the NVCS.

Highly Altered Habitats

In addition to the naturally occurring communities located within the refuge, there are several highly altered communities present. Highly altered forests of John Heinz NWR consist of existing forested habitats that have either not been completely inventoried to understand and delineate their NVCS community types due to access restrictions or contain substantial variation from natural forest communities typical of the refuge and surrounding region. Despite their alteration, these habitats can still provide significant ecological value and quality habitat. The 145-acre impoundment already discussed provides significant value to migratory and overwintering waterfowl and shorebirds. Additionally, altered grasslands, forests, and wetlands provide diversity of habitat types and a unique set of ecological services that benefit both wildlife and visitors to the refuge.

Federally Listed Species

The refuge does not support any known federally listed threatened or endangered species. The refuge does provide potential foraging and nursery habitat for the federally listed, endangered shortnose sturgeon (*Acipenser brevirostrum*). This species is known to occur in the nearby Delaware River. However, this species has not been identified within Darby Creek or on the refuge to date.

State-listed Species

The refuge does support a number of State-listed threatened or endangered plants and animals. State endangered birds such as the American bittern, least bittern, black crowned night heron, king rail, great egret, yellow-crowned night heron, and sedge wren all forage and/or breed on the refuge. The same is true for State threatened species such as the bald eagle. The State endangered coastal plain leopard frog is known to breed in shallow wetlands found within refuge forests and grasslands. The State threatened reptile, the red-bellied turtle, is also known to breed on the refuge as well.

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).

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 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 300 plus avian species identified at the refuge utilize 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.

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. The area serves as a wintering ground for over 20 species of waterfowl with 1,100 to 1,400 individuals observed per day between September and March (Green et al. 2008).

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 endangered species that has recovered and been delisted, have historically utilized 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 pair returned to breed on the refuge in 2011.

The peregrine falcon (*Falco peregrinus*), another former federally listed, endangered species that has recovered and become federally delisted, 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. Osprey (*Pandion haliaetus*) is present during migration and is 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 use 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 species 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).

The refuge also provides habitat for occasional visits from species outside of their standard range. Recently in July 2011, the refuge confirmed its first occurrence of an immature white ibis (*Eudocimus albus*) foraging on the refuge. White ibis has been reported as a rare visitor to Pennsylvania (Audubon 1843), and New Jersey (Turnbull 1869) since the nineteenth century. The last sighting of this species occurred during the summer of 1980 (Miller 1982c, 1988, Paxton et al. 1981).

Mammals

John Heinz NWR is 1 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 coyote, 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 on recent declines of these important creatures due to white nose syndrome and habitat disturbances.

White-tailed deer (*Odocoileus virginianus*) are another mammal 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. Several different types of surveys were conducted in development of the refuge's deer management plan (D'Angelo 2011). Between 2001 and 2010, deer density estimates ranged from 57 to 163 deer per square mile based upon standardized deer drives conducted by refuge staff and volunteers. While standardized, this type of survey does have the potential to double-count individuals. Between 2008 and 2011, the refuge also conducted forward looking infared (FLiR) surveys, which reduce the likelihood of double-counting. According to these surveys, deer densities were between 57 and 83 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).

As noted, refuge staff estimates that the current deer population utilizing the refuge far exceeds this density. It is reasonable to assume, therefore, that these adverse effects on vegetation are present. Some of these effects were noted in vegetative surveys previously conducted on the refuge (Salas et al. 2006). More current surveys (D'Angelo 2011) also document these impacts. Oak and maple saplings were present within fenced deer exclosures, while similar vegetation outside of the exclosures was browsed to the ground. D'Angelo also noted that invasive plants, which are often consumed to a lesser extent by deer, have become dominate vegetation types on many portions of the refuge. While such impacts

affect current forest understory and wildlife dependent on this vegetation, the long term implications are that the refuge's native forested areas could lose the ability to replace themselves through time (D' Angelo 2011).

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 aka 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/or 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 potentially extirpated in PA) 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 road kill gravid female Eastern Mud Turtle was documented in nearby 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 important 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 2.6 (Herpetological Associates 2001; NOAA 2000; Sweka and Mohler 2010; Stolz personal communication 2011).

Darby Creek and the open water areas of the freshwater tidal marsh may also provide suitable habitat for the Federal and State-endangered shortnose sturgeon (*Acipenser brevirostrum*) and Atlantic sturgeon (*Acipenser oxyrhynchus*) (PNHP 2008; PGC & PFBC 2008). 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.

In June 2011, refuge staff confirmed the first record of a bowfin (*Amia calva*), a Pennsylvania candidate rare species, within the refuge boundaries. The individual fish was caught during a refuge interpretive fishing event and released back into waters located on the refuge. Another sighting of this species also occurred adjacent to the refuge in 2010 near the Ridley Park Marina along Darby Creek (Stolz personal communication 2011).

Table 2.6. Fish Species and Use of Lower Darby Creek and Freshwater Tidal Marsh Habitats (Herpetological Associates 2001; NOAA 2000; Sweka and Mohler 2010; Stolz personal communication 2011)

Species		Habitat Use			
Scientific Name	Common Name	Spawning Area	Nursery Grounds	Shelter	Adult Forage
Freshwater Species					
Ameirus catus	White catfish	~	~	~	~
Ameirus nebulosus	Brown bullhead	~	~	~	~
Amia calva	Bowfin	~	~	~	~
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	~	~	~	~

Species		Habitat Use			
Scientific Name	**Common Name**	**Spawning Area**	**Nursery Grounds**	**Shelter**	**Adult Forage**
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	~	~	~	~
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		~	~	~

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 extinct in 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*).

In addition to mussels, the refuge lacks inventories of invertebrate insect species. Benthic macroinvertebrate sampling has been conducted upstream of the refuge in conjunction with water quality monitoring and characterization. No species of conservation concern were identified in those surveys. No terrestrial invertebrate inventories have been conducted on refuge to date.

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. This 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, or 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 2.7 (Salas et al. 2006). Management prescriptions for identified invasive species are included in the Draft HMP included in appendix B.

Table 2.7. Invasive Species Identified at John Heinz National Wildlife Refuge at Tinicum 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	●	◉	●	

Species	Ranking	Impact	Extent	Management Difficulty	Control Priority and Focus
Mile-a-minute *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

2.13 Special Use Permits, Including Research

Special use permits are issued to individuals, organizations, and agencies that request the use of refuge facilities or resources beyond what is available to the public. To ensure that wildlife disturbance is minimized, special conditions and restrictions are analyzed individually for each request.

Currently, the refuge maintains several special use permits for various ongoing research utilizing the refuge:

- USDA-APHIS is currently permitted to continue the ongoing research related to deer abundance and effects on refuge vegetation and habitats. This research will continue to inform refuge staff of the level of deer controls necessary to restore biological integrity and diversity to the refuge.

- The Academy of Natural Sciences and the Partnership for the Delaware Estuary are establishing long-term data collection sites to monitor sea level rise over the coming decades through the use of surface elevation tables. Surface elevation tables (SETs) and rod-SETs (rSETs) measure changes in marsh elevation at the millimeter scale, on an annual, and in some cases, seasonal basis. This level of precision is required to track very slow accretion or subsidence rates over time. SETs and rSETs can be used to determine a marsh's change in elevation due to a response to climate stressors such as sea level rise and/or non-climate stressors including management activities like burning and invasive species control.

- Philadelphia Zoo has conducted annual and ongoing amphibian vocalization surveys throughout the spring breeding season. This research provides the refuge with species inventory and habitat use information for frog species across the refuge.

Ongoing Research and Monitoring Projects

Impoundment Management Study
In 2005 to 2007, John Heinz NWR participated in the Service 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 more 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 Monitoring and Management
In 2008, the Service contracted with the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, and Wildlife Services 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 (D'Angelo 2011). See previous discussion under Mammals in Section 2.11 Refuge Biological Resources.

2.14 Refuge Visitor Services Program

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. John Heinz NWR currently provides opportunities for the public to participate in five of the six priority uses.

Environmental education, interpretation, wildlife observation, photography, and fishing are all provided via access throughout the refuge's extensive trail network. Kiosks and signs provide interpretive materials for trail users. The visitor center is an impressive facility, free to the public, Americans with Disabilities Act (ADA) compliant, and accessible by public and private transportation. The facility is visited by many schools and conservation organizations for classroom use and meeting space. The building is also an important example of sustainable design and environmentally friendly construction.

With over 10 miles of trails, the refuge provides many areas for visitors to explore. Most refuge visitors are families, wildlife observers, and neighborhood residents interested in viewing nature and wildlife. Well over 90 percent of the estimated 135,000 visitors take part in some sort of wildlife-dependent recreation activity, be it wildlife observation, photography, or fishing (table 2.8). Many visitors post images of refuge wildlife on the internet via photo-sharing sites. Fishing within Darby Creek draws regular visitation from surrounding communities throughout the summer months. While fishing is supported on the refuge, we encourage participants to practice catch and release due to the presence of contaminants within Darby Creek.

Table 2.8. Number of Refuge Participants by Activity (2009)*

Activity	Number of Refuge Visitors
Wildlife Observation	133,000
Nature Photography	6,000
Freshwater Recreational Fishing	4,950
Environmental Education Programs Onsite	8,400
Environmental Education Programs Offsite	1,200
Interpretative Programs Onsite	13,300
Interpretative Programs Offsite	4,800

**Numbers outlined here are not additive. Refuge visitors may have participated in more than one activity during a visit. Numbers provided here are representative of the primary activity of a particular visit.*

Annual refuge visitation is estimated through multipliers of the number of visitors by activity, from visitor contacts at refuge headquarters, road-traffic counts, program attendance, and observations by our refuge staff and volunteers. According to numbers reported by refuge staff, approximately 133,000 visits were made to the refuge in 2009. Out of this total, over 13,300 people visited the visitor center that same year. A summary of participants in refuge programs is provided below:

Being located in a large urban center allows the refuge to host a variety of visitors including school groups, homeschoolers, youth groups, family groups, anglers, birders, paddlers, bicyclists, refuge neighbors, surrounding community members, tourists (primary local, but regional, national and international visitor numbers are growing), as well as businesses.

The main goals of the visitor services program are to work with partners to promote the benefits of wildlife and habitat conservation and management; to foster an awareness and appreciation for the refuge and its role along the Atlantic flyway and within the Refuge System; and to provide quality wildlife dependent recreational experiences to visitors. Through these goals, refuge staff seek to develop a sense of environmental stewardship and conservation ethics in visitors.

The visitor services staff, and refuge staff overall, are passionate about and dedicated to, natural resources and their roles at the refuge; the entire staff is involved in the visitor services program. Since the refuge has been established, in part, to offer environmental education and wildlife-dependent recreation, refuge staff is not only in the business of habitat restoration and conservation, but also in "customer service" on behalf of the Service itself. For many residents of Philadelphia, the staff of John Heinz NWR may be their one and only interaction with the Service. Refuge staff is very active in outreach and partnership development. The refuge staff is dedicated to reaching out to new audiences, while maintaining the value of the refuge to its core audience.

Because environmental education is one of the establishing purposes of the refuge, much of the visitor services program focuses on environmental education programs. Currently, about 9,400 students a year participate in environmental education opportunities led by their teachers or by refuge staff and volunteers. Of that, 8,200 participate in onsite programs while another 1,200 participate in

offsite programs. Education activities currently offered by refuge staff focus primarily on assisting teachers in developing environmental lesson plans for both onsite and offsite learning, sponsoring various onsite environmental workshops, and conducting onsite field trips for school groups.

Staff offer teacher trainings in delivering some of the widely-used conservation education programs such as Project WET, WILD, and Learning Tree workshops. About 200 teachers a year participate in these programs. Typical audiences for existing education activities consist of School District of Philadelphia elementary classes, summer camps, and some interest from local college programs for architecture, wildlife, and environmental studies. The refuge receives a number of education visits through field trips. These are generally guided by the teacher and/or chaperones that accompany the group. See appendix I (USGS Phase 1 Environmental Education Needs Assessment) for additional information on the refuge's current environmental education program.

The refuge recently completed an environmental education needs assessment as part of the CCP process to identify opportunities for future refuge educational programming and reduce potential for overlap with similar programs across the refuge. This effort is being conducted in two phases: Phase 1 Summary of Current Environmental Education Program is included as appendix H. Phase 2 has recently been completed. Recommendations from Phase 2 will be incorporated into future visitor services planning.

The refuge is not open to hunting because of potential conflicts with local refuge regulations and safety and staffing availability concerns. Pennsylvania Game Commission (PGC) regulations only allow hunting within Philadelphia County through the use of archery or crossbows. While the refuge does not currently allow hunting, it does support hunting activities through sponsoring hunter education courses, managing the Pennsylvania Chapter of the Federal Junior Duck Stamp Program, and making informational materials available.

For additional details on the refuge's current visitor service program, please see chapter 3, section 3.4, Current Management.

2.15 Archeological and Historical Resources

The portion of the refuge within Tinicum Township now consists entirely of tidal marsh or artificial landforms, including the refuge dike system. Examination of historic maps as well as a sequence of aerial photographs beginning in the 1920s reveals that has been the situation for at least the last150 years, probably far longer. However, two areas of terrace on the north side of Darby Creek in Folcroft and a considerably larger area within Eastwick appear to consist of natural upland having potential to contain intact pre-Contact Native American archaeological sites. Historic period archaeological sites could also exist in those three areas, though examination of historic maps and aerial photographs indicate that after the 17th century those areas were more likely used as pasture associated with farmsteads built closer to the historic road system.

Map evidence indicates that some refuge dikes follow the alignment of dikes constructed prior to the mid-19th century, some perhaps even originating in the 17th or 18th century. However, virtually all of the surviving dike system was modified in the mid-20th century by installation of water control structures, addition of interior dikes in some areas, and widening of most dikes to support a modern maintenance road system atop them. Erosion associated with relatively recent storm events has also obliterated considerable portions of the historic period system. Although the appearance of refuge dikes now differs substantially from that of the historic period, it seems probable that in at least some places the timber cribbing of early dikes may remain intact beneath wider modern cross-sections. Therefore, archaeological monitoring may be advisable if any future dike repairs will extend beneath the fabric of 20th century modifications.