U.S. Fish & Wildlife Service

Prime Hook National Wildlife Refuge

Final Comprehensive Conservation Plan and Environmental Impact Statement

December 2012

Volume 1—Chapters 1 through 6

including Bibliography, Glossary, and Acronyms

Front cover:
Pintails taking flight
©Kevin Fleming

This blue goose, designed by J.N. “Ding” Darling, has become the symbol of the National Wildlife Refuge System.

The U.S. Fish and Wildlife Service (Service) is the principal Federal agency responsible for conserving, protecting, and enhancing fish, wildlife, plants, and their habitats for the continuing benefit of the American people. The Service manages the National Wildlife Refuge System comprised of over 150 million acres including over 560 national wildlife refuges and thousands of waterfowl production areas. The Service also operates 70 national fish hatcheries and 86 ecological services field stations. The agency enforces Federal wildlife laws, manages migratory bird populations, restores nationally significant fisheries, conserves and restores wildlife habitat such as wetlands, administers the Endangered Species Act, and helps foreign governments with their conservation efforts. It also oversees the Federal Assistance Program which distributes hundreds of millions of dollars in excise taxes on fishing and hunting equipment to state wildlife agencies.

Comprehensive Conservation Plans (CCPs) provide long-term guidance for management decisions on a refuge and set forth goals, objectives, and strategies needed to accomplish refuge purposes. CCPs also identify the Service’s best estimate of future needs. These plans detail program levels that are sometimes substantially above current budget allocations and, as such, are primarily for Service strategic planning and program prioritization purposes. CCPs do not constitute a commitment for staffing increases, operational and maintenance increases, or funding for future land acquisition.

U.S. Fish & Wildlife Service

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Prime Hook National Wildlife Refuge Vision Statement

The vision statement below qualitatively describes our desired future character of Prime Hook National Wildlife Refuge. We will refine it throughout the planning process with input from our partners and the public, and it will guide program emphases and priorities at the refuge.

> *Prime Hook National Wildlife Refuge will comprise a variety of Delmarva coastal plain habitats, such as barrier island beach, freshwater and tidal wetlands, grassland, shrubland and forest. The refuge will manage, maintain, enhance and, where appropriate, restore habitats for native plants and animals, with an emphasis on migratory birds and rare species. A balanced approach will be used to ensure all wildlife dependent recreational users experience quality opportunities. The refuge will be a leader in conservation, research and community partnerships, adapting to physical and community changes as necessary to maintain the ecological integrity of the refuge and build a stewardship ethic for current and future generations.*

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Summary

Type of Action: Administrative – Development of a Comprehensive Conservation Plan

Lead Agency: U.S. Department of the Interior, Fish and Wildlife Service

Location: Prime Hook National Wildlife Refuge
Milton, Delaware

Administrative Headquarters: Coastal Delaware NWR Complex
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This Final Comprehensive Conservation Plan and Environmental Impact Statement analyzes three alternatives to managing the 10,144-acre Prime Hook National Wildlife Refuge over the next 15 years. This document also contains 13 appendices (in a separate document) that provide additional information supporting our analysis. Following is a brief overview of each alternative:

Alternative A: This alternative is referred to as our "No Action" or "Current Management" alternative, as required by the National Environmental Policy Act. Alternative A is to continue to manage the refuge as we do at the present time. This alternative provides a basis for comparing the other two alternatives.

Alternative B: Alternative B, the Service-Preferred Alternative, combines actions that we believe would most effectively achieve refuge purposes, vision and goals, and respond to public needs. This alternative will focus on focal species with proactive habitat management and expanded public use. Alternative B is our preferred alternative and the action that we recommend for final selection.

Alternative C: Alternative C proposes to return to habitat management programs which were conducted on the refuge for several decades, but had been stopped in recent years for various reasons. Re-establishment of such programs would require substantial refuge action. This alternative included some modifications to public use programs.

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Chapter 1

©Chuck Fullmer

Seaside sparrow

The Purpose of, and Need for, Action

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- Refuge Establishment, History, and Purpose
- Refuge Vision Statement
- Refuge Goals
- Issues, Concerns, and Opportunities
- Decision to Be Made

Introduction

This final plan for Prime Hook National Wildlife Refuge (hereafter referred to as Prime Hook NWR, or the refuge) combines two documents required by Federal law: a comprehensive conservation plan (CCP) required by the National Wildlife Refuge System Administration Act of 1996, as amended by the National Wildlife Refuge System Improvement Act of 1997 (16 U.S.C. 668dd, et seq.; Refuge Improvement Act), and environmental impact statement (EIS) required by the National Environmental Policy Act of 1969 (NEPA). The CCP will serve as a guide for the refuge's management over the next 15 years. This document has six chapters, 13 appendices, and a glossary of terms and bibliography.

Chapter 1, The Purpose of, and Need for, Action, explains why and how we must prepare a CCP and EIS for Prime Hook NWR. It states the purpose and need for Federal action, i.e., what U.S. Fish and Wildlife Service (Service, we, our) needs we want to meet by preparing a CCP and what goals we wish to accomplish. It explains the legislated purposes of the refuge; explains the regulations, policies, and laws covering units of the National Wildlife Refuge System (NWRS or Refuge System); states our vision and long-range management goals for managing and protecting the land, waters, and Federal trust resources of Prime Hook NWR in the future; and identifies issues of public concern.

Chapter 2, The Planning Policies and Process, explains the planning steps in developing the CCP; describes the influences of other national, regional, ecosystem, and State plans; and identifies refuge operational or step-down plans.

Chapter 3, Affected Environment, describes the physical, biological, and human environment of the refuge, and explains some of the ecological processes that influence the affected environment in a manner that impacts management outcomes.

Chapter 4, Alternatives, Including the Service-preferred Alternative, presents and analyzes three management alternatives that offer different strategies in fulfilling the refuge's goals and objectives, and responds to key issues.

Chapter 5, Environmental Consequences, evaluates the foreseeable consequences of implementing each of the three management alternatives.

Chapter 6, Consultation and Coordination with Others, describes the public and partner involvement used throughout the planning process, and identifies those individuals involved in preparing this document.

Comments received on the draft CCP/EIS, and our responses to them, can be found in Volume 2, Appendix M. In this appendix, we also summarize all significant changes and modifications from the draft CCP/EIS to this final CCP/EIS.

Need for the Action

When Prime Hook NWR was established in 1963 *"for use as an inviolate sanctuary, or for any other management purpose, for migratory birds,"* the marshes, uplands, and waters now encompassed by the refuge had already been manipulated for more than 50 years through ditching and impoundments, draining agricultural lands, reducing mosquito habitat, and increasing freshwater waterfowl habitat. While many Service management actions over the ensuing years improved the condition of the natural ecosystems, the Service also intentionally increased some of these manipulations and allowed others to continue. Climate change and natural processes, apart from human actions, have altered, and will continue to alter, this coastal environment apart from human actions. Over the nearly 50 years of Service management, the national directives from Congress and the Service for managing uses and planning for units of the

Refuge System have become more comprehensive and attuned to the essential features of natural systems. Current Refuge System policies direct refuge managers to assess the historic (pre-human condition) or natural conditions of refuge ecosystems to inform management decisions. These policies direct the Service to avoid additional degradation of environmental conditions and natural processes and to restore degraded environmental components.

Development of a CCP addresses three needs.

First, there is currently no master plan to formally establish and ensure strategic management for the refuge. A vision statement, goals, objectives and management strategies are all necessary to successful refuge management. Public and partner involvement throughout the planning process will also help to resolve various management issues.

Second, the Refuge Improvement Act of 1997 requires that all national wildlife refuges have a CCP by 2012.

Third, management practices should be consistent with current policies; the new CCP will bring the refuge into conformity with all current law and policies.

Purpose for the Action

This CCP has been developed in the context of a changing world. Our natural environment, human uses, and management direction have all changed over the past 50 years. This CCP is designed to address management and protection of valuable natural resources into the future; a future where continued change is even more likely to occur. Thus, the purpose of this CCP is to provide strategic management direction to ensure that our management of the refuge will best respond to four key areas of concern. Strategic here means approaches that are ecologically sound and sustainable in light of physical and biological change, practical, viable, or economically realistic, and responsive to the following:

(1) Abide by and contribute to the mission, mandates and policies of the U.S. Fish and Wildlife Service and the National Wildlife Refuge System.

(2) Meets the refuge's goals.

(3) Addresses key issues.

(4) Responds to public concerns.

While explained in more depth beginning on page 1-7, briefly this CCP will address:

(1) The mission of the National Wildlife Refuge System is "*To administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans.*" Important Refuge System laws and policies concerning habitat management and wildlife conservation include a key Service policy addressing biological integrity, diversity, and environmental health, known as "BIDEH." Other Service policies regarding human uses require that all uses of a refuge be evaluated for their appropriateness, and direct that inappropriate, incompatible, or harmful uses be prevented or eliminated. Compatible uses can be allowed and, in particular, six wildlife-dependent public uses should be facilitated whenever possible. Not every aspect of refuge management implemented at earlier times complies with current directives. Other policies and laws direct how long-term refuge planning is conducted. This CCP is designed to bring all aspects of refuge management into conformity with current laws and policies.

(2) The refuge's goals (pages 1-14 and 1-15) describe the desired future condition of the refuge and provide a framework for developing alternative objectives to achieve that desired future condition. Along with a vision statement, six fundamental goals were developed for Prime Hook NWR to frame how its purpose *"as an inviolate sanctuary, or for any other management purpose, for migratory birds"* can be best achieved in the future. Four of the goals direct management attention to protection and restoration of the ecological integrity, diversity, and sustainability of four key habitat types (barrier island beach and coastal salt marsh habitats, forests, wetland impoundments, and early successional uplands.) Other refuge goals address public uses of the refuge and collaborative initiatives with partners and the local community.

(3) Through the NEPA scoping process and the refuge's understanding of its particular challenges, and incorporating the best available scientific and technical information, several key issues have been identified which this CCP will address. They are:

- Climate change/sea level rise/barrier island overwash/marsh management and restoration
- Mosquito control
- Cooperative farming
- Hunt management

(4) Public interest in the future management of Prime Hook NWR is widespread. The concerns and situations of the interested members of the public are diverse. We have heard from neighboring farmers and residents of barrier island communities; hunters and harvesters of waterfowl, fish, and shellfish, and upland species; visitors who come to observe birds and other wildlife or who seek solitude and respite in the natural world; boaters, dog walkers, beach-goers and other non-priority recreation users; and State agencies and other programs and organizations concerned about the role and contributions the refuge can play in a larger network of natural areas across the State, the mid-Atlantic, and the migratory bird flyway of the Atlantic coast.

NEPA requires a thorough analysis be made of a range of alternatives, including the proposed action and no action. Ultimately we will select among these alternatives based on their greater or lesser ability to meet the purposes and needs described above. We analyze the socioeconomic, biological, physical, and cultural consequences of implementing each alternative. Both the draft CCP/EIS and this final CCP/EIS evaluate three alternatives that represent different ways to achieve the five areas of concern outlined above. For most alternatives, the refuge's goals will be achieved through different objectives, although there are some objectives and actions that are common to more than one alternative. Alternative A fulfills the NEPA requirement for a no action alternative, one that proposes no change in the current management of the refuge. Alternative A is to continue to manage the refuge as we do at the present time. Alternative B will focus on focal species with proactive habitat management and expanded public use. Based on comments we received on the draft CCP/EIS, we have made several changes to alternative B. This modified alternative B is our preferred alternative and the action that we recommend for final selection. Alternative C proposes to return to habitat management programs which were conducted on the refuge for several decades, but had been stopped in recent years for various reasons. Reestablishment of such programs would require substantial refuge action. This alternative included some changes to public use programs.

Developing a CCP with partner and public involvement is vital to the success of management at every national wildlife refuge. A CCP will provide management direction for the next 15 years by:

- Stating clearly the desired future conditions of refuge habitat, wildlife, visitor services, staffing, and facilities.
- Providing state agencies, refuge neighbors, visitors and partners with a clear understanding of the reasons for refuge management actions.
- Ensuring that refuge management reflects the policies, legal mandates and the mission of the Refuge System and refuge purpose.
- Ensuring the compatibility of current and future public use.
- Providing long-term continuity in refuge management.
- Providing justification for our staffing, operations and maintenance, and projected budget requests.

After its completion, the CCP will be reviewed, evaluated, and subsequently updated approximately every 15 years. However, if and when significant new information becomes available, ecological conditions change, major refuge expansion occurs, or when we identify the need to do so, the plan can be reviewed sooner. All plan revisions will require NEPA compliance.

Project Area

Prime Hook NWR is located in the outer Atlantic Coastal Plain, along the southwestern shore of the Delaware Bay in Milton, Sussex County, Delaware. Located within 2 hours driving time from metropolitan Baltimore, Maryland; Washington, D.C; Wilmington, Delaware; and Philadelphia, Pennsylvania, the refuge lies 22 miles southeast of the State capital of Dover (population 35,808). Historically, agricultural lands dominated the area around the refuge. However, residential development starting in the 1990s and continuing to the present is rapidly changing the watershed. Sussex County lost 14,000 acres of farm land to development from 2002 to 2007 (DDA 2007 Census of Agriculture).

The 10,144-acre refuge stretches along the southeastern coastline of Delaware just north of Cape Henlopen. The eastern boundary of the refuge runs next to three beachfront communities: Slaughter Beach, Prime Hook Beach, and Broadkill Beach. Eighty percent of the refuge's vegetation cover types are characterized by tidal and freshwater creek drainages that discharge into the Delaware Bay and associated coastal marshes. The remaining 20 percent is composed of upland habitats. The land uses near the refuge are intensive agricultural and developed residential.

The natural environment of Prime Hook NWR features several different wildlife habitats, as delineated in the Delaware comprehensive wildlife management plan (DeWAP, 2005). They are based on the National Vegetation Classification System and the known existence of species of greatest conservation need. Key refuge habitats include unvegetated sandy beach, dune grasslands, interdunal wetlands, *Spartina* high salt marshes, intertidal mudflats, *Spartina* low salt marsh, bishop-weed mixed species, brackish marsh, freshwater impoundments, red maple/Atlantic white cedar/seaside alder swamps, mixed herb deep peat wetlands, forested uplands, early successional uplands, and ancient sand ridge forests. Those cover types provide habitat for 308 species of birds, 51 species of fish, 45 species of reptiles and amphibians, 37 species of mammals, and an array of rare insect and plant species.

The refuge is divided into four management units that include their wetlands and associated uplands (Map 1.1). Unit I comprises the northern most end of the refuge and is delineated by Slaughter Beach Road as its northern boundary, overwashed barrier dunes and a portion of the Slaughter Beach community houses on the east, Fowler Beach Road on the south, and an upland fringe of scrub-shrub areas on the western boundary. There is currently no water level management capability in Unit I, which contains about 1,400 acres of salt marsh. Tidal saltwater is the primary source of water for the unit, which flows approximately 2 miles from the Delaware Bay through the Mispillion Inlet and into Cedar Creek, entering through Slaughter Canal.

Attenuated tidal flow provided by Slaughter Canal bisects Unit I and receives its afflux from the ditches and creeks within the salt marshes in Unit I. The Draper-Bennett Tax Ditch drains the southwestern portion of this unit, which ultimately feeds into the Slaughter Canal. Daily tidal action has a 4.4-foot range and salinities range from 5 to 25 ppt in the canal. During drought periods, the salinity can get as high as 30 ppt. Rainfall, new and full moon tides, and spring and neap tides maintain the salt marsh community within Unit I. Natural formations of inlets from overwash events along the bay shoreline rejuvenate tidal marsh habitats in Unit I through maintenance of salinity levels and deposition of nutrients and sediments carried by tidal flow. Over the past 100 years, the dune line has been overwashed several times along this shoreline. Currently, a breach in the southern portion of Unit I has restored tidal flow into the unit east of the Slaughter Canal.

Unit II is just south of Unit I and has been managed as an impounded, nontidal freshwater system that is manipulated by water control structures. It is bounded on the north by Fowler Beach Road, barrier dunes, and the Prime Hook beach community on the east, Prime Hook Road on the south, and an upland interface on the west.

During storm tides this sand dune system has been breached several times and washouts have deposited sand and salt water into the Unit II impoundment. Freshwater input is from Slaughter Creek, which flows from the west. Delaware Bay's normal tidal ranges are from 3 to 3.5 feet, except for storm surges and spring tides (± 6.5 ft). Tidal flow enters Slaughter Canal from the Delaware Bay through Unit I salt marshes into the northern portion of Unit II and through the breached along the shoreline and fresh water flow enters Unit II on the west from Slaughter Creek and from Unit III to the south.

Landowners had the marsh drained and dug Slaughter Canal in the early 1900s to improve drainage of their upland areas by channelizing water north to Cedar Creek. In 1906, the Slaughter Canal dredging reached into Unit II and ended at Oak Island. Portions of Unit II were also heavily grid-ditched during the 1930s for mosquito control. To maintain water on the marsh during the fall and winter for muskrat trapping and waterfowl hunting, private owners built water control structures at Fowler Beach Road, Oak Island, and near the bridge at Slaughter Creek to hold water.

Management Unit III is bounded by Prime Hook Road on the north, Route 16 (Broadkill Beach Road) on the south, upland edge on the western boundary, and the Prime Hook and Broadkill Beach developments immediately adjacent to the refuge's eastern boundary.

Unit III consists of roughly 3,600 acres, which include impounded freshwater emergent marsh, red maple-seaside alder swamp, low-lying farmed areas, brush, barrier beach on the east, and 140 acres of flowage easement (tract numbers

Map 1-1. Overview Map of Prime Hook National Wildlife Refuge

84R, 99F and 99i) on the southeastern boundary of Unit III. This flowage easement drains directly into Prime Hook Creek and flows south to the water control structure of this watercourse. Twenty-five hundred acres of marsh were impounded in the 1980s to create the freshwater marsh it is today.

About 150 years ago, Unit III was a tidal marsh system with several small creeks and abundant potholes where Prime Hook Creek and Deep Hole Creek drained directly into the Delaware Bay (1.5 miles north of current Prime Hook Creek water control structure) (USFWS 1982). A major storm in 1911 plugged and sealed the Deep Hole Creek and Prime Hook Creek outlets to the Delaware Bay. The closing of these two outlets drastically changed the daily tidal influence and hydrology of Unit III. Prime Hook Creek now flows through the Petersfield Ditch to empty into the Broadkill River, which drains into the Delaware Bay about 2 miles south of the present-day refuge.

Management Unit IV is surrounded by Route 16 on the north, the Broadkill Beach community on the east, the Broadkill River on the south and west, and the upland edge on the west. Prior to Service ownership, this marsh had been excessively drained by man-made ditches. When the refuge was established, about 1,000 acres of tidal salt marsh surrounded about 150 acres of farm fields. Before 1963, private owners maintained pumping stations for ponds in Units III and IV for cattle and to manage waterfowl and muskrats.

Tidal action occurs along the Broadkill River, whose salinity ranges from 10 to 30 ppt. The majority of the water for Unit IV is provided through the Broadkill River. Some tidal action and leakage of salt water into the Unit IV impoundment also occurs during peak tides from a ditch connected to the Broadkill Sound. Rainfall and runoff from Unit III are other sources that provide fresh water. However, normal runoff and tidal action are not sufficient to recharge the impoundment above its perimeter elevation.

The U.S. Fish and Wildlife Service, its Policies, and Legal Mandates

This section highlights the Service, the Refuge System, and Service policy, laws, regulations, and mandates that directly influenced the development of Prime Hook NWR CCP/EIS document.

The Service and its Mission

The Service administers the Refuge System. The Service is an agency under the Department of the Interior and its purpose is to conserve the nature of America. The Service's commitment to safeguard the nation's fish, wildlife and their habitats is reflected in its vision statement and mission: *"We will continue to be a leader and trusted partner in fish and wildlife conservation, known for our scientific excellence, stewardship of lands and natural resources, dedicated professionals, and commitment to public service."*

Its mission is *"Working with others, to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people."*

The Service is the primary Federal agency responsible for conserving, protecting, and enhancing America's fish and wildlife populations and their habitats. These include migratory birds, federally listed endangered or threatened species, interjurisdictional fish, wetlands, certain marine mammals, and national wildlife refuges. The Service oversees the enforcement of Federal wildlife laws and international treaties on importing and exporting wildlife, management and protection of migratory bird populations, restoration of national fisheries, administration of the Endangered Species Act, and restoration of native plant habitats. The Service also assists states with their fish and wildlife programs and helps other countries develop conservation programs.

The Service Manual, *http://www.fws.gov/policy/manuals/*, contains the standing and continuing directives to implement its authorities, responsibilities, and activities. Special Service directives that affect the rights of citizens or the authorities of other agencies are published separately in the Code of Federal Regulations (CFR); the Service Manual does not duplicate them (see 50 CFR 1-99 at *http://www.gpoaccess.gov/cfr/index.html*; accessed November 2012).

The National Wildlife Refuge System, its Mission, and Policies

The Refuge System is the world's largest collection of lands set aside specifically for the conservation of fish, wildlife and plants. The Refuge System began in 1903, when President Theodore Roosevelt designated Pelican Island, a pelican and heron rookery in Florida, as a bird sanctuary. Today, this unique wildlife conservation system consists of over 560 national wildlife refuges. These refuges encompass more than 150 million acres of lands and waters in all 50 states and several island territories. More than 45 million visitors hunt, fish, observe and photograph wildlife, or participate in environmental education and interpretive activities on refuges across the nation each year.

The Refuge System is home to more than 700 species of birds, 220 species of mammals, 260 reptile and amphibian species, and more than 200 species of fish. This unique network of conserved lands also provides critical habitat for more than 250 threatened and/or endangered plants and animals. As a result of international treaties for migratory bird conservation, such as the Migratory Bird Conservation Act, many refuges have been established to protect migratory birds. Refuges are also places where people can enjoy wildlife-dependent recreational and educational opportunities about the great outdoors, and the Refuge System provides some of the best places across the country where people can hunt, fish, observe, and enjoy wildlife throughout the year.

In 1997, the Refuge Improvement Act was passed. This law established a unifying mission for the Refuge System, a new process for determining compatible public use activities on the refuges, and the requirement to prepare a CCP for each refuge. The Refuge Improvement Act states first and foremost that the Refuge System must focus on wildlife conservation. This law established several new mandates to make the management of the Refuge System more cohesive and standardized to ensure that wildlife is considered first when managing refuges. The preparation of this CCP fulfills many of these mandates.

The Refuge Improvement Act directs the Secretary of the Interior to ensure that the mission of the Refuge System and purposes of the individual refuges are carried out. It states that the national mission, coupled with the purpose(s) for which each refuge was established, will provide the principal management direction for each refuge. It also requires the Secretary to maintain the biological integrity, diversity, and environmental health of the Refuge System. The mission of the Refuge System is

> *To administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans.*
>
> *—Refuge Improvement Act, Public Law 105-57*

The Refuge Improvement Act identifies six wildlife-dependent public uses – hunting, fishing, wildlife observation and photography, environmental education, and interpretation – that will receive priority consideration on refuges and in CCPs. The Refuge Improvement Act also declares that all existing or proposed refuge uses must be "compatible" with the refuge's purpose and consistent with public safety.

These Refuge System goals have been designed to help guide the development of CCPs and improve the administration, management, and growth of the Refuge System in a unified and consistent manner. These goals are:

- Conserve a diversity of fish, wildlife and plants and their habitats, including species that are endangered or threatened with becoming endangered.
- Develop and maintain a network of habitats for migratory birds, anadromous and interjurisdictional fish, and marine mammal populations that are strategically distributed and carefully managed to meet important life history needs of these species across their ranges.
- Conserve those ecosystems, plant communities, wetlands of national or international significance, and landscapes and seascapes that are unique, rare, declining, or underrepresented in existing protection efforts.
- Provide and enhance opportunities to participate in compatible wildlife-dependent recreation (hunting, fishing, wildlife observation, photography, environmental education and interpretation).
- Foster understanding and instill appreciation of the diversity and interconnectedness of fish, wildlife, plants, and their habitats.

The Refuge System Manual provides a central reference for current policies governing the operation and management of the Refuge System not covered by the Service Manual, including technical information on implementing refuge policies and guidelines. This manual can be reviewed at refuge headquarters. A few noteworthy policies instrumental in developing this CCP and EIS follow.

Maintaining Biological Integrity, Diversity and Environmental Health Policy (BIDEH policy)
This policy provides guidance on maintaining or restoring the biological integrity, diversity, and environmental health of the Refuge System, including the protection of a broad spectrum of fish, wildlife, and habitat resources found in refuge ecosystems. Refuge managers are provided with a process for evaluating the best management direction to prevent the additional degradation of environmental conditions and restoring lost or severely degraded environmental components. They accomplish this by assessing the current status of biological integrity, diversity, and environmental health on each refuge through baseline vegetation surveys and studies and by understanding historic conditions, (i.e., those which were/would be present and self-sustaining without human changes to the landscape). Historic conditions serve as a frame of reference to understand the functional processes that naturally shaped the refuge's ecosystem and the scale and frequency of such processes (e.g., fire, flooding, and plant succession) to ascertain the refuge's natural ecosystem. First and foremost, refuges are directed to preserve habitats that maintain a high degree of biological integrity and environmental health. Lost or severely degraded habitats shall be restored, via natural processes or by using management measures that mimic natural ecosystem processes or functions. Guidelines are also provided for dealing with external threats to the biological integrity, diversity, and environmental health of a refuge and its ecosystem. The BIDEH policy (601 FW 3) can be viewed online at: *http://www.fws.gov/policy/601fw3.html* (accessed November 2012).

Appropriate Refuge Uses Policy

Federal law and Service policy provide the direction and planning framework for protecting the Refuge System from inappropriate, incompatible, or harmful human activities and ensuring that visitors can enjoy its lands and waters. This policy (603 FW 1) provides a national framework for determining appropriate refuge uses in an effort to prevent or eliminate those uses that should not occur in the Refuge System. It describes the initial decision process the refuge manager follows when first considering whether to allow a proposed use on a refuge. An appropriate use must meet at least one of the following four conditions:

- The use is a wildlife-dependent recreational use as identified in the Refuge Improvement Act.
- The use contributes to fulfilling the refuge purpose(s), the Refuge System mission, or goals or objectives described in a refuge management plan approved after October 9, 1997, the date the Refuge Improvement Act was signed into law.
- The use involves the take of fish and wildlife under state regulations.
- The use has been found to be appropriate after concluding a specified findings process using 10 criteria.

This policy can be viewed online at: *http://www.fws.gov/policy/603fw1.html* (accessed November 2012).

Compatibility Policy

This policy (603 FW 2) and its regulations, including a description of the process and requirements for conducting compatibility reviews, can be viewed online at *http://www.fws.gov/policy/603fw2.html* (accessed November 2012). The refuge manager must first find that a use is appropriate before undertaking a compatibility review of that use. If the proposed use is not appropriate, the refuge manager will not allow the use and will not prepare a compatibility determination. Below is a summary of this policy.

- The Refuge Improvement Act and its regulations require an affirmative finding by the refuge manager on the compatibility of a public use before allowing it on a national wildlife refuge.
- A compatible use is one “that will not materially interfere with or detract from the fulfillment of the mission of the Refuge System or the purposes of the refuge.”
- The act defines six wildlife-dependent uses that are to receive enhanced consideration on refuges: hunting, fishing, wildlife observation and photography, environmental education, and interpretation.
- The refuge manager may authorize those priority uses on a refuge when they are compatible and consistent with public safety.
- When the refuge manager publishes a compatibility determination, it will stipulate the required maximum reevaluation dates: 15 years for wildlife-dependent recreational uses or 10 years for other uses.
- However, the refuge manager may reevaluate the compatibility of any use at any time, for example, sooner than its mandatory date, or even before we complete the CCP process if new information reveals unacceptable impacts or incompatibility with refuge purposes (602 FW 2.11, 2.12).

- The refuge manager may allow or deny any use, even one that is compatible, based on other considerations such as public safety, policy, or available funding.

Wildlife-Dependent Recreation Policy
The Refuge Improvement Act defines and establishes that compatible wildlife-dependent recreational uses (hunting, fishing, wildlife observation and photography, environmental education, and interpretation) are the priority general public uses of the Refuge System and will receive enhanced and priority consideration in refuge planning and management over other general public uses. The Wildlife-Dependent Recreation Policy explains how we will provide visitors with opportunities for those priority public uses on units of the Refuge System and how we will facilitate these uses. The policy

- Promotes safety of participants, other visitors, and facilities.
- Promotes compliance with applicable laws and regulations and responsible behavior.
- Minimizes or eliminates conflict with fish and wildlife population or habitat goals or objectives in an approved plan.
- Minimizes or eliminates conflicts with other compatible wildlife-dependent recreation.
- Minimizes conflicts with neighboring landowners.
- Promotes accessibility and availability to a broad spectrum of the American people.
- Promotes resource stewardship and conservation.
- Promotes public understanding and increases public appreciation of America's natural resources and our role in managing and conserving these resources.
- Provides reliable and reasonable opportunities to experience wildlife.
- Uses facilities that are accessible to people and blend into the natural setting.
- Uses visitor satisfaction to help to define and evaluate programs.

This policy can be viewed online at *http://www.fws.gov/policy/605fw1.html* (accessed November 2012).

Refuge System Planning Policy
The planning policy provides guidance, systematic direction, and minimum requirements for developing all CCPs, and stipulates a systematic decision-making process that fulfills those requirements. This policy also establishes requirements and guidance for Refuge System planning, including CCPs and step-down management plans. It states that we will manage all refuges in accordance with an approved CCP which, when implemented, will achieve refuge purposes, help fulfill the Refuge System mission, maintain and, where appropriate, restore the ecological integrity of each refuge and the Refuge System, help achieve the goals of the National Wilderness Preservation System, and meet other mandates (Fish and Wildlife Service Manual [602 FW 1,2,3]). Additional information on the CCP planning process and other relevant mandates and plans is provided in chapter 2.

Refuge Establishment, History, and Purpose

In the early 1960s, the southeastern coastal marshes of Delaware were under the threat of industrial development by oil refinery and manufacturing industries. To help preserve those coastal wetlands, the refuge was established under the authority of the Migratory Bird Conservation Act (16 U.S.C. 715–715r), as amended, on August 21, 1963, *"for use as an inviolate sanctuary, or for any other management purpose, for migratory birds."*

We later expanded the boundaries of the refuge to include 934 acres of land purchased with funding from the Land and Water Conservation Fund, under the authority of the Refuge Recreation Act (16 U.S.C. 460k–460k-4), as amended, for the following purposes: *"[land] suitable for (1) incidental fish and wildlife-oriented recreation development; (2) the protection of natural resources; and (3) for the conservation of endangered species."* The refuge has acquired 10,144 acres encompassing 100 tracts ranging in size from 0.4 acres to 1,600 acres from 75 landowners (Table 1-1).

Table 1-1. History of Refuge Land Acquisition

Date of Acquisition	Acreage
1963	101.35
1964	1,468.88
1965	2,283.39
1966	471.06
1967	356
1968	1,756.90
1972	516.22
1974	1,561.60
1975	317.60
1976	92.80
1981	140.10
1983	635
1987	1.10
1998	20.36
2001	343.73
2003	47.02
2007	11.20
2009	8.60
2012	11.69
TOTAL	**10,144**

The acquisition of land for the refuge was highly controversial. In 1963, Delaware Governor Elbert N. Carvel wrote to President Kennedy, requesting that acquisition not be carried out. Secretary Udall's reply to Governor Carvel advocated the continued Federal acquisition of Prime Hook wetlands to protect migratory bird resources for future generations.

Prime Hook NWR historically consisted of tidal marshes and agricultural lands cultivated in corn and small grains. These refuge areas were also grazed by cattle. The landscape surrounding the refuge was dominated by small farms producing vegetables and small grains. Today, resort and residential development increasingly surround the refuge. Agriculture is still one of Delaware's major industries, with more than 480,000 acres in croplands, mostly to support a considerable poultry industry located in Sussex County. The refuge's 10,000 acres are adjacent to three bay front communities: Slaughter Beach, Prime Hook Beach, and Broadkill Beach. Eighty percent of the refuge is dominated by emergent wetlands, mostly impounded freshwater marshes with various inclusions of red maple, Atlantic white cedar, and seaside alder swamps. The remaining area consists of 700 acres of upland mixed pine and hardwood forest, 600 acres of farmed fields, and 700 acres of early successional habitats.

The Service's management over the years was designed to foster freshwater habitats to maximize migratory waterfowl production. In the late 1980s a water level management structure was constructed in Unit II, which allowed this unit as well as Unit III to be flooded with fresh water. These two impoundments rely upon three cross-marsh State roads (Fowler Beach Road, Prime Hook Road, and Broadkill Road) and sand manipulations on the barrier beach to separate these freshwater areas from the adjacent two salt marsh units (I and IV) and from the Delaware Bay.

Game agencies use farming to attract and provide forage for waterfowl on wildlife management areas. On the Delmarva Peninsula, crop or food plot management has been largely to attract Canada goose, and to a lesser extent, dabbling ducks. Cropland management has also historically been a traditional habitat management tool on national wildlife refuges nationwide. Refuges have used farming to attract and feed waterfowl species to support migrating goose and duck populations, as well as to provide hunting and viewing opportunities for the public. Some refuge visitors have come to expect vast acreages of row crops on refuges. Prime Hook NWR began a cooperative farming program when the refuge was created in the 1960s. At its peak in the 1970s, 1,070 acres were in agricultural production on the refuge. In 2006, the last year of the cooperative farming program, the refuge farmed 485 acres. The program ceased until the farming program could be formally evaluated through this CCP process.

The Delmarva fox squirrel was extirpated from Delaware the 1800s. The recovery team decided to re-introduce fox squirrels throughout the Delmarva area and beyond. Prime Hook NWR's translocations occurred in 1986 and 1987. A founder Delmarva fox squirrel population of 17 individuals, 4 from Dorchester County, Maryland, and the remainder from Blackwater NWR was introduced into the refuge. By 1993, the Prime Hook translocations were deemed "successful" as per the 1993 second Recovery Plan. Recent changes in land use surrounding Prime Hook NWR (i.e., development), a small scale of available habitats on Prime Hook NWR, climate change, and sea level rise modeling data, all suggest poor prospects for long-term viability and persistence for the refuge Delmarva fox squirrel population.

The wildland urban interface is defined as the line, areas, or zone where structures and other human development meet or intermingle with undeveloped wildland or natural vegetative fuels. Past marsh management practices along with deferred funding decisions have contributed to a buildup of highly flammable *Phragmites* fuels on refuge lands adjacent to private beach communities. The result is that fire hazards and higher associated risks, as well as increasing beach populations, have augmented the wildland urban interface fire hazard potential directly associated with refuge lands. In recognition of these facts, the refuge received funding to reduce fire hazards and risks associated with the refuge's current wildland urban interface situation. A large majority of homes lie immediately adjacent to refuge wetland and upland habitats and would be directly affected by any marsh fires fueled by *Phragmites*. It was estimated that approximately 4,000 acres of *Phragmites* located on and off the refuge pose an extreme fire hazard at the wildland urban interface. The refuge initiated a plan to reduce the hazardous fuels on the refuge and other areas adjacent to the local beach communities. This program continues today.

Refuge Vision Statement

The vision statement below qualitatively describes our desired future character of Prime Hook NWR. It was refined throughout the planning process with input from our partners and the public, and it will guide program emphases and priorities at the refuge.

> *Prime Hook National Wildlife Refuge will comprise a variety of Delmarva coastal plain habitats, such as barrier island beach, freshwater wetlands, tidal salt marshes, grassland, shrubland, and forest. The refuge will manage, maintain, enhance, and, where appropriate, restore ecologically sustainable habitats for native plants and animals, with an emphasis on migratory birds and rare species. A balanced approach will be used to ensure all wildlife-dependent recreational users experience quality opportunities. The refuge will be a leader in conservation, research, and community partnerships, adapting to physical and natural changes as necessary to maintain the ecological integrity of the refuge and build a stewardship ethic for current and future generations.*

Refuge Goals

Goals describe the desired future condition of the refuge and provide a framework for what the refuge is trying to accomplish in adopting a CCP. Developing goals early in the planning process helped focus our thinking about management actions. Our goals are described below in three categories: habitat, public use, and other.

Habitat

We will preserve, restore, and enhance the biological diversity and ecological integrity of Prime Hook NWR's native plants and wildlife in wetland and upland habitats within the Delmarva coastal plain ecosystem with the following goals:

Barrier Island Beach and Coastal Salt Marsh Habitats
Manage, enhance, and protect the dynamic barrier beach island ecosystem for migratory birds, breeding shorebirds, and other marine fauna and flora. Perpetuate and restore the biological integrity, diversity, natural sustainability, and environmental health of North Atlantic high and low salt marsh habitats.

Forested Habitats
Manage the biological diversity, integrity, and environmental health of refuge upland and wetland forested cover types to sustain high quality habitats for migratory birds and increase quality habitat for the endangered Delmarva fox squirrel, forest interior breeding and wintering landbirds, reptiles, amphibians, and other resident wildlife.

Refuge Impounded Marsh Complex
Maintain the quality of the wetland habitats within and surrounding the refuge's wetland impoundment complex for migrating shorebirds, breeding rails, wading birds, American black ducks, and migrating and wintering waterfowl consistent with the BIDEH policy. Support other native wetland-dependent species and provide fish passage and nursery habitats for anadromous fish species.

Early Successional Upland Habitats
Maintain, enhance, and/or restore the native vegetation, biological diversity, and ecological integrity of early successional upland habitats to create a mosaic of

native grassland, herbaceous scrub/shrub habitats, and transitional young forest to conserve migratory birds, breeding landbirds, and endangered species, and maximize benefits for other priority resources of concern.

Public Use

Provide visitors with a place to safely take part in the six priority wildlife-dependent recreational uses established by the Refuge Improvement Act, as well as such other public uses as may be allowed without interfering with refuge purposes and objectives for wildlife.

Other

Collaborate with the local community and partners to complement habitat and visitor services programs on the refuge and the surrounding landscape.

Issues, Concerns, and Opportunities

We developed a list of key issues and opportunities from our issues workbook, public and focus group meetings, and planning team meetings. Along with the goals stated above, these key issues formed the basis for developing and comparing the proposed alternatives.

Key Issues and Concerns

Since a key purpose of this CCP is to develop management goals and strategies for the next 15 years, the CCP will focus on several key issues that have been identified by Service staff and through public input.

Climate Change/Sea Level Rise/Overwash

Climate Change

A growing body of evidence indicates that accelerating climate change, associated with increasing global temperatures, is affecting water, land, and wildlife resources (Titus et al. 2009). While climate change has occurred throughout the history of our planet and the planet has been warming over the past 20,000 years, current changes are occurring at a greatly accelerated rate as compared to the relatively slow warming trend of the most recent 7,000 years. These accelerated rates are largely a result of the accumulation of greenhouse gases from human activities since the onset of the U.S. Industrial Revolution (USCCSP 2009). Across the continental United States, climate change is affecting migratory phenology and body condition of migratory songbirds (Van Buskirk et al. 2009). Along our coasts, rising sea levels have begun to affect fish and wildlife habitats, including those used by waterfowl, wading birds, and shorebirds on our national wildlife refuges.

Successful conservation strategies will recognize that climate change is a continuing, ongoing condition, so we need to understand how natural systems have evolved in this context and predict how those changes will affect fish and wildlife at multiple scales. We need to develop, test, and implement conservation strategies to cope with the physical changes in the coastal environment resulting from climate change. Some of the current and predicted impacts of climate change in the coastal zone include:

- Shoreline erosion and shoreline displacement.
- Displacement of wildlife (as critical habitats decline).
- Conversion of upland habitats to wetter habitats, freshwater habitats to saline.
- Conversion of forested areas to emergent wetlands.
- Conversion of tidal wetlands to mudflat or open water.
- Decreased nearshore and/or freshwater recreational opportunities.
- Damage to refuge facilities, roads, trails, towers, etc.

- Decreased water quality as a result of increased temperatures and runoff associated with stronger, more frequent storm events.

- Decreased groundwater availability due to changes in precipitation regimes.

Refuge staff will need to increase cooperative efforts with science partners, such as Delaware Department of Natural Resources and Environmental Control (DNREC), Ducks Unlimited, U.S. Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), and others to research and monitor the current and likely physical and biological impacts of climate change, and to assess species and habitat vulnerabilities. This information will be used to formulate guidelines or thresholds to mitigate habitat losses and assist ecosystem adaptation to the refuge's changing environment.

Sea Level Rise

Sea level rise (SLR), a manifestation of a warming climate, has been gradually occurring for thousands of years. Increasing ocean water volumes are caused by thermal expansion of water and the melting of polar ice caps. In addition to the volume of the ocean increasing, land in the mid-Atlantic region is actually sinking as a result of geologic changes near the surface and deep within the Earth (Holdahl and Morrison 1974). This is known as shallow and deep zone subsidence. Thermal expansion, melting of the polar icecaps, and subsidence all contribute to relative SLR.

SLR has been recognized as a key issue facing coastal communities for decades. The Federal Coastal Zone Management Act of 1972 directed local governments to anticipate and plan for the effects of SLR. At the international level, the Intergovernmental Panel for Climate Change (IPCC) was formed to assess SLR on a global scale. In its fourth assessment report, the IPCC estimated that global sea level could rise between 0.2 and 0.6 meters by the year 2100 based on projected greenhouse gas emission scenarios. Some climatologists believe that these projections far underestimate the potential rise in sea levels and suggest that SLR may exceed 1.0 meters (Rahmstorf 2007) or substantially more if rapid polar melting is considered. At the national level, the U.S. Climate Change Science Program was formed to investigate climate change and SLR. This committee recently released a multi-year study entitled Coastal Sensitivity to Sea Level Rise: A Focus on the Mid-Atlantic Region. This study discussed the potential impact from SLR using three scenarios for the year 2100: a rise of 1.3 feet (current rate), 1.6 feet, and 3.3 feet. The third projection is consistent with the higher estimates suggested by recent publications (USCCSP 2009).

Potential impacts from SLR can vary significantly depending upon the scenario; therefore, different SLR scenarios should be evaluated to consider an entire range of potential effects. SLR has the potential to significantly impact the refuge, Delaware's coastal resources and communities, and Delaware's overall economy over the next several decades. Because of higher sea levels, low-lying coastal communities are becoming more frequently inundated during storm events. As storm events are predicted to become more frequent and more intense, coastal erosion and flooding events will likely be more severe than previously experienced. These impacts will have profound effects on the refuge.

In 2008 and 2009, the Delaware Coastal Program (DCP) conducted a sea level rise affecting marsh model (SLAMM) exercise, using high resolution elevation data, at Prime Hook NWR. The SLAMM model that was used (version 5) incorporated inundation, erosion, overwash, and saturation processes into modeled predictions about land cover change under various SLR scenarios. However, the SLAMM model does not incorporate a dynamic accretion rate that changes with varying SLR, which could influence and possibly improve the ability of the wetlands to keep pace with SLR. It also does not account for potential accelerated bluff erosion, and may thus underestimate the availability of sediment to replenish wetlands in some cases. The model used estimated minimum and maximum sea level predictions and incorporated a minimum and maximum accretion rate estimate, assuming that the actual values will probably fall somewhere within those ranges. Certain conditions are predicted by both scenarios and we assume they are good predictors of the future environment at the refuge, even in light of the limitations of the model. By the year 2050, the model projects that at least half of the current upland area of the refuge will be lost (either converted to wetlands or open water), decreasing from 20 percent to, at most, 12 percent of the current land base. Open water and tidal mud flat areas may increase throughout the next 100 years.

If sea level rises at an accelerated rate to 1 meter in the next 100 years, the impact will be much greater on the refuge. By the year 2050, open water and mudflats are predicted to constitute 26 percent of the refuge under conditions that would allow marshes to build at high accretion rates, or up to 58 percent of the refuge with low accretion rates. Under the worst case scenario, by the year 2100, up to 88 percent of the today's refuge could be open water or tidal mud flats and only 1 percent of the refuge would be uplands. Predicted land cover changes under each SLR scenario are fairly similar with or without the bay dunes remaining intact. It is worth noting, however, that as conditions on the refuge change in the predicted manner, the ability of the refuge to manage wetlands through water level manipulation and exclusion of salt water from impoundments will be lost long before the full effects of SLR are realized. The more immediate effect of SLR on the management of refuge resources is a critical issue for the refuge to consider during planning. The full SLAMM modeling report (Scarborough 2009) can be found at: *http://www.swc.dnrec.delaware.gov/coastal/Pages/SeaLevelRiseAdaptation.aspx* (accessed November 2012). Additional information regarding climate change and SLR can be found at the Service's Web site: *http://www.fws.gov/home/climatechange/* (accessed November 2012).

Overwash

Overwash is a natural manifestation of rising sea levels; it is anticipated that the refuge will be confronted with an increasing frequency of these natural events. Overwashes are also critical to maintaining healthy emergent wetlands in barrier island systems of estuaries, such as the Delaware and Chesapeake Bays. Emergent marshes must, in part, receive periodic influxes of sediment to help build marsh elevation to keep pace with rising sea levels. When humans impede natural overwash and marsh building processes by constructing dunes or filling overwash areas, they impede back-bay marsh development. This natural process of migrating landward is a barrier island system's response to SLR as they would otherwise be inundated. Overwashes provide nutrients and sedimentation that are vital for tidal salt marshes and provide critical habitat for priority coastal migratory birds.

Notable storm-induced overwashes occurred on the refuge in 1982, 1988, and 1998. The dunes were artificially rebuilt in 1999. In 2006, Hurricane Ernesto caused a beach overwash just north of Fowler Beach Road on Prime Hook NWR. On May 12, 2008, a nor'easter brought flooding that overtopped or completely removed portions of the beach dunes extending from the Slaughter Beach community to the Prime Hook Beach community, which includes the 2006 overwash area. The overwash north of Fowler Beach Road (Unit I) joins the Delaware Bay to a lagunal tidal salt marsh. As explained in more detail in chapter 3, this area has experienced overwash events in the past, which form and heal naturally over time. For example, an overwash in nearly the exact same location was present in the 1930s (Figure 1-1).

The beach immediately south of Fowler Beach Road has formed inlets the past few years, as well. The impacted area south of Fowler Beach Road (Unit II) covers approximately 4,000 linear feet of beach, with 30 percent of the breaches on private land or a mix of private and refuge-owned lands. These inlets have flooded the formerly managed freshwater impoundment in Unit II with saline bay water. DNREC enhanced the dunes in this area when the Unit II impoundment was established in 1988, and DNREC and the Service have reconstructed them on several occasions between 1988 and 2008 to prevent high tides from entering the freshwater impoundment from the bay. The refuge reasoned that allowing the overwashes to continue could result in a shift in vegetation composition in Unit II, which would reduce value of the impoundments as waterfowl habitat and in the quality of the Prime Hook NWR hunt program. However, it should be noted that prior to the extensive alteration of hydrology in this area caused by construction of roads, ditches, and canals, the native vegetation consisted largely of salt marsh communities. A former salt marsh peat sediment layer persists beneath the upper sediment, despite more than 20 years of freshwater inundation.

Unit III has also been managed as a freshwater impoundment for the benefit of waterfowl. Although not directly impacted by overwashes and inlets as Unit II is, the two units share water exchange through culverts under Prime Hook Road. Increased salinity in Unit II will influence the salinity in Unit III, even as freshwater inputs reduce the salinity in at least the central portion of Unit III. The impacts of the coastal overwashes on Unit III are not as direct as in Unit II, but they are present. Management challenges associated with the overwashes and inlets will ultimately affect both of these freshwater impoundment units.

The refuge's response to recent overwashes has been controversial, particularly within local beachfront communities. Some believe that overwashes, inlet formation, and subsequent flooding of the road and impoundment system are the fault of the refuge, and have suggested that the refuge should be managed to prevent flooding of private properties. Others, including some waterfowl hunters, insist that maintenance of the freshwater impoundments is critical to meet the refuge's management objectives for migrating and wintering waterfowl. However, also at issue is the recognition that management of freshwater wetlands through water level manipulation and repeated dune reconstruction over the long term is at odds with the BIDEH policy and with the Service's climate change strategic plan. The refuge also faces ecological uncertainty regarding how the impounded wetland will respond to rapidly increasing tidal flow, given its physical condition after decades of salt water exclusion, and must consider how best to address that uncertainty. At the current rate of overwash, the refuge would be restoring dunes on average every 5 years, if not more often, in order to prevent tidal waters from entering the impoundments directly. Even with dunes along Unit II in place, salt water intrusion would continue to impact freshwater habitats on the refuge periodically, as bay water enters the Unit II impoundment either through or over Fowler Beach Road.

Chapter 3 of this CCP provides further details about the various factors that influence freshwater impoundment management in the face of the three coastal processes of climate change, SLR, and overwash. The status of the physical environment and the condition of the management infrastructure are described to set the stage for considering the management options presented in the alternatives, as outlined in chapter 4. Shortly following the formation of the major breaches in 2009, the refuge proposed to fill inlets and reestablish dunes along Unit II to maintain short-term stability of wetland habitats until the CCP was

Figure 1-1. Historic Overwash Activity near Fowler Beach, showing portions of Units I and II. [Imagery from DNREC (1937, 1954, 1997), USGS (2007), USDA (2009), and Google Earth (2010)]

finalized and to prevent break-up of the peat layer, which protects the upland shoreline from direct wave action and is vital to an effective marsh restoration effort. The size of these breaches elevated the situation from that of minor dune repair to a more substantial management activity. Thus an Environmental Assessment was prepared to conduct dune repair one more time (USFWS 20120). Legal challenges delayed the dune repair until 2011. By the time the repair was conducted, Hurricane Irene (August 2011) had reduced the amount of onsite material available significantly. The repair was conducted by the Shoreline section of DNREC to the best of their ability, but the breaches reopened merely days later. Daily tidal flow of salt water through the breaches and into Unit II continues. Ultimately, the options that the refuge can reasonably consider in managing the impounded coastal wetlands will be guided by the challenging dynamic coastal conditions.

Mosquito Control

Balancing the needs of wildlife and people is becoming more difficult as residential developments encroach upon wild areas and more visitors participate in wildlife-dependent recreational opportunities on Prime Hook NWR. Providing quality habitat at sufficient quantities for an increasing number of species and individuals is challenging to wildlife managers and biologists. Another critical factor to take into account is the threat of disease to wildlife and humans and how to gauge this threat in making decisions. Numerous factors must be considered before actions are implemented to ensure that all precautions and long-term consequences of those actions are considered.

Mosquito control has a long history in Delaware. The Service has worked cooperatively with the DNREC Mosquito Control Section to provide access and permits to control mosquitoes on Prime Hook NWR for nearly 40 years. Numerous techniques have been employed to reduce nuisance mosquitoes on the refuge, including the use of open marsh water management to allow biological control of mosquito larvae and pesticide application of larvicides and adulticides.

The aim of the refuge is to work in cooperation with the Mosquito Control Section to establish appropriate and compatible mosquito control activities on the refuge based on sound science. This includes relying on Center for Disease Control guidelines, the Service's BIDEH and compatibility policies, draft mosquito control policy, the State's best management practices, and American Mosquito Control Association (AMCA)/Environmental Protection Agency's Pesticide Environmental Stewardship program.

Mosquitoes are a part of the natural environment and a food source for a variety of wildlife. Insecticides, in particular adulticides, used to control mosquitoes can have significant impacts on insects, including nontarget insects, that are used by fish, amphibians, and migratory birds as important food sources.

The refuge will continue to work with the State while striving to protect the biological integrity, diversity, and environmental health of the refuge. This working relationship will eventually lead to the development of a mosquito control plan for the refuge. The refuge's strategies associated with mosquito control, along with their impacts, are discussed further in the chapters to follow.

Cooperative Farming Program

Agriculture, more than any other human activity, has had a profound influence on North American waterfowl and other wildlife (Ringelman 1990). In the past, farming has been an effective wildlife management tool as crops were used to supplement native food resources. When wildlife objectives were not being met through the maintenance of native vegetation, the more intensive method of cropland management was employed. Migratory waterfowl fed on waste crops left behind after harvest, and the refuge used farming as part of a cooperative farming program. Today, even though the potential agricultural production of row crops can be high for wildlife, improvements in combine headers and other farm equipment have resulted in harvest efficiencies of greater than 95 percent and rapidly approaching 99 percent (Gliem et al. 1990). As harvesting has taken place earlier, what waste grain remains usually germinates before migratory Canada geese arrive.

The refuge's overall contribution to the dietary consumption of agricultural foods by trust resources has been insignificant when considering the available cropped acreage on the local and regional scale. Prime Hook NWR has never tilled more than 870 acres in any year. This farmed acreage was incrementally reduced over the years to a total 544 acres in 2006. Presently, there are 40,565 acres of production cropland in the watershed. Waterfowl are not sedentary. Geese especially will make lengthy foraging flights between roosts and suitable feeding habitats. The State of Delaware maintains 490,000 acres of production farmland, while the Delmarva Peninsula as a whole has 1.5 million acres.

Major concentrations of wintering snow geese use Prime Hook NWR; in excess of 100,000 snow geese have been found during the fall and winter season. Extensive wetland acreage used by snow geese as safe loafing and roosting sites. In 2007, the final EIS for light goose management was published. The preferred management alternative supports the reduction of farming and sanctuary for snow geese on the refuge. In 2008, Delaware House Joint Resolution No. 12 was signed, asking the Service to issue the final rule of the light goose management EIS and the implementation of the conservation measures it recommends. The final rule on the EIS was issued by the Service in 2008, and is referred to as the snow goose conservation order. This conservation order is a special management action authorized by the Migratory Bird Treaty Act to control certain wildlife populations when traditional management programs are unsuccessful in preventing overabundance. It is consistent with the preferred alternative's plan to reduce overabundant snow geese populations on the refuge that can destroy marsh habitats and displace other species.

We know today that fragmenting native habitats has contributed substantially to the decline in many trust resources, including numerous species of migratory birds. In addition, fertilizers required to maintain farming, which is a relatively sterile, nearly monotypic habitat by ecological standards, may have substantial negative impacts on the local ecosystem. Sediment and nutrient runoff have affected fish and wildlife species far downstream, and aquifers once used as sources of human drinking water on Delmarva are now deemed unsafe for consumption due to applied nitrate leaching from the surface.

Under the Migratory Bird Conservation Act and Refuge Recreation Act, Prime Hook NWR was approved by the Migratory Bird Conservation Commission on August 21, 1962, to protect and preserve coastal wetlands that are historically of high value as waterfowl habitat. Agricultural lands were not of primary importance. Additionally, lands were acquired under the Migratory Bird Conservation Act "for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." For lands acquired under the Refuge Recreation Act states the purpose of the acquisition is "…suitable for (1) incidental fish and wildlife-oriented development, (2) the protection of natural resources, (3) the conservation of endangered species or threatened species…" Although agricultural practices were viewed as a common management tool at the time the refuge was established, it is apparent that the intent of the refuge's establishing legislation gives no undue weight or particular mandate to agricultural activity.

Two acts of Congress also play a role in the cropland management program: NEPA and National Refuge System Improvement Act (1997). NEPA requires the Government to evaluate the impacts of its management actions on the affected environment. The Refuge Improvement Act requires Prime Hook NWR to ensure that cooperative farming is compatible (see section 1.423 in this chapter) with the purpose for which the refuge was established. Cooperative farming is also considered an economic use, refuge policy 5 RM 17 also plays a role in the formation of cropland management planning.

In 2006, the Delaware Audubon Society, Center for Food Safety, and Public Employees for Environmental Responsibility filed suit against the Service alleging the refuge's failure to comply with these acts and policies. The refuge ceased all farming operations in 2006. In 2009, the judge enjoined the refuge from farming and planting genetically modified organisms until the refuge completed compatibility determinations and environmental assessments dealing with the impacts. We are now complying with the court's directive by assessing the impacts of agriculture in this CCP and the attached compatibility determination.

Hunting

Hunting on the Delmarva Peninsula is a traditional outdoor past time and is deeply rooted in American and Delaware heritage. Opportunities for public hunting are decreasing with increasing private land development. Refuge lands thus become increasingly important in the region as a place to engage in this activity. Hunting has and will continue to be an integral component of the public use program at the refuge. Section 605 (FW 2) of the U.S. Fish and Wildlife Service Manual states that hunting programs will be compatible, provide quality experiences, and to the extent practicable, be consistent with State fish and wildlife laws and regulations. In preparation of the CCP, the refuge closely examined aspects of the current hunting program that some have described as inefficient, overly complex, and requiring a significant amount of staff resources. It has also addressed whether increasing opportunities for one user group, i.e. hunters, might appreciably reduce opportunities for non-consumptive wildlife-dependent uses, such as wildlife observation and photography.

Opportunities

The refuge should seek to establish new and strengthen current partnerships with conservation organizations, such as the Service's Partners for Fish and Wildlife program, the Coastal program, private individuals, etc. The refuge relies on partnerships with several organizations and individuals for help with refuge programs, biological surveys, environmental education, and habitat restoration on private lands that support the refuge's purpose. Opportunities exist to establish an outstanding research and monitoring site, develop wetland and hydric soil indicator reference sites, expand the environmental education program, etc.

Decision to Be Made

Our Regional Director will select a preferred alternative based on the Service and Refuge System missions, the purposes for which the refuge was established, other legal mandates, and public and partner responses to the CCP/EIS. The selection among alternatives is based on the degree to which an alternative meets the purpose and need, defined on pages 1-2 to 1-4. The final decision will identify the desired combination of species protection, habitat management, public use and access, and administration for the refuge. A Record of Decision (ROD) will present and explain the decision, and certify that we have met agency compliance requirements and that the CCP, when implemented, will achieve the purposes of the refuge and help fulfill the Refuge System mission. Once the Regional Director has signed the ROD and we have completed the CCP for the refuge, we will notify the public in the *Federal Register*, and implementation can begin.

Chapter 2


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Field sparrows

The Planning Policies and Process

- **Introduction**
- **The Comprehensive Conservation Planning Process**
- **Conservation Plans and Initiatives Guiding the Project**
- **Existing Refuge Operational Plans**
- **Formulating Alternatives Using Refuge Resources of Concern and Focal Species Management**

Introduction

This chapter explains the planning policies and planning steps in developing the CCP; describes the influences of other national, regional, ecosystem, and State plans; and identifies refuge operational or step-down plans.

Refuge System Planning Policy

The planning policy provides guidance, systematic direction, and minimum requirements for developing all CCPs, and stipulates a systematic decision-making process that fulfills those requirements. This policy also establishes requirements and guidance for Refuge System planning, including CCPs and step-down management plans. It states that we will manage all refuges in accordance with an approved CCP which, when implemented, will achieve refuge purposes; help fulfill the Refuge System mission; maintain and, where appropriate, restore the ecological integrity of each refuge and the Refuge System; help achieve the goals of the National Wilderness Preservation System; and meet other mandates [Fish and Wildlife Service Manual (602 FW 1,2,3)].

The Refuge Improvement Act of 1997 stipulates that each CCP shall identify and describe:

(A) The purposes of each refuge comprising the planning unit [*found in this chapter*].

(B) The distribution, migration patterns, and abundance of fish, wildlife, and plant populations and related habitats within the planning unit [*Chapter 3, Affected Environment*].

(C) The archaeological and cultural values of the planning unit [*Chapter 3*].

(D) Such areas within the planning unit that are suitable for use as administrative sites or visitor facilities [*Chapter 4, Alternatives*].

(E) Significant problems that may adversely affect the populations and habitats of fish, wildlife, and plants within the planning unit and the actions necessary to correct or mitigate such problems [*Chapters 1, 2, 3,and 4*].

(F) Opportunities for compatible wildlife-dependent recreational uses [*Chapter 4*].

The use of sound science is also mandated by the Refuge Improvement Act and subsequent Service policies. The Refuge System planning policy specifically requires that CCPs be based on a *"comprehensive assessment of the existing scientific literature."* Refuge planning policy also states that *"refuge planning will reflect conservation goals and objectives for the landscapes in which refuges are located. Refuges must review goals and objectives of existing ecosystem plans and determine how the refuge can best contribute to the functioning of the ecosystem."* A great deal of study and effort has been devoted to this task and is extensively outlined and reviewed on page 2 through 6, Conservation Plans Guiding The Project, of this chapter.

Other Mandates
Although Service and Refuge System policy plus each refuge's unique legislated purposes provide foundation for its management, other Federal laws, executive orders, treaties, interstate compacts, and regulations on the conservation and protection of natural and cultural resources also affect how national wildlife refuges are managed. The *Digest of Federal Resource Laws of Interest to the USFWS* lists many of them, and can be accessed at: *http://fws.gov/laws/lawsdigest.html* (accessed January 2012).

Federal laws also require the Service to identify and preserve its important historic structures, archaeological sites, and artifacts. NEPA mandates our consideration of cultural resources in planning Federal actions. The

Refuge Improvement Act requires that the CCP for each refuge identify its archaeological and cultural values.

The National Historic Preservation Act (Pub. L. 102–575; 16 U.S.C. 470) requires Federal agencies to locate and protect historic resources—archaeological sites and historic structures eligible for listing or listed in the National Register of Historic Places and museum property—on their land or on land affected by their activities. It also requires agencies to establish a program for those activities and carry them out in consultation with state historic preservation offices (SHPOs).

The act also charges Federal agencies with locating, evaluating, and nominating sites on their lands for the National Register of Historic Places. We maintain an inventory of known archaeological sites and historic structures in the Northeast Regional Office and file copies of the sites at each refuge. Our regional historic preservation officer in Hadley, Massachusetts, oversees our compliance with the act and our consultations with state preservation offices. We must also comply with the Archaeological Resources Protection Act (pub. L. 96–95, 16 U.S.C. 470aa-mm) which requires that we protect our archaeological sites from vandalism or looting and issue permits for site excavation.

The Service also owns and cares for museum properties. The most common are archaeological collections, art, zoological and botanical collections, historical photographs, and historic objects. Each refuge maintains an inventory of its museum property. Our museum property coordinator in Hadley, Massachusetts, guides the refuges in caring for that property, and helps us comply with the Native American Graves Protection and Repatriation Act (25 U.S.C. 3001, et seq.) and Federal regulations governing Federal archaeological collections. Our program ensures that Service collections will continue to be available to the public for learning and research.

Chapter 5, Environmental Consequences, evaluates this plan's compliance with the cultural and historic acts cited above, as well as the Clean Water Act, Clean Air Act, and Endangered Species Act. We designed this draft CCP/EIS to fulfill our NEPA compliance.

The Comprehensive Conservation Planning Process

Service policy establishes an eight-step planning process that also facilitates compliance with NEPA (Figure 2-1). Each of the individual steps is described in detail in the planning policy and CCP training materials (602 FWS 3, "The Comprehensive Conservation Planning Process"). The planning policy can be accessed at: *http://www.fws.gov/policy/602fw3.html* (accessed January 2012).

Planning Process

The key to effective conservation begins with community involvement. To ensure future management of the refuge reflects the issues, concerns, and opportunities expressed by the public, a variety of public involvement techniques were used.

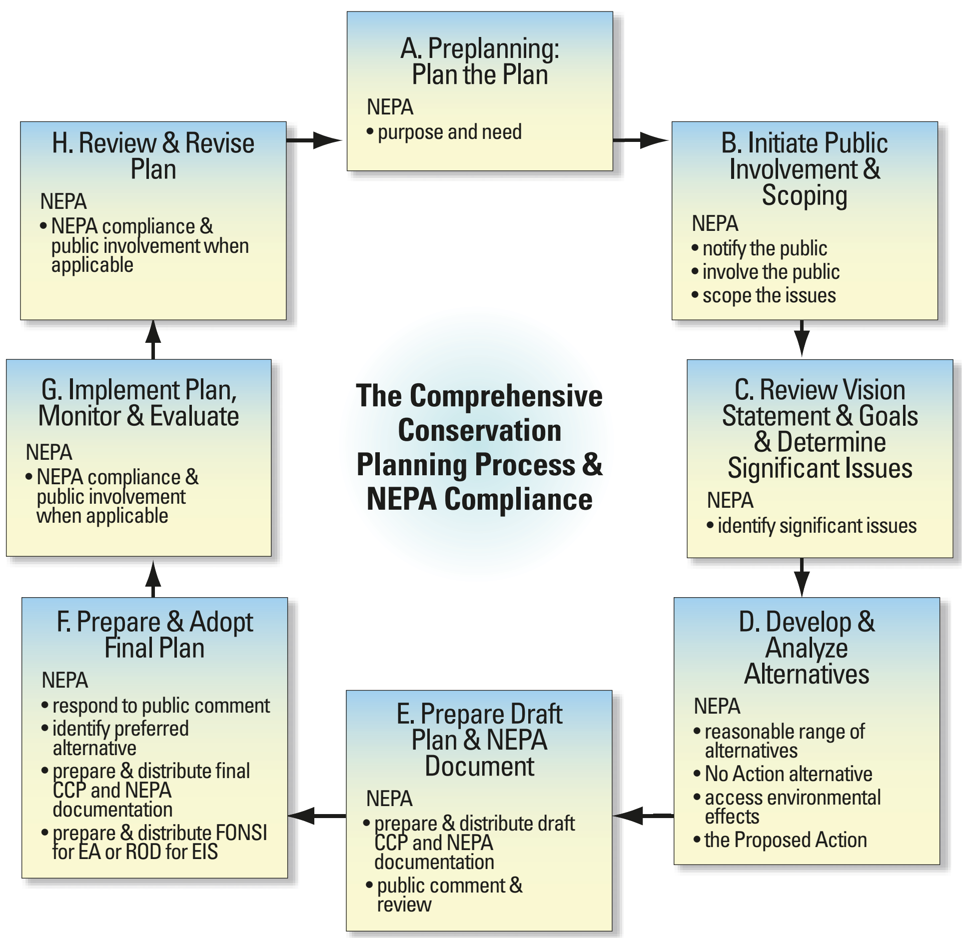
Open houses and public information meetings were held throughout the area at three different locations (Milton, Dover, and Lewes) during November 2005. Meetings were advertised locally through news releases, Web sites, and through our mailing list. For each meeting, the open house session was planned where people could informally learn of the project, and have their questions or concerns addressed in a one-on-one situation. The evening public information meeting sessions usually included a presentation of the refuge, a brief review of the Refuge System and the planning process, and a question and answer session. Participants were encouraged to actively express their opinions and suggestions. The public meetings allowed us to gather information and ideas from local residents, adjacent landowners, and various organizations and agencies.

A visitor survey and community survey were developed to encourage written comments on topics such as wildlife habitats, exotic nuisance species, and public access to the refuge. The visitor survey was distributed to 435 individuals representing various user groups on the refuge. The community survey was distributed to 1,430 members of the local community using a stratified random sampling design. The response rates for the visitor and community surveys were 79 percent and 39 percent respectively.

We completed the draft CCP/EIS and initiated a public comment period that totaled 89 days, from May 31, 2012 to August 27, 2012. We also held 7 public meetings in Milford, Milton, and Lewes, Delaware. We evaluated all the letters and e-mails sent to us during that comment period, along with comments recorded at our public hearing. Appendix L summarizes all of the substantive comments we received and provides our responses to them.

At its completion, the CCP will be reviewed, evaluated, and subsequently updated approximately every 15 years in accordance with the Refuge Improvement Act and Service planning policy (602 FWS 1, 3, and 4). However, when significant new information becomes available, ecological conditions change, major refuge expansion occurs, or when we identify the need to do so, the plan will be reviewed sooner. All plan revisions will require NEPA compliance. If minor plan revisions are required and they meet the criteria of a categorical exclusion, then an environmental action statement, in accordance with (550 FW 3.3C) will only be needed. But if the plan requires a major revision, then the CCP process starts anew at the preplanning step [602 FW 3.8(B)].

Figure 2-1. Steps in the Comprehensive Conservation Planning Process and its relationship to the National Environmental Policy Act of 1969



Conservation Plans and Initiatives Guiding the Project

Service Migratory Bird Strategic Conservation Initiatives

The 1988 amendment to the Fish and Wildlife Conservation Act mandates the Service to "identify species, subspecies, and populations of all migratory nongame birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act (ESA) of 1973." Publication of the Birds of Conservation Concern (BCC) 2008 is the most recent effort to carry out this mandate (USFWS 2008a). The goal of the BCC report is to accurately identify the migratory and non-migratory bird species (beyond those already designated as federally threatened or endangered) that represent our highest conservation priorities. The underlying philosophy behind BCC 2008 is that proactive bird conservation actions are necessary at a time when human impacts are at an all-time high to ensure the future of healthy avian populations and communities. BCC 2008 data and information serve as a barometer of the condition of the nation's avifauna from a national landscape scale funneled down to regional details.

The national BCC 2008 priority bird list provides an early warning of what birds species have the potential to decline to levels requiring ESA protection; it is to be consulted before actions are taken on Federal lands, and for research, monitoring, and management funding in accordance with Executive Order # 13186 (Responsibilities of Federal Agencies to Protect Migratory Birds). This list contains 147 bird species of which 13 nest on the Prime Hook National Wildlife Refuge and 26 species are migrants utilizing refuge habitats during some part of the year. The national list serves as an outreach tool for educating the public about the precarious status of selected bird species across the United States and as a general rule is not used to foster bird conservation at smaller geographic scales; that is the purpose of the BCR 30 and Service region lists.

Funneling the national bird list down to regional levels, the BCC 2008 report generates two other lists that include the refuge geographically: the (BCR-30) Bird Conservation Region of New England/Mid-Atlantic and the Service Region 5 list. The BCR 30 list identifies 45 species of conservation concern, of which 37 occur on the refuge; the Region 5 list identifies 52 species of concern, of which 40 occur on the refuge as either nesters or migrants in their annual life cycle (see High Priority BCR 30/R5 Composite Lists of Bird Species breeding or migrating on Prime Hook NWR below). These bird species in need of additional conservation actions were targeted as resources of concern in the development of this draft CCP/EIS and were also incorporated in upgrading of goals and objectives that will direct and guide the future of refuge management.

High Priority BCC 2008 Bird Species Nesting on Prime Hook NWR Based on BCR 30/R5 Composite lists:

Pied-billed grebe
American bittern
Least bittern
Black rail
American oystercatcher
Least tern
Whip-poor-will
Wood thrush
Prairie warbler
Worm-eating warbler
Henslow's sparrow
Salt marsh sharp-tailed sparrow
Seaside sparrow

High Priority BCC 2008 Migrant Bird Species on Prime Hook NWR Based on BCR 30/R5 Composite lists:

Red-throated loon
Snowy egret
Peregrine falcon
Yellow rail
Short-billed dowitcher
Gull-billed tern
Black skimmer
Red-headed woodpecker

Solitary sandpiper
Lesser yellowlegs
Whimbrel
Hudsonian godwit
Marbled godwit
Red knot
Semipalmated sandpiper
Buff-breasted sandpiper
Olive-side flycatcher
Sedge wren
Blue-winged warbler
Golden-winged warbler
Cerulean warbler
Kentucky warbler
Canada warbler
Nelson's sharp-tailed sparrow

In tandem with the BCC 2008 effort, the Service has also developed a 10-year national strategic migratory management plan to collaborate with its partners to recommit and set a successful course for migratory bird conservation over the next decade. The finalized plan, A Blueprint for the Future of Migratory Birds: A Strategic Plan 2004-2014, describes the challenges facing migratory bird conservation, with associated management strategies to meet these future challenges. The Service's plan formulates a strong recommitment to migratory bird conservation with the following vision statement *"Through careful management built on solid science and diverse partnerships, the Service and its partners will restore and sustain the epic sweep of bird migration and the natural systems on which it depends—fostering a world in which bird populations continue to fulfill their ecological roles while lifting the human spirit and enriching human lives in infinite ways, for generations to come."*

The blueprint document points out that "birds enrich people's lives and have intrinsic value as threads in the earth's ecological tapestry, as pollinators, predators, and prey. Birds serve as excellent indicators of the health and quality of the environment as clean air, clean water and abundant, diverse natural habitats are essential for birds to survive and flourish." The plan also recognizes that birds are enjoyed by a large proportion of Americans, as more than 82 million residents of the U.S. (39 percent of adult population) participate in wildlife-related activities, and 64 million pursue bird-related recreation, contributing substantially to local economies throughout the nation by spending more than $40 billion dollars annually on these pursuits (Blueprint 2004).

Also identified were the major future challenges to conserve migratory birds. Declines in abundance of many landbird, shorebird, and waterbird populations are indicative of ecosystems that have been highly stressed and altered. Reductions in natural habitat quantity and quality are acknowledged as the primary causes of negative population trends in many bird species and are exacerbated by the direct loss of bird life from an array of environmental contaminants. Pesticides continue to poison birds and their food supplies. Invasive species and disease outbreaks also contribute to migratory bird mortality. Global climate change and demand for fresh water supplies pose current and future threats.

The Blueprint document explains that meeting these challenges will require consistent adherence to the principles of sound science. Many of these threats will be addressed in this CCP/EIS and we will use the best available scientific information to mitigate environmental dangers to migratory birds. The refuge and its partners will focus on these challenges in the most cost-effective manner to perpetuate avian populations.

Strategic Habitat Conservation/National Ecological Assessment Team Report Guidance

The Regional Director has stated that "The Service is looking at a new way of doing business. The goal is to focus our work on conservation priorities and outcomes and less on program and regional organization." Recent advances in the field of conservation science are leading the Service toward a new direction of "strategic pursuit of sustainable landscapes." In the past, the Service relied more on conservation opportunities, however, the strategic habitat conservation approach features more scientific ecosystem-level analysis used to better coordinate local, on-the-ground, habitat conservation actions.

Strategic habitat conservation (SHC) is a science-driven framework for the strategic pursuit of defining and implementing conservation priorities for sustainable landscapes. This framework provides a scientific approach in identifying habitat conservation deficits on the landscape and filling in the gaps. SHC involves both cross-programmatic Service groups and non-Service conservation science partners' participation to restore, enhance, and manage local wildlife habitats. It features stepping down ecosystem-level Geographic Information System (GIS) analysis to coordinate local, on-the-ground conservation actions. SHC is trust-resource-centric, which focuses on under-represented habitats across the landscape, and relying on cross-pollination from all Service programs, state partners, and other conservation science expertise.

The SHC approach has been used in development of this CCP/EIS to formulate proposed refuge-specific habitat objectives and management strategies. This was done by stepping-down the combined habitat goals of the Delaware River/Delmarva Coastal (DR/DC) ecosystem plan and Delaware wildlife action plan. We focused on conservation target species of greatest conservation need and under-represented habitats identified in both ecosystem and State comprehensive wildlife plans, and used ecosystem-level GIS analysis and refuge vegetation mapping for to produce refuge-specific habitat objectives and management strategies. These objectives include conservation assessment elements of measurable biological outcomes, so we can develop an effective inventory and monitoring step-down plan after finalization of the CCP. Development of an inventory and monitoring plan will enable us to monitor and assess successes and failures of future conservation actions, and adjust or adapt new management strategies accordingly.

SHC provides an iterative framework of planning, implementation, and evaluation actions. It is an adaptive conservation management scheme that rotates around four main functions: strategic biological planning, conservation design, conservation delivery, monitoring, and research. The framework provides for continual refinement of management strategies at each iteration, constantly improving the achievement of desirable outcomes and examining the consequences of site-scale actions on landscape-scale functions.

The practice of SHC provides improved and defensible methods of habitat management planning and execution, with the greatest transparency possible to explain the rationale for refuge-specific habitat objectives and management strategies contained in this document. Prime Hook NWR has built into this CCP a working capacity for SHC and will continue to build an SHC working capacity in subsequent stepped-down management plans from the approved and final Prime Hook National Wildlife Refuge CCP.

"Conserving the Future and Fulfilling the Promise" Document Guidance and Wildlife-Habitat-Process Report

Fulfilling the Promise

The 1999 report, Fulfilling the Promise, The National Wildlife Refuge System: Visions for Wildlife, Habitat, People, and Leadership (USFWS 1999), was a culmination of a year-long process by teams of Service employees to evaluate the Refuge System nationwide. This report was a result of the first-ever Refuge System conference held in Keystone, Colorado, in October 1998. It was attended by every refuge manager in the country, other Service employees, and scores of conservation organizations. The report contains 42 recommendations packaged with three vision statements dealing with wildlife and habitat, people, and leadership. We have often looked to the recommendations in the document and subsequent promise team reports, when writing the CCP/EIS. For example, the 1999 report recommends forging new alliances through citizen and community partnerships and strengthening partnerships with the business community. One of the goals in our CCP is devoted almost entirely to the development of community partnerships, while several of our strategies focus on forging new partnerships or strengthening existing ones.

Conserving the Future: Wildlife Refuges and the Next Generation
Published in October 2011, Conserving the Future: Wildlife Refuges and the Next Generation establishes the Refuge System's new vision as it moves into the next decade of conservation following Fulfilling the Promise (USFWS 1999). This document builds upon the framework of Fufilling the Promise. It is the result of 18 months of study and public conversation about conservation and the future of the Refuge System. It was drafted by Service employees and their conservation partners with input from Service employees, other state and federal agencies, tribes, conservation agencies, and private citizens. When developed, this new course had to consider changes that occurred since Fulfilling the Promise was published, such as, an increasing and more diverse population, a challenged economy, a changing climate and U.S. involvement in war. The report contains 24 recommendations packaged with eight vision statements. It seeks not only to further the System's mission, but also to raise the Service's profile in the broader national conservation effort. This new vision embraces bold new ideas to realize the full conservation potential of the National Wildlife Refuge System. It relies strongly on utilizing partnerships with both traditional and non-traditional partners. It also acknowledges that strategic, collaborative, science-based landscape conservation - along with effective public outreach, education and environmental awareness is the only path forward to conserve America's wildlife. As with the Fulfilling the Promise document, we have looked to the recommendations in this document when writing the CCP/EIS.

National Wildlife Refuge System Wildlife Habitat Goals Report
Another important Fulfilling the Promise team effort focused on the need to have clear objectives on how the Refuge System will contribute to biological diversity in North America. In January 2004, the wildlife habitat goals team completed its final report, A Process for Integrating Wildlife Population, Biodiversity, and Habitat Goals and Objectives of the NWR System: Coordinating with Partners at all Landscape Scales. The report recognized the conservation biology principles that would be used by each refuge on how to best contribute to maintaining biodiversity and the process to determine biodiversity objectives and indicators for each individual refuge. These included native plant and animal species richness as important and useful indicators of biodiversity; species as a function of habitats; animal habitats as characterized by plant species composition, and plant habitats as characterized by physiographic features; and conservation of a broad range of physiographic features and plant communities to ensure the conservation of a wide range of species and other components of biodiversity.

The process describes how to compile national wildlife population, habitat, and biodiversity goals, and then step those down through regional, ecosystem and refuge levels. During the development of the CCP, we adopted the report's vegetation-based coarse-filter approach to identify habitat objectives, coupled with wildlife population-based fine-filter approach for biodiversity conservation (Berendzen et al. 2004).

Prime Hook NWR relied heavily on many partners when establishing refuge-specific conservation priorities, habitat objectives, and alternatives included in this document. These partners included Service Delaware Bay Estuary Project, U.S. Geological Survey (USGS) Water Resources Division Office, the Delaware Natural Heritage and Endangered Species Program, and the NatureServe Network.

The North American Waterfowl Management Plan (NAWMP)

The North American Waterfowl Management Plan (NAWMP) was originally written in 1986 to help protect continental habitat conditions that could sustain and improve waterfowl populations. It was updated in 1994, 1998, and 2004. This plan outlines the strategy among the United States, Canada, and Mexico to protect North America's remaining wetlands and restore waterfowl populations through habitat protection, restoration, and enhancement actions. The intent in preparing the 2004 plan was to define and update the needs, priorities, and strategies with a 15-year planning horizon, increase stakeholder confidence in the direction of plan actions, and guide partners in strengthening the biological foundation of North American waterfowl conservation (USFWS 2004). The 2004 update can be accessed at: *http://www.fws.gov/birdhabitat/NAWMP/Planstrategy.shtm* (accessed January 2012).

Implementation of this plan is accomplished at the regional level within designated regional habitat joint venture areas. Planned recovery actions identified in the plan, such as habitat restoration and enhancement, occur through these regionally based, self-directed partnership joint ventures that involve Federal, state, and provincial governments, Tribal nations, local businesses, conservation organizations, and individual citizens for the purpose of protecting habitat within joint venture areas. Prime Hook NWR is located within the Atlantic Coast Joint Venture (ACJV) area, which covers all Atlantic Flyway states from Maine to Florida, as well as Puerto Rico.

Atlantic Coast Joint Venture
The mission of the ACJV has continued to evolve with the decision to embrace a more comprehensive approach that addresses all-bird conservation, with an emphasis on waterfowl management. The goal of the ACJV is to *"Protect and manage priority wetland habitats for migration, wintering, and production of waterfowl, with special consideration to black ducks, and to benefit other wildlife in the joint venture area."*

The ACJV implementation plan was revised June 2005 (USFWS 2005). The purpose of this plan is to step-down the continental and regional goals of the 2004 NAWMP to the ACJV area, present a current status assessment of waterfowl and their habitats within the joint venture, update focus area data for each state, and present habitat conservation goals and population indices for the ACJV consistent with the NAWMP. This revised version of the implementation plan also provides baseline information needed to move forward with a thorough approach for setting future habitat goals. The 2005 update of the implementation plan can be accessed at: *http://www.acjv.org/wip/acjv_wip_main.pdf* (accessed January 2012).

In order to capture the conservation needs of the diversity of landscapes within the ACJV, a three-tiered, hierarchical approach to mapping and defining areas, from coarsest to finest, was used. These include planning areas, focus areas and sub-focus areas, which target more than 113 million acres for conservation action to benefit waterfowl and other wetland-dependent species. The State of Delaware contains four focus areas and three sub-focus areas delineating 924,069 acres for intensifying waterfowl conservation management actions. Prime Hook NWR lies within the Bayshore focus area, which encompasses approximately 407,857 acres of land.

The best waterfowl breeding and wintering habitats in the State of Delaware are found in the Bayshore focus area, which encompasses the coast of central Delaware, from the Cedar Swamp wildlife areas in northern Kent County to Lewes in Sussex County. During the fall and winter, hundreds of thousands (251,706 – Jan 2004) of waterfowl use the area for feeding and roosting, there are significant numbers of Canada goose, snow goose, pintail, black duck and mallard. Over 80 percent (200,000) of the Atlantic Flyway's snow goose population winters in this focus area (Delaware 2004). In addition, this area also contains the largest concentration of northern shoveler, American widgeon, and gadwall in the State and is also noted for the production of American black duck and wood duck.

The Bayshore focus area is also very important for other migratory birds. Located along the eastern coast of Delaware, it provides some of the most critical habitat (e.g., beach, dunes, adjacent marshes and impoundments) for migratory shorebirds. More specifically, this focus area is the major stopover refueling site for over a million shorebirds during the spring migration, including 80 percent of the Western Hemisphere's red knot population and significant numbers of dunlin, ruddy turnstone, semipalmated sandpiper, least sandpiper, short-billed dowitcher, and others.

Major threats to waterfowl in the Bayshore focus area include increasing development, decreasing water quality, oil spills, and invasive species. Vast areas of forest and wetland habitats are being lost to facilitate agriculture and residential development. Conservation recommendations focus on protecting, restoring, and enhancing wetlands and associated upland habitats to form larger contiguous blocks of natural habitats along with connections to undisturbed habitat within the Bayshore area. With respect to Delaware's portion of the ACJV plan, 3,000 acres have been targeted for protection, 40,000 acres for enhancement and 500 acres for restoration. We have used this ACJV information when developing the various alternative scenarios with respective future management goals, objectives, and strategies.

North American Waterbird Conservation Plan

The North American Waterbird Conservation Plan (NAWCP) is the product of an independent partnership of individuals and institutions wanting to conserve waterbirds and their habitats (version 1.0 – 2002). The plan provides a continental framework for the conservation and management of 210 species of waterbirds utilizing aquatic and wetland habitats. It sets goals and priorities for waterbirds during nesting, migration and non-breeding periods. The plan provides an overarching framework for regional conservation planning, provides focused guidance for local conservation planning and action, and gives a larger context for local habitat protection. The plan can be accessed online at: *http://www.waterbirdconservation.org* (accessed January 2012).

Partners in Flight North American Landbird Conservation Plan

The Partners in Flight (PIF) North American Landbird Conservation Plan reviewed the conservation status of 448 native landbird species that regularly breed in the U.S. and Canada. The purpose of this continental plan is to provide an overview of the highest priority landbirds in North America. These birds include not only those species that are of conservation concern due to population declines and small ranges, but those that are characteristic of major habitat types and are essential to the biological integrity and long-term ecological stability of entire eco-regions. Following the lead of the NAWMP, PIF have made the commitment to conserve the resident, short-distance, and neotropical migrant landbirds and their regional habitats on the continental landscape (Rich et al. 2004). The PIF vision states *"Populations of native birds will occur in their natural numbers, natural habitats, and natural geographic ranges, through coordinated efforts by scientists, government, and private citizens."*

Two groups of bird species were identified as having high conservation importance: the PIF Watch List, made up of species with the greatest conservation need, and stewardship species that are particularly characteristic of regional avifauna. Watch list species are considered to be in immediate trouble and are at risk of extinction or serious decline, while stewardship species are native bird species that are characteristic of unique ecosystems.

Of the 100 watch list species, 66 are also stewardship species. Examples of high-priority watch list species that Prime Hook NWR manages for include salt marsh sparrow, seaside sparrow, Nelson's sparrow, Henslow's sparrow, black rail, prairie warbler, prothonotary warbler, short-eared owl, willow flycatcher, red-headed woodpecker, and wood thrush. Significant stewardship species that can be managed for on the refuge include Acadian flycatcher, pine warbler, yellow-throated warbler, eastern towhee, chuck-will's widow, and white-eyed vireo.

Mid-Atlantic Coastal Plain–Physiographic Area 44 Plan
Several regional PIF plans have been stepped-down from the national effort and the regional plan pertinent to the refuge is the Mid-Atlantic Coastal Plain–Area 44 Plan, which covers about 13 million acres including portions of Virginia, Maryland, Pennsylvania, New Jersey, and all of Delaware (Watts et al 1999). The PIF 44 plan identifies that managing human population growth (more than 11 million) while maintaining functional natural ecosystems is the greatest conservation challenge in Area 44.

The pace of habitat loss within this area suggests that future success of conservation planning will require swift identification and preservation of remaining habitat patches. Priority bird species were sorted by habitat to delineate the highest priority habitats in need of critical conservation attention to conserve regionally important PIF bird populations. Priority habitats pertinent to Prime Hook NWR conservation planning with keystone bird species are: salt marsh–black rail, salt marsh sparrow, seaside sparrow, and American black duck; forested wetlands–prothonotary warbler and Acadian flycatcher; mixed upland forest–wood thrush, Eastern wood-pewee, scarlet tanager, red-headed woodpecker, Cooper's hawk, and barred owl; and early successional–prairie warbler and Henslow's sparrow.

Specific conservation recommendations for this physiographic area include strict protection of beach and barrier dune habitat to minimize productivity losses of priority species; prioritize and protect all sites with greater than 125 acres of high marsh; protect forest blocks that support significant populations of prothonotary warbler or wood thrush; and manage or restore early successional habitats greater than 125 acres to support Henslow's sparrow. We will consider the restoration and maintenance of identified priority habitats and habitat requirements of the highest priority species in the development of the CCP/EIS.

U.S. Shorebird Conservation Plan

The U.S. Shorebird Conservation Plan was developed with the purpose of creating conservation goals, identifying critical habitat, and promoting education and outreach programs to facilitate shorebird conservation. Several groups and individuals, including local, state, and Federal agencies, non-governmental organizations, business-related sectors, researchers, educators, and policymakers helped craft the plan document, which summarizes all the latest hemispheric and national population shorebird estimates and recommendations for regional step-down plans along with conservation goals and critical habitat identification. The plan can be accessed at: *http://www.fws.gov/shorebirdplan/USShorebird/downloads/USShorebirdPlan2Ed.pdf* (accessed January 2012).

At the regional level, Prime Hook NWR is part of the North Atlantic planning region within the Atlantic Flyway, which includes 12 states and encompasses Biological Conservation Regions numbers 30 and 14. The Northern Atlantic Regional Shorebird Plan (version 1.0–Clark et al. 2001) identified the major habitat types supporting shorebirds in this region, which include beachfront and high beach dune, intertidal mudflats, vegetated intertidal marshes, and managed impoundments. Inland habitats such as forested wetlands and peninsulas that concentrate migrants, as well as managed uplands are also included. The North Atlantic region is extremely important for transient shorebirds during both northbound and southbound migrations.

The region is critical for the Western Hemisphere population of red knot, which is highly concentrated in Delaware Bay each spring. It also supports most of the Atlantic Flyway's breeding piping plovers. Shorebird species of the highest regional priority that can be managed for on refuge lands by habitat type include:

beachfront–red knot, piping plover, ruddy turnstone, and sanderling; intertidal mud–semipalmated sandpiper, American golden plover, greater yellowlegs; intertidal marsh–willet; and earlier successional habitats–American woodcock and buff-breasted sandpiper.

The Emergency Wetlands Resources Act

The Emergency Wetlands Resources Act was enacted in 1986 to Regional Wetland Concept Plan, Northeast Region to promote the conservation of wetlands nationwide. Through this act, the Department of the Interior was directed to develop a national wetlands priority conservation plan identifying the location and types of wetlands that should receive priority attention for acquisition by Federal and state agencies using Land and Water Conservation Fund appropriations. In 1990, the Service's Northeast Region completed a regional wetlands concept plan that complemented the national plan by providing more detailed information about the wetland resources of the Northeastern states (USFWS 1990).

The regional wetlands concept plan identifies 850 wetland sites that warrant consideration for acquisition. It also describes wetland functions and values as well as identifies habitat loss and threats to wetlands remaining in the region. Of the 16 wetland sites identified in the State of Delaware, 8 sites are located in Sussex County. Two sites are immediately adjacent to the refuge: 300 acres (Huckleberry Swamp) and 200 acres (Sowbridge Branch) in Milton/Ellendale, while the remaining 6 sites are scattered throughout the county. We used this information as we develop our land protection strategies.

Partners in Amphibian and Reptile Conservation

Partners in Amphibian and Reptile Conservation (PARC) is a diverse partnership of public and private organizations, and is the most comprehensive herpetofauna conservation effort undertaken in the United States. PARC, which is a unique national and international conservation network of comprehensive information on all reptiles and amphibians, is solely habitat focused. It provides the best available science to conserve and protect herpetofaunal habitats and species.

PARC keys in on endangered and threatened species but also advocates keeping common native species common. Their mission is “to conserve amphibians, reptiles and their habitats as integral parts of our ecosystem and culture through proactive and coordinated public and private partnerships.” PARC's partners include Environmental Protection Agency (EPA) Office of Wetlands, Service-Northeast Region, USGS Biological Resources Division, and many more. (See: *http://www.parcplace.org*; accessed January 2012.)

In 2000, the Northeast regional working group of Partners in Amphibian and Reptile Conservation (NEPARC) began work to assess factors contributing to the risk and potential vulnerability of northeastern amphibians and reptiles. Their Web site serves as a repository of biological attributes for Anura (frogs and toads), Caudata (salamanders and newts), Squamata (snakes and lizards) and Testudines (sea and freshwater turtles): *http://www.northeastparc.org/* (accessed January 2012)

This information, along with Habitat Management Guidelines for Amphibians and Reptiles of the Northeast (Mitchell et al. 2006) and Southeast (Bailey et al. 2006), was used to develop habitat management objectives and strategies to maintain the common native species and protect some of the rarest Delaware herpetofaunal species documented on the refuge.

Delaware Comprehensive Wildlife Conservation Strategy

In 2001, new funds appropriated by Congress known as the state wildlife grants program, were used to challenge the states to demonstrate wildlife conservation management in complete terms—not just game, sport fish, and endangered species, but comprehensive wildlife conservation (i.e., all species and all habitats). The Delaware Division of Fish and Wildlife developed its Delaware wildlife action plan (DEWAP 2005). The plan is a compilation of comprehensive strategies for conserving the full array of native wildlife and habitats, both common and uncommon, as vital components of the State's natural resources.

This plan recognizes development pressure and loss of wildlife habitats as threatening the existence of many of Delaware's indigenous species of concern, such as the hooded warbler, carpenter frog, Bethany firefly, Delmarva fox squirrel, coastal plain swamp sparrow, and hundreds of others. The State is implementing a new comprehensive approach to wildlife conservation to keep common species common and healthy ecosystems healthy. The plan was developed with the participation of several Statewide conservation partners, which included refuge staff.

The plan identifies 457 species of greatest conservation need and 50 different types of habitats. Habitats of conservation concern are highlighted in yellow in chapter 3 and featured as key wildlife habitats. These habitats are rare and under-represented within the State's landscape, have special significance in Delaware, are particularly sensitive to disturbance, or have a high diversity of rare plants. Habitats with any of these factors are known, or expected, to harbor species of greatest conservation need, especially insects that are often dependent on specific host native plants.

Large blocks of unfragmented forests and wetlands were also designated as key wildlife habitats because of their importance to area-sensitive species, particularly invertebrates. A minimum size of 250 acres, criteria established by the State for the Delmarva conservation corridor demonstration program, has been used. Key wildlife habitats consist of any areas with species of greatest conservation need occurrences, habitats of conservation concern, forest blocks greater than 250 acres, and wetland blocks greater than 250 acres.

The Delaware wildlife action plan identified and summarized 90 different conservation issues affecting State species or habitats of conservation concern. Implementation steps have included listing 230 different conservation actions to remedy these conservation issues. We have relied heavily on the plan and conferring with our State partners when developing habitat objectives and management strategies during the CCP process. We have incorporated State information in the development of this document, and will continue to coordinate conservation actions for both plans (DEWAP and Prime Hook NWR CCP) in the future.

Sussex County Comprehensive Plan

The Sussex County comprehensive plan update, a 5-year plan that outlines Sussex County's vision for itself in the future and how best the county and its people can make that vision a reality, was adopted June 24, 2008, and certified by Governor Ruth Ann Minner on October 27, 2008. This plan considers parks, natural areas, forests, wildlife habitats, greenways, and waterways as important components of Delaware's quality of life. The objective of the strategies in the revised plan is to direct new growth toward existing communities and avoid unplanned sprawl and loss of open space (*www.sussexcountyde.gov/*; accessed January 2012).

The conservation element of the Sussex County plan has the stated goal of "protecting critical natural resources by documenting their locations and developing growth management strategies that limit development in these areas." This chapter of the plan describes State ownership (5 parks, 8 wildlife management areas, 19 ponds, nature preserves, and cultural sites), Redden State Forest, and Federal lands (Prime Hook NWR) in Sussex County, which collectively define the excellent examples of Delaware's remaining natural and cultural heritage. These include productive wetlands, mature forests, rare plant and animal habitats, geological and archeological sites, and open space for recreation and greenway connectors.

Sussex County's open space program has multiple sources of funding targeted to protect additional acres planned for natural resource area protection. Seven resources areas have been delineated with proposed acreage add-ons. The program activity in the plan's summary identifies 42,259 acres as currently protected and an additional 44,441 acres to be included in the future. Topping the list is the Prime Hook area, which is currently listed as 11,668 acres protected with a proposed addition of 14,678 acres. Three other areas (Ellendale/Redden, Great Cypress, and Nanticoke River additions) have important implications for the Service and the Delaware Division of Fish and Wildlife's joint venture of developing a proposed endangered species habitat conservation plan for Sussex County for the Delmarva fox squirrel.

Broadkill River Watershed Pollution Control Plan

Water quality assessments performed by DNREC have shown that more than 90 percent of Delaware's waterways are considered impaired. For example, 2,506 miles of rivers and streams have been tested for water quality attainment, and 2,490 miles have been documented as impaired. Likewise, 2,954 acres of lakes, ponds and reservoirs have been tested Statewide, and 2,796 acres were found to be impaired. Impaired waters are deemed polluted waters that could be suffering from excess nutrients, low dissolved oxygen, toxins, bacteria, or any combination of these problems.

The most common impairments in Delaware are pathogens and nutrients (nitrogen and phosphorus). The majority of impairments come from hard-to-control nonpoint sources. Sources of impairments in the State are agricultural runoff, municipal (urbanized, high-density areas) impervious runoff, land disposal, decentralized septic systems, municipal point source discharges, industrial point discharges, Resource Conservation and Recovery Act hazardous waste sites, and combined sewer overflows. (National EPA Assessment Database for State of Delaware Year 2002; available at: *http://iaspub.epa.gov/waters10/w305b_report_v2.state?p_state=DE*; accessed January 2012.)

Impervious cover, such as blacktop and concrete, prevents water from permeating the ground. Many scientists look to impervious percentages as an indicator of water health. Research has consistently shown that once a watershed exceeds a threshold of 10 percent imperviousness, water and habitat quality irreversibly decline (Broadkill watershed land-use trend data at: *http://broadkill.ocean.udel.edu*; accessed January 2012). Currently, the Broadkill River watershed's impervious cover is 6.7 percent, but DNREC notes that surface waters are already impaired within the watershed. During a 10-year period from 1992 to 2002, there was a 40.2 percent increase in residential development, while agricultural and forested land area each decreased by 7.1 percent during this same period.

Wetlands are estimated to occupy about 16,000 acres of the watershed's land base. These include 8,361 palustrine acres, 6,786 estuarine acres, 539 lacustrine acres, and 146 riverine acres. Prime Hook NWR contributes approximately 8,000 acres of wetland habitats to the watershed total. Wetlands are critically important for helping achieve water quality standards and are useful for reducing nonpoint source pollutants. The town of Milton is the urban center of the watershed with small portions of the city of Lewes and the town of Georgetown lying on the outer edges of the watershed boundary. Protecting the natural resources and the water quality of the Broadkill River watershed is currently being addressed by the State and local governments and citizens.

As the problem is very complex, DNREC and the University of Delaware Sea Grant Program have coordinated a group of stakeholders (refuge is a participant in this process) to develop a comprehensive Broadkill River pollution control plan. Section 303(d) of the Federal Clean Water Act requires states to develop a list (303(d)-List) of waterbodies for which existing pollution control activities are not sufficient to attain water quality criteria and to develop total maximum daily loads (TMDLs) for pollutants causing impairments. A TMDL sets a limit on the amount of pollutant that can be discharged into a waterbody and still protect healthy water conditions. DNREC has listed the Broadkill River on several of the State's 303(d) listings and has set various TMDLs regulating nitrogen, phosphorus and enterococcus bacteria (section 7418–Total TMDL's for the Broadkill River Watershed DNREC 2004, *http://broadkill.ocean.udel.edu*; accessed January 2012).

Other Scientific Information Guiding the Project

Sea Level Affecting Marshes Model (SLAMM)

The Service is addressing the potential for significant changes that will be felt by all coastal refuges due to climate change and sea level rise. A comprehensive modeling effort using what is called the sea level affecting marshes model (SLAMM) has been used to generalize gross effects of sea level rise on coastal national wildlife refuges. SLAMM was first developed by the EPA in the 1980s (Park et al. 1986) and attempted to simulate the dominant processes (inundation, erosion, overwash, and saturation) involved in wetland conversion and shoreline modification from long-term sea level rise in an effort to predict future land cover changes in response to sea level rise. The model has been continuously refined and updated; the results incorporated into this planning effort used SLAMM version 5 in 2007. An updated version of SLAMM (6.0.1) is now available, but was not available at the time the analysis was completed for the refuge. However, the refuge analysis did use high resolution elevation data not typically utilized for applications of SLAMM at that time (Scarborough 2009). The limitations of the modeling analysis conducted in 2009 are acknowledged in Scarborough 2009, below, and elsewhere in the CCP/EIS. Although modeling data should be considered with caution, as high levels of uncertainty and unforeseeable factors can significantly alter model output projections and habitat predictions for the future, the results of this modeling effort can give us a general sense of how climate change and sea level rise will likely affect refuge habitats in the future. The potential land cover changes predicted by the SLAMM modeling are incorporated into the discussion of the affected environment (chapter 3), considered in the development of management objectives and strategies (chapter 4), and considered in the evaluation of impacts of each alternative (chapter 5). However, these modeling results are certainly not the primary factor driving proposed changes in shoreline and wetland management regimes on the refuge, as the refuge increasingly has current locally collected data to rely upon.

Prime Hook NWR was included in an initial SLAMM simulation of the Chesapeake Bay region contracted by the National Wildlife Federation in 2008. SLAMM model accuracy depends on available elevation data. Because the 2008 report used very coarse elevation measurements (5-foot contours), the results provided minimal information containing questionable value for Prime Hook Refuge. Therefore, a second SLAMM simulation for Prime Hook NWR was conducted by the Delaware Coastal Program (Scarborough 2009). The simulations done by the Delaware Coastal Program used Light Detection And Ranging (LiDAR) data with a vertical accuracy better than 15 cm, or less than 6 inches, which is a significant improvement over the 2008 simulation. The results of this modeling effort show 2007 conditions, and project future conditions in 2025, 2050, 2075, and 2100 (Scarborough 2009).

In the 2009 SLAMM modeling effort, two sea level rise conditions were used as inputs, representing the range of predicted local sea level rise levels (0.50 meters and 1.0 meters). The SLAMM model does not incorporate a dynamic accretion rate that changes with varying sea level rise, which could influence and possibly improve the ability of the wetlands to keep pace with sea level rise. Delaware salt marshes generally have been keeping up with the rate of sea level rise over the past century, but it is uncertain whether the marshes may experience increasing accretion rates as sea level rise occurs. Therefore, two rates for the accretion of salt marsh were used in model simulations: 3.1 mm/year, which represents keeping pace with current sea level rise, and 5.0 mm/year, which represents an increase in accretion rates in response to increased sea level rise. Tidal range was also incorporated into the model at two levels. A 50 percent coastal tide value (0.79 m) approximates the tidal range at the refuge's wetland complex at the time the modeling was conducted in 2007, and assumed that the bay dunes would remain intact. The 100 percent coastal tide value (1.58 m) assumes the expansion of the existing dune breaches along the bay front so that the full tidal range of the bay occurs in the refuge's impoundments. The model used these estimated minimum and maximum input values, assuming that the actual values will probably fall somewhere within those ranges.

By the year 2050, the SLAMM model projects that at least half of the current upland area of the refuge will be lost (either converted to wetlands or open water), decreasing from 20 percent to, at most, 12 percent of the current land base. Open water and tidal mud flat areas may increase throughout the next 100 years. If sea level rises at an accelerated rate to 1 meter in the next 100 years, the impact will be much greater on the refuge. By the year 2050, open water and mudflats are predicted to constitute 26 percent of the refuge under conditions that would allow marshes to build at high accretion rates; up to 58 percent of the refuge would covert to open water or mudflats under the condition of low accretion rates. Under the worst case scenario, by the year 2100 up to 88 percent of the today's refuge could be open water or tidal mud flats and only 1 percent for the refuge would be uplands. Predicted land cover changes under each sea level rise scenario are fairly similar with or without the bay dunes remaining intact. Although these long-term predictions are helpful for refuge planning, it is worth noting that as conditions on the refuge change in the predicted manner, the ability of the refuge to manage wetlands through water level manipulation and exclusion of salt water from impoundments will be lost long before the full effects of the sea level rise impact are realized. The full SLAMM modeling report (Scarborough 2009) can be found at: *http://www.dnrec.delaware.gov/coastal/Documents/PHNWR%20SLAMM.pdf* (accessed August 2012).

NatureServe: Terrestrial Ecological Classifications, Vegetation Alliances, and Associations of Prime Hook National Wildlife Refuge

The inventory and creation of vegetation mapping of the Prime Hook NWR was conducted during the pre-planning and planning phase of this CCP. The Refuge System planning policy notes that all Federal agencies are required to comply with data standards established by the Federal Geographic Data Committee. The policy comments on the use of two standards important to refuge planning: National Vegetation Classification Standard (NVCS) and Classification of Wetlands and Deep Water Habitats (*http://www.fgdc.gov*; accessed January 2012).

The Service contracted with the Delaware Natural Heritage Program and NatureServe to develop vegetation cover maps of Prime Hook NWR for the CCP. The NVCS classifies vegetation on a national scale for the United States and is linked to an international vegetation classification. NVCS for terrestrial vegetation is classified within a nested, seven-level hierarchy of plant communities. The finest floristic unit of the classification standard is called the association, characterized by diagnostic species of vegetation. An alliance represents an aggregation of associations that share at least some primary dominant species. NatureServe completed a NVCS vegetation alliances and associations report of refuge cover-types in December 2006, which complemented the refuge-mapping project undertaken by the Natural Heritage Program. NatureServe resolved some classification problems of several communities unique to Prime Hook NWR that were not adequately described in previous community keys.

The NatureServe report included vegetation descriptions and global conservation rankings for natural communities that were found on the refuge. These vegetation coverages included 5 NVSC classes and 38 alliances and associations. Eight associations were ranked globally rare (G2 and/or G3) with distinctive native plant assemblages and unique vegetation communities restricted to the Coastal Plain of the mid-Atlantic. This data and information has been used in the development of this CCP document. The maps can be found in chapter 3 and in the Habitat Management Plan in appendix B.

Natural Heritage and Endangered Species Program (DNREC): Final Report on Botanical Zoological and Natural Community Surveys for Prime Hook National Wildlife Refuge

The primary focus of botanical surveys at Prime Hook NWR was to locate and identify State and Federal rare plant species within refuge boundaries. Surveys in 2004 and 2005 focused on a variety of upland and wetland habitat types and built upon work conducted by the Delaware Division of Fish and Wildlife in the past. All rare plant species discoveries were GPS-located with detailed habitat and population notes recorded. In addition, trees of exceptional size (as compared to State records) were documented, an extensive general Prime Hook flora list was catalogued, zoological surveys were conducted for reptiles, amphibians, and rare insects and management recommendations for protecting and enhancing habitat occupied by rare species and/or unique plant communities were detailed (McAvoy et al. 2007).

Notable rare and unique communities found at the refuge included Atlantic white cedar/seaside alder, red maple/seaside alder woodlands, slender seaside purslane *(Sesuvium maritimum)* community, and a peat mat community. The twig-rush peat mat community is extremely rare in Delaware and on the East Coast and contains the largest array of the rarest plant species of any community mapped on the refuge. It is a distinctive community that forms in open-water depressions, impoundments, and seeps within a freshwater shrub-dominated swamp matrix. Prime Hook NVCS mapping and community survey data were used to develop habitat objectives and associated management strategies during the CCP planning process (McAvoy et al. 2007).

Maryland, Delaware New Jersey GAP Project

Gap analysis provides an overview of the distribution and conservation status of several components of biodiversity. There are five major objectives of the national GAP analysis program:

- Map actual vegetation as closely as possible to the alliance level.
- Map predicted distribution of animals, habitat associations, and habitat variables.
- Document occurrence of vegetation types that are inadequately represented (GAPS) in special management areas.
- Document occurrence of animal species that are inadequately represented (GAPS) in management areas.
- Make all information available to resource managers and land stewards in a readily accessible format.

The Maryland-Delaware-New Jersey Gap Analysis Project (MDN-GAP) involved a 10-year effort of researchers from various government natural resource agencies and universities in all three states, with the bulk of the work and project administration carried out by the Service, Delaware Bay Estuary Project, University of Maryland Eastern Shore, U.S. Geological Survey–BRD Gap Analysis Program and the New Jersey Department of Environmental Protection. The three-state project area includes a complex mixture of habitats, ranging from coastal beaches and estuarine tidal marshes to upland forests and bogs, and human-dominated urban and agricultural landscapes.

Data from the project was used to develop maps to conduct refuge habitat analysis discussions during CCP public and technical meeting forums. Maps were developed at three scales: refuge-specific (10,000 acres), Statewide (1.3 million acres), and an intermediary-scale of an immediate impact zone surrounding the refuge (88,000 acres). The impact zone map encompassed acreage from two watersheds where Prim Hook NWR is located: the Mispillion River and Broadkill River watersheds.

Habitat analysis layers depicted on these maps were derived from several sources, including the MDN-GAP project, National Wetlands Inventory Data, and National LandCover Data set developed by the EPA. Approximately 100 habitat classes were clumped into 10 habitat-types, providing a coarse-filter analysis across all three scales. These habitat-types included: upland herbaceous, upland shrub, upland forest, wetland herbaceous, wetland shrub, wetland forest, sparsely vegetated, aquatic, agricultural, and urban. Impact zone maps also depicted municipal boundaries, State agricultural preservation districts, and agricultural easements (appendix A).

Delmarva Fox Squirrel Recovery Plans

The Delmarva Peninsula fox squirrel *(Sciurus niger cinereus)* was listed as federally endangered in 1967 because of concerns for a reduction in its distribution to only 10 percent of its historic range. There have been three recovery plans written for this subspecies with the most recent completed in 1993. The recovery plans emphasized two action objectives: identify critical Delmarva Peninsula fox squirrel habitat requirements and translocate Delmarva Peninsula fox squirrel into suitable habitat outside occupied areas within their historical range. The range of the Delmarva Peninsula fox squirrel has expanded since the 1993 recovery plan, as the squirrel is now considered likely to occur in approximately 25 percent of the Delmarva Peninsula. This expansion has occurred through 11 successful translocations, of which one was on Prime Hook NWR.

By 1995, the refuge translocations were deemed successful as per the recovery plan definition, (i.e., a new reproductive population established on the release site had persisted for at least 5 years and increased beyond the original group size; the founder population at Prime Hook NWR was 15 individuals). Refuge management recommendations by the recovery team in 1995/1996 emphasized the need to augment the current Delmarva Peninsula fox squirrel refuge population with additional translocations, reforest fallow fields to add to the refuge's base acres of forested upland habitat, and conduct a population viability analysis to estimate the minimum viable population needed to prevent inbreeding, problems of genetic drift, and loss of heterozygosity, and then manage accordingly.

Today, the effective Delmarva Peninsula fox squirrel population size on Prime Hook NWR is very small, estimated at approximately 15 squirrels. The population size has remained small even after three decades of persistence with minimal recruitment. The chronically small population size of squirrels within refuge boundaries contributes to unmitigated inbreeding depression and genetic drift and is a major conservation concern. Limited recruitment coupled with small population size negatively affects long-term survival of the squirrels on the refuge.

Currently, new data and a population viability analysis are available. The analysis was constructed for Delmarva Peninsula fox squirrel that developed a basic model using estimates of life history parameters to identify the minimum viable population. Under model scenarios, analysis suggests that a population with 65 females or 130 animals has a less than 5 percent chance of extinction in 100 years. Using an average density calculated 0.3 squirrels/acre, 435 acres are needed to minimally support 130 Delmarva Peninsula fox squirrel. The analysis estimates that a contiguous 435-acre block could establish a minimally secure population. We have used this information when developing refuge habitat objectives and future conservation strategies for endangered species management on the refuge.

Other Recovery Plans

Atlantic Coast Piping Plover Recovery Plan
Federally threatened piping plovers use the refuge during spring and fall migrations. Up to half a dozen piping plovers have been observed using refuge impounded marsh habitats during late August and September. Nesting has not yet occurred on refuge beaches, but an increase in overwash habitats is occurring in our Unit I salt marsh management area. State endangered species personnel and refuge staff conduct periodic shorebird surveys and are alert to piping plover nesting possibilities, and will follow standard protocol if nesting occurs.

In 1996, a revision was made to the original 1988 Atlantic Coast piping plover recovery plan (USFWS 1996). The primary objective of the revised recovery program is to remove the piping plover population from the List of Endangered and Threatened Wildlife and Plants. The plan hopes to do this by achieving well-distributed increases in numbers and productivity of breeding pairs and providing for long-term protection of breeding and wintering plovers and their habitat. The strategies within the plan provide for the ensured long-term viability of piping plover populations in the wild. Documented piping plover breeding sites in Delaware occur immediately south of the refuge.

In Delaware for the past 17 years, a range of 8 to 12 pairs have successfully fledged young and DNREC has been working to halt the species' population decline by adopting a State piping plover management plan, implemented by the Division of Parks and Recreation, Division of Fish and Wildlife, and Division of Soil and Water Conservation. We have incorporated both the Atlantic Coast piping plover recovery plan and State plan information into this CCP document and will coordinate with the State in all Delaware conservation actions to manage and monitor piping plover use of the refuge.

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Bald eagle

Chesapeake Bay Region Bald Eagle Recovery Plan
National improvements in bald eagle recovery have led to Federal delisting, though eagles are still protected by the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act; and are still listed as State endangered in Delaware. The first successful bald eagle pair fledged two young on the refuge in 1993. This pair uses several nests they have constructed through the years in Unit II, and has continued to produce young in recent years. During winter 2006, a second pair established a nest near the headquarters area in Unit III and successfully fledged three young in fall 2006, although nesting activity has been inconsistent each year since then. We have also incorporated the guidelines of the Chesapeake Bay Recovery Plan and the Service's and State's bald eagle management guidelines in this document when developing habitat conservation strategies and managing public use to protect bald eagles.

Archeological, Historical, and Geomorphological Study of Prime Hook NWR
The Service, Region 5 contracted with Tetra Tech FW, Inc., to provide a set of interrelated studies of Prime Hook NWR, including lands within its acquisition

boundary that have not yet been acquired. The resulting effort fulfilled the Service's responsibilities to cultural resources under the National Historic Preservation Act (P.L. 102-575, Sec. 110), NEPA (P.L. 91-190), and DOI-Service regulations. The archeological, historical, and geomorphological study of the refuge provided a comprehensive background of data and analysis to improve our understanding of the refuge's prehistory and history, and assist in both visitor interpretation and long-term management of cultural resources.

NEXRAD (Radar) Data Of Critical Stopover Habitat For Songbirds Along The Delmarva Peninsula.
The New Jersey Audubon Society and Service partnered on a project in fall 2003. With the goal of developing products that would assist land acquisition and management strategies to conserve stopover habitats used by songbirds during migration passage through the Delmarva Peninsula. This project was unique because of its methodological approach and operational scale. The National Weather Service's Doppler weather surveillance radar system was used to delineate the spatial distribution of songbird migrants.

The objectives of the project were to use the radar data identify areas that contain high rates of occupancy; investigate relationships between high-use stopover sites and specific habitat types and landscape features; determine spatial congruence between season-specific stopover occupancy models; and identify specific songbird species or species groups involved in migration events during passage through the Delmarva Peninsula (Mizrahi, 2006).

Flight call recording systems were installed at both Prime Hook NWR and Blackwater NWR during the spring (3 April to 6 June) and fall (24 July to 15 November) 2003 migrational periods. We applied and utilized significant refuge songbird use with species identification and correlated habitat use data in this CCP when we developed migratory songbird conservation strategies and associated habitat objectives.

Neotropical Migratory Songbird Coastal Corridor Study

This study examined the distribution and habitat associations of fall migrating landbirds within the coastal regions of four states along the Atlantic Coast (McCann et al. 1993). These states of New Jersey, Delaware, Maryland, and Virginia make up the Cape May and Delmarva peninsulas. These two areas are well-known for their contribution of stopover habitat for migratory birds. The study revealed that neotropical migrants are not randomly or evenly distributed over the Cape May and Delmarva peninsulas during stopover, but rather are concentrated in particular geographic areas within the region.

More specifically, the study suggested that migrant birds are more abundant in areas close to the coastlines than in equivalent areas farther from the coast. Other distribution patterns discerned were that bay coastal zones have higher densities of migrants than seaside coastal zones or interior regions; migratory songbirds are more abundant on barrier islands than the coastal mainland, and migrants are associated with particular habitats on a species-specific basis. The refuge used this information in developing habitat objectives and strategies and shaping various alternative scenarios. We also assimilated and dove-tailed the habitat objectives and conservation strategies for migratory songbirds of other refuges within the coastal Delmarva Peninsula corridor that have completed CCPs.

USGS Visitor and Community Frequency Results Report for Prime Hook NWR
Refuge-specific visitor use and community opinions research was conducted by the Policy Analysis and Science Assistance Branch (PASA) of the USGS/Fort Collins Science Center. This report summarized community and visitor surveys

conducted at Prime Hook NWR in fall 2004 through fall 2005, and its purpose of this study was to determine how current and future CCP planning strategies for the refuge could affect visitor use, experiences, and spending, and community residents' perceptions and opinions about the refuge. Much of the research results have been included in chapter 3 of this document and were also used in developing visitor management objectives.

SCORP—State Comprehensive Outdoor Recreation Plan
Delaware's State comprehensive outdoor recreation plan (2003 to 2008) identifies State and individual counties' outdoor recreation needs and issues and provides recommendations on how to meet those needs. The SCORP also maintains Delaware's eligibility to receive Federal Land and Water Conservation Fund (LWCF) grants and is also required by the Delaware Land and Conservation Trust Fund Act. The plan directs funding for both grant sources into open space acquisition and facilities that best meet Delaware's outdoor recreational needs.

In order to remain eligible to receive LWCF grants, states are required by the National Park Service to develop an outdoor recreation plan every 5 years. We have incorporated much of the plan's information into the refuge's visitor service objectives and public use strategies to complement some of the State's recreational needs and programs.

Existing Refuge Operational Plans

Step-Down Management Plan

The Service Manual (602 FW 4, Refuge Planning Policy) lists more than 25 step-down management plans that may be appropriate to ensure safe, effective, and efficient operation on every refuge. These plans contain specific strategies and implementation schedules for achieving refuge goals and objectives. Some plans require annual revisions; others are on a 5- to 10-year revision schedule. Some require additional NEPA analysis, public involvement, and compatibility determinations before they can be implemented.

Two step-down plans will be available in conjunction with the CCP:

- Habitat management plan (HMP) (2012) (appendix B)
- Hunt plan (2012) (appendix C)

The following plans are available, but need updating. Listed below are those plans and the anticipated revision dates.

- Inventory and monitoring plan (2013)
- Fishing plan (2013)
- Law enforcement plan (2013)
- Visitor services plan (2014)
- Animal damage control plan (2014)
- Furbearer management plan (2014)

The following step down plans are complete and/or updated annually:

- Safety plan (2009)
- Avian influenza plan (2008)
- Hurricane action plan (updated annually)
- Fire management plan (2009)

Formulating Alternatives Using Refuge Resources of Concern and Focal Species Management

Defining Refuge Resources of Concern and Management Priorities

As described in the Service's policy on habitat management planning (620 FW 1) resources of concern are defined as:

> *"all plant and/or animal species, species groups, or communities specifically identified in refuge purpose(s), [Refuge] System mission, or international, national, regional, State, or ecosystem conservation plans or acts. For example, waterfowl and shorebirds are a resource of concern on a refuge whose purpose is to protect migratory waterfowl and shorebirds. Federal or State threatened and endangered species on that same refuge are also a resource of concern under terms of the respective endangered species acts."*

Habitats or plant communities are also resources of concern when they are specifically identified in refuge purposes, when they support species or species groups identified in refuge purposes, when they support Service trust resources, and/or when they are important in the maintenance or restoration of biological integrity, diversity, and environmental health (USFWS 2007b).

We used the process outlined in Identifying Refuge Resources of Concern and Management Priorities: A Handbook (USFWS 2007a) to develop the refuge's management goals and objectives for the CCP and habitat management plan (HMP). The handbook draws from legislative mandates, Service and Refuge System policies, manuals, and Promises recommendation reports. This process enabled us to:

- Meet our specific legal mandates as directed in statute and policy.
- Determine resources of concern and management priorities specific to the refuge using focal species management strategies.
- Contribute to wildlife and habitat priorities at all scales.

This process of identifying refuge resources of concern entailed analyzing specific planning steps divided into three stages that included various action items. These three planning stages encompassed the following tasks:

(1) Understanding refuge-specific management mandates.
  - *Action 1: Identify refuge purposes.*
  - *Action 2: Identify Service trust species.*
  - *Action 3: Identify refuge-specific elements of biological integrity, diversity, and environmental health.*

(2) Identifying resources of concern and management priorities on the refuge.
  - *Action 4: Compile a comprehensive list of resources of concern.*
  - *Action 5: Filter out focal species, consider site capabilities, response to management, and expert analysis, and then list priority resources of concern.*
  - *Action 6: List priority habitats.*

(3) Establish final assumptions for the future direction and management agenda for the refuge.
  - *Action 7: Write goals.*
  - *Action 8: Write objectives.*

Focal Species Management

To understand the above process and how it was incorporated into our CCP effort, the idea of focal species management and the definition of focal species must be appreciated. A focal species is a species or group of species (guild) that is directly targeted for conservation and habitat management actions. The selection of focal species is associated with important habitat elements or ecosystem attributes of identified species with the greatest and most urgent conservation needs. These needs are based on the Service's BCC (2008), national, ecoregional, and regional plans, and the State of Delaware's wildlife action plan.

Focal species for the refuge have been determined to be those specific species requiring immediate conservation action due to declining populations and other factors. Vulnerability to threats has limited the life history requirements needed to ensure their persistence into the future. Once identified, these species were used to define our habitat management objectives, strategies, and conservation actions contained in this CCP.

The use of focal species facilitated the complex tasks of writing habitat objectives for refuge purpose species (e.g., migratory birds and endangered species) and other Service trust species (e.g., interjurisdictional fish), while incorporating legal mandates of maintaining and enhancing biological integrity, diversity, and environmental health on refuge lands. Identifying focal species served as a shortcut to simplify dealing with a huge list of wildlife species (birds, native plants, insects, fish, reptiles, amphibians, etc.) that currently reside or seasonally use the refuge, and focus habitat management objectives on a shortened list of migratory birds and other wildlife species.

For example, there are over 900 species of migratory birds in North America that are trust species for the Service. The Service's national focal species strategy in its strategic migratory bird management plan (2004 to 2014) has shortened this list to 412 focal bird species. The selection of focal species is a subset of the bird species protected by the Migratory Bird Treaty Act. In 2008, the Service's BCC list narrowed to 139 focal species, targeted for conservation actions based on declining trend data. This list and other ecoregional and State plans, these lists reduced our CCP and HMP biological planning efforts to 45 refuge focal bird species and 4 focal bird guilds. These bird focal guilds and species are listed below.

Refuge Focus Guilds

- Fall migrating and wintering dabbling ducks
- Spring migrating dabbling ducks
- Migratory landbirds
- Migratory shorebirds

Refuge Focal Bird Species

- American oystercatcher
- Sanderling
- Whimbrel
- Wood thrush
- Black-and-white warbler
- Yellow-throated vireo
- Kentucky warbler
- Great crested flycatcher
- Northern flicker
- Bay-breasted warbler
- Bald eagle
- Acadian flycatcher
- Prothonotary warbler
- Black rail
- Clapper rail
- Least tern
- Gull-billed tern
- Black skimmer
- Willet
- Sharp-tailed sparrow
- Seaside sparrow
- Coastal plain swamp sparrow
- American black duck
- Snow goose
- Virginia rail
- Forster's tern
- Least bittern
- American bittern
- Piping plover
- Dunlin
- Short-billed dowitcher
- American avocet
- Greater yellowlegs
- Lesser yellowlegs
- Prairie warbler
- Blue-winged warbler

- Brown thrasher
- Willow flycatcher
- Eastern towhee
- Field sparrow
- Northern bobwhite
- Henslow's sparrow

The focal species approach was then used to write CCP/HMP wildlife and habitat objectives that linked focal species to habitat management strategies and new conservation actions targeting these wildlife species. It is a multispecies management approach in which the life history and habitat structural requirements of focal species and guilds have been used to define the future management direction and desired conservation outcomes for the refuge, based on the best contribution the refuge makes to both State and regional landscape conservation scales.

In addition to migratory birds, we have included other focal species that include one federally endangered mammal species, four fish species, and four insect species. All focal species and guilds characterize the various NVCS habitat types mapped on the refuge that are also representative of a healthy Delmarva Coastal Plain ecosystem.

It should be noted that with the exception of snow geese, our conservation objectives in this CCP are to increase the population size of all focal bird species. However, due to the disproportionate negative impacts that overabundance of snow geese are having on the functioning of ecosystems on both the breeding and wintering grounds that are adversely impacting other waterfowl and shorebird species, our conservation objectives and strategies in this case are designed to decrease their population size and curtail their use of refuge habitats.

Targeting conservation actions to a few focal species, specifically in habitat management objectives, is made with the assumption that hundreds of other fish, wildlife, and native plant species will benefit (see appendix D–table 6 for benefiting species list related to focal species and NVCS vegetation communities.) The total tally for the refuge of focal species (54) and guilds (5) includes the birds mentioned above and the following.

Other Refuge Focal Species

Endangered species
- Delmarva Peninsula fox squirrel

Fish
- Striped bass
- Alewife
- Blueback herring
- American eel

Invertebrate
- Beach dune tiger beetle
- Little wife underwing
- Long-horned beetle
- Maritime sunflower borer

The work products generated from the resources of concern handbook took more than 1 year to develop with input from State, Federal, private and local partners, and the public. The information provided was used in the developing of our goals and habitat objectives for the CCP and subsequent step-down plans that reflect the conservation needs of these focal species. The first product that served as the foundation for subsequent products or tables was a comprehensive list of biological resources found on the refuge. A species matrix was then developed of these potential refuge resources of concern and how they ranked on a State, regional, and national scale (see appendix D).

Other products included summary tables describing all current elements of biological integrity, diversity, and environmental health for each of the natural habitat types found on the refuge. Four tables were generated that describe specific habitat attributes and natural processes responsible for current habitat conditions representing the elements of biological integrity, diversity, and environmental health for barrier beach island, forested upland, wetland forest, and emergent wetland habitats and their associated focal species (appendix D–Tables 1-4).

The next product was a habitat management prioritization table that identified refuge NVCS habitat priorities, listed reasons for their rankings, and described limiting factors and threats that would hinder the conservation of these resources of concern (appendix D–Table 5).

The last resources of concern product was a final comprehensive list of the priority Resources of Concern for Prime Hook NWR that identified the specific focal species or focal group with associated prioritized habitat-types, their life history and habitat requirements, plus other benefiting wildlife species that would profit by managing for a specific focal species or focal group (appendix D–Table 6).

When reviewing table 6 within appendix D, it should be noted that some focal species have also been chosen as “umbrella” and “indicator species”. Similar use of focal species has been made by other conservation biologists for site-specific biological planning projects (Chase and Geupel 2005). We have used the concept of umbrella species as appropriate targets for management, and the concept of indicator species as representatives of historic biological integrity, or environmental health conditions. In conservation biology, the protection of an umbrella species with concentrated management of its habitat requirements can extend protection for other priority resources of concern. For example, our decision to manage for larger Delmarva fox squirrel habitat patches makes the squirrel a good candidate umbrella species that benefits many breeding forest interior bird species, migratory landbirds, and other forest-dependent resident wildlife. Similarly, American oystercatchers have been used as an umbrella species representative of overwash and sandy beach habitats.

An indicator species can be used to represent a measure of biological integrity and environmental health. A reliable indicator species can operate as a habitat assessment tool, saving time and money. We have chosen indicator species to be either an individual species or guild whose presence, absence, abundance, or relative well-being in a given habitat type is a sign of the overall health of its environmental condition and ecosystem functioning. For example, presence of the beach dune tiger beetle is indicative of quality, healthy beach and functional panic grass dune grassland habitats. In some cases, a species may serve as both an umbrella species and an indicator species simultaneously. We have chosen certain species or a particular guild as umbrella and/or indicator representatives of a habitat type and used them in developing habitat management objectives and strategies. As such, both groups of identified species are useful as monitoring targets.

Monitoring will be an integral component of biological planning using focal species, such as presence/absence as an inexpensive measure to gauge environmental health, relative abundance, and density of focal species as measures of biological integrity and diversity. Our habitat objectives incorporating specific focal species are based on numerous hypotheses and assumptions using the most recent and best available plant and wildlife survey information. These assumptions will be tested in ongoing refuge monitoring studies where focal species serve as key targets for monitoring endeavors to test the effectiveness of habitat management strategies and conservation actions, or to adjust strategies and actions when outcomes do not meet expectations.

Chapter 3


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Seaside sparrow

Affected Environment

- Introduction
- Refuge Management Units
- Physical Environment
- History of Vegetation on and Around the Refuge
- Refuge Vegetation Resources
- Influence of Climate Change on Physical Environment and Refuge Management
- Biological Resources of Delaware Bay Estuary
- Refuge Biological Resources
- Socioeconomic Environment
- Refuge Administration

Introduction

We begin this chapter with a brief description of the refuge management units to provide a context for the discussions that follow. Then we describe the surrounding physical environment, which includes the refuge's geographic setting, its hydrogeomorphic features, soil information, and air and water quality. Next we describe the role of prehistoric and historic climatic influences, cultural setting and land use history in and around the refuge (EIS project area). We also review Delaware's remaining natural habitats and the historic context of the refuge's wetlands as they have been influenced by human activity and management. We finish the description of the physical environment by summarizing the vegetation communities on the refuge.

Rapid climate change is proving to be the defining conservation issue of the 21st century, and climate change adaptation strategies used by the refuge must anticipate an increasingly different physical environment than the one we have managed in the 20th century. To that end, this chapter also contains extensive reviews of the relevancy of global climate change, sea level rise, local coastal storm activity, refuge shoreline dynamics, and vulnerability assessments of some of the refuge's coastal habitats. These factors influence the physical environment of the refuge, but also are directly related to the conservation and management of the refuge's fish, wildlife, and plant resources in the near future. We also investigate, throughout the remaining chapters of this CCP, how sea level rise is likely to affect the refuge's wetland habitats and clarify how managing for and facilitating ecological transitions in the refuge's physical environment will be an increasingly significant part of our adaptation to climate change.

Next we represent the biological environment of the surrounding area. We describe the biological resources within the context of the Delaware Bay Estuary, associated with the current condition of the refuge's plant and animal populations. We also map out the different vegetation communities found on the refuge and their associated rare plant species relationships. We end with an analysis of the socioeconomic environment of the refuge, including the economic benefits of refuge visitation to local communities and refuge administration details.

Refuge Management Units

The refuge can be described as an elongated coastal strand covering 10,144 acres that lies parallel to the Delaware Bay. For management purposes and to facilitate understanding of the descriptions of habitats and biological resources within management areas, Prime Hook NWR is divided into four management units delineated by four State roads which transect the refuge and run perpendicular to the bay (map 1-1).

UNIT I. This area comprises the northern most end of the refuge and is delineated by Slaughter Beach Road as its northern boundary, overwashed barrier dunes and a portion of the Slaughter Beach community houses on the east, Fowler Beach Road on the south, and an upland fringe of scrub-shrub areas on the western boundary. There is currently no water level management capability in Unit I, which contains about 1,400 acres of salt marsh. Tidal salt water is the primary source of water for the unit, which flows approximately two miles from the Delaware Bay through the Cedar Creek at the Mispillion Inlet and into Slaughter Canal. An overwash formed on the coast of Unit I in 2006, creating a small inlet, creating more direct flow of saline bay water into Unit I.

UNIT II. This management unit is just south of Unit I. It is bounded by Fowler Beach Road on the north, artificial barrier dunes and a sand dike connected to the Prime Hook beach community on the east, Prime Hook Road on the south, and an upland interface on the west. During storm tides, this sand dune system has been breached several times and washouts have deposited sand and salt water into the Unit II impoundment.

UNIT III. Management Unit III is bounded by Prime Hook Beach Road on the north, Route 16 (Broadkill Beach Road) on the south, upland edge on the western boundary, and the Prime Hook and Broadkill Beach developments immediately adjacent to the refuge's eastern boundary. Unit III consists of roughly 3,600 acres, which include impounded freshwater emergent marsh, red maple-seaside alder swamp, low-lying farmed areas, brush, barrier beach on the east, and 140 acres of flowage easement on the southeastern boundary of Unit III. This flowage easement drains directly into Prime Hook Creek and flows south to the water control structure of this watercourse.

UNIT IV. Management Unit IV is surrounded by Route 16 on the north, the Broadkill Beach community on the east, the Broadkill River on the south and west, and the upland edge on the west. The majority of water and tidal action associated with Unit IV is provided by the Broadkill River, whose salinity ranges from 10 to 30 ppt. Prior to Service ownership, this marsh had been excessively drained by man-made ditches. Rainfall and runoff from Unit III are other sources that provide fresh water. Due to the strong influence of the Broadkill River, this impounded area has a more brackish character with salinities ranging from 5 to 20 ppt.

Further details regarding the soils, hydrological features, wetland and management history, and vegetation of each of these four management units are provided later in this chapter.

Physical Environment

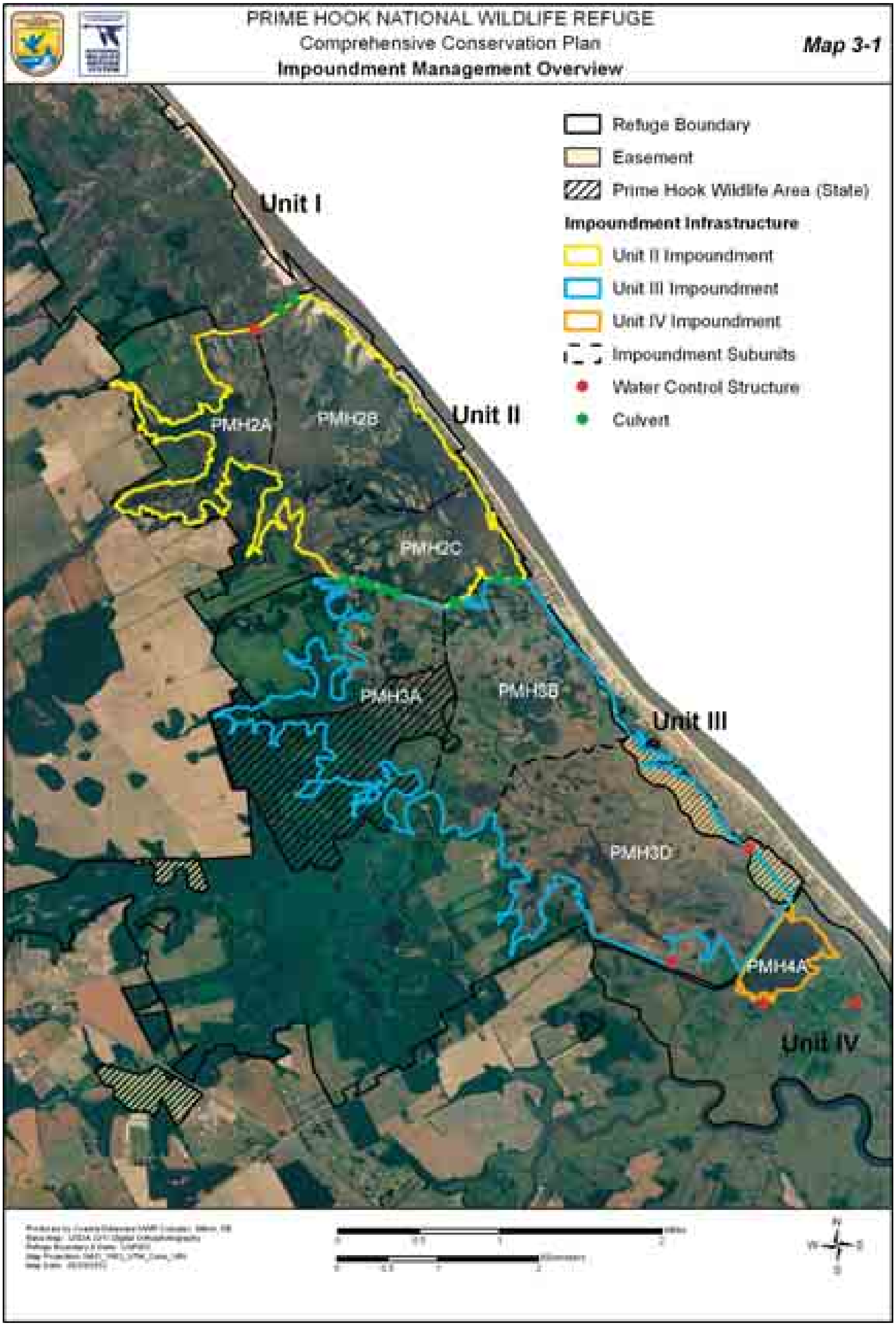
Geographic Setting

The refuge is located in Sussex County, Delaware, within the Atlantic Coastal Plain Province, along the southwestern shore of the Delaware Bay. It is part of Bird Conservation Region 30, which encompasses the New England/ Mid-Atlantic Maritimes and the Partners in Flight Physiographic Region 44 (BCR 30 and PIF 44). Prime Hook NWR is one of two refuges of the Coastal Delaware NWR Complex. The refuge was established in 1963 and historically consisted of tidal marshes and agricultural lands that were grazed by cattle. The landscape surrounding the refuge was dominated by small farms producing vegetables and small grains. From the 1990s to present day, beach and residential development and intensive agricultural operations (corn, soybean, and poultry production) are the dominant land uses bordering the refuge.

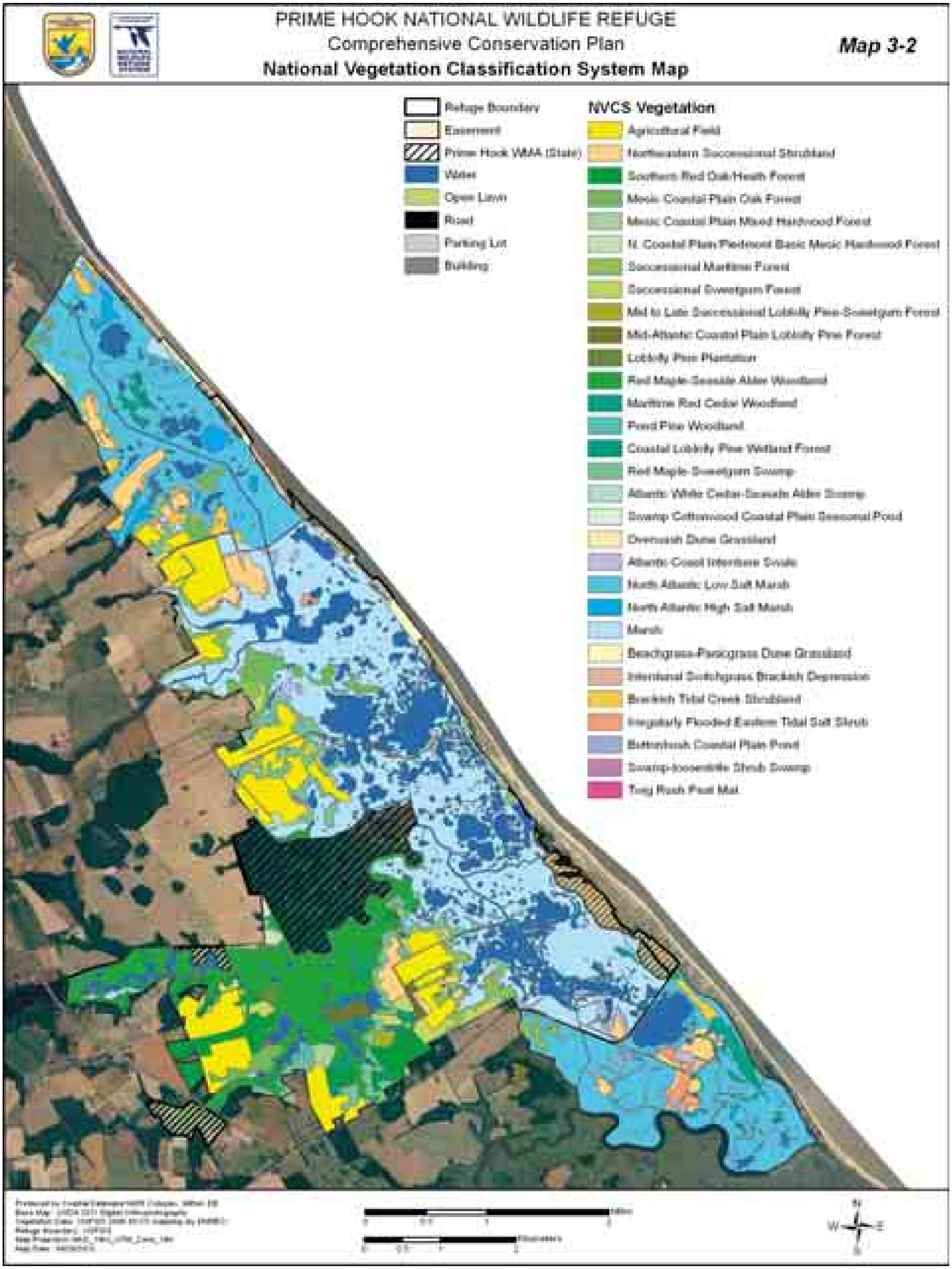
The four roads that bisect the refuge have significantly altered the hydrology and other ecological processes of the refuge's wetland habitats. The two interior roads, Fowler Beach and Prime Hook roads have the greatest hydrological impacts on the refuge's impounded marsh complex and management actions. These roads, with their associated culverts and water control structures located in Units II, III, and IV, are directly linked to the refuge's water level management capabilities (map 3-1).

The refuge is representative of the natural vegetation of the Delmarva Coastal Plain ecosystem which is dominated by emergent wetlands interspersed with swamp and forested upland, grasslands and open water habitats. Eighty percent of Prime Hook NWR's vegetation cover types are shaped by tidal and freshwater creek drainages that discharge into the Delaware Bay with associated coastal barrier island habitats. The remaining twenty percent are composed of upland habitats. National Vegetation Classification Standard (NVCS) cover typing of the refuge has resulted in the delineation of 37 land cover types including vegetation and anthropogenic communities and water surface coverages (map 3-2).

Map 3-1. Impoundment Management Overview



Map 3-2. Vegetation Community (NVCS) Overview



Other natural wildland habitats and managed wetlands immediately adjacent to or near Prime Hook NWR include:

- The Great Marsh (1,000 acres of salt marsh, owned by the town of Lewes) located just south of the refuge
- Milford Neck WMA (5,459 acres), 3 miles north of the refuge above Mispillion Inlet
- Ted Harvey Conservation Area (2,661 acres), 9 miles north of Prime Hook NWR above Bower's Beach
- Little Creek WMA (4,721 acres), 15 miles north of Prime Hook NWR above Port Mahon
- Prime Hook WMA (698.2 acres), adjacent to Prime Hook NWR
- Bombay Hook NWR (16,000 acres), 25 miles north of the refuge

Geology and Hydrology

Past geological events in Delaware have created two distinct physiographic provinces; the northernmost 5 percent is in the Appalachian Piedmont Province and the Atlantic Coastal Plain Province covers the remaining 95 percent. Appalachian mountain building episodes between 500 and 200 million years ago formed the Piedmont, which is composed of metamorphosed, igneous, and sedimentary rocks. The Piedmont region is characterized by low, rolling hills and steeply incised stream valleys. A fall zone occurs at the junction of the Piedmont and Coastal Plain in the proximity of Route 2, Kirkwood Highway, in New Castle County, which is an ecological transition area between these two provinces (Thompson 1976) (map 3-3).

The Coastal Plain Province lies south of the fall line and makes up the vast majority of the State's land area, including the refuge. Much younger than the Piedmont, the coastal plain consists of unconsolidated sediments that have accumulated as a result of erosion of the Appalachian Mountain chain, and marine sediments deposited as a result of frequently fluctuating sea levels. The deposition of the unconsolidated sediments of the coastal plain began 120 to 150 million years ago. Eroded water-borne sands, silts, and clays were deposited, followed by marine sediment shifting during periods alternating between sea encroachment and retreat. With the advance and retreat of continental glaciers and dramatic changes of sea levels, the flowing sediments were capped by fluvial sands and gravels during the Pleistocene (1.8 million years ago). During the past 10,000 years, rising sea level has filled coastal valleys with sediment, forming extensive tidal marshes. The coastal plain today is a region of little topographic relief, with broad, slow-moving streams and extensive tidal estuaries (Hess et al. 2000).

About 5,000 years ago, the current refuge shoreline was located 3 to 4 miles east of its current position, resting what is now in the middle of the Delaware Bay. Retreating shorelines and rising sea levels systematically began to drown the ancient Delaware River valley, gradually transforming the narrow river into the wide Delaware Bay as it is currently shaped. Atlantic Coastal Plain creeks and streams meander broadly in shallow channels and the landscape is generally flat, with elevations ranging from sea level to 125 feet. The highest point in Delaware is 448 feet, located north of Wilmington near the Pennsylvania State line (Ebright Azimuth). Prime Hook NWR has very flat terrain typical of Atlantic Coastal Plain areas. The highest point within the refuge is about 15 feet mean sea level but the majority of refuge lands lie below the 9-foot contour. The uplands are gently sloping with very few steep grades; these are mostly limited to areas immediately adjacent to drainage ditches and creeks.

Map 3-3. Delmarva Peninsula Hydrology and National Wildlife Refuges

Along the immediate shoreline of the refuge's barrier island habitats from Slaughter Beach to Prime Hook Beach, the topography is highly variable. Natural dune ridge areas sloping away from mean high water level of the Delaware Bay vary from 1 to about 10 feet, interspersed with overwash areas ranging from 0.5 to 3-foot elevation contours based on DNREC topographic maps of Delaware beaches (1979). Short-term geological events like coastal storms and long-term geological processes of marine transgression and landward movement of the coastline have and will continue to constantly change coastline position and elevations along the refuge's sandy beach ecosystem (map 3-4).

The directional flow of Delaware's rivers south of the Piedmont is dictated by a dividing ridge, which is a visually unimpressive land form that rises only a few feet above the surrounding countryside. Acting as the watershed of central and southern Delaware, the dividing ridge bisects the State so that all of flat Delaware's significant river systems flow eastward into the Delaware Bay or the Atlantic Ocean, with the exception of the Nanticoke River, which drains into the Chesapeake Bay (map 3-3).

The directional flow of water bodies and upland runoff drainage patterns traveling eastward toward the Delaware Bay places the refuge at the receiving end of watershed runoff and stream flows. Therefore heavy rainfall events not tied to coastal storm events can also have significant impacts on the refuge's physical environment.

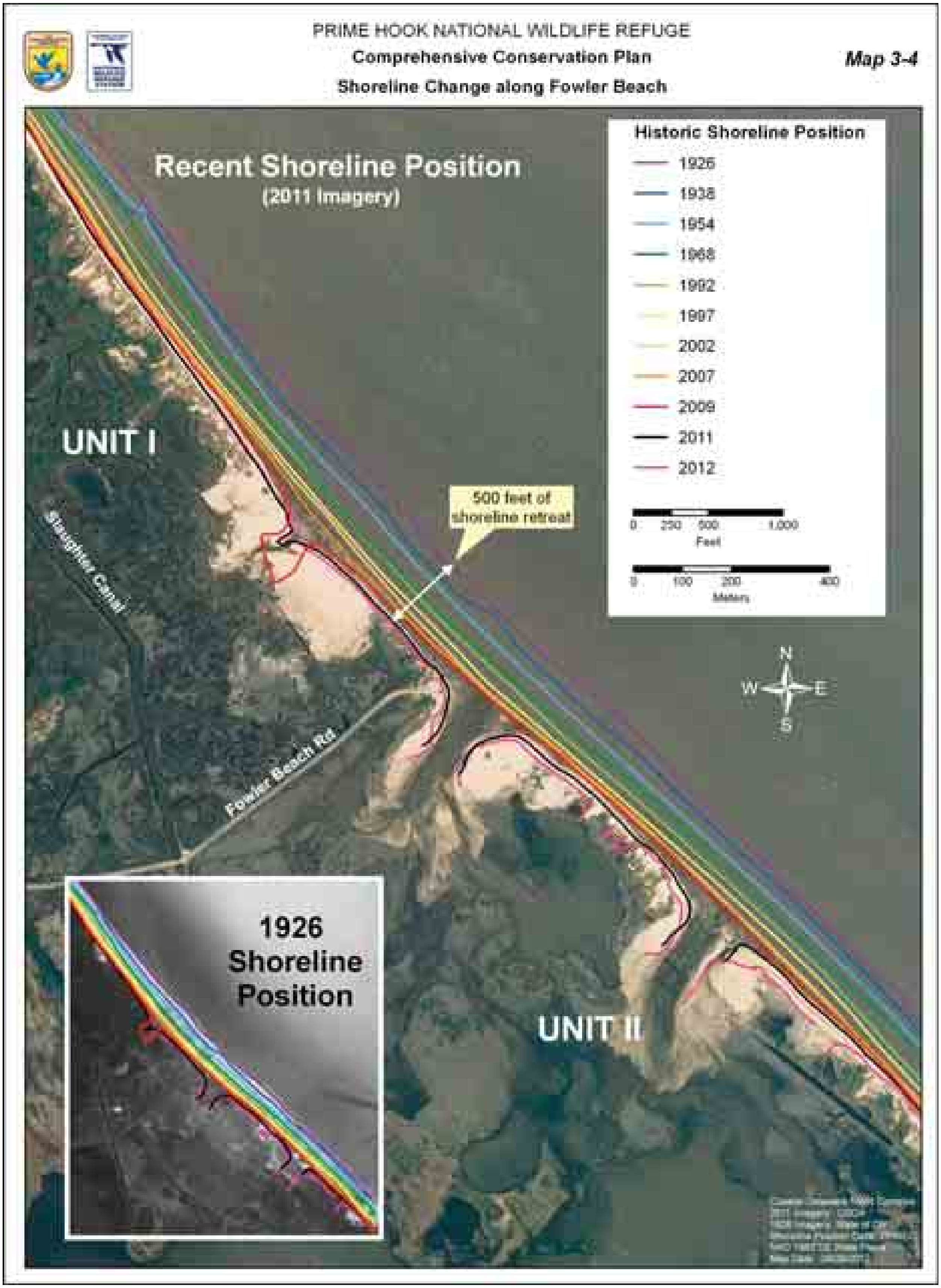
The geology of the Delaware Bay's coastline is part of larger geological structure known as the Atlantic coastal plain-continental shelf geosyncline. This shoreline of the entire lower Delaware Bay is migrating in geologic time, in a landward direction. This is caused by many geological processes. The first is subsidence or sinking. The continental shelf and Atlantic Coastal Plain are known to be subsiding. The second process is sea level rise relative to the land. A third coastal process is the erosion and redistribution of sediments in the active coastal littoral zone as the shoreline shifts in a landward and upward direction (Kraft et al. 1976).

The Beers Atlas (1868) showed the two creeks (Prime Hook and Slaughter) feeding freshwater through the marsh system flowing directly through the barrier beach into the Delaware Bay. These outlets provided unimpeded flows of freshwater from the uplands to the west; they also provided ample primary inlets for the saline waters of the Delaware Bay to inundate the lowland marshes on each high tide.

Overtime, however, with changes in the Delaware Bay shoreline, these inlets would occasionally close with sand, stopping the general eastward flow of water from the uplands. This interferred with the drainage and ultimate cultivation of the lands bordering the marshes. Around 1911, both outlets were sealed shut by a storm. The Broadkill River meandered to a new outlet two miles south. This new outlet was later improved by man and called the rossdvelt Inlet. Prime hook Creek ended, which histocially flowed near California Ave in the Broadkill community, In Unit III marsh with the Petersfield Ditch then taking over as the major water outlet emptying into the Broadkill River.

Attempts were made, first at the outlet of Slaughter Creek on the northern end of the marsh to build structures that would keep the natural outlets of the creek open to the Delaware Bay. This project was subsequently abandoned and a new, man-made channel, Slaughter Ditch, was dug. This ditch carried the waters of Slaughter Creek and Cedar Creek into the Mispillion River.

Map 3-4. Shoreline Change Along Fowler Beach



As with Slaughter Creek, the mouth of Prime Hook Creek also closed premanently. With no major draingage outlet, therefore the freshwaters flowing off the uplands backed up over the marsh extending flood waters from Broadkill Road to Fowler Beach Road.

Origin and Evolution of Estuarine Washover Barriers of Delaware Bay and the Refuge
Initiation of sandy barriers along the shoreline of the Delaware Bay requires a source of coarse-grained sediment, and sufficient wave and current energy to redistribute sediments to the nearshore zone. Evolution of the estuarine barrier island habitats along the bay varies spatially and temporally as factors change in space and time. Field observations and analysis of historic data suggest that wave erosion of pre-Holocene headlands and longshore transport of sediment are the principal mechanisms for estuarine barrier formation. A conceptual model representing three stages of the development of estuarine barrier islands along the western shore of the Delaware Bay, including the project area, has been described (Maurmeyer 1978). This sequence is controlled by pre-Holocene topography and variable rates of sea level changes represented by the following stages:

(1) Initial formation of barrier as a beach abutting a pre-Holocene headland

(2) Salt marshes surround the headland as sea level rises and long-shore transport of sand forms barriers against marshes

(3) Burial and/or erosion of headland as sea level rises; barrier migrates landward and upward across marshes by overwash

At the present time, stage one occurs on the northern barriers of the bayshore to Bowers Beach. Stage 2 occurs in the vicinity of headlands surrounded by marshes such as Woodland Beach, Kitts Hummock, and Big Stone Beach, along centrally located barriers along the bay shorelines. However, most of the southern barriers along the western shore of the bay are in the third stage and are dominated by overwash processes, including the refuge (Maurmeyer 1978).

Rates of Coastal Change of the Delaware Bay Shoreline
Hydrogeomorphic studies conducted by University of Delaware coastal scientists provide a baseline about the rates of shoreline transgression or migration landward of Delaware Bay shorelines. Over the 120-year period from 1834 to 1954, the Bay shoreline from Slaughter Beach to Roosevelt Inlet retreated at a rate of from 1 to 25 feet per year. The refuge lies just below the Slaughter Beach community location, and the shoreline position bracketing the refuge has experienced a total change of -1,100 feet or roughly a loss of about 10 feet/year on average (Kraft et al. 1976).

This is one of the higher erosion rates along the bayshore and similar to Slaughter Beach coastal change rates. The only two areas along this stretch of the Delaware Bay shorelines that have been or are presently accreting are the Broadkill Beach groin field and the area behind Cape Henlopen near the Lewes Breakwater. Most shoreline erosion in the Delaware Bay is caused by waves generated across the Bay by local winds. Wave velocities during normal and storm events push excessive water onto the shore. The highest rates of erosion tend to occur in areas where marsh sediments and old remnant peat covered by sand form the shoreline (Kraft et al 1976). These coastal change rates serve as a fairly precise baseline indication of the present and future refuge shoreline rates of erosion. However, a 10 foot/year rate may be too conservative in light of recent and predicted future climate change and sea level rise rates as discussed later in this chapter.

Refuge Water Level Information
Throughout the refuge, water levels change on time scales that range from minutes to thousands of years. Daily water level changes due to astronomical tides for both Mispillion and Roosevelt inlets vary from -0.7 to 5.8 feet. Even on short time scales (minutes, hours, days), wind energy and wind stress can increase water level changes to deviate significantly from astronomically predicted levels. The coastal geology of an area, bay morphology, and bathymetry are factors that influence and constantly change the periodicity and magnitude of refuge water level changes from day to day under normal conditions and with large variations during storm events. Even coastal storms that never make landfall can cause refuge water levels to change in excess of those normally predicted monthly variations in the lunar phase.

Based on averaged predicted tidal fluctuations and other geological factors, the refuge coastal zone can be characterized as a mesotidal (between 2 to 4 meters) coastal area. Massilink and Huges (2003) define coastal zone tidal ranges as microtidal (0 to 2 meters), mesotidal and macrotidal (greater than 4 meters).

Water level ranges are much more restricted within refuge impounded marshes. However, correlations between impoundment water levels are difficult to make because the Unit II water control structure was surveyed in its present location in 1988, referencing the National Geodetic Vertical Datum of 1929 (NGVD 29), and the Units III and IV water control structures were surveyed into location, including staff gauge positioned on the concrete structures, in 1984 and 2005 respectively, using a tidal (mean sea level) datum. Because the water gauges used to measure water levels in the impoundments do not all reference the same elevation datum, it is currently difficult to make direct comparisons between water level measurements in different impoundments for water management purposes.

Soils

The soils of Delaware are made up of differing combinations of sand, silt, and clay. Sand was the most abundant of the three components, proportionally increasing from the Christiana Valley to Sussex County. The soils of eastern Kent and Sussex Counties from the coast to 10 miles inland tend to have more clay and less sand components than soils located further west, especially those areas flanking the dividing ridge.

The soils of the Piedmont, which are derived from the underlying gneiss and schist bedrock, are older and tend to be more fertile than soils of the coastal plain. Piedmont soils in the valleys are rich and loamy, while the soils at higher elevations are often eroded and stony. The soils of the coastal plain vary a great deal depending on geography and habitat. Sandy soils dominate much of the region, but areas of clay or loamy texture are not uncommon. Soil drainage ranges from that which is excessively drained in beach sands and on sand ridges, to very poorly drained soils in tidal marsh and swamp muck (Matthews and Ireland 1974).

Delaware's soils are classified into four major soil orders: Ultisols (well developed, acidic mineral soils), Histosols (organic soils), Inceptisols (mineral soils in early development) and Entisols (mineral soils in late development). They are grouped into associations by location, drainage characteristics, and parent material. A soil association is a landscape that has a distinctive proportional pattern of soils. It consists of one or more major soils and at least one less extensive soil, and it is named for the major soils. Two major associations found within the refuge include the Broadkill-Mispillion-Acquango Association and the Unicorn-Carmichael Association (USDA/NRCS – D. Shields, personal communication).

Broadkill-Mispillion-Acquango Association consists of mineral and organic soils that are regularly subject to tidal flooding by salt water, and narrow areas of loose, salty beach and dune sands. This association occupies about 80 percent of the refuge and about 5 percent of the total land area in Sussex County. The Broadkill, Mispillion, and similar soils occur on open grassy tidal marsh areas dissected by tidal creeks and streams and crisscrossed in places by mosquito-control ditches. In many places there is a brush border adjacent to higher ground. The soils consist of mostly peat or mucky remains of vegetation, some loamy soil material, and large amounts of sulfate. The marshes range from strongly saline to almost fresh along the upper reaches of streams.

A smaller portion of this association includes the Acquango soils and associated beach areas. It occupies a narrow band separating the tidal marsh areas from open water. This part of the association consists of shifting, loose, salty sand that is moved by waves and wind. The part regularly washed by waves and tides is smooth and slopes gently up from the water. That part above normal high tide consists of dunes and hummocks constantly changed by the wind. The vegetation is a sparse cover of beach grass, a few forbs, and scattered low shrubs. The beaches and dunes are used intensively for summer recreation activity and as sites for beach houses. The marshes are on the Atlantic Flyway of migratory waterfowl. Recreational activities in these marshes include waterfowl hunting, crabbing and fishing. Less extensive in this association are Purnell, Sunken, and Saltpond soils (USDA/NRCS – D. Shields, personal communication).

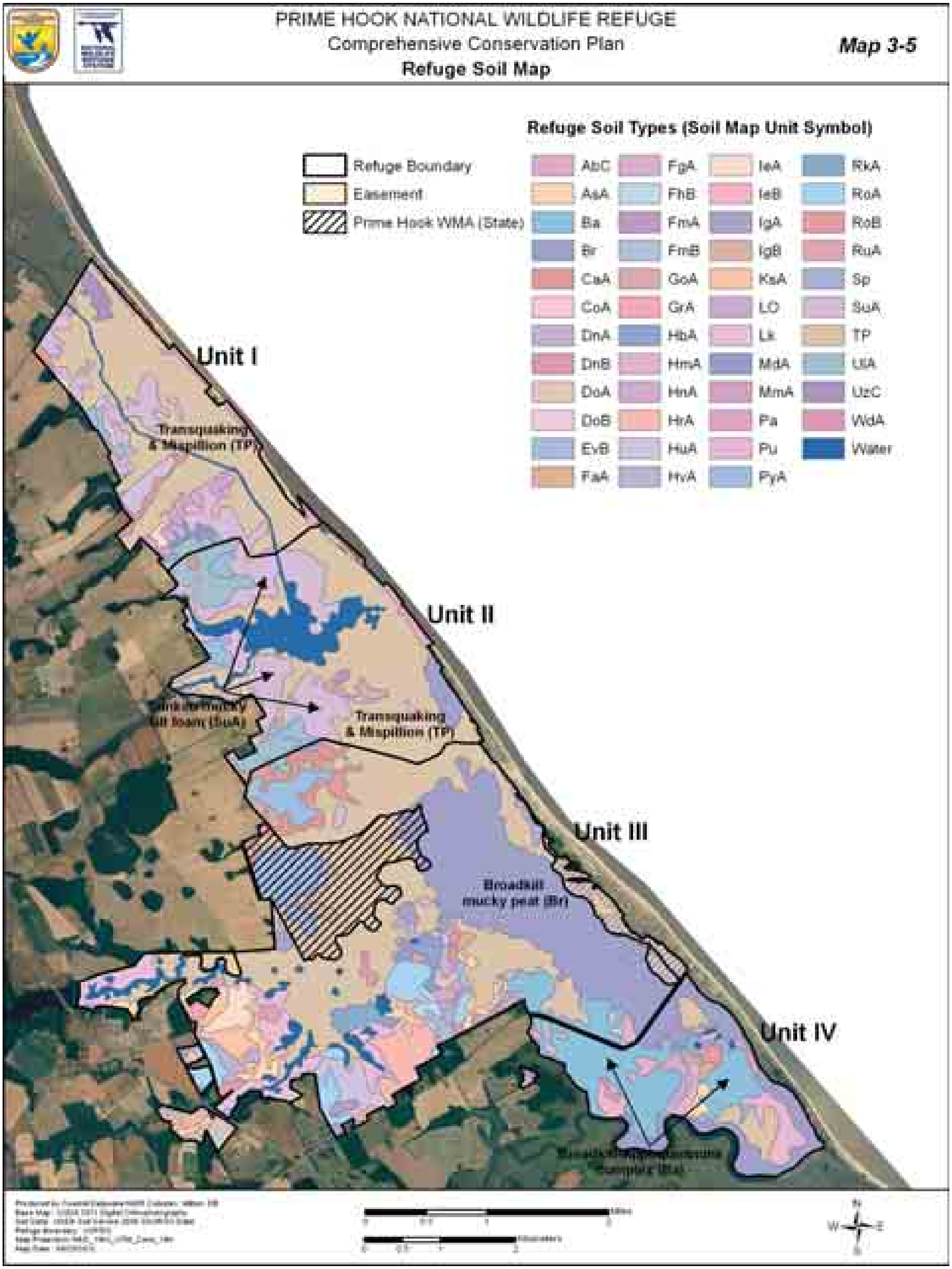
Unicorn-Carmichael Association consists of well-drained and poorly drained soils that have a moderately permeable subsoil of loam to sandy loams. This association accounts for about 15 percent of the total refuge area and occupies about 10 percent of the total land area in Sussex County. This association consists of approximately 55 percent Unicorn soils, 25 percent Carmichael soils, and 20 percent less-extensive soils.

Unicorn soils have a surface layer of grayish-brown loam and subsoil of strong-brown sandy loam or loam. In most areas they are nearly level to gently sloping and are moderately permeable and well-drained. Carmichael soils have a surface layer of gray to dark grayish-brown loam and a subsoil of gray loam or sandy loam. They are nearly level, moderately permeable, and poorly drained. The water table is at or near the surface for long periods during the year. Less extensive in this association are Greenwich, Pineyneck, and Longmarsh soils. Longmarsh soils are on flood plains. Well-drained Greenwich soils and moderately well-drained Pineyneck soils are intermingled with areas of the major soils and do not appreciably affect overall land use. They differ primarily in drainage class (USDA/NRCS – D. Shields, personal communication).

Coastal plain soils vary widely in the proportions of sands, silts, and clays in their location relative to the water table. Soils with high amounts of clays and silts have a tendency to be wetter because water percolates poorly. The mineral organic materials of tidal and freshwater marshes comprise three associations of very poorly drained soils rimming Delaware's coastline from Wilmington down to Fenwick's Island, surrounding the inland bays and the confluence of the Broadkill River (Matthew and Ireland 1974).

Soil associations are further delineated into more specific soil map units (map 3-5). Unit I and Unit II are dominated by Transquaking and Mispillion soils (TP) which, along with a smaller proportion of Sunken mucky silt loam (SuA), constitute most of the wetland habitats. Other soil types found in upland areas of Unit I include Hammonton sandy loam (HnA) and loam sand (HmA), Carmichael

Map 3-5. Refuge Soil Types



loam (CaA), Hurlock sandy loam (HvA) and loamy sand (HuA), Ingleside loamy sand (IeA and IeB), Marshyhope sandy loam (MdA), Pineyneck loam (PyA), and Unicorn loam (UlA). Within Unit II, Negro Island consists of Hurlock loamy sand (HuA), Second Hill soils are Glassboro sandy loam (GoA), First Hill consists of Ingleside sandy loam (IgA) and Glassboro sandy loam (GoA), and Oak Island is made up of (SaB) Sassafras sandy loam with 2 to 5 percent slopes. The remaining 600 acres of upland forest, croplands and grasslands in Unit II consist of Pineyneck loam (PyA), Unicorn loam (UlA), Carmichael loam (CaA), and Glassboro sandy loam (GoA).

The predominant soil types in Unit III are Transquaking and Mispillion soils (TP) and Broadkill mucky peat (Br), characterized by having large quantities of organic matter on 2,500 acres of impounded wetlands (map 3-5). Soft sediments reach to about 30 feet below the marsh surface. Adjacent upland soils are non-plastic to slightly plastic sandy soil derived from fluvial deposits of the Pleistocene (Matthews and Ireland 1974). The other major soil types found in the Unit III Prime Hook Creek drainage basin include Rosedale loamy sand, Lenape mucky peat, Pineyneck loam (PyA), Carmichael loam (CaA), Hurlock loamy sand (HuA), and Henlopen-Rosedale complex.

Minor soil types found in Unit III include Askecksy loamy sand, Broadkiln-Appoquinimink complex, Downer loamy sand, Evesboro loamy sand, and Klej loamy sand.

Dominant soils found in Unit IV are Broadkill-Appoquinimink complex (Ba), Broadkill mucky peat (Br), Transquaking and Mispillion (TP), and Purnell mucky peat (Pu) (map 3-5). The largest variation in tidal marsh soil profiles is the depth to underlying material, which in most places is sandy. The depth ranges from 2 to 3 feet in some hummocks and near the boundaries with upland soils, to an undetermined depth in the interior of broad marsh areas. In these areas where tidal fluctuations are great, the horizons are completely liquid. Other minor soil types found in upland habitats in Unit IV include Askecksy loamy sand (AsA), Fallsington sandy loam (FaA), Hammonton loamy sand (HmA) and sandy loam (HnA), Hurlock sandy loam (HvA), and Rosedale loamy sand (RoB).

Unit IV topography is relatively flat with less than one percent slope. An ancient beach ridge capped by low dunes and consisting of deep coarse sandy soils occurs in the both the Nanticoke and Broadkill River watersheds of Sussex County, which runs through the southern portion of the county (Hess et al. 2000). These soil types and sand ridge features support the ancient sand ridge maritime forest community found in Unit IV. Most of Unit IV lies below the 3-foot contour.

Air Quality

The mission of the Service's air quality program is to protect and enhance air quality in support of ecosystem management in the National Wildlife Refuge System. The Service's vision "is a Refuge System free of impacts from human-caused air pollution and is consistent with the Refuge System Improvement Act, which requires that 'the biological integrity, diversity, and environmental health of the [Refuge] System are maintained…'" *(http://www.fws.gov/refuges/AirQuality/index.html;* accessed January 2012).

Prime Hook NWR's greatest contribution from human-caused air pollution would occur from prescribed fire activities as a short-term intermittent source of fine particulate concentrations. Prescribed fire is an important tool to decrease dead fuel load accumulations of wildland vegetation for public safety and to improve the health of natural ecosystems. Full consideration of air quality values has been made in Prime Hook NWR's fire management plan for all prescribed fire planning and operations (see Smoke Management Section 4.2.1.5 of Prime Hook NWR's wildland fire management plan (March 2009)).

The Air Quality section of DNREC's Division of Air Quality and Waste Management monitors levels of ozone and particle pollution from nine locations throughout the State. The Lewes monitoring station is the closest to the refuge. These sites have been monitoring air quality since the late 1960s. Air monitoring stations are used to house continuous monitoring instruments that measure criteria air pollutants.

A criteria air pollutant has a national ambient air quality standard (NAAQS) established for it by the EPA. There are currently seven criteria pollutants: sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, particulate matter less than 10 microns in diameter (PM10) and particulate matter less than 2.5 microns (PM 2.5).

Local air quality is affected by regional issues. In general, air quality in Sussex County is good during the winter and spring, but only fair in summer and fall. From Memorial Day to Labor Day, Sussex County is often in non-attainment state for NAAQS, meaning pollution limits set by the EPA have been exceeded for several consecutive years. Limiting smoke impacts resulting from prescribed fire is important to protect public health and safety. For this reason, prescribed refuge burns usually occur in late winter or early spring.

Water Quality

DNREC's Division of Water Resources manages and protects the State's water quality through seven sections. The Water Assessment Section protects water from nonpoint source pollution and plans monitoring and management actions to improve water quality on a watershed scale to protect human health and the State's environment. There are 45 delineated watersheds in Delaware and Prime Hook NWR is influenced by three: Mispillion River, Cedar Creek, and Broadkill River watersheds. The most recent water quality assessments performed by this Section (State of Delaware 2008 Combined Watershed Assessment Report [305(b) and Determination for the Clean Water Act Section 303 (d) List of waters needing TMDLs) indicates that a majority of the State's water resources are suffering from poor water quality.

Water quality monitoring has shown that more than 92 percent of Delaware's waterways are considered impaired. Impaired waters are defined as polluted waters based on EPA water quality standards. Of 2,506 miles of rivers and streams tested for water quality attainment, 2,497 miles have been documented as impaired. Of the 2,954 acres of lakes, ponds and reservoirs, 2,798 acres were found to be impaired (State of Delaware 2008 303(d) Impaired Waters List pp 89-125).

Pathogenic indicators (bacteria) are the most widespread pollutants in the State. The pathogen indicator monitored by DNREC for primary contact recreation is *Enterococcus* bacteria. Other pathogen indicators (total and fecal coliform bacteria) are monitored to regulate shellfish harvesting areas.

Although pathogenic indicators are the most widespread in Delaware, nutrients and toxics pose the most serious threats to water quality. All of the State's estuarine waters are considered nutrient-enriched. Water quality and negative impacts to aquatic organisms from nutrient enrichment include eutrophication and low dissolved oxygen levels. Large portions of nutrients are transported to estuaries and ponds via rivers and ground water.

The presence of toxic substance concentrations above EPA standards for human health triggers the publication of fish advisories by the State. In 2007, the State fish consumption advisories included, for the first time, waterways within Prime Hook NWR or immediately adjacent to the refuge. These included Prime Hook Creek, Slaughter Creek, and Waples Pond (see table 3-1 below).

Table 3-1. State of Delaware Fish Consumption Advisories

State of Delaware Fish Consumption Advisories			
Waterbody	**Species**	**Geographic Extent**	**Contaminants**
Mouth of Delaware Bay	Striped Bass White Perch American Eel White Catfish	South of C and D Canal entire Delaware Bay to Mouth of Atlantic Ocean	PCBs, Mercury
Waples Pond	All Finfish	Entire Pond	Mercury
Prime Hook Creek	All Finfish	Entire Creek	Mercury
Slaughter Creek	All Finfish	Entire Creek	PCBs, Dioxin, Furans

Multiple sources are cited for poor water quality of Delaware's waterways. These include nonpoint sources of agricultural runoff, septic system failures, animal feed lot operations, urban runoff, and municipal and industrial point sources as the primary origins of nutrients and toxic substances.

The Delmarva Peninsula is one of the largest poultry production areas in the United States, generating more than 600 million chickens and 1.6 billion pounds of manure annually. The State of Delaware ranks 7th in the nation in the number of broilers produced. Statewide, this industry is represented by about 900 chicken farms with the largest portion found in Sussex County. There are four chicken farms immediately adjacent to Prime Hook NWR that produce 500,000 to 1 million birds per year. Within a 6-mile radius of the refuge, about 19 poultry farms are located that produce 3 to 5 million birds annually (DDA 2007).

Water quality problems associated with the animal feeding operations were investigated on Prime Hook NWR by contaminant biologists in the Chesapeake Bay Field Office concerned that excessive land application of poultry litter has resulted in severe water quality problems in surface and groundwater on the Delmarva Peninsula (McGee et al. 2003). The study provided direct evidence for transport of tetracycline compounds found in waterbodies from poultry litter applied on the fields in the Delmarva peninsula. It should be noted the data are very limited, both in terms of the number of samples and the geographic coverage.

Cladophora **Algal Bloom Event During Winter, Spring, and Summer of 2010**

Large mats of native *Cladophora* algae began to develop in early February in the Unit II impoundment. By April, the bloom expanded to encompass 700 acres immediately adjacent to Prime Hook Road. Since the algal mats emerged in late winter, robust thick mat growth developed by early spring, effectively allowing the *Cladophora* to out-compete other marsh plants during the growing season.

The bloom remained confined to the southern portion of Unit II until early May when it spread into the northern part of the Unit III impoundment adjacent to Prime Hook Road. The spread was probably facilitated by the hydrological connection between Units II and III via several road culverts. By mid-July, the algal mats began to decrease in size and disappear. This was the first time that such an algal bloom event occurred on the refuge, and was probably triggered by a combination of changing environmental conditions in Unit II and climatic influences.

The breaching of Unit II dune line in 2009 changed the salinity conditions of the impoundment where ranges of 20 to 25 ppt became the norm throughout the entire 1,500-acre impoundment. Then heavy snowfall in January and early February triggered extensive runoff from upland areas into the refuge. Marine *Cladophora* species have an optimal temperature range that maximizes development (50 to 77 ^{0}F). Snow melt and extensive runoff spiked phosphorus loading into the system and perfect growth conditions triggered the bloom. When temperatures exceeded 80 ^{0}F by August, algal mats began to disappear.

As a result of the algal bloom, refuge staff was concerned about excessive nutrient loads within Unit II. Water samples were taken at three locations on May 19, 2010. The samples were analyzed by the University of Maryland, Center of Environmental Science, Chesapeake Biological Laboratory in Solomons, Maryland. Two of the samples were located on the refuge and one on upper Slaughter Creek, which flows into the refuge.

Delaware has no numeric water quality standards for total nitrogen or different forms of phosphorus. For ammonia (NH4), the numeric values are pH and temperature-dependent. The results for the three water bodies (pH 8; 25 ^{0}C) are found in table 3-2.

Table 3-2. Results of water quality testing in May 2010

Sample Id	CBL	NO2	NH4	PO4	NO23	TDP	TDN
	NUMBER	(mg N/l)	(mg N/l)	(mg P/l)	(mg N/l)	(mg P/l)	(mg N/l)
UNIT II	1	0.0009	0.016	0.0027	1.094	0.0336	2.36
SLAUGHTER CREEK	2	0.0495	0.746	0.0530	4.940	0.1213	6.70
UPPER SLAUGHTER CREEK	3	0.0594	0.091	0.0476	5.640	0.1423	6.81

Total dissolved nitrogen (TDN), total dissolved phosphorus (TDP), nitrite plus nitrate (NO23), phosphate (PO4), and nitrite (NO2) are all nearly equal in the creek, but Slaughter Creek is nearly ten times higher in ammonia content. The bloom in Unit II does not correspond with high nutrient concentrations, as the concentrations for all nutrients in Unit II are the lowest of the three areas.

Geochemical changes associated with the intrusion of salt water back into these wetland areas are potentially evident in these water quality findings. Sediment subsidence is of particular concern in diked flooded marshes following tidal restoration, which could lead to prolonged flooding and sulfide toxicity (Portnoy et al. 1997). Plant death and peat collapse have been noted after salt water intrusion in Louisiana brackish marshes. Ferrous iron toxicity, which may also inhibit *Spartina* growth, is also a concern. As for sulfide, however, FE (II) and Al phytotoxicity could be offset by abundant nutrients, especially NH4. The potential large mass of nutrients mobilized by increased decomposition, cation exchange, and phosphate mineral dissolution during saltwater intrusion could depress dissolved oxygen in surface waters by promoting algal production and organic loading (Portnoy et al. 1997).

Portnoy's research emphasizes that salt water intrusion can substantially affect estuarine plants and animals. These changes include sulfide accumulation, metal increases, and nutrient mobilization as well as subsidence.

Concerns were also raised regarding the algal mats containing *Enterococcus* and *E. Coli* bacteria. These bacteria are naturally occurring in the environment. The refuge contracted with DNREC's Division of Water Resources to analyze water samples from July through August. The results concluded that neither bacteria exceeded State or EPA standards.

Ground-Water Contamination from Lead Shot

For 37 years, the Broadkiln Sportman's Club, which is adjacent to Prime Hook NWR on the southwestern corner of the headwaters of the Prime Hook Creek, operated a trap-shooting range. Clay target launchers were oriented so that expended lead shot dropped into a forested wetland and upland grassland areas on Prime Hook NWR. After many years of lead shot deposition, it was discovered that lead shot concentrations were as high as 57,868 pellets per square foot in many areas on the refuge lands adjacent to the Club.

The club was founded in 1962 in Pikes Neck, Sussex County. The club used five trap houses, each with five shooting stations. Shotgun rounds were projected across a grassy field toward a wooded wetland intending to hit airborne clay targets above the field. Numerous lead shot pellets from misses and overshot trajectories often hit trees inside the refuge boundary, fell to the ground, and accumulated through the years.

The portion of Prime Hook NWR bordering the club, which is down range from the trap-shooting area, consists of a forested wetland along a small tributary or slough draining into Prime Hook Creek. The slough varies in size and shape with the seasonal rise and fall of the water table, and dries up completely on occasion. This slough is heavily forested and used by migratory birds, small mammals, and amphibians.

The trap-shooting range was operated from 1962 to 1998 until a proposed land swap with the Service was initiated by the club. Upon this request, the Service initiated a level one contaminant survey of refuge lands. In August and October of 1998, Service personnel collected soil samples to determine the extent of lead shot deposition and lead soil concentrations. Results showed significant lead contamination. The Service ordered the club to discontinue depositing lead shot onto refuge lands, and in 2000 initiated a three-year refuge cleanup project.

A preliminary assessment in 2000 determined that an affected area of 22 acres down range of the club had accumulated most of the lead shotgun pellets with the highest densities concentrated in a zone approximately 26,200 square feet referred to as the drop zone (Crowley and Richardson 2001), as part of an environmental risk assessment prepared by Service contaminants biologists and the U.S. Geological Survey investigated the potential for lead soaked soils to leach into the groundwater.

Results from 2 sampling rounds of 19 wells (May 2000 and April 2001) showed that elevated levels of dissolved lead were present in the groundwater on Prime Hook NWR. The U.S. Geological Survey study was designed as a field screening to give the Service some indication of the scope of the groundwater lead problem. Lead transport through shallow ground is an unusual occurrence, as metallic lead is generally considered immobile. The U.S. Geological Survey further investigated the chemistry of the process of lead mobilizing from the surface down to the groundwater.

Study results verified that low pH values were recorded in the groundwater ranging from 4.8 to 6.4. These acidic environmental conditions were responsible for dissolving the lead carbonate from the pellets. Because of the lack of buffering capacity and adsorption sites in the silica-rich sediments of the area, the dissolved lead was mobilized and moved into the groundwater on the refuge.

A biomonitoring study was initiated in the spring of 2002, prior to removal of the contaminated uplands that occurred in 2003. The study was repeated the following two years to document changes in the levels and bioavailablity of lead in the downgradient wetland sediments. Southern leopard frog *(Rana* *sphenocephala)* tadpoles at Gosner stage 24 were collected from an unimpacted pond on the NWR and placed in enclosures in wetlands at a reference site and at two wetland sites within the shooting trajectory with different concentrations of lead. The amphibians were removed when those at the reference site completed metamorphosis. The gut was removed, and the body analyzed for lead and the liver analyzed for amino levulinic acid dehydratase (ALAD) activity. We found statistically significant differences in ALAD in 2002 among the three sites, indicating inhibition at both the hot and warm locations (less than 0.015 nmol porphobilinogen/per gram liver per hour) relative to the reference (0.20 nmol). In 2004, both sites had significantly lower activity than the reference. The warm site improved in 2005 (0.18nmol) but was still significantly lower than the reference (0.25 nmol). The hot location average also improved to an average of 0.086 nmol, about five times the initial average. Lead concentrations were significantly different at sites (p less than 0.001) in each of the three years. In 2002, the average whole body lead concentration was 59.9 ppm at the hot location, 1.34 ppm at the warm location, and 0.176 ppm at the reference location. At the hot site, there was a steady decrease in whole body lead concentrations from 2002 to 2004 and 2005, but average concentrations were still 350 times that for the reference. Warm site average concentrations decreased and then increased back to the 2002 concentration, which was about 17 times the reference. The study is planned to be repeated in 2011 to note any changes.

The Service has physically excavated and removed part of the pellet-contaminated soils on Prime Hook NWR, which has since re-vegetated with native plants. The major source of groundwater contamination has been remediated on Prime Hook NWR. The attenuation of high lead concentrations in the ground water will require long-term monitoring to confirm the potential of natural attenuation of the system (Soeder and Miller 2003). Water quality monitoring by the Service's Chesapeake Bay Field Office is still ongoing. The refuge has not acquired any of the lands owned by the shooting club, so it does not control all of the impacted or unremediated lands affected by the lead shot deposition. Today, the gun club is no longer operating as such, and the private lands remain unremediated.

History of Vegetation on and Around the Refuge

Prehistoric Climatic Influences on Delmarva Landscape Vegetation

Prehistoric climatic influences that shaped the landscape of the Delmarva Peninsula and refuge lands revolved around the rise and fall of sea levels. All of the Delmarva Peninsula south of Elkton, Maryland and Newark, Delaware is essentially a large sandbar built from sediment left by the sea or eroded off the ancient Appalachian continent over the past 150 to 200 million years. The peninsula is located in the Atlantic Coastal Plain, itself a relatively recent emergence of the continental shelf (Scott 1991).

For tens of millions of years, the sea continued to rise and fall and the rivers washed sediments off the land creating today's features of the Delmarva Peninsula. The last Ice Age on Delmarva occurred about 25,000 years ago with the Wisconsin Glacier. Each time the climate warmed, the amount of water released by this melting ice floe caused sea levels to rise high enough to flood the entire peninsula. During these melting phases the water rose 30 to 40 feet above its present levels, depositing a thick layer of maritime sediment sandy soil on southern Delmarva.

During freezing periods, so much of the earth's available water was incorporated into ice that the sea dropped hundreds of feet below current sea level. The receding of the sea from the peninsula often left behind the poorly drained depressions that are now known as Delmarva bays (Scott 1991). A well-known Delmarva Bay adjacent to the refuge (Huckleberry Swamp) and several similar depressional swamp areas on the refuge (total of six depressional wetlands) have been recently mapped by Delaware Heritage Program botanists in 2005 and 2006 (McAvoy et al. 2007).

These depressional wetland types are an important natural resource in Delaware and are considered a top priority for protection by DNREC. They are today becoming rare because they are not regulated and are easily destroyed by ditching, draining and filling. Important groundwater recharge areas also provide habitat to State rare plant species and are extremely valuable to amphibians that utilize refuge depressional wetlands for breeding purposes (McAvoy et al. 2007).

Delaware Bay and adjacent land surfaces have undergone substantial environmental and vegetative changes. During the Late Pleistocene geological epoch, approximately 15,000 years before present (BP), continental ice sheets of the Late Wisconsin Glacier advanced south to New York and northern Pennsylvania. The glacier stopped just north of Trenton, New Jersey. It was a veritable mountain of ice, several thousand feet thick. Ice sheets, which covered the entire globe, incorporated so much of the earth's available water that the sea dropped more than 300 feet and caused the continental shelf to emerge from the sea east of the Delmarva Peninsula. Pollen samples dating 11,500 BP, when the Wisconsin Glacier was at its height, show that extensive grasslands covered its exposed face and were interspersed with patches of pine, spruce, fir, and hemlock tree species representative of a boreal forest stand (Scott 1991).

During the 1970s, John Kraft and his students from the University of Delaware conducted stratigraphic coring on and near the refuge. These studies indicated the magnitude of coastal changes during the Holocene period of human occupation of the southern Delaware coastal environments. Slaughter Beach is underlain by 40 feet of soft mud deposited by estuaries during the early and middle Holocene. From Prime Hook Beach south to Broadkill Beach, modern barrier beaches cover estuarine mud from depths of 10 to 60 feet. At Fowler Beach, Pleistocene sand and gravel of the former Slaughter Neck headland occur at depths of eight feet below present mean sea level (Kraft et al. 1976).

Hoyte (1980) extracted nine stratigraphic cores on the refuge along Slaughter Creek and has suggested that lagoons behind barrier beaches changed from freshwater marshes to brackish marshes over the past five centuries. In upland area, core samples near the creek (Slaughter Neck) contained Delmarva fox squirrel bone fragments, identified by their unique feature of glowing under black light. In March 2004, Tetra Tech Research, Inc. extracted six additional vibracores from streamsides and near-shore wetlands, and excavated four machine trenches on adjacent refuge uplands to examine erosion and sediment accretion related to sea level rise and associated vegetative changes.

Prehistoric and Historic Cultural Setting and Human Land Use History

Land use refers to the way land is developed or conserved. Review of the land use history of the project area provides a context for understanding physical environmental change. Many changes in the patterns of North American land forms, vegetation, and habitats (collectively referred to as landcover change) have resulted from or been heavily influenced by prehistoric and historic land use by humans.

The prehistory of Delaware is usually described by archaeologists in terms of five major chronological periods (Custer 1989) that correspond to broad adaptive shifts in changing natural and cultural conditions. These cultural periods are the Paleo-Indian (14,000 to 8,500 BP), Archaic (8,500 to 5,000 BP), Woodland I (5,000 to 1,000 BP), Woodland II (1,000 to 500 BP) and Contact Period. Cultural periods have been identified from chronologically diagnostic artifacts such as projectile points, ground and chipped-stone technologies, and pottery styles during the Woodland I and II periods (Custer 1984). The following cultural landscape discussions and land use history also include Prime Hook NWR's archaeological and historical resources.

(1) **Paleo-Indian Period (14,000 to 8,500 BP).** Paleo-Indian archeological sites and artifacts are extremely rare in Delaware. One Paleo-Indian artifact was recovered at a site on the refuge. An isolated kirk point was recovered in 1991 by Cherie Clark, Delaware Historic Preservation Officer, during field excavations performed on the refuge by State Mosquito Control personnel. The find was located on a narrow neck of moderately well-drained soil leading out to a salt marsh area, and was archived by State personnel.

(2) **Archaic Period (8,500 to 5,000 BP).** Climatic warming led to forest closure after 10,000 BP and heralded a dominance of northern and southern hardwoods over boreal conifers (Davis 1983). The Archaic Period is believed to reflect hunting, fishing, and plant gathering subsistence patterns developed in response to increasing environmental diversity. Exploitation of anadromous fish was first indicated in New England during the Archaic Period and Atlantic fisheries, as known today, began to develop within Delaware Bay habitats.

During Atlantic climatic changes of the Archaic Period, hot and dry climates led to the drying out of many interior ponds and wetlands in Delaware and elsewhere across the mid-Atlantic region (McWeeney and Kellogg 2001). At present, no clearly defined Archaic Period archeological sites or artifacts have been found on Prime Hook NWR. The kirk point might date from the Archaic or Paleo-Indian periods. Another artifact reported from the Morris prehistoric site might date between 6,000 and 2,000 BP. However, most refuge estuarine habitats dating from the Archaic Period have been inundated by rising seas (Tetra Tech FW 2004).

(3) **Woodland I Period (5,000 to 1,000 BP).** Archeological evidence increases dramatically after 5,000 BP in the mid-Atlantic and New England regions, reflecting expanding human populations. Climates became wetter and cooler during the sub-Boreal period (5,000 to 2,500 BP), recharging interior wetlands and increasing stream flows (Custer 1984). Custer (1984) has defined the development of estuarine adaptations, population growth, exchange networks, and mortuary ceremonialism during the Woodland I Period. At present, no evidence has been established for the presence of the eastern agricultural complex involving domesticated crop cultivation in Delaware or the mid-Atlantic Region.

Many woodland archeological sites in Delaware were repeatedly occupied over thousands of years, implying that residents were focusing on highly productive habitats and resources as a basis for depending solely on annual hunting, gathering, and fishing subsistence grounds (Custer 1984). Four archeological sites on the refuge are associated with Woodland I occupations. No evidence for Woodland I cemeteries have been reported on Prime Hook NWR (Tetra Tech FW 2004).

Black and white warbler

©Chuck Fullmer

(4) **Woodland II Period (1,000 to 500 BP).** The Woodland II Period was a time of major cultural change in the mid-Atlantic. The bow and arrow replaced spear hunting technologies (Blitz-1988). It is speculated that increased hunting efficiency might have led to overkill of local deer populations, requiring the necessity for agricultural surpluses or intensified estuarine exploitation to meet hunting shortfalls. The first evidence for corn agriculture in the Chesapeake Bay appears at 1,070 BP, and corn expanded rapidly north to Long Island Sound by 880 BP (Tetra Tech FW 2004). Tetra Tech Research Inc. (2004) identified pollen evidence for Woodland II corn agriculture within vibracore samples on Prime Hook NWR.

Other prehistoric sites have been found on Prime Hook NWR that presently lack sufficient quantity of diagnostic artifacts to be definitively placed in a chronological period (MAAR 1981). Insufficient archeological data due to lack of systematic excavations conducted in these areas is the reason sites have not been eligible for National Register of Historical Places designation (MAAR 1981).

(5) **Contact Era (500 to 300 BP).** European contacts with Native peoples near Prime Hook NWR area began during the 16th century; subsequent disease outbreaks were catastrophic to Native Americans. At the time of European contact, Delaware Bay was occupied by numerous small, independent Algonquian-speaking Lenni Lenape bands. Most of northern Delaware's human residents were Lenni Lenape (labeled "The Delawares" by the English) who occupied the west bank of the Delaware River down to the Leipsic River and south to the St. Jones River. These people were politically and linguistically different from the larger bands of the Nanticoke (People of the Tides), who occupied the river drainages in Sussex County along the Broadkill and Indian Rivers.

Estimates of the total number of Native Americans in Delaware in 1600 A.D. ranged from 0.2 to 1.3 people per square mile. This population estimate is comparable to 1.1 people per square mile in Alaska in 2000, but far below Delaware's 401 people per square mile in the same year (Williams 2008).

Contact Period sites are indicated on historic maps, documents, and through artifacts of European trade goods found in archeological digs. For example, south of Prime Hook NWR, historic Nanticoke villages were identified with mixed European artifacts along the Indian River into the 19th century. A mixed community of Lenni Lenape, Nanticoke, and African Americans developed during the 17th century in Kent County, (Heite 2000), but no Contact Period archaeological sites have been identified at Prime Hook NWR. Extensive Woodland II occupations and Paleo-Indian use along the Slaughter Creek were abandoned by the arrival of the first European land grants and land surveys of the 1680s. No documentary references have been identified for Indian villages on the refuge (Tetra Tech FW 2004).

(6) **Post-Contact Period.** The first European settlement along the Delaware River occurred in 1623, when Dutch Captain Cornelis Mey established a trading fort at Fort Nassau, now Gloucester, N.J. In 1629, Holland issued a land grant for Cape Henlopen, Delaware, to Dutch settlers. In 1631, Captain Peter Heyes with 28 men established a trading fort at Zwaanaendael, which is now Lewes, Delaware. This garrison was wiped out in 1632 by local Native Americans. In 1638, Swedes established Fort Christiana in New Castle County. By 1654, New Sweden had established a settlement near the head of Delaware Bay with 368 settlers. In 1658, the Dutch reestablished another trading post at Hoornkill, which was later named the Broadkill River near Milton, Delaware (Tetra Tech FW 2004).

Following the attempts by the Swedes and Dutch to settle the area, two English ships, commanded by Sir Robert Carr took possession of the Dutch settlements along Delaware Bay. Around 1680, the English under William Penn made permanent the settlement at Lewes and surrounding area along the Broadkill River. By 1680, Sussex County was formed and a courthouse was authorized at the cost of 5,000 pounds of tobacco. In 1681, the province of Pennsylvania was granted to William Penn and the three Delaware counties all passed into Penn's administrative realm (Tetra Tech FW 2004).

Through intensive documentary research, chains of title can be identified for early colonial landholdings that now make up the refuge. For example, John Fisher traveled with William Penn when the English made permanent settlements in Lewes and environs. In 1685, Fisher bought several properties of thousands of acres which are now portions of Prime Hook NWR's Unit III and IV upland and wetland areas, referred to as the Island Farm (Tetra Tech FW 2004).

The earliest colonial settlement of current refuge lands goes back to a number of land grants and patents dating back to the latter part of the 17th century found in Scharf's History of Delaware: "A tract of land one thousand by four hundred and eighty perches, containing three thousand acres, and lying between Prime Hook and Slaughter Creeks, was patented on June 21, 1671 by Governor Lovelace to Richard Perrott, of Virginia" (Scharf 1888:1247/MARR 1981).

Other colonial owners of refuge lands included Halmanus Wiltbank (Unit IV Wiltbank Landing) and William Dyer, who owned sections of the Unit III tracts known as Walker's Neck. Tilney Clarke Conwell compiled a detailed documentary history of 1,100 acres in and around the current headquarters area called Dyer's Delight from the 17th century until the refuge was established in 1963. Early colonial sites on Prime Hook NWR for this era are typical 17th century property locations near navigable waters (Tetra Tech FW 2004).

Understanding what the historic natural vegetation types were in refuge areas, how they were distributed, and what ecological processes influenced them prior to major human-induced influences provides a reference point to manage for biological diversity, integrity, and environmental health. These can pinpoint a baseline framework to evaluate future restoration and management options. However, we have noted that, when considering the restoration of areas to native vegetation, ecologists caution against selecting one point in time and instead recommend managing for a historical range of variation for each habitat type (Egan and Howell 2001).

Historic range of variability is a method used in restoration ecology to describe how natural ecosystems have a range of historic conditions in which they are self-sustaining and beyond which they move to a state of unsustainability due to degraded biological integrity, low biodiversity, or impoverished environmental health (Egan and Howell 2001).

Agriculture was the primary cause of deforestation and draining of wetlands. Soil fertility over much of the Delmarva Peninsula continued to decline as the soils had no time to recover from tobacco cultivation followed by the intensive plantings of wheat and corn. Many of Delmarva's rivers became clogged with silt as deforestation and agriculture facilitated erosion of uplands, so once prosperous shipping and coastal towns became economically stranded.

Negative impacts to wildlife continued as natural habitats were destroyed. With the elimination of natural predators, squirrel populations increased. Bounties were established for squirrels, which were damaging crops. Deer numbers were drastically reduced due to overharvesting. Wild turkeys, estimated at more than 10,000 birds in Delaware before the advent of European settlement (Williams 2008), were hunted nearly to extinction by the early 19th century, along with Delmarva fox squirrels.

Sussex County underwent substantial development during the 20th century. The advent of the automobile funneled large numbers of tourists and vacationers to coastal areas. Most 19th century structures continued to be occupied into the 20th century. The Service has identified several sites constructed during the 20th century, including sport-hunting camps and other historic sites on the refuge (Tetra Tech 2004).

Increased beach resort development and beach home construction continued in the latter part of the 20th century and into the 21st, shrinking the size of undeveloped sandy beach ecosystems remaining in the State. Undeveloped bay and ocean shorelines represent a disappearing natural habitat type in Delaware.

History of Agricultural Management on and around the Refuge

In pre-settlement North America, waterfowl were dependent on aquatic, marsh, and shoreline vegetation and the mast and seeds of terrestrial plants of seasonally flooded bottomland forests for food. The conversion of North American forests and wetlands to agricultural lands, and the degradation and loss of wetland habitats to development, drainage, and pollution, gradually changed North American waterfowl feeding habits. As wetlands diminished and farmlands increased, many waterfowl adapted to foraging in croplands, i.e., in crop stubble, on waste grain, and on the weedy herbs that colonize fields between crop rotations.

Game agencies use farming to attract and provide forage for waterfowl on wildlife management areas. On the Delmarva Peninsula, crop or food plot management has been conducted largely to attract Canada geese, and to a lesser extent, dabbling ducks. Cropland management has also been a traditional habitat management tool on national wildlife refuges nationwide. Refuges have used farming to attract and feed waterfowl species to support migrating goose and duck populations, as well as to provide hunting and viewing opportunities for the public. Prime Hook NWR began a cooperative farming program when the refuge was created in the 1960s. At that time, the refuge also managed the farming program to support duck production, with croplands in grass/clover stages of rotations designed to provide nesting habitats for ducks. At its peak in the 1970s, 1,070 acres were in agricultural production on the refuge. In 2006, the last year of the cooperative farming program, the refuge farmed 485 acres.

Historically, waterfowl were the most closely monitored and managed bird populations on national wildlife refuges. Much of the Refuge System's land acquisition and management capability was funded by an interest in game birds. Emerging status and trends data on many migratory bird groups, such as songbirds, colonial waterbirds, shorebirds, and raptors, as well as other wildlife, including mammals, fish, herpetiles, insects and plants, has expanded the conservation mission of the National Wildlife Refuge System beyond waterfowl alone. The current purposes and mission of Prime Hook NWR include conserving all processes and organisms comprising healthy ecological communities of coastal Delaware.

At its peak, the cooperative farm program at Prime Hook NWR managed 48 small fields averaging 22.3 acres each, for a total of 1,070 acres, or 0.073

percent of the total cropland (2007 acres) on the Delmarva peninsula. As part of a cooperative agreement on Prime Hook NWR, farmers historically planted several hundred acres of non-native cover crops (barley, clover, or wheat) as green browse for geese after the harvest of the corn or soybean crop. In 2007, Sussex County alone managed nearly 35,000 acres of green browse; there was a total of 306,120 acres of green browse on Delmarva.

Prior to establishing a cropland management program, Refuge Policy 6 RM 4 states the refuge must develop a cropland management plan. The plan must describe how refuge wildlife population objectives will be achieved through the production of grain. Prime Hook NWR's cropland management plan was approved in 1970. Since its development, the refuge cropland management expanded to include additional lands acquired in the 1970s to the present. Farming techniques, pesticides, best management practices, etc., have changed tremendously since the original cropland management plan. Prime Hook NWR's cropland management plan has been outdated and obsolete for many years; it did not include the use of more advanced agricultural techniques and best management practices, such as integrated pest management.

In addition to Refuge Policy 6 RM 4, two acts of Congress also play a role in the cropland management program: the National Environmental Policy Act of 1969 (NEPA) and National Refuge System Improvement Act (1997). NEPA requires the government to evaluate the impacts of its management actions to the affected environment. The Improvement Act requires the refuge to ensure that cooperative farming is compatible with the purpose for which the refuge was established. Cooperative farming is also considered an economic use and Refuge Policy 5 RM 17 plays a role in the formation of cropland management planning.

In 2006, the Delaware Audubon Society, Center for Food Safety, and Public Employees for Environmental Responsibility filed suit against the Service for the refuge's failure to comply with these acts and policies. In 2009, the judge enjoined the refuge from farming and planting genetically modified organisms until the refuge completed compatibility determinations and environmental assessments dealing with the impacts. The refuge ceased all farming operations in 2006, and this CCP serves as the required NEPA analysis of farming as a management option.


©Kevin Fleming
American bittern

History of Refuge Wetlands and Wetland Management

The wetlands on and around the refuge have been shaped by many natural and human-caused factors over the last century. Table 3-3 provides a summary of wetland history.

Table 3-3. Summary of Historic Wetland Survey Findings in the Prime Hook NWR Area. 1976 DE Wetland Atlas Designations: Zone I dominated by salt marsh cordgrass *(Spartina alterniflora)*; Zone II dominated by salt hay *(Spartina patens)* and spike grass *(Distichlis spicata)*; Zone III dominated by salt bush species *(Iva frutescens* and/or *Baccharis halimifolia)* mixed with salt hay or spike grass; Zone IV dominated by giant reed grass *(Phragmites australis)*; Zone V is a transitional wetland type with no dominant species.

	Early 1900s	1951 Survey of Delaware Wetlands Findings			Wetland Survey Work Conducted by the University of Delaware and DNREC in the 1970s	
Refuge Unit(s)	**Compiled from early narratives and accounts**	**Dominant Vegetation Species**	**Salinity Range**	**Additional Comments**	**1973 Vegetation Map Dominant Species**	**1976 DE Wetland Atlas Zone(s)***
Unit I	Slaughter Canal was dug by landowners to improve drainage on nearby uplands, thus altering and limiting tidal flow in the salt marsh.	big cordgrass, salt marsh cordgrass, salt hay, cattail, *Phragmites,* three-square, panic grass, marsh mallow, high tide bush, groundsel bush; **In the brackish portions:** duckweeds, pondweeds, bur-reed, cattail, water willow, wild rice, pond lilies, rushes, smartweeds	1.7 – 38.8 ppt	In spite of the large acreage encompassed by this marsh survey unit, use of the area by waterfowl was low compared to other parts of the State.	*Spartina patens* *Spartina alterniflora* *Phragmites australis* *Iva frutescens* *Spartina cynosuroides* *Typha* spp. *Panicum virgatum* *Hibiscus palustris*	Zone I Zone II Zone III Unit I shoreline categorized as Zone IV
Unit II	Slaughter Creek flowed through this marsh directly into the Delaware Bay until the outlet was closed by a storm. Much of the marsh was grid-ditched for mosquito control.				*Phragmites australis* *Spartina alterniflora* *Spartina patens* *Iva frutescens* *Spartina cynosuroides* *Hibiscus palustris*	Zone I Zone II Unit II shoreline categorized as Zone IV
Unit III	Prime Hook Creek flowed through this marsh and through the barrier beach directly into the Delaware Bay. It brought tidal water into this salt marsh daily, until the outlet was closed by a storm.	**In the saline portions:** *Phragmites,* big cordgrass, salt marsh cordgrass, cattail, salt hay, groundsel bush, marsh mallow; **In the fresher portions:** cattail dominates; also, bur-reed, pondweeds, smartweeds, chufa, wild millet, three-square, sweet pepper bush, rushes, common ragweed	0.1 – 18.6 ppt	A high barrier along the coast is cited as the reason there as less true salt marsh vegetation in this unit than in areas north and south. Occasional influx of saltwater through breaks in the dune are also noted. Expansion of *Phragmites* is noted. Survey unit contains areas recommended for future water level management.	*Phragmites australis* *Spartina alterniflora* *Iva frutescens* *Spartina patens* Mixed Species *Typha* spp. *Hibiscus palustris*	Zone IV Zone V Southern portion of Unit III categorized as Zone II
Unit IV	Much of this marsh was grid-ditched in the 1930s for mosquito control.	**In the coastal portion:** salt hay, big cordgrass, salt marsh cordgrass, high tide bush, groundsel bush, marsh mallow, panic grasses **In the small fresher areas:** cattails, smartweeds, swamp dock, water willow, pondweeds, *Phragmites*	1.4 – 29.0 ppt	Low muskrat production was attributed to presence of mosquito control ditches that were cleaned each year.	*Spartina patens* *Spartina alterniflora* *Iva frutescens* *Phragmites australis* *Typha* spp. *Hibiscus palustris* *Spartina cynosuroides*	Zone I Zone II

Refuge Vegetation Resources

Mapping Refuge Vegetation

Mapping of vegetation communities was conducted from 2005 to 2007 by the Delaware Natural Heritage Program (DNHP) and NatureServe on the refuge, excluding about 827 acres of easements. Mapping was conducted according to the National Vegetation Classification Standard (NVCS), which is the Federal standard. This system classifies vegetation on a national scale for the United States and is linked to the international vegetation classification. The NVCS provides a uniform name and description of vegetation communities found throughout the country and helps determine relative rarity. The NVCS classification standard is organized into a natural vegetation hierarchy that consists of eight levels based on floristic and physiognomic criteria that include:

(1) Formation class
(2) Formation subclass
(3) Formation
(4) Division
(5) Macrogroup
(6) Group
(7) Alliance
(8) Association

The NatureServe group generated a report summarizing a subset of the international classification standard covers of vegetation associations attributed to Prime Hook NWR in 2006. Their report includes vegetation community element descriptions, element distributions along the mid-Atlantic and Northeast, and global rarity rankings of refuge communities (McAvoy et al. 2007). Vegetation communities were described using 2002 aerial photography and field studies.

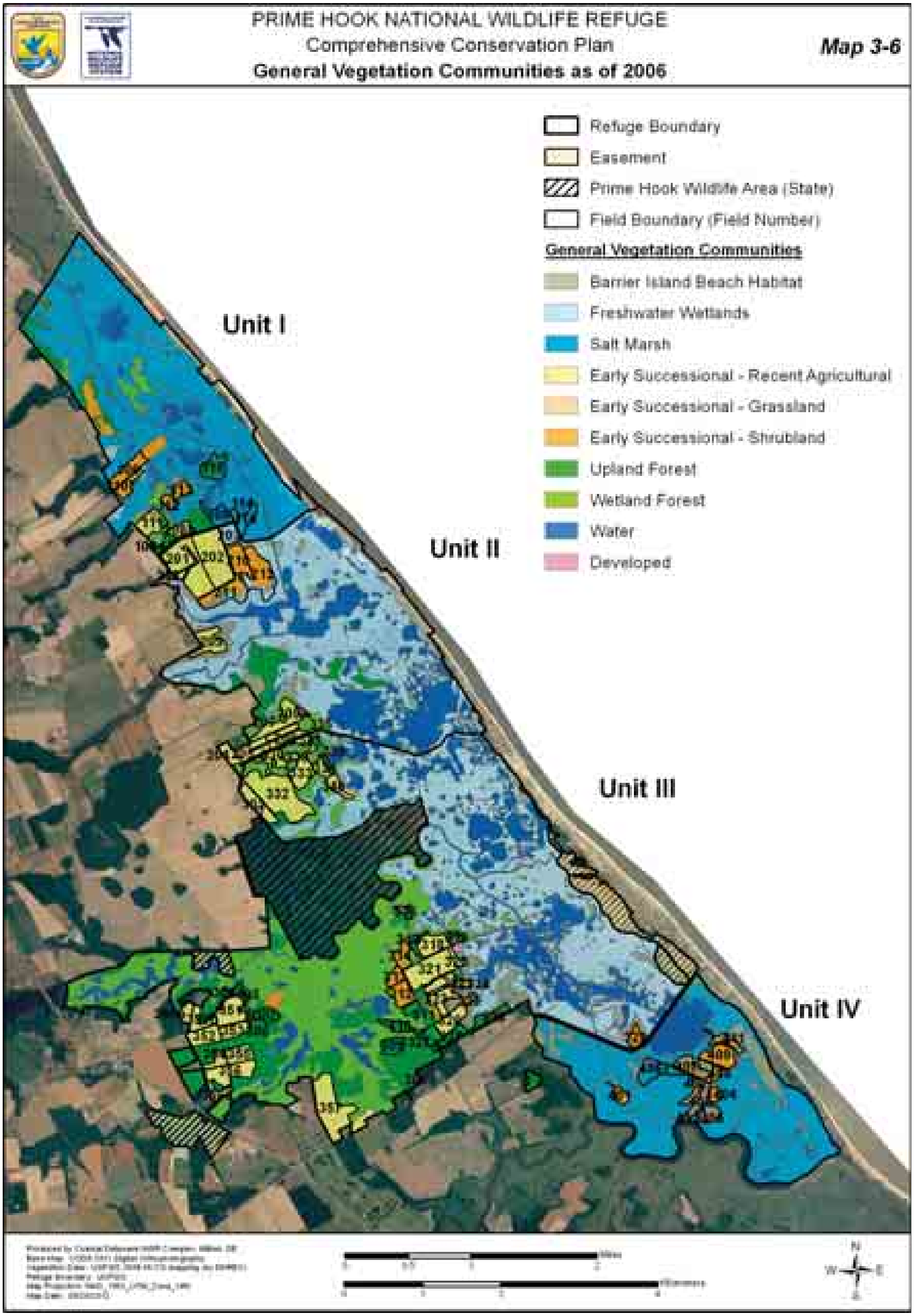
It should be noted that, as a result of the recent shoreline changes in Unit II (overwashes, inlets), these vegetation communities may be changing in composition and in size. With many of these areas in transition, the exact nature and extent of these changes are not known.

Prime Hook NWR General Flora Description

Refuge plant surveys conducted in 2004 and 2005 by Delaware Natural Heritage botanists provided data on vegetation conditions and species composition at that time (McAvoy et al. 2007). Natural habitats dominate refuge vegetation. Approximately 80 percent of habitat cover types represented by emergent wetlands are shaped by tidal and freshwater creek drainages that discharge into the Delaware Bay. These coastal marsh habitats are also interspersed with swamps, upland forests, shrublands, and grasslands representative of the Delmarva coastal plain ecosystem. NVCS cover typing delineated 37 distinct vegetation community types, including anthropogenic communities and water surface coverages (map 3-2). For more general discussions during the CCP development, a less detailed map combined the NVCS communities into 10 broad vegetation and land cover classes (map 3-6).

The flora of Prime Hook NWR is represented by 100 families and 247 genera. The largest families are the sedge family (Cyperaceae) with 60 taxa and 11 genera, followed by the aster family (Asteraceae) with 57 taxa and 34 genera, and the grass family (Poaceae) with 45 taxa and 30 genera. The largest genera include *Carex* (28 taxa), *Quercus* (nine taxa), *Eleocharis* (eight taxa), *Polygonum* (eight taxa), *Bidens* (seven taxa), *Eupatorium* (seven taxa), *Juncus* (seven taxa), *Asclepias* (six taxa), *Cyperus* (six taxa), and *Rhynchospora* (six taxa) (McAvoy et al. 2007).

Map 3-6. General Refuge Vegetation Communities



The majority of refuge plants are perennial broadleaf herbs with 131 taxa, followed by annual broadleaf herbs with 58 taxa. Graminoids (grasses, sedges, and rushes) are a large component of the refuge's flora, equaling 112 taxa, (45 taxa of grasses, 60 taxa of sedges, and 7 taxa of rushes). Trees and shrubs are also very prominent in the flora, with 29 taxa of deciduous trees, 6 taxa of evergreen trees, 32 taxa of deciduous shrubs, and 5 taxa of evergreen shrubs. True ferns [e.g., cinnamon fern *(Osmunda)*] and their relatives [e.g., tree club-moss *(Lycopodium)*] form a unique assemblage of the flora with 16 taxa.

Most of the refuge's flora is wetland plants (wetland indicator status of facultative-wet and obligate) represented by 236 taxa, compared to 189 that occur either occasionally in wetlands, or never occur in wetlands. Documented rare plants included 44 species (seven -S1, 20-S2, and 17-S3).

National Vegetation Classification Standard Refuge Communities

Thirty-four natural NVCS vegetation communities were found on Prime Hook NWR in addition to three anthropogenic communities (open lawn, agricultural field, and loblolly pine plantation) (table 3-4; map 3-2). The *Spartina* low marsh (1,685 acres) was the largest association and the buttonbush coastal plain pond was the smallest (1 acre). Four associations **(*)** were identified on the refuge that are unique in Delaware and found nowhere else in the State. These include the red maple/seaside alder (799 acres), pond pine woodland (8 acres), coastal bay shore/succulent beach (150 acres), and twig rush peat mat (10 acres) associations.

Table 3-4. List of NVCS Associations Mapped on Prime Hook NWR

Habitat Type Common Name	NVCS Association
Overwash dune	*Spartina patens, Schoenoplectus pungens, Solidago sempervirens* Herbaceous vegetation
Beachgrass/panicgrass dune grassland	*Ammophila breviligulata, Panicum amarum* Herbaceous vegetation
Atlantic Coast interdune swale	*Morella cerifera, Spartina patens* Shrubland
Interdunal switchgrass brackish depression	*Morella cerifera, Panicum virgatum, Spartina patens* Herbaceous vegetation
Mid-Atlantic maritime salt shrub	*Baccharis halimifolia, Iva frutescens, Spartina patens* Shrubland
Maritime red cedar woodland	*Juniperus virginiana, Morella pensylvanica* Woodland
Successional maritime forest	*Prunus serotina, Sassafrass albidum, Amelanchier Canadensis, Quercus velutina, Smilax rotundifolia* Forest
Southern red oak/heath forest	*Quercus alba, Q. falcate (Pinus taeda), Gaylussacia frondosa* Forest
Mesic coastal plain oak forest	*Quercus falcate, Q. phellos/Ilex opaca* Forest
Coastal loblolly pine	*Pinus taeda, Morella cerifera, Vitis rotundifolia* Forest
Mesic coastal plain rich forest	*Liriodendron tulipifera, Quercus rubra, Fraxinus Americana/, Uvularia perfoliata* Forest
Mesic coastal plain mixed hardwood forest	*Fagus grandifolia, Quercus (alba,rubra), Liriodendron tulipifera /Polystichum acrostichoides* Forest
Successional sweetgum forest	*Liquidambar styraciflua* Forest
Pond pine woodland*	*Pinus serotina, Magnolia virginiana, Vaccinium corymbosum, Carex atlantica* Woodland
Red maple/seaside alder swamp*	*Acer rubrum, Alnus maritima* Woodland
Coastal plain depression swamp	*Liquidambar styraciflua, Acer rubrum, Quercus phellos/Leucothoe racemosa* Forest

Habitat Type Common Name	NVCS Association
Coastal loblolly pine wetland forest	*Pinus taeda, Morella cerifera, Osmunda regalis* var. *spectabilis* Forest
Atlantic white-cedar swamp	*Chamaecyparis thyoides, Alnus maritima* Woodland
Cottonwood swamp	*Populus heterophylla, Acer rubrum, Quercus palustris, Liquidambar styraciflua* Forest
Atlantic Coast wild rice marsh	*Zizania aquatica* Herbaceous vegetation
Cattail brackish marsh	*Typha angustifolia, Hibiscus moscheutos* Herbaceous vegetation
Brackish meadow	*Panicum virgatum, Spartina patens* Herbaceous vegetation
Pickerelweed marsh	*Peltandra virginica, Pontedaria cordata* Herbaceous vegetation
Pond lily marsh	*Nuphar lutea ssp. advena* Herbaceous vegetation
Cattail marsh	*Typha anustifolia, latifolia, Schoenoplectus spp*. Sparse vegetaion
Coastal bay shore/succulent beach*	*Sesuvium maritimum, Atriplex spp.*, *Suaeda spp*. Sparse vegetation
River seedbox marsh	*Ludwigia leptocarpa* Semipermanently flooded herbaceous vegetation
Twig rush peat mat community*	*Cladium mariscoides, Eriocaulon decangulare, Eriophorum virginicum* Herbaceous vegetation
Water willow shrub swamp	*Decodon verticillatus* Semipermanently flooded shrubland
Buttonbush coastal plain pond	*Cephalanthus occidentalis, Polygonum hydropiperoides, Panicum verrucosum* Shrubland
Brackish tidal creek shrubland	*Morella cerifera, Baccharis halimifolia, Eleocharis fallax* Shrubland
Spartina high salt marsh	*Spartina patens, Distichlis spicata (Juncus gerardii)* Herbaceous vegetation
Spartina low salt marsh	*Spartina altemiflora/ (Ascophyllum modosum)* Herbaceous vegetation
Salt panne	*Salicornia (virginica, bigelovii, maritima), Spartina alterniflora* Herbaceous vegetation

We have listed the NVCS community associations and habitat descriptions that apply to each of the four refuge management units. These vegetation inventories and resulting maps represent the best available information regarding vegetation cover on the refuge. As stated above, we recognize that the information is already outdated for portions of our managed wetland impoundments that have been affected by recent coastline changes. Detailed NVCS maps for each refuge unit are found in the habitat management plan (HMP; appendix B).

Vegetation in Refuge Management Units

NVCS Vegetation Communities in Management Unit I

Unit I totals 1,624.9 acres [657.5 ha (table 3-5)]. Of the total acres, 1,504.7 acres (608.9 ha) are natural communities and 120.2 acres (48.6 ha) are anthropogenic communities. Unit I receives tidal, brackish water inputs from Slaughter Creek, which results in the development of *Spartina* low salt marsh, which is the largest vegetation community in Unit I. A small wax-myrtle shrub swamp, located at the south end of the unit, is the smallest vegetation community mapped. Part of this unit experienced an arson-set marsh fire under high wind conditions (45 + mph) on March 10, 2002, that burned approximately 1,500 acres.

Table 3-5. Natural and Anthropogenic Communities in Management Unit I

Natural Community	Unit I acreage (ha)
Atlantic Coast interdune swale	0.3 (0.1)
Beachgrass-panicgrass dune grassland	12.5 (5.1)
Brackish tidal creek shrubland	73.9 (29.9)

Natural Community	Unit I acreage (ha)
Coastal loblolly pine wetland forest	34.2 (13.8)
Coastal plain depression swamp	39.9 (16.1)
Marsh	33.2 (13.4)
Mesic coastal plain oak forest	49.6 (20.1)
Mesic rich forest	10.6 (4.3)
Mid-Atlantic maritime salt shrub	10.8 (4.4)
Overwash dune	5.1 (2.0)
Successional sweetgum forest	31.2 (12.6)
Spartina high salt marsh	75.2 (30.4)
Spartina low salt marsh	982.0 (397.4)
Water	146.2 (59.2)
Natural Community Total	***1,504.7 (608.9)***
Anthropogenic Community	
Agricultural Field	25.6 (10.4)
Northeastern Successional Shrubland	90.1 (36.4)
Road	4.5 (1.8)
Anthropogenic Community Total	***120.2 (48.6)***
Unit 1 Total	**1,624.9 (657.5)**

NVCS Vegetation Communities in Management Unit II

Unit II is just south of Unit I and is an impounded, nontidal freshwater system that is manipulated by water control structures. Freshwater input is from Slaughter Creek, which flows from the west. Total acreage of Unit II is 1,997.5 acres (808.3 ha), of which 1,681.8 acres (680.6 ha) are natural communities and 315.7 acres (127.7 ha) are anthropogenic communities (table 3-6). The generic marsh cover type is the largest vegetation community and the smallest is the maritime red cedar woodland. As of 2006, this unit is being overrun (approximately 100 acres) by river seedbox *(Ludwigia leptocarpa)*, a native plant of the south, but is considered nonnative in Delaware; it has invasive characteristics at the refuge. Furthermore, storms in 2008 and 2009 created overwashes along the coast of Unit II, which have formed inlets. The resulting flow of saltwater into Unit II killed much of the freshwater vegetation that was present when the NVCS mapping was done. This list represents a baseline inventory of cover types in Unit II as of 2005 when the mapping work was conducted.

During late February and early March 2010, an algal bloom started in the most southern areas of Unit II, adjacent to Prime Hook Beach Road. By the end of May, the algal bloom had continued to expand, covering about 700 acres in Unit II and 300 acres in Unit III. This algae has been identified as *Cladophora*, a genus of reticulated filamentous Ulvophyceace (green algae) found naturally along coastline habitats within the littoral zone (open water areas near shorelines). A common component of freshwater ecosystems, *Cladophora* can provide food and shelter for invertebrates and small fish. Problems arise when environmental conditions of light, substrate, and nutrients (especially phosphorus) suddenly change and become favorable for luxuriant growth of algal mats over extensive areas. This is the first time such a nuisance bloom has occurred on the refuge. *Cladophora* itself does not present a risk to human health but decaying *Cladophora* can promote bacterial growth and a pungent septic odor like sewage. Nuisance *Cladophora* outbreaks indicate an ecosystem under stress.

Table 3-6. Natural and Anthropogenic Communities in Management Unit II

NVCS - Natural Community	Unit II acreage (ha)
Atlantic Coast interdune swale	20.1 (8.1)
Beachgrass-panicgrass dune grassland	22.6 (9.1)
Brackish tidal creek shrubland	3.3 (1.3)
Coastal plain depression wwamp	47.2 (19.1)
Maritime red cedar woodland	1.9 (0.8)
Generic marsh	918.9 (371.8)
Mesic coastal plain oak forest	99.0 (40.0)
Mid-Atlantic maritime salt shrub	7.2 (2.9)
Overwash dune	4.2 (1.7)
Successional maritime forest	71.3 (28.8)
Successional sweetgum forest	9.4 (3.8)
Water	476.7 (192.9)
Natural Community Total	***1,681.8 (680.6)***
Anthropogenic Community	
Agricultural field	221.8 (89.8)
Northeastern successional shrubland	82.2 (33.2)
Open lawn	0.2 (0.1)
Road	11.5 (4.6)
Anthropogenic Community Total	***315.7 (127.7)***
Unit II Total	**1,997.5 (808.3)**

NVCS Vegetation Communities in Management Unit III

Unit III is the largest of the units and lies between Unit II and Unit IV. Like Unit II, it has been managed as a nontidal freshwater system since the mid-1980s. It is 4,431.0 acres (1,793.1 ha), of which 3,822.6 acres (1,546.9 ha) are natural communities and 608.4 (246.2 ha) are anthropogenic communities (table 3-7). The generic marsh is the largest cover type and an overwash dune at the north end of the Unit is the smallest. Generic marsh consists of various freshwater and brackish wetland species, mostly annuals, which can vary each year based on growing conditions. Biologically and ecologically, Unit III is the most important of all the units. (Note: Generic marsh and open water roughly correspond to impounded wetland areas.) Unit III supports three vegetation communities that are currently known in Delaware only from Prime Hook NWR. These include the twig rush peat mat, pond pine woodland, and red maple-seaside alder woodland. Prime Hook Creek flowing west to east roughly divides this unit into a northern half and southern half. This unit contains the largest amount of anthropogenic communities at 608.4 acres (246.2 ha), more than the other three units combined.

Table 3-7. Natural and Anthropogenic Communities in Management Unit III

NVCS – Natural Community	Unit III acreage (ha)
Atlantic Coast interdune swale	15.8 (6.4)
Atlantic white cedar-seaside alder woodland	9.8 (4.0)
Brackish tidal creek shrubland	1.3 (0.5)
Buttonbush coastal plain pond	0.8 (0.3)
Coastal loblolly pine forest	41.5 (16.8)
Coastal loblolly pine wetland forest	56.3 (22.8)
Coastal plain depression swamp	248.7 (100.6)
Interdunal switchgrass brackish depression	0.7 (0.3)
Loblolly pine plantation	10.6 (4.3)
Loblolly pine-sweetgum semi-natural forest	39.0 (15.8)
Maritime red cedar woodland	7.8 (3.2)
Marsh	1314.7 (532.0)
Mesic coastal plain mixed hardwood forest	19.2 (7.8)
Mesic coastal plain oak forest	43.8 (17.7)
Mesic rich forest	24.5 (9.9)
Mid-Atlantic maritime salt shrub	1.5 (0.6)
Overwash dune	0.2 (0.1)
Peat mat	9.0 (3.6)
Pond pine woodland	7.2 (2.9)
Red maple-seaside alder woodland	699.3 (283.0)
Reed canarygrass eastern marsh	1.9 (0.7)
Southern red oak/heath forest	289.1 (117.0)
Successional maritime forest	90.6 (36.6)
Successional sweetgum forest	88.0 (35.6)
Swamp cottonwood coastal plain pond	1.5 (0.6)
Water	797.9 (322.7)
Water-willow shrub swamp	2.2 (0.9)
Natural Community Total	***3,822.6 (1,546.9)***
Anthropogenic Community	
Agricultural field	507.1 (205.2)
Building	0.3 (0.1)
Northeastern successional shrubland	73.4 (29.7)
Open lawn	5.0 (2.0)
Parking lot	1.6 (0.6)
Road	21.0 (8.5)
Anthropogenic Community Total	***608.4 (246.2)***
Unit III Total	**4,431.0 (1793.1)**

NVCS Vegetation Communities in Management Unit IV

Unit IV is the southernmost management unit and is the smallest of all the units with a total area of 1,176.4 acres (476.0 ha), of which 1,111 acres (449.6 ha) are natural communities and 65.3 acres (26.4 ha) are anthropogenic communities (table 3-8). Unit IV receives tidal and brackish input from the Broadkill River and as a result, the largest natural community in Unit IV is the *Spartina* low salt marsh. The smallest natural community is an interdunal switchgrass brackish depression. A coastal bay shore/succulent beach is located within the impounded portion of Unit IV and is covered under the generic marsh category. Unit IV at Prime Hook NWR is the only known location for this community in the State of Delaware.

Table 3-8. Natural and Anthropogenic Communities in Management Unit IV

NVCS - Natural Community	Unit IV acreage (ha)
Atlantic coast interdune swale	30.5 (12.3)
Brackish tidal creek shrubland	17.7 (7.1)
Coastal loblolly pine forest	9.7 (3.9)
Interdunal switchgrass brackish depression	5.7 (2.3)
Maritime red cedar woodland	66.2 (26.8)
Marsh	4.1 (1.6)
Mid-Atlantic maritime salt shrub	40.4 (16.3)
Spartina high salt marsh	7.8 (3.1)
Spartina low salt marsh	774.8 (313.5)
Successional maritime forest	22.0 (8.9)
Water	132.2 (53.5)
Natural Community Total	***1,111.1 (449.6)***
Anthropogenic Community	
Building	0.2 (0.1)
Northeastern successional shrubland	58.7 (23.7)
Road	6.4 (2.6)
Anthropogenic Community Total	***65.3 (26.4)***
Unit IV Total	**1,176.4 (476.0)**

Federal and State-Listed Plants and Communities

In addition to producing high quality vegetation cover maps of the refuge, the Service contracted the DNHP to collect baseline data on rare, endangered, or threatened flora and fauna. During 2004 and 2005, rare plant surveys were conducted through areas that mapped rare vegetation community elements, and zoological surveys were conducted that assessed the presence and location of rare herpetafauna, odonates, lepidopterans, small mammals, and other invertebrates. A final report summarizing composite data was submitted to the Service in June 2007 (McAvoy et al. 2007).

Modern scientific resource programs using the principles of conservation biology are premised on understanding and mapping the elements of rarity across the landscape. Determining which plants and animals are thriving and which are rare or declining is crucial for targeting conservation actions toward those species and habitats of greatest conservation need. The rankings provide an estimate of extinction risk to protect species before they become listed as threatened or endangered. Status is assessed and documented at three geographic scales: global (g), national (N), and state (S). Status assessments are based on the best available information and consider a variety of factors, such as abundance, distribution, population trends, and threats.

Exemplary Natural Communities

Exemplary natural communities are those that have been minimally impacted by humans and contain an exceptional diversity of rare plant species. The most significant community found on the refuge was the twig rush peat mat. These sites (six were mapped by McAvoy and Coxe 2007) support many State rare plant species (table 3-9) and occur in open water within a shrub-dominated swamp matrix. This unique habitat develops on deep, mucky, peat that appears to float (true "quaking bog"). Of the six quaking bogs inventoried and mapped, the most exemplary was the Prime Hook Bog. The Prime Hook Bog is about 1.5 acres in size and is floristically diverse with 66 species and varieties documented. Twig rush sedge *(Cladium mariscoides)* is the dominant herb associated with many rare plants (24 species), including several insectivorous plants like purple pitcher-plants, round-leaf sundew, fibrous bladderwort, and southern bladderwort. In addition, a subspecies new to the flora of the State of Delaware and the Delmarva Peninsula was discovered here: bushy bluestem *(Andropogon glomeratus* var. *hirsutior).*

Table 3-9. State Rare plants associated with Twig Rush Peat Mat Community on Prime Hook NWR

Scientific Name	Common Name	State Rank	Habit & Duration	Wetland Indicator Status
Alnus maritime	Delmarva alder	S3	deciduous shrub	OBL
Andropogon glomeratus var. hirsutior	bushy bluestem	S1	perennial grass	$FACW^{+}$
Bartonia paniculata	twining bartonia	S2	annual broadleaf herb	OBL
Bidens coronata	tickseed sunflower	S3	annual broadleaf herb	OBL
Bidens mitis	small-fruit beggar-ticks	S2	annual broadleaf herb	OBL
Cyperus diandrus	umbrella flatsedge	S1	annual sedge	FACW
Drosera rotundifolia	round-leaf sundew	S2	perennial grass	OBL
Eleocharis robbinsii	Robbins spike-rush	S3	perennial grass	OBL
Eriocaulon decangulare	ten-angle pipewort	S1	per broadleaf herb	OBL
Eriophorum virginicum	tawny cotton-grass sedge	S1	perennial sedge	OBL
Eriocaulon parkeri	Parker's pipewort	S2	perennial sedge	OBL
Fuirena pumila	hairy umbrella-sedge	S2	annual sedge	OBL
Fuirena squarrosa	dwarf umbrella sedge	S3	perennial sedge	OBL
Juncus pelocarpus	brown-fruited rush	S2	per broadleaf herb	OBL
Lycopus amplectens	sessile-leaved bugleweed	S2	perennial broadleaf herb	OBL
Pogonia ophioglossoides	rose pogonia	S2	per broadleaf herb	OBL
Rhynchospora alba	white beakrush	S2	perennial sedge	OBL
Rhynchospora scirpoides	long-beaked beakrush	S2	perennial annual	OBL
Sagittaria engelmanniana	Engelmann's arrowhead	S2	perennial aquatic herb	OBL

Scientific Name	Common Name	State Rank	Habit & Duration	Wetland Indicator Status
Sagittaria graminea	grass-leaf arrowhead	S2	per aquatic herb	OBL
Sarracenia purpurea	purple pitcher-plant	S2	per broadleaf herb	OBL
Spiranthes cernua	nodding ladies'-tresses	S3	perennial broadleaf herb	FACW
Utricularia fibrosa	fibrous bladderwort	S2	per aquatic herb	OBL
Utricularia juncea	southern bladderwort	S2	per. broadleaf herb	OBL

Other Rare Plant Communities

Survey data identified a diverse assemblage of rare flora and fauna in the following refuge forest community types: red cedar maritime forest, coastal plain depression swamp, Atlantic white cedar/seaside alder saturated forest, swamp cottonwood coastal plain seasonal pond, and coastal loblolly pine. Based on current knowledge the red-maple/seaside alder woodland occurs only at Prime Hook NWR and may not occur anywhere else in Delaware or North America. Other rare and unique communities mapped on the refuge include the coastal bay/succulent beach and pond pine wetland communities.

Red Maple/Seaside Alder Community
This community is typified by the dominance of red maple in the overstory and seaside alder on the edges and in the understory within a swamp environment of standing water. The substrate is peat and muck characterized by hummock-and-hollow microtopography. The shrub layer consists of water willow, sweet pepperbush, southern bayberry, and occasionally buttonbush and fetterbush. The herbaceous layer forms on hummocks and hollows and is dominated by royal fern, northern marsh St. John's wort, cardinal flower, weak stellate sedge, three-way sedge, and mild water-pepper.

Rare plant species that occur in this community include seaside alder, Mitchell's sedge, green-fringe orchis, and gibbous grass. Seaside alder occurs on hummocks along the edges of open water, green-fringe orchis is found at base of trees within the understory and blooms in mid-summer, and Mitchell's sedge is found within the interior of this community growing on hummocks in the shade of the understory. The gibbous grass grows in sun and shallow water on the edges of this community and at times forms dense, pure stands. For a complete description of all NVCS vegetation alliances and associations mapped on the refuge see the NatureServe 2006 report in McAvoy et al. 2007.

Coastal Bay Shore/Succulent Bush
This community is dominated by sea purslane with patches of spearscale, panic beachgrass, barnyard grass, brackish sprangletop, small spike-rush, and salt marsh fleabane. Although this community is located within a 200-acre impoundment in Unit IV, it is surrounded by salt marsh habitats and is often irregularly flooded by storm tides from the Broadkill River and Delaware Bay waters. As to its current Statewide distribution, this community is not known to occur anywhere else in Delaware.

Other rare plants found on the refuge are included in table 3-10. Within the coastal plain depression swamp community type about 25 individuals of the State-rare cattail-sedge *(Carex typhina*, S3) in Unit III and scattered colonies of slender blue-flag iris *(Iris prismatica*, S2) were recorded by DNHP. Both species are growing in closed canopy and would prefer more sun to expand populations (McAvoy and Coxe 2007). Several rare plants were inventoried in Atlantic white cedar/seaside alder saturated forest growing in association with Atlantic white cedar. These species included: seaside alder, *(Alnus maritima*, S3, G1), coast sedge *(Carex exilis*, S1), bayonet rush *(Juncus militaris*, S2), and flattened pipewort *(Eriocaulon compressum*, S2) (McAvoy 2007). Within coastal loblolly pine wetlands, the southern twayblade orchid's *(Listeria australis*, S3) distribution and abundance is significant. Two locales have been documented, with 500 to 1,000 plants occurring between both locations. This species can easily be overlooked due to its small size (15 cm/6 inches) and ephemeral nature (blooms in early spring and persists for only a few weeks). Also growing here is Walter's greenbriar *(Smilax walteri*, S3), an uncommon woody vine in Delaware that is an obligate wetland species and prefers swampy habitats. The fruit of Walter's greenbriar is red in color, as opposed to other greenbriar species with black fruit.

Table 3-10. Other Rare Plants found on Prime Hook NWR

Scientific Name	Common Name	State Rank	Habit & Duration	Wetland Indicator Status
Asclepias lanceolata	lance-leaf orange milkweed	S1	perennial broadleaf herb	OBL
Bartonia paniculata	twining bartonia	S2	annual broadleaf herb	OBL
Carex exilis	coast sedge	S1	perennial sedge	OBL
Carex typhina	cattail sedge	S3	perennial sedge	$FACW^{+}$
Conoclinium coelestimun	blue boneset	S3	perennial broadleaf herb	FAC
Eriocaulon compressum	flattened pipewort	S2	perennial broadleaf herb	OBL
Helianthus angustifolius	swamp flower	S3	perennial broadleaf herb	FACW
Helianthus giganteus	tall sunflower	S3	perennial broadleaf herb	FACW
Hudsonia ericoides	golden heather	S1	evergreen shrub	UPL
Iris prismatica	slender blue-flag	S2	perennial broadleaf herb	OBL
Juncus militaris	bayonet rush	S2	perennial aquatic rush	OBL
Listeria australis	southern twayblade	S3	perennial broadleaf herb	FACW
Passiflora lutea	passionflower	S3	herbaceous vine	UPL
Platanthera lacera	green-fringe orchis	S3	perennial broadleaf herb	FACW
Polygonum ramosissimum	bushy knotweed	S3	annual broadleaf herb	FAC
Pyrrhopappus carolinianus	Carolina false-dandelion	S3	annual broadleaf herb	UPL
Smilax walteri	Walter's greenbriar	S3	woody vine	OBL
Utricularia radiate	small swollen bladderwort	S3	perennial aquatic herb	OBL

Moist-Soil Management and Production

Moist-soil management provides plant and animal foods that are a critical part of the diet of wintering and migrating waterfowl and shorebirds, and has been a significant part of wetland management of the project area of Prime Hook NWR for the last 20 years. Native moist-soil wetland plants provide seeds and other plant parts (leaves, roots, and tubers) that generally have low deterioration rates after flooding and provide substantial energy and essential nutrients to wintering waterfowl, unlike common agricultural grains (corn, mile, soybeans) and nonnative cover crops (Strader and Stinson 2005).

Moist-soil management also supports diverse and abundant populations of invertebrates, which are an important protein source for waterfowl, shorebirds, and other waterbirds. For the moist-soil impounded habitats on the refuge, the annual seed yield production and foraging values greatly vary in each of the sampled areas from year to year depending on weather, rainfall patterns, and snow goose herbivory, which all affect moist-soil plant production, annual seed yields, and food availability for target bird species.

Water level manipulations make food resources available to waterfowl, shorebirds, and other wetland-dependent birds at critical times of the year. The plants and invertebrates available year-round in moist-soil impoundments provide food resources necessary for wintering and migrating birds to complete critical aspects of their annual cycles such as molt and reproduction.

During the past decade, the primary wetland habitat management focus of the refuge has been to increase the foraging carrying capacity of its impoundment complex for waterfowl and shorebirds using impoundment-specific strategies for water level manipulations (Fredrickson 1994). An integrated management approach using moist-soil management techniques has consistently generated annual seed production of moist-soil plants that provide a range from 689 to 2,630 pounds of native wetland plant seeds per acre within 4,000 acres of impounded marsh.

A seed estimator sampling technique was used to quantify annual moist-soil seed production as discussed in *Waterfowl Management Handbook,* chapter 13.4.5 entitled, "A Technique for Estimating Seed Production of Common Moist-soil Plants." For seven consecutive years, annual moist-soil seed production was monitored on the refuge within several impoundment subunits (PMH2A, PMH2C, PMH3A, PMH3B, PMH3D, and PMH4A), documenting the successful annual production of native plant food resources available to waterfowl and other wetland dependent bird species (table 3-11, Figure 3-1).

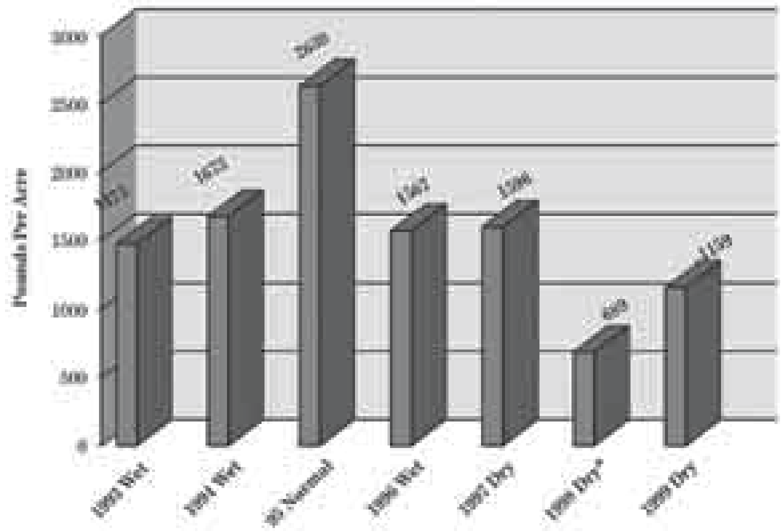
Table 3-11. Moist-Soil Production Data (Impoundments)

Comparison of Seed-Yields (lbs/acre) during Adverse Weather Conditions							
Year	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
PMH2A	1,442	3,020	2,229	2,290	1,574	1,567	962
PMH2C	5,443	2,572	5,147	2,524	2,778	0	484
PMH3A	0	1,671	2,891	872	1,740	458	1,159
PMH3B	1,306	1,670	2,470	2,001	1,548	158	667
PMH3D	0	0	799	648	949	948	596
PMH4A	648	1,107	2,246	1,069	985	0	0
Weather	WET	WET	NORM	WET	DRY	DRY**	DRY
Total Avg. Production	2,209	2,008	2,630	1,567	1,596	522	645

** *Extreme flood conditions in early winter followed by 6 months of extreme drought.*
{*Mean for wet years:* X_{wet} *= 1,928 lbs/acre*} {*Mean for dry years:* X_{dry} *= 921 lbs/acre*}
{*Grand Mean for all years = 1,425 lbs/acre*}

Quantified seed yields were estimated by measuring a few dominant moist-soil plants: *Echinochloa walteri* (Walter's millet), *Cyperus esculentus* (nutsedge), *Leptochloa fasicularis* (Sprangletop), *Panicum dichloromiflorum* (Fall panicum), *Polygonum* sp. (smartweeds), and *Setaria* sp. (foxtail) (Laubhan and Fredrickson 1992). Therefore, seed production estimates were very conservative as calculated, using the data contained in Prime Hook NWR's Annual Marsh and Water Management Program Reports from 1993 through 2000.

Figure 3-1. Average Seed Yields Sampled in Prime Hook NWR Impoundment Subunits



**Note: 1998 depressed seed yields were attributed to extreme drought conditions experienced during 6 months of the growing season preceded by a severe Nor'easter season.*

Invasive Plants

The presences of invasive plants can have a major adverse impact on the biological integrity, diversity, and environmental health of refuge lands and other natural areas.

Of the 426 plant taxa listed in refuge plant inventories, 45 are nonnative, of which 10 are considered to be invasive and negatively impacting native habitats. These include spotted knapweed, Canada thistle, kudzu, mile-a-minute, Japanese honeysuckle, river seedbox, Japanese stilt-grass, reed canary grass, alien common reed, usually referred to in this document as *Phragmites*, and multi-flora rose.

Spotted knapweed, Canada thistle, mile-a-minute, Johnson grass, and kudzu are restricted to roadside areas, fallow agricultural fields, edges of hedgerows, and early successional fields throughout the refuge. Japanese honeysuckle is ubiquitous throughout the refuge in mostly wooded habitats. Japanese stilt grass (about 50 acres) is mostly found on Oak Island, where it dominates the herbaceous layer.

River seedbox, a new addition to the flora of Delaware first discovered on the refuge in 2005, is an adventive plant species that has at times dominated portions of impounded marsh Unit III. River seedbox is native further south in the eastern United States but is not considered native in Delaware.

By fall 2006, this species had spread to about 500 acres in Units II and III impounded wetlands parallel to Prime Hook Beach Road. River seedbox is similar to alien common reed *(Phragmites australis)* in its aggressiveness. It is surmised that river seedbox became established on the refuge by waterfowl, who are attracted to this plant's large seeds. A single plant can produce thousands of seeds. One positive outcome of the May 11, 2008 nor'easter storm is that saltwater intrusion into river seedbox colonies has eliminated existing stands. As with all aggressive invasive plants, we must remain vigilant to their presence and spread and continue our active programs to control them.

Reed canary grass, which is another adventive species in Delaware, dominates an old field habitat in Unit III (corners of field 328). This is the same location where the State-rare plant, lance-leaf orange milkweed, grows. The lance-leaf orange milkweed is abundant here and is the largest known population in the State (100+ individuals). Current annual mowing late in the growing season appears to be favoring this milkweed species by suppressing woody vegetation. Encroachment by reed canary grass should be monitored and hand-treated. Multi-flora rose is widespread throughout the refuge, growing in scattered areas within hedgerows, thickets, early successional fields

***Phragmites* control**

Since the era of no management early in the refuge's history, *Phragmites* control has been a major concern and activity on Prime Hook NWR. From the late 1960s to 1982, *Phragmites* cover expanded by 34 percent and 3,000 acres of the refuge were covered in dense stands of *Phragmites* (Figure 3-2). In 1983, the refuge prepared an environmental assessment to deal with this problem. The assessment described a rehabilitation program to reclaim the 3,000 acres of *Phragmites*. The project's primary objectives were to chemically treat 2,000 acres in Unit II and 1,000 acres in Unit III and reduce the severe fire hazard near private property.

Figure 3-2. Condition of refuge marsh near Fowler Beach in 1978, showing dense stand of *Phragmites*

Prior to this rehabilitation project, the refuge conducted several years of research to find effective and economical methods to control *Phragmites* on Prime Hook NWR. Refuge staff began consulting and coordinating a refuge-specific *Phragmites* control program in June 1978 with representatives of Delaware, New Jersey, North Carolina, and Rhode Island fish and game departments.

During the initial coordination sessions, Prime Hook NWR was selected as a test area to be sprayed with the then-new chemical glyphosate (N-phosphonomethyl glycine). A pilot spraying program was granted and experimental use permit (24-EUP-29) issued by the EPA in 1978. From 1976 to 1982, the before-mentioned State agencies, Monsanto researchers, and refuge personnel consulted and coordinated research activities by experimenting and assessing the effectiveness of herbicide treatments to control *Phragmites*.

Biologists with the Delaware Division of Fish and Wildlife provided technical and physical assistance in conducting trial applications of glyphosate to assess its efficacy in several wetland plots on the refuge. Prior to these field tests, Monsanto had also conducted extensive field studies on the effects of glyphosate on fish, wildlife, and vegetation. Short-term and long-term toxicity tests had been conducted on a wide variety of aquatic, avian, and mammalian wildlife species. The aquatic test organisms included fresh and salt water species, as well as vertebrates and invertebrates. Waterfowl, upland game, fish, shrimp, and shellfish are some examples of the wildlife guilds included in these tests (USFWS 1983).

Acute (short-term) testing conducted on avian species, honey bees and fish showed that glyphosate was essentially non-toxic to these organisms. Chronic (long-term) toxicity tests also showed that glyphosate does not cause cancer, tumors, or reproductive problems in mammals (USFWS 1983). Further ecotoxicity studies of non-target impacts of glyphosate on birds, fish and aquatic life, mammals, and terrestrial invertebrates have demonstrated the same trends of minimal non-target effects (Sullivan et al. 1997). The most recent data for reregistration eligibility decision data for glyphosate maintain these past results of the nontoxicity of glyphosate on fish and wildlife species (NPIC 2011).

The timeframe for reclaiming Prime Hook NWR's marshes from *Phragmites* in the early 1980s was three years. From 1984 to 1986, approximately 3,000 acres were treated with consecutive double spray treatments between years and some prescribed fire used to reduce hazardous dead cane fuels. The program was a success.

Twenty years later, a second large-scale *Phragmites* control project was undertaken by the refuge to reduce or eliminate expanded stands located on refuge lands and private lands adjacent to the refuge. In close cooperation with the Delaware State Forestry Division and other partners, the refuge was funded for a three-year, million dollar wildland urban interface project, which was executed from 2002 to 2004. During that project, approximately 3,000 acres were treated on refuge lands and 1,000 acres were treated on private properties immediately adjacent to the refuge, resulting from the refuge partnering with 255 landowners in the Prime Hook, Broadkill, and Slaughter Beach communities.

Influence of Climate Change on Physical Environment and Refuge Management

Current Climate, and Local Coastal Storm Activity

Delaware's climate is generally mild, continental weather moderated by the effects of the Atlantic Ocean, causing brief periods of sustained hot or cold temperatures. Extreme temperatures are moderated by the Delaware Bay, the Atlantic Ocean and the Chesapeake Bay. On Prime Hook NWR, weather conditions are mild year-round with temperatures ranging from 32 ^{o}F to 80 ^{o}F. Normally, summer ocean breezes keep the refuge cooler than inland areas and most winter days are mildly attenuated by the same breezes.

Annual and seasonal precipitation is highly variable. Average annual refuge rainfall is 41.98 inches. Snowfall is usually light, averaging 10 to 15 inches per year. Prevailing winds from March through October are from the northwest except during summer months when they become more southerly. Prevailing winds from November through February are northeast. Average annual wind speed is about 9 miles per hour, but winds can reach 50 to 60 miles per hour or higher during summer thunderstorms, hurricanes, or intense winter northeasters. These climatic conditions correspond to USDA plant hardiness zone 7a. Native plant and ecological restoration biologists refer to the USDA zones for guidance in selecting appropriate species and planting times.

The entire refuge lies within Delaware's coastal zone and is subject to periodic flooding by coastal storms. Most of the refuge lies within the 100-year floodplain. The refuge's coastal environments such as beaches, barrier islands, wetlands and estuarine ecosystems are closely linked to the local climate conditions created by coastal storms. Stronger and more frequent coastal storms are posing immediate threats and challenges to impounded wetland management schemes used on the refuge in the last three decades.

Hurricanes are usually more powerful than coastal storms along the Atlantic Coast, but coastal storms are more frequent in Delaware, last longer, and impact larger areas. While hurricane season runs from June 1 to November 30, coastal storms called nor'easters are a year-round threat to coastal Delaware. Prolonged flooding and extensive property damage are serious hazards more associated with nor'easters than hurricanes along the Delaware coast.

In Delaware, tidal flooding, or storm surge, associated with a nor'easter can actually exceed the levels associated with hurricanes. Storm surge is the result of water being dragged onto the shoreline by the storm's strong winds coupled with very low atmospheric pressure at the storm's center. Storm surge heights of 3 to 10 feet above normal are especially damaging when they bracket several high tide full and new moon cycles. The torrential rainfall from nor'easters can also cause extensive flooding in both coastal and inland areas and increase coastal erosion of sandy beach ecosystems (Carey and Dalrymple 2003).

It has been documented in the past that normal daily tide cycles and coastal storm processes actively change the configuration of the coastline. Normal low-energy processes move small volumes of sand and are both erosional and depositional in nature. High-energy coastal storm processes involve large volumes of sediment movement (Kraft et al. 1976).

Delaware's most damaging coastal storm on record occurred over a three-day period and five extreme full moon, high tide cycles March 6 to 8, 1962. Winds reached speeds of 70 miles per hour. Offshore waves were recorded at higher than 40 feet, while waves in the surf zone were 20 to 30 feet high. The storm surge associated with the storm was 9.5 feet, the highest tide ever recorded in Breakwater Harbor (Lewes Tide Gauge) at the mouth of the Delaware Bay (Carey and Dalrymple 2003).

Coastal storms with sustained winds can lead to prolonged flooding of refuge impoundments and roads and increase the erosion of refuge dunes. The surge of storm water landward results in heavy saltwater intrusion of freshwater wetlands and adjacent upland habitats. Long-term geologic changes from these coastal storms include beach erosion, dune erosion, and possible inlet formation from stronger flood and ebb tide surges.

Wind and saltwater intrusion, nearshore channeling, and sedimentation associated with coastal storms also cause landscape changes. In the past, this scenario and associated geological changes may have been experienced every other decade. Overwash at barrier coastlines is determined by the height and wave parameters. In 1978, Maurmeyer noted that "barriers along the southwestern shore of the bay generally require tide levels in excess of 3.0 meters (about 9 feet) above mean low water, which occur approximately once in 25 to 30 years before they overwash."

Since the 1990s, the refuge has been experiencing more frequent nor'easter activity with multiple big coastal storms making landfall during a single season, creating more rapid landscape and coastal changes. For example, the coastal storms of December 10 to 14, 1991 and January 4, 1992 had associated storm surges of up to 8.5 feet above mean high water. After these two storms, washovers and breaching of dunes occurred at scattered locations along the Delaware Bay. Geologic observations made by Delaware Geological Survey (June 1992) included the following notes relevant about the refuge (Ramsey et al. 1992):

> *"The dunes were flattened between the north end of Prime Hook Beach and the south end of Slaughter Beach. Washovers were observed to extend 20 to 30 feet into the marsh throughout this area. An artificial earthen berm that originally stood approximately 8 to 10 feet high at the end of Road 199 at Fowler Beach was almost completely removed. Based on the relative position of a concrete structure at the south end of Fowler Beach (WWII tower) to the beach profile after the October 31 1991 storm and the January 4, 1992 storm, beach retreat in this area may be as much as 20 feet inland."*

Six years later, another set of back-to-back coastal storms occurred again on January 27 to 29 and February 4 to 6 in 1998. Recorded storm surges from 1999 topped the 1992 storm surges, peaking at 9.0 feet above mean higher high water. Both storms produced near-record high tides, but the January 28 storm was slightly higher than the February 5 storm; ironically, the February 5 storm was more damaging. From a comparison of Lewes Tide Gauge data, the February 5 storm was more severe because the low tides were exceptionally high before the storm developed off the coast. Of all the storms of record, even the 1962 storm, this particular phenomenon is very unusual and this makes this storm unique among those recorded to date in Delaware (Ramsey et al. 1998). Damage and erosion of artificial dunes was extensive, as the entire duneline was flattened and large overwashes developed similar to those of the 1992 storms.

Not until the category one hurricane Ernesto in 2006 did a distinctive inlet form north of Fowler Beach Road in 2006. A relatively mild storm, Ernesto made landfall with little rain. However, Ernesto blew off shore for several days, generating higher than normal tide cycles that intensified flood and ebb tide water surges even before making landfall. Since Delaware Bay is a relatively shallow body of water, waves build up more quickly than in the open Atlantic (Kraft et al. 1976). The water level continued to rise and waves attacked the shoreline for several days with increasing intensity. Finally, when landfall did occur, a new inlet broke through the refuge's sandy barrier in Unit I.

A year and half later, a severe Mother's Day coastal storm on May 11, 2008, caused considerable coastal erosion and overwashed all refuge marshes in Units I and II. One year later, two more back-to-back nor'easters occurred on October 15 to 19 and then November 12 to 15, 2009. Both nor'easters generated tide surges of 9.0 feet above mean higher high water. Sand in the form of washover fans was transported across the flattened beach dunes back into the adjacent marsh and a new tidal water flow channel was created in Unit II just south of Fowler Beach Road. Several tide cycles after the second storm hit, high tide cycles continued to pile water across the barrier, intensifying flood and ebb tide water surges that etched out two additional mini-inlets further south of the first inlet, across the Unit II duneline.

The increased frequency and severity of coastal storms over the past decade has a direct impact on the management options and capability along the refuge shoreline and in the adjacent coastal wetlands.

Climate Change, Sea Level Rise and Refuge Shoreline Dynamics

In 2007, the Intergovernmental Panel on Climate Change (IPCC) projected that average global sea level will likely rise between 19 and 59 centimeters (7 and 23 inches) by the end of the century (2090 to 2099), relative to the base period (1980 to 1999), excluding any rapid changes in ice melt of Greenland and Antarctica ice floes. According to the IPCC, the average rate of global sea level rise is very likely to exceed the average rate recorded over the past four decades [IPPC Fourth Assessment Report-AR4] (USCCSP 2009).

The U. S. Climate Change Science Program (USCCSP) has generated a synthesis and assessment report in 2009 (product 4.1) determining coastal sensitivity to sea level rise and climate change scenarios with a focus on the mid-Atlantic region. Accelerated rates of sea level rise with stronger and more frequent storms pose increasing impacts to coastal communities, infrastructure, beaches, wetlands, and natural ecosystems.

Two major processes cause global mean sea level rise: ocean temperature increases causing water to expand and increase in volume, and land reservoirs of glaciers and ice sheets melt due to rising earth temperatures.

At the same time, the land in coastal areas is subsiding. When the rates of actual sea level increase is combined with the subsidence of land areas, scientists add these two factors and refer to the total as “relative sea level rise”, i.e. that the actual impact is the net of the two processes

Global sea level rise rates rose to an average of about 1.7 mm/year over the twentieth century. However, in the mid-Atlantic region from New York to North Carolina, tide-gauge observations indicate that relative sea level rise rates ranged from 2.4 to 4.4 mm/year, or about 0.3 meters (1 foot) during the same time frame (USCCSP 2009), which is higher than the global mean. Although the body of research supporting concerns regarding global climate change and sea level rise is substantial, the Service recognizes that there is not necessarily worldwide scientific consensus regarding global or even regional sea level rise rates and predictions (CITATIONS). Locally in Delaware, the rate of relative sea level rise has been estimated to be 3.2 ±0.28 mm/yr, (2.92 – 3.48 mm/yr, 95% confidence interval), which is approximately 1.5 mm/yr higher than the average global rate of seal level rise alone (NOAA Lewes, DE, Tide Gauge: *http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8557380;* accessed August 2012).

It is this current, local rate of sea level rise which will direct many of the refuge’s management decisions regarding achieving sustainable future conditions along the refuge shoreline and coastal wetlands. However, scientific projections for the 21st century are even higher, with predicted global sea level increase rates ranging from 2 to 7 mm/year (Rahmstorf 2007). Increasing sea level rise would greatly stress coastal wetlands, leading to either accelerated migration landward or wetland disintegration. Quantitative predictions of these future coastal changes remain difficult due to the complexity of coastal systems (Ashton et al. 2007). Predicting sea level rise impacts on shoreline changes or associated wetland losses with quantitative precision and certainty is not yet possible. If existing wetland habitats cannot keep pace with sea level rise through vertical accretion, the result will likely be extensive loss of coastal wetland habitats on the refuge and across the mid-Atlantic. Also the quality, quantity, and spatial distributions of other coastal habitats will change as a result of erosion, shoreline and salinity changes, and wetland loss (USCCSP 2009).

Regardless of the future rate of sea level rise locally, it is not simply a rise in sea levels, per se, that poses the most significant threat to refuge management. Higher sea levels will also provide an elevated base for storm surges to magnify flooding effects and diminish the rate and capability at which low-lying coastal areas can drain water. This will further intensify the magnitude of flooding and erosion effects from coastal storms. Rapid sea level rise will exacerbate existing problems experienced by coastal areas from waves, storm surges, shoreline erosion, wetland loss, and saltwater intrusion.

Natural coastal ecosystems evolved under conditions of sea level rise. Barrier islands and salt marshes can sustain their features, but not necessarily their location or configuration, in the face of more frequent coastal storm events, provided they are healthy and processes such as vertical accretion are not hindered.

Increased coastal storm-generated wind, waves, and higher astronomical tides will continually modify and change the refuge's physical shoreline and sandy beach templatesthrough breaching (inlet formation) and overwash processes with greater frequency. The refuge's undeveloped barrier island habitats may become completely reconfigured geomorphologically after each coastal storm. This reconfiguration will directly affect habitat availability and functionality and contribute to the redistribution of sediment along sandy beaches, shorelines, and refuge back barrier wetlands. This is how coastal ecosystems adjust to climate change, sea level rise, and more frequent storm surges (USGS 2010). Narrow, low-elevation barrier island communities, as found on the refuge, will become more susceptible to storm overwash development, barrier segmentation, the formation of new tidal inlets, and closing of previous inlets. These physical and geomorphic responses expedite landward migration or roll-over of shorelines as they readjust their equilibrium position in relation to rising sea levels and local storm conditions (USGS 2010).

In the past, the refuge coastal area was generally managed under the premise that sea level was relatively stable, shorelines remained static, and storms were regular and of predictable magnitude. Significant changes along the shoreline happened infrequently, and were considered to be unusual events. Within that scenario, little to no thought was given to shoreline and coastal monitoring or management. However, today it is recognized that refuge shoreline dynamics will be increasingly dominated by overwash and inlet processes as the coastline responds to the increased storm frequency and severety and relative sea level rise associated with climate change.

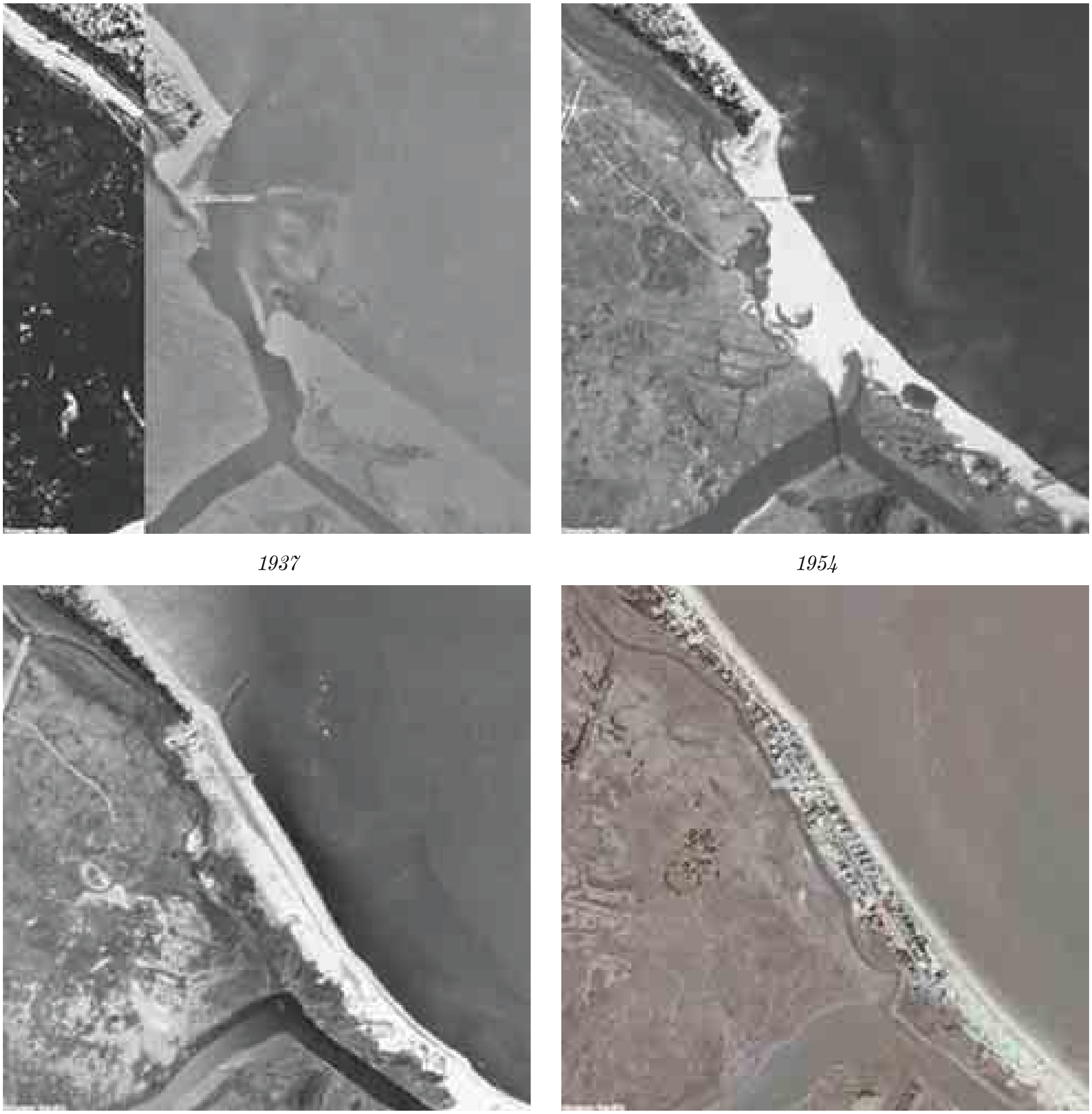
Refuge Shoreline Dynamics

Overwash and inlet processes are both integral parts of shoreline dynamics. Overwash processes deposit large sand fans across the beach and adjacent wetlands and serve to build barrier island elevation, widen beach width, and accrete sand in back barrier marshes. Storm overwash events assist in expanding barrier island width and also contribute to island roll-over or migration landward. Overwash deposition in many studied barrier island marsh systems have increased sedimentation rates that have promoted relatively stable marsh communities by enhancing vertical accretion mechanisms in the face of increased local rates of sea level rise (Ashton et al. 2007). Throughout Delaware, evidence of these coastal processes is prominent in the historic aerial imagery (appendix J). For example, portions of the Broadkill Beach community are constructed on sediments deposited naturally by the closure of an inlet that was present as recently as the 1940s (Figure 3-3). The formation, recovery, and reformation of overwashes in the Fowler Beach area is illustrated in figure 1-1 in chapter 1.

Inlet formation is also vital to the short-term maintenance of barrier island ecosystems and their estuaries, and long-term barrier island evolution necessary to maintain and conserve coastal wetlands (Mallinson et al. 2008). Once an inlet is created, usually during a storm event, active flood and ebb tide deltas form in association with an inlet. As the inlet closes, the ebb-tide delta collapses, causing temporary and localized shoreline accretion while adjacent shoreline areas may erode (map 3-7).

The floodtide delta, which provides a platform for the colonization of salt marsh, is abandoned and the marsh redevelops behind the newly positioned shoreline. This increases the barrier island's width and continues the evolutionary succession of the barrier island, while facilitating the vertical accretion of back barrier wetlands (Mallinson et al. 2008).

Figure 3-3. Former inlet at south end of Broadkill Beach, dated 1937, 1954, 1968, and 2007 showing pattern of natural inlet filling, overwash, revegetation, and subsequent island community development



1937 *1954*

1968 *2007*

The most important impacts on the physical environment resulting from overwash and inlet formations are the natural transport and deposition of sand to back barrier wetlands. Overwash fans and inlets that develop across wetlands and adjacent beaches are in equilibrium with the coastal dynamics of rising sea levels, more frequent storm surges, and local geomorphic conditions. If a barrier island is not allowed to roll back or migrate landward and provide back barrier marsh environments with the only potential to accrete sand, the barrier island shoreline will eventually collapse and back barrier marshes will not be able to keep up with sea level rise.

Map 3-7. Development of Overwash and Breaches near Fowler Beach

Where shoreline regression landward is not allowed, sea level rise can expedite coastal fringe marshes reverting to open water habitats sooner and quicker. Where wetlands are degraded, the reversion to open water can be even more rapid. As described in more detail in the next section, this disruption of natural coastal processes and resulting consequences in adjacent wetlands has become evident in the impoundment complex on the refuge.

Climate Change Adaptation and Vulnerability Assessment of Refuge Wetland Impoundments

Climate change and associated impacts such as sea level rise and increased storm frequency and severity are proving to be the defining wetland management issue for the refuge, increasing our challenges to managing the refuge's impounded wetland complex. Future climate change adaptation strategies used by the refuge must anticipate an increasingly different physical environment than the one in which we managed our impounded marshes from 1988 to the present. Numerous factors associated with climate change and coastal processes are interacting to affect the refuge's ability to conduct wetland management as it has been for recent decades, particularly in Unit II.

During the last phase of establishing the refuge impoundment in Unit II in 1988, DNREC required that the Service build up the duneline from the last house in Slaughter Beach (Unit I) to the first house on Prime Hook Beach in Unit II, which incorporated about 3 miles of shoreline. Although the Service felt it was not necessary, the State of Delaware reconfigured the natural barrier island berm in 1988 in anticipation of the potentially erosive effects of natural barrier beach movement. Artificial dunes were again rebuilt in 1992, 1998, 2006, and 2008 by the State, in coordination with the refuge. In 2006, a breach (mini-inlet) developed across the Unit I duneline, and in 2009 several breaches (1 large and 2 smaller inlets) of the duneline across Unit II occurred (map 3-7). Efforts to restore the dune line one more time while management and restoration plans could be developed were made by DNREC, in coordination with the refuge, in September 2011. However, Hurricane Irene (August 2011) had further depleted the affected shoreline of sand and the dune restoration failed shortly after completion, during a period of high tides and strong winds. As of the completion of this final CCP/EIS, the Unit II shoreline contains several persistent breaches, permitting salt water to continue entering Unit II. Much of Unit II has converted to open water as a result.

Numerous factors are influencing our management capability and the response of the managed wetland ecosystem. We have been striving to better understand the various components of this comprehensive system, which includes natural elements and processes as well as human-controlled infrastructure. Information about the state of the ecosystem, the physical processes at work, and the management investments that would be necessary to maintain the Unit II impounded marsh are outlined below. Although these management challenges most imminently affect Unit II, it is clear that the future of management in Unit III will be affected by these same factors.

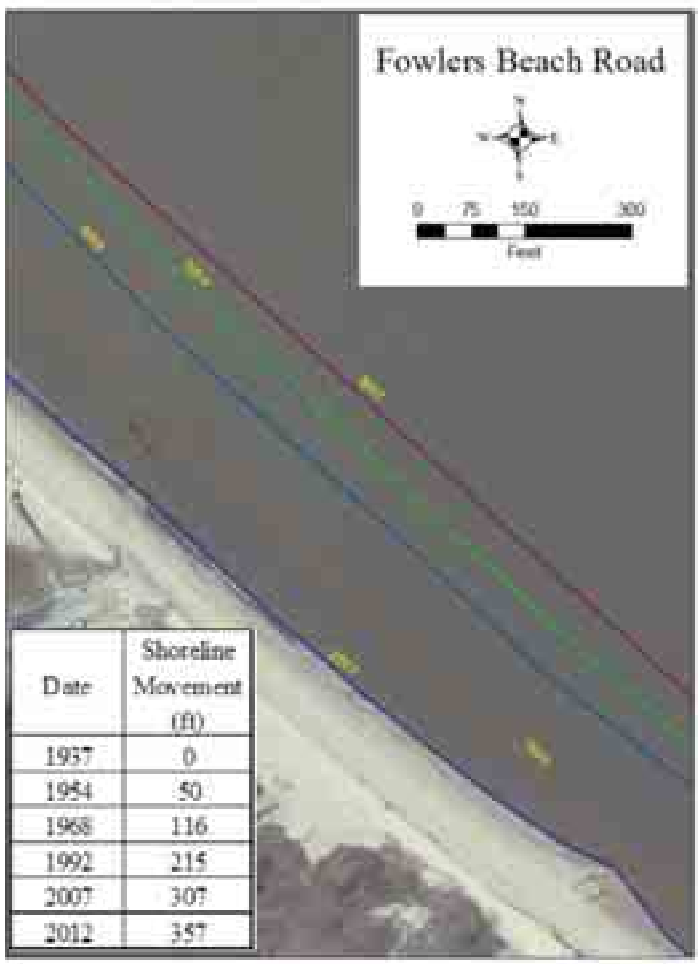
Washover and Beach Migration:
Starting in 2006 with tropical storm Ernesto, the natural beach barrier has been breached or overwashed numerous times. The physical forces that shape, move, and maintain barrier beach systems have been recognized by many government agencies and studied by coastal geographers for decades. Lewis et al. (2005), described the nature of fetch limited barrier islands, or those barrier islands typical of estuaries, in contrast to the ocean front. Of particular note is the relatively thin veneer of sand laid over a salt marsh base and the lack of significant wave energy outside of storm events necessary to maintain a relatively consistent beach profile. Large, continuous dunes, such as found along the Atlantic Ocean coast, are rare in estuarine environments.

Fetch limited barrier islands are backed by salt marshes and maintained in part by the overwash of beach and marine sediments. The direction of beach movement as periodic storms occur is landward. These events are natural and outside the control of refuge management. However, they impact refuge coastlines through creation of overwashes and landward migration of the shoreline. It is well established that these processes are natural and beneficial to salt marsh communities (Ashton et al. 2007), and are common along the Delaware Bay shoreline (Appendix J).

The rate of erosion and landward migration of the refuge shoreline along Unit II, in the vicinity of Fowler Beach, from 1937 to 2012 has been quantified using a series of historic aerial images (DNREC Coastal Programs unpub. data), and more recently ground measurements and observations (Psuty et al. 2010). It has been clearly demonstrated that the rate of shoreline erosion and retreat has been increasing during that time frame. Whereas the shoreline at Fowler Beach eroded 50 feet in the 17 years between 1937 and 1954, it later eroded 50 feet in only 5 years between 2007 and 2012 (Figure 3-4). The rate of erosion between 1937 and 1954 was under 3 feet/year, and increased steadily to a rate of 10 feet/year between 1997 and 2012 (Figure 3-5). This non-linear increase in the erosion rate will be problematic for refuge management for many years into the future (Figure 3-6).

In 2011, the refuge began tracking shoreline position seasonally following a detailed protocol developed and used widely by the National Park Service (Psuty et al. 2010). That protocol will allow more detailed observation of seasonal and annual changes in shoreline position, as well as shoreline responses to management and restoration actions in the future.

Figure 3-4. Shoreline erosion in the vicinity of Fowler Beach Road in Unit II. Shoreline position from 1937 was determined using aerial imagery. Shoreline position in 2012 was determined through ground measurements and observations (Courtesy of DNREC Delaware Coastal Programs)



Date	Shoreline Movement (ft)
1937	0
1954	50
1968	116
1992	215
2007	307
2012	357

Figure 3-5. Annual shoreline erosion rates in the vicinity of Fowler Beach Road in Unit II. Shoreline position from 1937 was determined using aerial imagery. Shoreline position in 2012 was determined through ground measurements and observations (Courtesy of DNREC Coastal Programs)

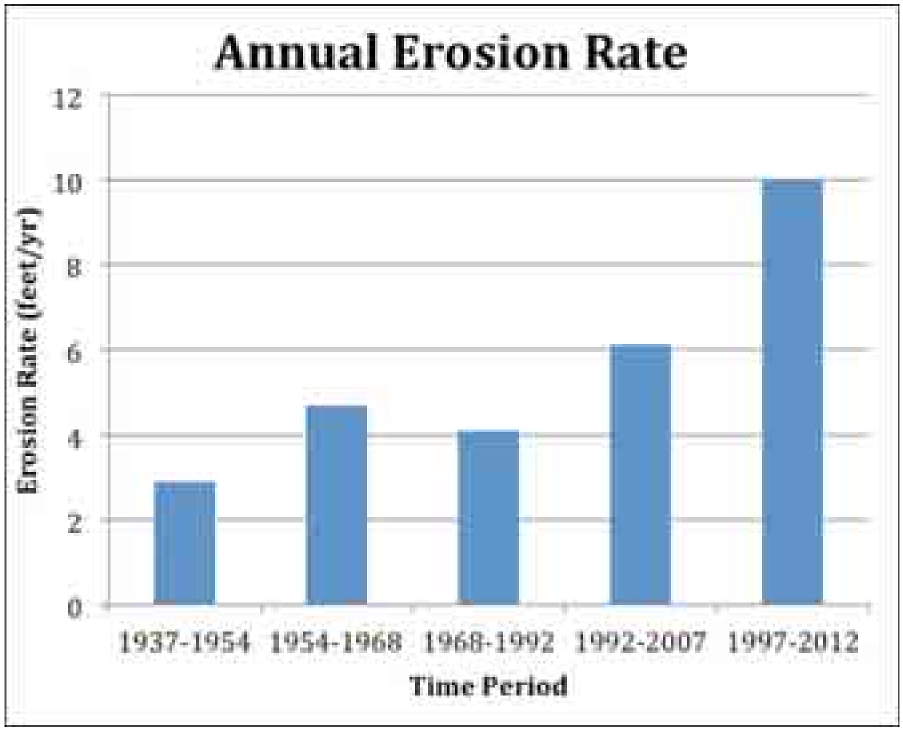
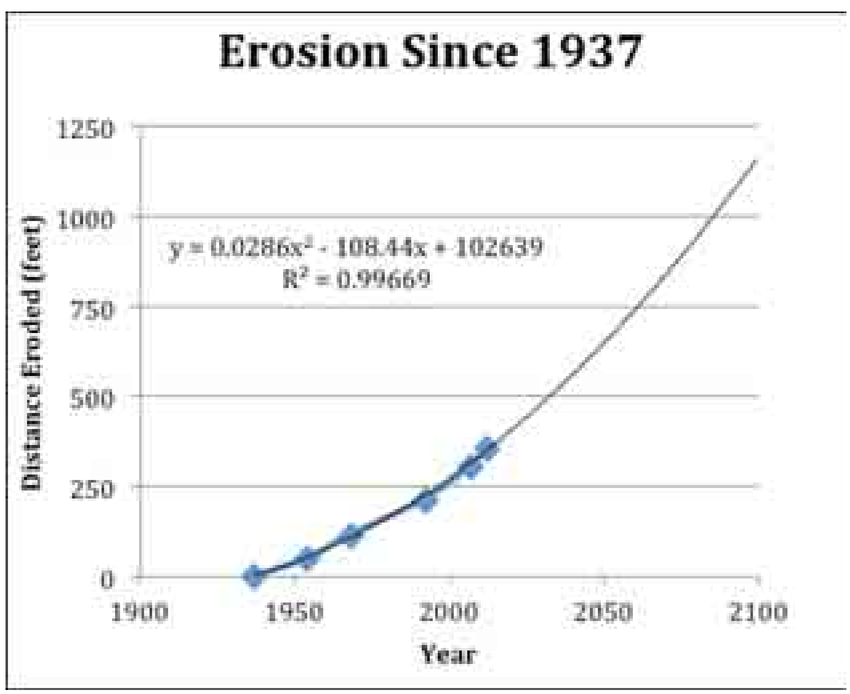
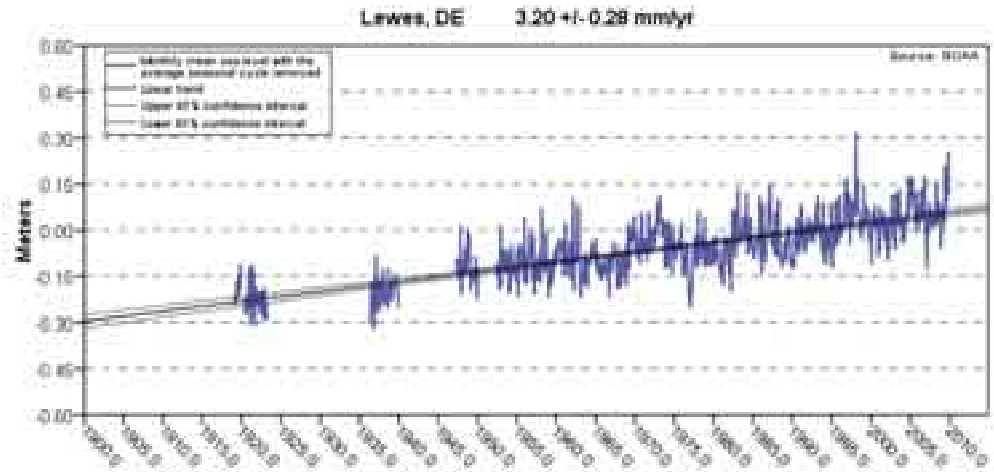


Figure 3-6. Trend of increasing annual shoreline erosion rates in the vicinity of Fowler Beach Road in Unit II. Shoreline position from 1937 was determined using aerial imagery. Shoreline position in 2012 was determined through ground measurements and observations (Courtesy of DNREC Delaware Coastal Programs, unpublished data)



Sea Level Rise:
Sea levels have been rising due to melting of major ice sheets after the last major glaciation 20,000 years ago and thermal expansion of ocean water as it warms (CCSP, 2009). The Atlantic coast was located about 180 miles to the east of its present location during the immediate post-glacial period and the ocean has risen over 100 meters (330 ft) since that period. Currently, the average annual local sea level rise (Figure 3-7), as measured at the NOAA tide gauge in Lewes, is 3.20 mm/yr since 1919, or 1.05 ft. in 100 years *(http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8557380;* accessed January 2012).

Figure 3-7. Mean Sea Level Trend for NOAA Tide Station 8557380–Lewes, Delaware Increasing Frequency of Above Average High Tides

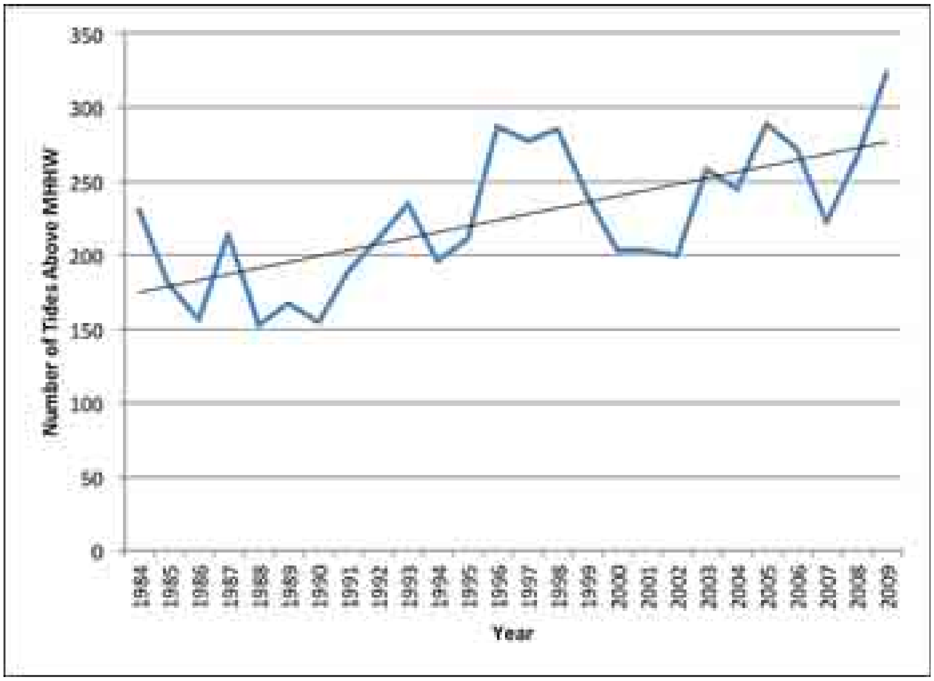


No official tide data is currently being collected on or in the immediate vicinity of the refuge. Tide data for the nearby gauge at Lewes (DISTANCE) have been collected by NOAA since 1919. Although tides at the Lewes station are likely to read somewhat lower than at the refuge for high tide, the data will be adequate for analysis of long-term trends. We acquired the daily high and low tide data for Lewes for the period 1984 to 2009. We selected this period because all data were available in a format relative to a single baseline elevation, referred to as an epoch, and coincides with the history of impoundment management on the refuge. NOAA's Web-based interface *(http://tidesandcurrents.noaa.gov/;* access January 2012) outputs all high and low tides in relation to the mean higher high tide, or the average of the higher of two high tides that occur per day. We extracted all individual tidal events falling at or above mean higher high water. Figure 3-8 plots the total number of individual events by year for the period 1984 to 2009, and shows an increase over time in the frequency of higher than average tidal events. The total number of individual events above mean higher high water ranged from a low of 152 in 1988 to 323 in 2009.

©Kevin Fleming

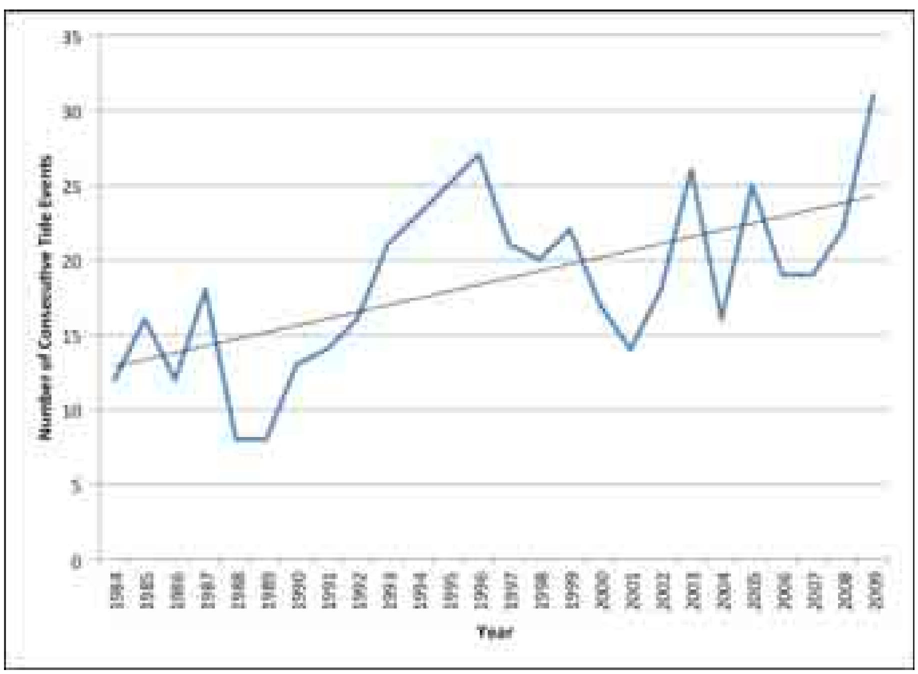
Short-billed dowitchers

Figure 3-8. Number of Individual High Tides Per Year Above MHHW Recorded at the Lewes, DE Tide Gauge



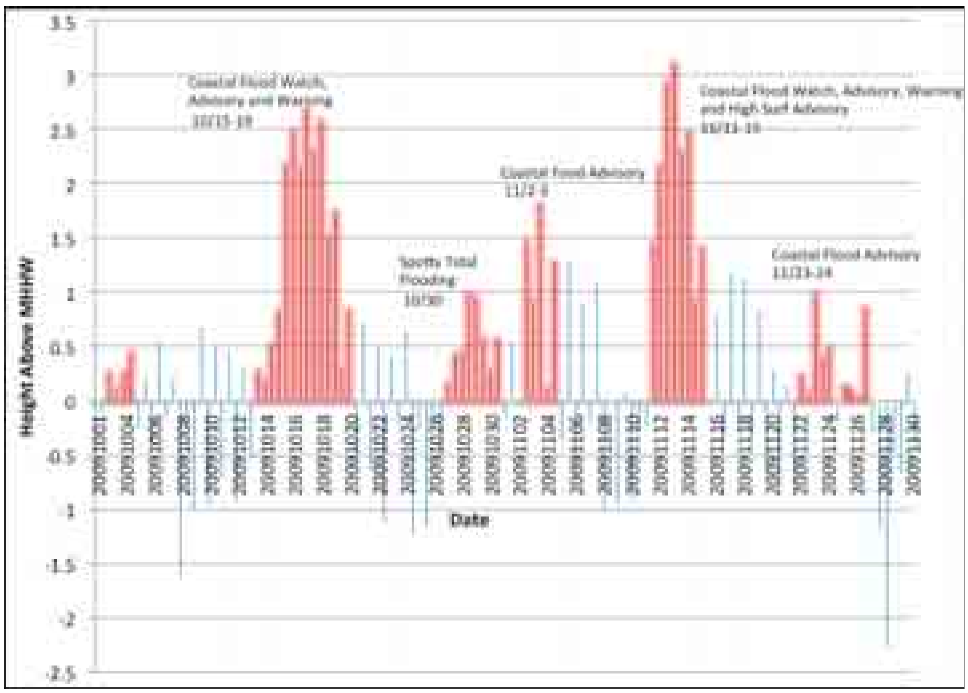
We also compiled consecutive above-normal high tide events, which are two or more consecutive high tides that were recorded at or above mean higher high water. Figure 3-9 shows an increase over time of the frequency of these events. The consecutive events ranged from 2 to 24, or the equivalent of 1 day to 12 days of consecutive high tides above mean higher high water. The total number of such events ranged from 8 in 1988 and 1989 to 31 in 2009.

Figure 3-9. Number of Consecutive High Tide Events Above MHHW Per Year Recorded at the Lewes, DE Tide Gauge



These figures show a general trend toward a higher frequency of individual above-average high tides, but perhaps more importantly, a higher frequency of consecutive above-average tides. This has important implications for the dynamics of tidal flooding, overwash, and beach migration along the Delaware Bay shore. More frequent periods of sustained high water in combination with high wave energy associated with storms contribute to erosion and overwash of natural beaches. To illustrate one period of particularly active high tide events, we have graphed all high tides occurring during October to November 2009 (Figure 3-10). The zero line on the Y axis represents mean higher high water. All highlighted red lines above mean higher high water represent periods of consecutive above average tides. The periods range from 4 to 14 consecutive tides, or the equivalent of 2 to 7 days. As noted, five of the seven highlighted periods were accompanied by NOAA coastal flood watches, advisories, warnings, and in one case during the period November 11 to 15, a high surf advisory. Much of the undeveloped region along the Delaware Bay shore sustained significant breaching and overwash during these events. As a result of a breach, much of refuge Unit II was opened to daily tidal flow.

Figure 3-10. Consecutive High Tide Events Above MHHW During Oct–Nov 2009



Wetland Elevation:
Under natural conditions, salt marshes build elevation by trapping sediment during flood events, building up below ground biomass (e.g. roots and rhizomes), and accumulating organic matter (Cahoon et al. 2009). The accretion of marsh elevation must be maintained in relation to sea level or the marsh will drown, deteriorating and leaving open water in its place. Analysis of sediment cores for the presence of radioisotope fallout (^{137}Cs and ^{210}Pb) deposited at a known time in the past can provide a measure of marsh accretion over recent decades. Preliminary data from radiometric coring conducted by DNREC's Coastal Program, in partnership with the University of Delaware (UD), indicate that the salt marshes in refuge Units I have been accreting over approximately the last 50 years at a rate nearly equal to or greater than the current local sea level rise

of approximately 3.2 mm/yr (Figure 3-11). However, the average rate of accretion for the same period in the Unit II is 1.7 mm/year, nearly half of the sea level rise rate.. While the average accretion rate for the southern half of Unit III was determined to be 3.85 mm/year, a core in the northern half of Unit III suggests accretion in that portion is only 1.6 mm/year – the lowest recorded anywhere in the state of Delaware during the DNREC/UD study (Figure 3-11). It should be noted that these estimated accretion rates are an average for about the past 50 years, and the current management regime has only been in place for a portion of that time.

Figure 3-11. Historic accretion rates within refuge wetlands and impoundments as determined by analysis of radiometeric core (137Cs content). (Courtesy of DNREC Delaware Coastal Programs and University of Delaware, unpublished data).

In addition to radioisotopic cores, the Delaware Coastal Program conducted elevation surveys of the various wetland units utilizing real-time kinematic GPS survey techniques. The surveys documented the difference in elevation between the wetland vegetation and open water areas. In some areas, less than an inch of elevation stands between the existing vegetation and open water/mud flat (appendix K). Marshes with such a small amount of elevation capital are the most vulnerable to increases in sea level (Cahoon and Guntenspergen 2010). As of the preparation of the final CCP/EIS, elevation/bathymetric data throughout the wetland complex was being updated again using new sonar technology ideal for collecting such data in shallow water environments. Because the elevation of the impoundments is barely above sea level, they are susceptible to salt water inundation in the short term during coastal storm events, unless and until additional sediment is present to increase the elevation. New and proposed marsh elevation monitoring (surface elevation tables and marker horizons) on the refuge will add additional critical data to our understanding of short-term accretion within the impoundments under current management regimes, as we evaluate refuge wetland management options, and as we monitor the impacts of future management actions.

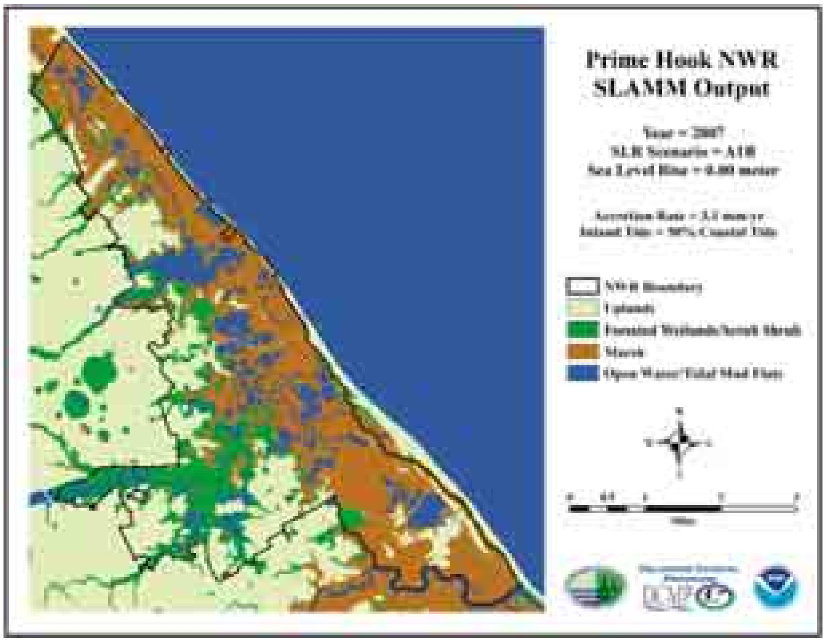
The potential effects of sea level rise on refuge land cover have been modeled through the sea level affecting marshes model (SLAMM) effort described in chapter 2. The model was applied utilizing inputs representing a range of possible future scenarios. It is anticipated that the reality could fall anywhere within these predicted outcomes. As an example, if sea level rises as predicted by the A1B greenhouse gas emission scenario in the Special Report on Emissions Scenarios (IPCC 2000), the total sea level increase on the refuge would be 0.50 meters in 100 years. If the model assumes that salt marsh accretion keeps pace with current sea level rise rates and that there is full tidal influence along the coast, then the refuge is predicted to lose more than half of its marsh and the amount of open water and tidal mudflat (combined) will more than quadruple (Figure 3-12). If the model assumes that salt marsh accretion will increase to 5.0 mm/yr, keeping pace with sea level rise as salt marshes often can, then the loss of marsh is small and conversion to open water and tidal mud flat are not as pronounced (Figure 3-12). In both cases, more than half of the upland is predicted to be lost. The primary difference is whether or not the remaining areas are maintained in some form of wetland cover or are converted to open water, which may depend on marsh accretion processes. Under each sea level rise and marsh accretion scenario, if the model assumes that coastal dunes will instead be maintained, these predictions do not change appreciably. Results for additional scenarios, such as an increased rate of sea level rise, can be found in Scarborough (2009).

An updated version of SLAMM (6.0.1) is now available, but was not available at the time the analysis was completed for the refuge. Although modeling data should be considered with caution, as high levels of uncertainty and unforeseeable factors can significantly alter model output projections and habitat predictions for the future, the results of this modeling effort can give us a general sense of how climate change and sea level rise will likely affect refuge habitats in the future. The potential land cover changes predicted by the SLAMM modeling are considered in the development of management objectives and strategies (chapter 4). However, these modeling results are certainly not the primary factor driving evaluatoins of shoreline and wetland management regimes on the refuge, as the refuge increasingly has current locally collected data to rely upon.

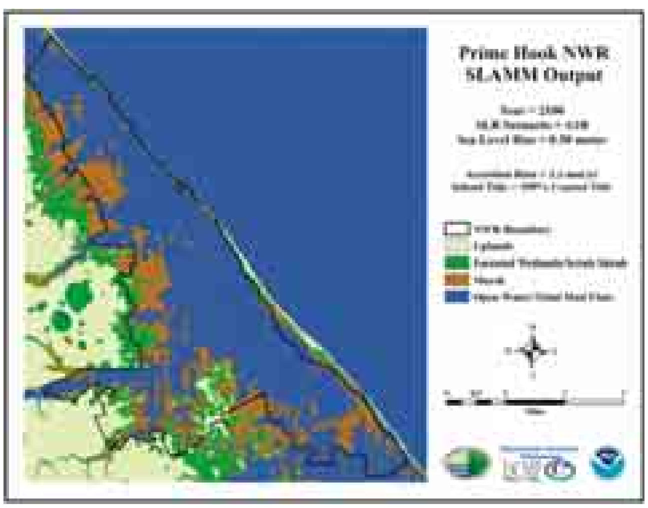
Diamondback terrapin

Figure 3-12. Selected SLAMM Output Maps from Scarborough 2009. (A) = Current (2007) land cover; (B) = 2100 Predicted land cover assuming 0.5 meters of sea level rise, marsh accretion keeping pace with current sea level rise (3.1 mm/yr), and full tidal influence

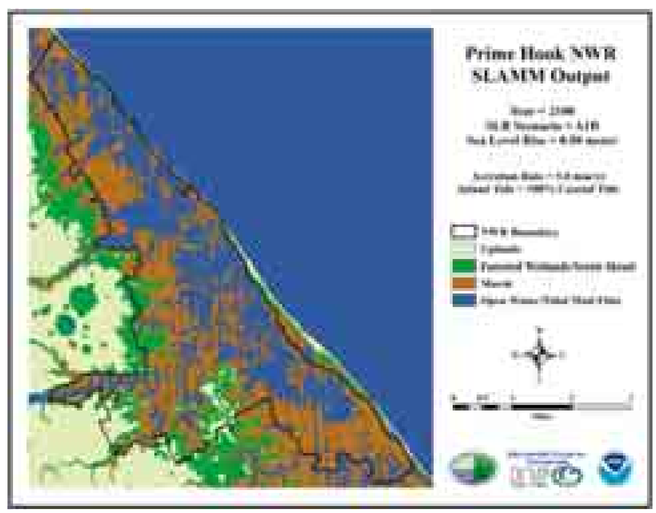
(A)



(B)



(C)



The Cost of Infrastructure Rehab/Replacement:
To maintain Unit II as a freshwater system, it is anticipated that significant infrastructure rehabilitation or replacement would be necessary. A cost analysis included three factors: dune construction, water control structure redesign and replacement, and elevating two State roads, Fowler Beach Road and Prime Hook Road.

Dune Construction
No formal beach management plan has been developed for Prime Hook NWR beaches. However, we can use the data provided in the management plan for Delaware beaches completed in March 2010 to make some rough estimates. Table

3-12 provides estimates for design, permitting, construction, and monitoring of existing sand dunes within the neighboring communities of Slaughter Beach and Prime Hook Beach. Design scenarios and their associated costs are estimated based on the projected average return interval of storm events that result in a particular degree of severity and resulting storm damage. The State's analysis considered the dune design that would be required to withstand a 5 or a 10-year storm. For example, a five-year storm is a severe storm that is expected to hit our area one year in five. Another way of stating it is that there is a 20 percent chance that we will experience a five-year storm in any given year. Similarly, one can expect a 10-year storm on average once every 10 years, or a 10 percent chance of having the storm in any one year. The actual number of years between storms of any given severity varies because of the naturally changing climate. It is possible to have more than one five-year storm in a year. Therefore, beaches that endure damage from successive five-year storms would require reconstruction on a more frequent basis. In addition to the 5 and 10-year scenario, the State has projected costs for strategic fill, i.e., fill placed along the specific locations of greatest need.

American oystercatcher

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Table 3-12. Cost Estimates from DNREC Beach Management Plan Associated with Dunes within Slaughter Beach and Prime Hook Beach communities

	Prime Hook Beach					Slaughter Beach				
Strategic Fill Placement	**Budget Estimate**									
Project Element	**FY10/11**	**FY11/12**	**FY12/13**	**FY13/14**	**Total**	**FY10/11**	**FY11/12**	**FY12/13**	**FY13/14**	**Total**
*Geotechnical Investigation	$45,193.00				$45,193.00	$139,802.00				$139,802.00
*Design/Permitting	$22,596.00				$22,596.00	$69,901.00				$69,901.00
Construction				$416,835.00	$416,835.00				$499,975.00	$499,975.00
Env. Permit Monitoring				$17,500.00	$17,500.00				$17,500.00	$17,500.00
Beach Survey	$8,000.00	$8,000.00	$8,000.00	$8,000.00	$36,000.00	$16,000.00	$16,000.00	$16,000.00	$16,000.00	$64,000.00
Total	$75,789.00	$8,000.00	$8,000.00	$442,335.00	$534,124.00	$225,703.00	$16,000.00	$16,000.00	$533,475.00	$791,178.00
5 Year Scenario										
Project Element	**FY10/11**	**FY11/12**	**FY12/13**	**FY13/14**	**Total**	**FY10/11**	**FY11/12**	**FY12/13**	**FY13/14**	**Total**
*Geotechnical Investigation	$45,193.00				$45,193.00	$139,802.00				$139,802.00
*Design/Permitting	$22,596.00				$22,596.00	$69,901.00				$69,901.00
Construction				$787,800.00	$787,800.00				$2,112,800.00	$2,112,800.00
Env. Permit Monitoring				$35,000.00	$35,000.00				$70,000.00	$70,000.00
Beach Survey	$8,000.00	$8,000.00	$8,000.00	$8,000.00	$36,000.00	$16,000.00	$16,000.00	$16,000.00	$16,000.00	$64,000.00
Total	$75,789.00	$8,000.00	$8,000.00	$830,800.00	$922,589.00	$225,703.00	$16,000.00	$16,000.00	$2,198,800.00	$2,456,503.00
10 Year Scenario										
Project Element	**FY10/11**	**FY11/12**	**FY12/13**	**FY13/14**	**Total**	**FY10/11**	**FY11/12**	**FY12/13**	**FY13/14**	**Total**
*Geotechnical Investigation	$45,193.00				$45,193.00	$139,802.00				$139,802.00
*Design/Permitting	$22,596.00				$22,596.00	$69,901.00				$69,901.00
Construction				$1,522,800.00	$1,522,800.00				$3,680,800.00	$3,680,800.00
Env. Permit Monitoring				$35,000.00	$35,000.00				$70,000.00	$70,000.00
Beach Survey	$8,000.00	$8,000.00	$8,000.00	$8,000.00	$36,000.00	$16,000.00	$16,000.00	$16,000.00	$16,000.00	$64,000.00
Total	$75,789.00	$8,000.00	$8,000.00	$1,565,800.00	$1,657,589.00	$225,703.00	$16,000.00	$16,000.00	$3,766,800.00	$4,024,503.00

*Notes: The costs for these items are proportional to total volume placed for all of the seven communities included in this management plan

Renourishment costs based on restoring 60 percent of initial volume to restore historic losses; costs are based on work being performed on a regional basis; costs shown are in July 2009 prices.

The costs range from $534,124 to $1,657,589 for the three scenarios at Prime Hook beach, and from $791,178 to $4,024,503 at Slaughter Beach. We have no cost estimates at this time for dune construction along the overwashed portion of Unit II barrier beach. The combined linear footage of privately and refuge owned beach along Unit II, of which only 60 percent is refuge owned, is approximately 1.5 miles. The 5 and 10-year scenarios at Prime Hook Beach are to be conducted along nearly 1.5 miles of beach, as well. It would therefore be reasonable to expect that the costs of constructing a dune along Unit II would be comparable with the costs of dune construction at Prime Hook Beach.

There are, however, some very important differences between the Prime Hook and Unit II beaches. First, active beach management has been occurring at Prime Hook beach to some degree throughout the years. Prime Hook beach has an intact dune system that is currently elevated several feet above mean high water. Conversely, the Unit II barrier has largely succumbed to natural overwash events, leaving small isolated dunes. The berm typically overwashes over much of its length during storm events. Additionally, there are 2 active inlets, currently on private land, that receive at least some tidal flow during most high tide events. We, therefore, conclude that the cost of strategic placement of sand as listed for Prime Hook beach is not a useful figure for comparison because strategic placement assumes supplementing an intact dune system. Since the existing berm along Unit II is barely above mean high water, a considerably larger quantity of sand, and a much higher cost, would be required to achieve the 5 or 10-year specifications considered adequate for Prime Hook beach. The costs of dune construction on Unit II may approach the cost of construction for 2.7 miles of Slaughter Beach, or as high as $4,000,000.

Table 3-13 summarizes the length of beach, quantity of sand required for initial fill, quantity of sand required in subsequent years, the return maintenance interval and cost of construction alone, without permitting, design, and monitoring costs. The maintenance intervals are 4, 5, and 10 years, respectively for strategic, 5-year and 10-year scenarios. Maintenance would be required more often if storm severity or frequency becomes more intense in the years after initial treatment.

Table 3-13. Summary of Material Requirements and Costs for Construction of Dunes According to DNREC Beach Management Plan

					Maintenance	Initial Constr.
	Berm Length	Berm Width	Berm Elev. (NAVD 88)	Initial Fill	Placement (Interval)	Cost Only
Prime Hook Beach						
Strategic	2,800′	20′	7.2′	24,000 cy	14,400 cy (4 years)	$416,835.00
5 Year	7,500′	20′	7.2′	71,000 cy	36,600 cy (5 years)	$787,800.00
10 Year	7,500′	55′	7.2′	176,000 cy	105,600 cy (10 years)	$1,522,800.00
Slaughter Beach						
Strategic	2,500′	15′	7.5′	36,500 cy	21,900 cy (4 years)	$499,975.00
5 Year	14,500′	15′	7.5′	252,500 cy	151,500 cy (5 years)	$2,112,800.00
10 Year	14,500′	55′	7.5′	476,500 cy	285,900 (10 years)	$3,680,800.00

Importantly, if the purpose of dune reconstruction is to provide an intact barrier to artificially maintain fresh water marshes, then constructing a berm with the assumption that it will be intact only in the face of a 5 or 10-year storm will not sustain a fresh water marsh system. Since fresh water marshes are very vulnerable to rapid increases in salinity, a barrier system should be designed to withstand, at least, a 30-year storm, otherwise the marsh vegetation and obligate fresh water biota can be expected to die frequently. A berm of this magnitude, with accompanying periodic replenishment, will increase costs, not by a factor of three above the 10-year costs, but more geometrically, because the commensurate increase in sediment requires substantially more sand to be placed over a far broader footprint, as well as formed into a higher berm.

Water Control Structures

In addition to the dunes, the three water control structures are maintained to manage water levels within the impoundment. The replacement costs of the three water control structures and associated levees are listed in table 3-14.

Table 3-14. Replacement Costs of Refuge Water Control Structures

Water Control Structure/Levees	Estimated Cost
Prime Hook Creek WCS	$436,000.00
Petersfield WCS	$852,040.00
Petersfield West Dike	$463,610.00
Petersfield East Dike	$208,311.00
Fowler Beach WCS	$1,033,725.00

Although the Prime Hook and Petersfield structures play a role in the Unit II water management, only the Fowler Beach water control structure is used for this analysis. The replacement of the structure would cost approximately $1,033,725, but could cost more. Even if the structure is replaced, the refuge can only manage water levels to 2.8 feet mean sea level (msl), according to deed restrictions. But, mean sea level in 1981 is different from mean sea level today. The deed is recorded in Deed Book 1097, page 249. Currently, larger storm events have overtopped the existing structure, allowing water in excess of 2.8 feet msl to enter the impoundment. Rising sea levels, subsidence, and other factors make it unlikely that the refuge will be able to manage water levels in the future. Saltwater intrusion is inevitable at the water control structures as we lose control to the rising seas.

Further complicating our water management challenges is the fact that the water control structures are sitting at an elevation different from the original planned construction elevation. Although we do not know the exact post-construction elevations of the water control structures, we assume they were very close to the planned elevations. In 2010, the Delaware Coastal Program resurveyed our water control structures to determine their current elevation. Subsidence of both upland and the marshes in the Delaware region is extensive, but varies based on local conditions. The results (table 3-15) show that the water control structures are lower than their planned construction elevations by approximately 5.8 to 11.25 inches. This data further supports our assumption that we will lose water management capabilities in the near future. See appendix K for further details.

Table 3-15. Estimated Subsidence of Refuge Water Control Structures

Water Control Structure	Suspected subsidence (inches)
Prime Hook Creek WCS	11.25″
Petersfield WCS	10.07″
Fowler Beach WCS	5.83″

Integrity of Road Infrastructure:
There are three roads crossing the marsh to the barrier island, forming the dikes on the northern and southern borders of Units II and III. These roadways, built in the 1950s and 1960s at relatively low elevation, have sustained numerous tidal overwashes in recent years. In 2009, the State conducted elevation surveys of the roads for analysis. Figure 3-13, Figure 3-14, and Figure 3-15 illustrate the results of those surveys for Fowler Beach, Prime Hook, and Broadkill Road, respectively. Road elevation has been plotted in relation to the local mean higher high water elevation (red line). For each road, significant portions of the road (blue line) lie below mean higher high water, suggesting that the roads may have subsided. These roads routinely flood during forecast NOAA coastal flood events. As sea levels and high tide events continue to increase, the ability of these roads to serve as dikes will be reduced.

Figure 3-13. Elevations along Fowler Beach Road in relation to MHHW along the segment depicted in red on the map

Figure 3-14. Elevations along Prime Hook Road in relation to MHHW along the segment depicted in red on the map

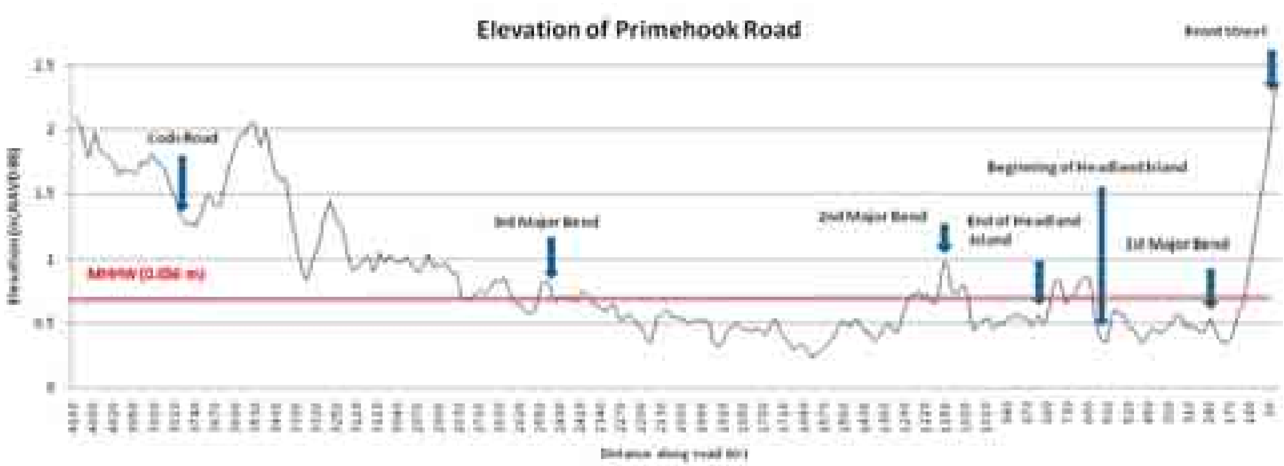
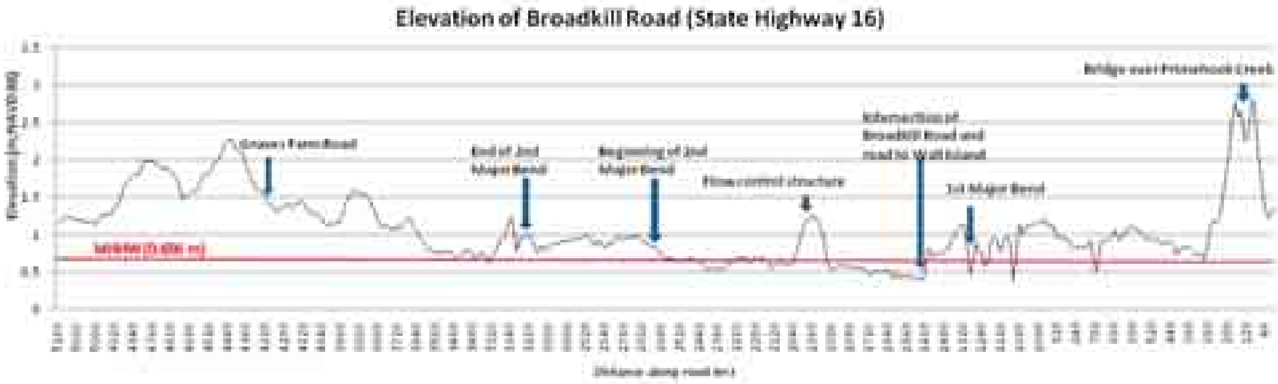


Figure 3-15. Elevations along Broadkill Beach Road in relation to MHHW along the segment depicted in red on the map



Delaware Department of Transportation (DelDOT) currently owns a 50-foot right-of-way easement on Prime Hook and Fowler Beach Roads. Additionally, it owns a 60-foot right-of-way along U.S. 16, also known as Broadkill Road. DelDOT is the responsible agency for the construction and maintenance of these roads.

There are a number of different options to consider for each roadway area that could be affected by restored tidal flows. These include raising the roadway elevation in its current location, tolerating a certain degree or frequency of flooding, and/or abandoning a specific road or portion of road, subject to DelDOT approval and procedures. Hydraulic analysis would be necessary before raising any road crossing the marsh. Some of these roadways are well-traveled and provide access for residents. Prime Hook and Fowler Beach Roads are not adjacent to higher ground, but may need widening. In order to raise these roadways and avoid costly retaining wall construction, the toe of each roadway embankment would need to extend horizontally into adjacent wetland resource areas.

Some low-lying roadways along the coast have historically been subjected to varying degrees of flooding during coastal storms. When such flooding is infrequent, such as during storm events, the effect on the public may be minimal and can be accommodated. Issues to consider include public health and safety relative to access. This would require further assessment as more detailed hydrologic analyses are conducted. At Fowler Beach Road, abandonment may be an option. Any decision on such roadway abandonment would be subject to public hearings in nearby towns.

Planning for reconstruction of these roads must also include an assessment of impacts to fire department and emergency medical vehicle access routes and alternative access options. The refuge has long-standing mutual aid agreements with Milton Fire Department, Inc. and the Memorial Volunteer Fire Department of Slaughter Beach. These agreements need to be updated to better describe the authority and responsibility and to include other emergency situations on refuge lands or adjacent to the refuge.

To maintain a freshwater system, these roads need to be elevated 2 to 4 feet with the sides sloped at a ratio of 3:1. Costs will easily exceed $1 million per road. Some estimates put the costs closer to $2 million per road (Service's cost-estimating guide). It should be noted that if Fowler Beach Road is abandoned, costs may be considerably less. Instead of a road, a levee or other type of barricade could serve the same purpose at a fraction of the cost. In either scenario, costs for road elevation and/or levee construction would range from over $1 million to $4 million.

Management Implications:
Significant environmental, physical, structural, monetary, and regulatory hurdles need to be addressed to maintain freshwater impoundments on Prime Hook NWR. The SLAMM model and the State's inundation maps (DNREC, unpublished) predict accelerated rates in sea level rise in the next 50 to 100 years. Portions of the refuge's marshes or impoundments may have already reached a tipping point. It is important to note that the time frame of impoundment management has been relatively short on the refuge, in relation to the time frame of natural coastline processes. Relatively speaking, freshwater impoundment management is not a long-standing management regime on the refuge but was conceived to meet valid wildlife management objectives. It was established, in part, using existing roads, which had not been formally engineered for long-term water level management as dike infrastructure.

Preliminary data indicate portions of our managed impoundments may be losing ground to sea level rise. Unit II, for example, is accreting new sediment at a pace that is half the documented rate of local sea level rise. It is not reasonable to expect that such a large deficit in elevation-capital can be recovered within Unit II under current freshwater impoundment management strategies. Freshwater marshes dominated by annual vegetation differ from salt marshes in that predominantly annual wetland plants contribute to high above-ground biomass, whereas the persistent below-ground organic matter of perennial vegetation, such as that found in tidal salt marshes, makes greater contributions to vertical accretion (Cahoon et al. 2009). This means that the vegetation in salt marshes build up the elevation of the marsh and that freshwater marsh plants do not, so that salt marsh can be sustained in light of rising sea levels but freshwater plants not only die if flooded by salt waters, they also leave the marsh substrate at a depressed elevation compared to salt marsh species.

Biological Resources of Delaware Bay Estuary

The Delaware Bay Estuary is an important ecosystem recognized nationally, internationally, and globally as a resting and feeding area for millions of migrating birds each spring and fall. It supports rare and endangered species, supports commercial fisheries, and acts as a major horseshoe crab spawning ground on the East Coast. It is an ecosystem where many biogeographic provinces come together, resulting in overlapping habitat types and high biodiversity. The increase in economic pressures on these habitats of the Delaware Estuary dictates that remaining natural uplands and wetlands conserved for wildlife will require extra protection and conservation efforts in the future (Webster 1996).

There are three major ecological zones of the Delaware Estuary, which are distinguished by differences in salinity, turbidity, and biological productivity. The upper zone is tidal freshwater and extends from Trenton to Marcus Hook. The transition zone, which extends from Marcus Hook to Artificial Island, has a wide salinity range (0 to 15 ppt) and is characterized by high turbidity and low biological productivity. The lower zone, where Prime Hook NWR is located, is open bay and extends to the ocean. It has higher salinity distributions fluctuating from polyhaline to euhaline waters (18 to 30 ppt), broad areas of fairly shallow water (less than 9 meters), and over 90 percent of the primary biological productivity of the three zones (Partnership for the Delaware Estuary 1996).

Land use is a term that refers to the way land is developed or conserved. Demographic predictions provide compelling evidence for planning growth and protecting natural resources. Nine of the ten most densely populated U.S. counties are in the Northeast. Because of our love of the water, almost half of the U.S. population now lives in coastal areas, including along the shores of estuaries.

This population trend is accelerating and coastal counties are growing three times faster than anywhere else in the nation.

Escalating population growth and the demand for new housing, shopping centers and places of employment are projected to rapidly continue throughout the Delaware River basin region between now and 2020 with an overall increase of 14 percent. The States of Delaware and New Jersey are expected to see population increases of 24.3 percent and 21.5 percent respectively, by that date. By 2020, projected development increases of 14 percent will affect over 50 percent of the total land area within the region, leaving less than 50 percent of the land cover in agricultural, wooded, open space, or water (Seymour 1994). Major problems and future threats for living resources of the Delaware Estuary are identified in the 1996 comprehensive conservation management plan.

The Delaware Estuary is one of the most heavily used estuary systems in the nation. The estuary supports one of the world's greatest concentrations of heavy industry, and the second largest oil refining and petrochemical centers in the U.S. About 70 percent of transported oil (over one billion barrels of crude and refined oil products) reaches the east coast of the U.S. through the Delaware Estuary by way of the ports of Philadelphia, Camden, Gloucester City, Salem, and Wilmington. The estuary also receives wastewater discharges from 162 industries and municipalities and approximately 300 combined sewer overflows. The Delaware River basin supplies 10 percent of the U.S. population (20 million people) with water for drinking and industrial uses. Much of this water is transferred out of the basin through runoff into the Delaware Estuary (Partnership for the Delaware Estuary 1996).

Phytoplankton are the dominant source of organic matter for most of the Delaware Estuary's biological communities forming the base of the food web. The phytoplankton in the estuary are relatively healthy despite high-nutrient concentrations and turbidity. The primary consumers of phytoplankton in the estuary are zooplankton. Copepods dominate the zooplankton and directly consume a high percentage of the phytoplankton (primary production) in the lower bay or zone three.

Marine mysids or small shrimp-like crustaceans also play a critical role in the Delaware Estuary food web. While mysids are often associated with bottom communities, they can also be found in the water column and in this way regularly make up a large part of the zooplankton. At times they are very abundant and serve as a significant food resource for juvenile fish.

Benthic organisms are important consumers and a major link in the food chain between primary producers and higher trophic levels such as fish, shellfish, birds, and other wildlife. The annual production of a healthy blue crab fishery is important to the Delaware economy. Water quality does not appear to be affecting these populations. Benthic organisms are also excellent indicators of the overall ecological health of the estuary due to their sensitivity to pollution exposures. Because benthic organisms stay in one place, they are affected by the pollution at a site over the long term.

The Delaware Bay horseshoe crab *(Limulus polyphemus)* population is the largest in the world and a key species in the estuary, which is the epicenter of spawning activity along the Atlantic coast. In addition to providing food for migratory shorebirds, the horseshoe crab is economically important, as bait and in the manufacture of products used for medical testing of drugs and presence of bacteria and for surgical sutures and implants. Limulus amoebocyte lysate (LAL), a clotting agent in horseshoe crab blood, has made it possible to detect human pathogens like spinal meningitis in patients, drugs, and intravenous equipment.

To obtain LAL, manufacturing companies catch large horseshoe crabs (mostly females) and collect a portion of their blood. The LAL test is currently the worldwide standard for screening medical equipment for bacterial contamination, and any drug produced by a pharmaceutical company must pass an LAL screening. No other known procedure has the same speed and accuracy as the LAL test, and if LAL were to become unavailable, there is no universally accepted, ready substitute yet available (ASMFC-PID 1995).

The socioeconomic impacts of horseshoe crabs are extensive. Horseshoe crabs are the primary bait for the American eel and conch fisheries in most Mid-Atlantic States. In 1996, the commercial harvest of these crabs was estimated to be $5 million. As part of the medical research and pharmaceutical products industry, the worldwide market for LAL is about $50 million per year. The biomedical industry pays about $375,000 annually for an estimated harvest of 250,000 horseshoe crabs. Eco-tourism is also critical to New Jersey and Delaware in relation to horseshoe crabs' dependence on a healthy bay estuary, and the horseshoe crab-shorebird connection. The 1996 regional economic impact of expenditures made by wildlife watchers in New Jersey and Delaware created 15,127 jobs and generated a total household income of $399 million (ERDG 2006).

The overharvesting of horseshoe crabs in the late 1800s to early 1900s for the fertilizer industry and again in the 1990s for bait used in the conch and eel fisheries has caused their populations in the estuary to decline. Since 1998, red knots *(Calidris canutus)*, which are highly dependent on horseshoe crabs spawning in dense numbers, have fallen from possibly as high as 150,000 to as low as 15,000. By 2000, the Atlantic States Marine Fisheries Commission implemented a state-by-state cap of horseshoe crab bait landings by 25 percent. In 2004, harvest in New Jersey and Delaware was further reduced to 150,000 per state and included a seasonal ban from May 1 through June 7. In 2006, additional reductions were imposed, eliminating all harvest of female horseshoe crabs and reducing the harvest of males to 100,000, in addition to expanding the seasonal ban from January 1 to June 7. As a result of these restrictions, Atlantic coastal states collectively reduced horseshoe crab landings by 75 percent in 2005 (ASMFC 2006).

On March 7, 2001, the Carl N. Shuster, Jr. Horseshoe Crab Reserve, which encompasses 1,500 square miles of Federal waters off the mouth of the Delaware Bay, was established by the National Marine Fisheries Service (NMFS) to prohibit the harvest of horseshoe crabs in these Federal waters. This action was taken to further the goal of the fishery management plan for *(Limulus polyphemus)* of "managing horseshoe crab populations for continued use by current and future generations of the fishing and non-fishing public (including the biomedical industry, scientific and educational research; migratory shorebirds; and other dependent fish and wildlife (including federally listed sea turtles)" (ASMFC 1998).

In 2006, New Jersey and Delaware took action to ban all harvest of horseshoe crabs in their states to address concerns of the declining population of red knots. Delaware's ban was overturned in court, but New Jersey was able to maintain its ban and in 2008 succeeded in getting legislation passed that implemented a ban that would remain in place until red knots have sufficiently recovered. In 2009, work was completed on an adaptive management framework for the management of horseshoe crabs in support of red knots (ASMFC 2009).

Dragonflies. More than 100 species of Odonata occur in the Delaware Estuary. Damselflies and dragonflies (Odonata) have received increased attention as indicators of the health of wetland habitats. Activities that adversely affect water quality or alter specific habitats can eliminate odonate species or alter the composition of an area. The alteration of aquatic environments through channelization, siltation, draining, or chemical spraying has resulted in notable recent declines in many odonates throughout their ranges (Carle 1991). Because odonates are widespread and inhabit all wetlands, their absence could be an early indication of environmental degradation from a variety of sources. Odonates are beneficial to man by consuming large numbers of mosquitoes (Barber 1995).

Fish. More than 200 fish species, both residents and migrants, use the Delaware Estuary. The residents include fresh and saltwater species like the white perch which has a broad range of salinity tolerances. Resident species conduct all aspects of their life history within the estuary. Migrant species are highly dependent on the estuary for spawning habitats and nursery and feeding grounds. Ocean migrants include both warm and cool water species. A large number of migrants, such as the herrings and shad, are anadromous, living in ocean water but migrating to fresh water to breed. One species, the American eel, is catadromous, living in fresh or brackish waters and migrating downstream toward the ocean to reproduce. In the Delaware Estuary, the American eel is a very important resource from both a biodiversity and human use perspective. In all its life stages, eel serves as a prey species for many species of fish, aquatic mammals, and fisheating birds. Eel continue to support valuable commercial, recreational, and subsistence fisheries in the bay.

Major fish species in the Delaware Estuary include various sharks, skates and rays, shortnose and Atlantic sturgeon, American eel, blueback herring, alewife, American shad, Atlantic menhaden, common carp, various catfish, white perch, striped bass, bluefish, weakfish, spot, Atlantic croaker, black drum, and various flounder species. In the Delaware Estuary, changes in abundance of anadromous species have been historically linked to a decline of available spawning habitat due to obstructions in watercourses (dams, pollution blocks) that prevent access to spawning beds, overall water quality, and overfishing. Destruction and alteration of wetland habitats have decreased available nursery areas for juvenile fish development, and recreational fishing pressure has consistently increased. There are at least 31 species that are commercially harvested from the estuary valued at about $1.4 million in 1996 (De. Estuary-CCMP).

Birds. Four major estuaries in North America are critical shorebird stopover areas, and each supports more than one million shorebirds during migration. These are the Bay of Fundy and the Delaware Bay on the East Coast, and Alaska's Copper River Delta and Washington's Grays Harbor on the West Coast. At these stopover areas, shorebirds feed on amphipods, chironomids, and horseshoe crab eggs and nearly double their weight before moving on. These areas are unique in their mix of natural resources and consistently support high percentages of the entire world's populations of certain bird species.

Historical survey data has recorded that up to 200,000 red knots (80 percent of the Western Hemisphere population), 10,000 short-billed dowitchers, and half the ruddy turnstones in North America visit the Delaware Bay to feed on horseshoe crab eggs. Red knots fly 19,000 miles round-trip between wintering and breeding grounds and rely on one or two staging areas. After leaving its wintering grounds in southern Argentina, the red knot makes only one stop on the coast of Brazil (Lagoa do Peixe), and then flies nonstop to Delaware Bay, which is a distance of 5,000 miles (Chipley 2003).

Total birds counted in aerial surveys in Delaware Bay over the six-week migration period from May to mid-June range from 250,000 to more than 1,000,000 birds. Birds observed in tidal marsh habitats are estimated at 700,000. Red knots, sanderlings, ruddy turnstones, and semipalmated sandpipers make up 97 percent of the individuals of 30 species of shorebirds utilizing Delaware Estuary habitats. Many migratory raptors, waders, and waterfowl also use the estuary, including brant and up to 400,000 snow geese (State-De/NJ aerial survey data).

Delaware Estuary Program Priority Species List. In spring 1993 a habitat task force brought experts from across the region to develop a list of priority species for management purposes. Of the thousands of plant and animal species in the estuary, participants extracted the indicator and keystone species and assemblages of species that are critical to maintain and monitor the biological integrity, diversity, and environmental health and functioning of the Delaware Estuary. Scientists have deemed that this ecosystem would lack wholeness and integrity without them.

A final list of approximately 100 species and assemblages were identified that are critical in maintaining the Delaware Bay's biological integrity, diversity and environmental health. A supplemental publication to the Delaware Estuary comprehensive conservation management plan describes the habitat requirements and species profile histories of these keystone and indicator species of ecosystem health. The document is entitled "*Living Resources of the Delaware Estuary*" (Dove and Nyman 1995). This information was stepped down to the refuge level when we developed and fine tuned our refuge-specific focal species list and identified the refuge's top priority resources of concern. This process is described in more detail in chapter 2 of this CCP, which describes the planning process.

The Delaware Estuary is impacted by toxic substances, mainly human-created chemicals that have been introduced into the waters. Elevated levels of many toxic substances have been detected in the sediments, the water column, and in the tissues of organisms dependent on the estuary. Primary toxic substances include heavy metals, mercury, and organic contaminants such as polychlorinated biphenyls (PCBs) and Dieldrin. High concentrations of these contaminants of concern have prompted DNREC to post fish consumption advisories from the C & D Canal down to the mouth of the Delaware Bay for following finfish species: striped bass, channel and white catfish, American eel, white perch, and bluefish (DNREC 2010).

Refuge Biological Resources

As in our discussion of rarity patterns of plant species, we also refer to Delaware Natural Heritage Program (DNHP) rankings in describing refuge biological resources such as birds, invertebrates, reptiles, and amphibian species.

The only resident federally endangered species on the refuge is Federal and State-listed Endangered or Threatened Species the Delmarva fox squirrel *(Sciurus niger cinereus).* The current population is very small but represents the core population for expanding Delmarva fox squirrel habitats on the refuge in coming years. In recent years, due to State-managed areas protecting and increasing piping plover productivity each summer, coupled with expanding overwash habitats and new beach acquisitions on Prime Hook NWR, greater numbers of piping plovers are using refuge sandy beach areas as foraging habitats during spring and fall migration periods. Piping plover breeding has not been observed occurring on the Refuge to date.

State endangered resident species on the refuge include two pair of bald eagles. State endangered species that breed on the refuge include pied-billed grebe, northern harrier, Cooper's hawk, black rail, and Forster's tern. In most recent years State endangered species that have attempted breeding on the refuge include American oystercatcher, least tern, and common tern. Uncommon occurrences of other State endangered species using the refuge in the spring, fall, or winter include brown creeper, black-crowned night heron, yellow-crowned night heron, least tern, hooded warbler, red-headed woodpecker, and sedge wren.

Birds

The bird assemblage in the project area is as diverse as its natural vegetation communities. The project area's geographic location on the southwestern shore of the lower mouth of the Delaware Bay situates the refuge at the heart of key staging areas for migrating, breeding, and wintering habitats for waterfowl, shorebirds, waterbirds, and land birds along the Atlantic Flyway and in the Western Hemisphere. The refuge is located in the Northeast Bird Conservation Region 30 and Partners in Flight Physiographic Region 44 of the Mid-Atlantic.

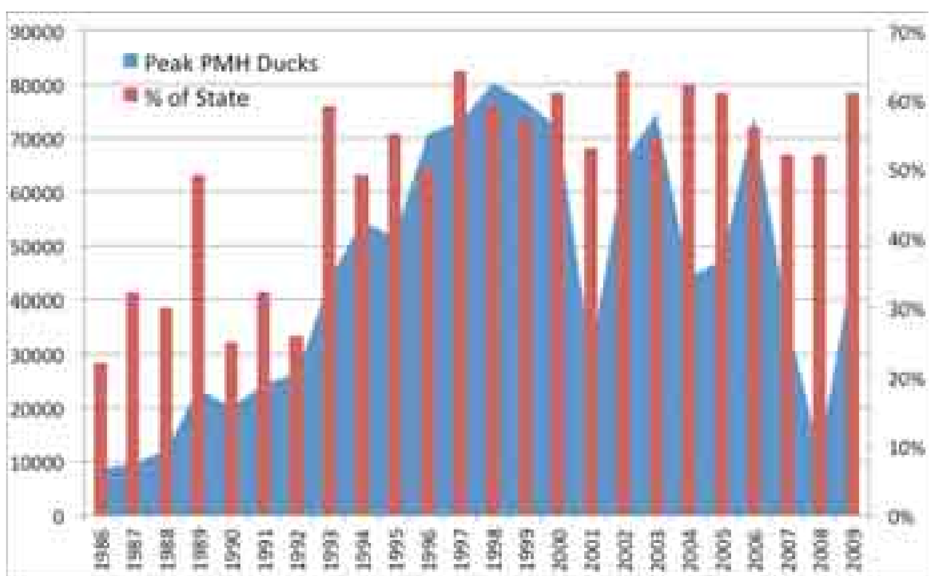
The project area has also been designated a significant site for shorebirds within the Western Hemispheric Shorebird Reserve Network (WHSRN 1986), a Ramsar Wetland Site of International Importance (1992) and an Important Bird Area of the Delaware Bay (IBA) in 2000.

Waterfowl

Waterfowl have been a target species group for refuge management since the refuge was first established. In the past, the refuge farming program was focused on providing food for certain duck species (mallard, American black duck, northern pintail, and wood duck) and Canada geese during the fall, winter, and spring. A secondary objective of the farming program was duck production, for which croplands in grass or clover stages of rotations were designed to provide nesting habitats for ducks. In addition, waterfowl have utilized the refuge's wetland habitats, throughout several different phases of wetland management.

Waterfowl management on the refuge greatly improved habitat conditions for migrating and wintering birds when water level management capability was established in the mid-1980s. Excellent freshwater wetland habitat conditions providing abundant food resources are reflected by subsequent increased bird use of the refuge after 1986. For example, in October 2005, the refuge hosted 52 percent of waterfowl surveyed in Delaware, 71 percent of the State's snow geese, 82 percent of Northern pintails (22,800 birds), 54 percent of American green-wing teal (20,360), and 40 percent (1,889) of the State's American black ducks wintering in Delaware (DNREC, personal communication). Peak duck numbers of 47,116 ducks wintering on the refuge's marsh-complex represented 61 percent of the State's peak number of ducks (Figure 3-16).

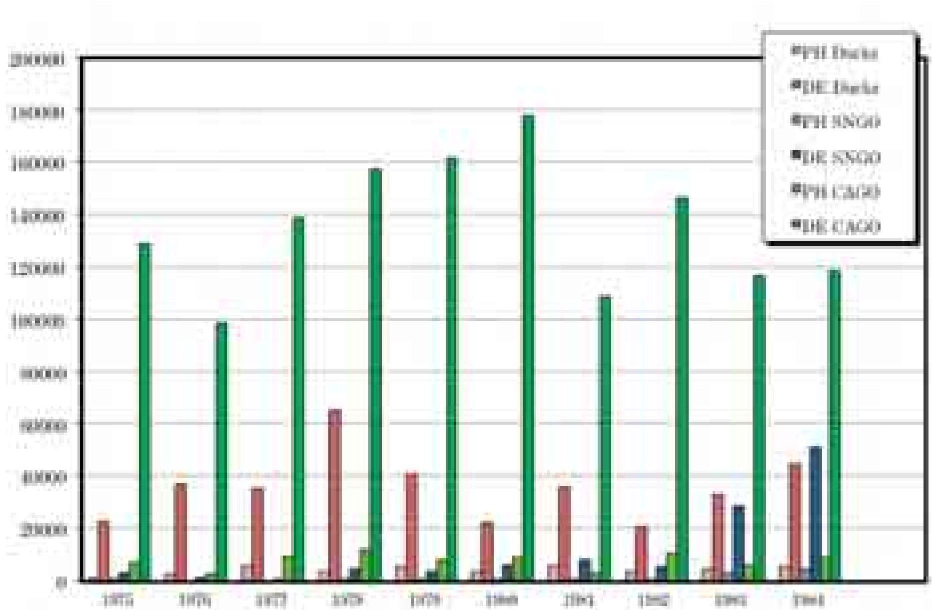
Figure 3-16. Peak Duck Populations Counted on Prime Hook NWR Marshes as a Percent of Delaware's Statewide Peak Duck Numbers



Historically, the Delaware Division of Fish and Wildlife has conducted aerial waterfowl surveys each year to measure long-term trends in duck and goose populations in the State. These surveys were flown in a small plane by the same waterfowl biologist for 30 years, using the same routes and techniques each time. The survey biologist staff changed after 2005, but DNREC waterfowl biologists have continued to provide waterfowl survey data directly to the refuge. These surveys cover the primary waterfowl habitats found in Delaware. The surveys give fairly accurate information about geese and most duck species with the exception of wood ducks and sea ducks, which are almost impossible to count from a fixed-wing aircraft. The important feature of these counts is that they provide long-term trends that are useful to measure changes in waterfowl management strategies and the environment. In most cases, no single count is especially important in itself but the collection of counts over the years has shown significant changes. These surveys detected the decline in the migrant Canada geese in the Atlantic Flyway, the loss of duck use in Christiana marshes after the construction of I-95, and recent increases in ducks using Prime Hook NWR. An analysis of this 30-year data set shows how marsh restoration and rehabilitation projects, after an early period of no management, improved habitat conditions for waterfowl.

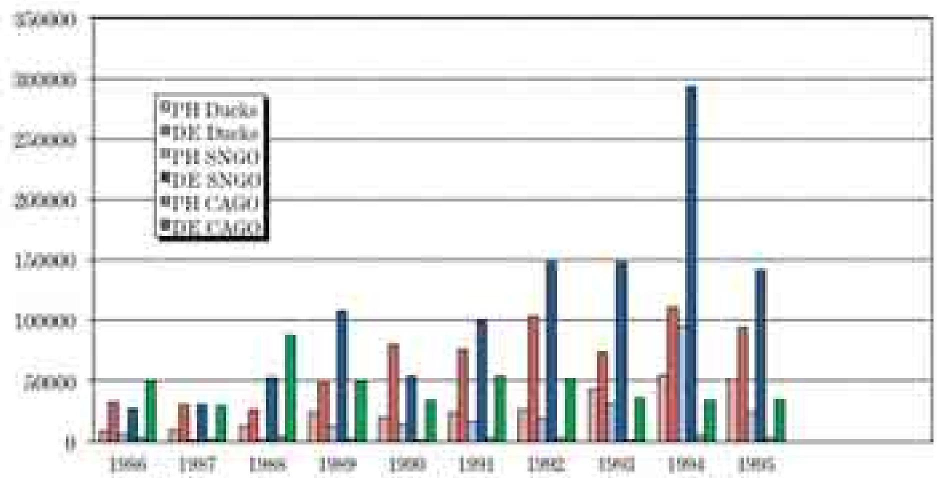
During a decade of the no wetland management era, proliferation and invasion of *Phragmites* throughout the refuge's wetland areas reduced the quality of habitat conditions for ducks. During this time, average duck use of refuge marshes was 3,905 birds (peak 5,795 to low of 2,254), which accounted for less than 10 percent of the State's total duck numbers. Average snow goose numbers were 748 birds, ranging from 0 to 4,310 birds. State average totals for snow geese were 11,000 and ranged from 678 to 50,726 birds. State migratory Canada goose numbers were at an all time high of 177,811 birds in 1980 and refuge peak numbers of Canada geese during this decade were 11,942 birds in 1978 (DNREC personal communication). For waterfowl population distributions and use of refuge marshes compared to Statewide numbers (Figure 3-17).

Figure 3-17. Average Waterfowl Use during the No Wetland Management Era



During the next decade of marsh rehabilitation of Prime Hook NWR's wetlands consisted of the large-scale control of *Phragmites* and establishment of impoundment infrastructure, waterfowl use increased. These habitat improvements and increased waterfowl use on the refuge are reflected in the State of Delaware’s waterfowl aerial survey data. Statewide, ducks numbers doubled from the 1986 to 1995 period compared to the 1975 to 1984 period, while duck use and numbers on the refuge increased sevenfold, ranging from a low of 8,582 ducks in 1986 to a peak of 54,606 in 1994. Pintails (28,920) and green-winged teal (39,611) were the duck species contributing the highest total numbers to duck counts during this period. Snow geese also showed increases on the refuge and throughout the State. Peak snow goose numbers recorded in 1995 for the refuge were 95,300 birds and 293,651 birds for the State. In contrast, Canada geese numbers dropped sharply with average numbers during the 10-years of no management of 7,486 dropping to 2,573 birds during the marsh rehabilitation era. Likewise, Statewide numbers of Canada geese dropped from an average of 135,213 birds down to 45,678 birds in the second decade of trend monitoring data (Figure 3-18) (DNREC, personal communication).

Figure 3-18. Average Waterfowl Use during Marsh Rehabilitation Era



Continuing this 30-year trend analysis, during the intensive wetland management strategies of integrative moist-soil management, waterfowl use of Prime Hook NWR’s marshes continued to increase. Teasing out the duck numbers from the waterfowl data, the State experienced a general 37 percent increase in duck numbers during this decade (1996 to 2005), while Prime Hook NWR recorded a 72 percent increase from prior decades in duck use. At Prime Hook NWR, duck use ranged from a low of 29,638 ducks in 2001 to a high of 80,261 ducks in 1998.

Increases in snow goose numbers were recorded both Statewide and refugewide. Peak snow geese numbers on the refuge were 143,432 birds occurring in 1999 and a low of 13,775 snow geese in 2005, compared to a Statewide high of 371,715 birds in 1997 and low of 91,654 also in 2005. Canada goose numbers using the refuge doubled from the prior decade but Statewide Canada goose numbers continued to spiral downward.

Thirty-two waterfowl species have been recorded using refuge habitats. The two duck species contributing the most in the 30-year trend data analysis were green-winged teal and northern pintail. Green-winged teal numbers were 41,047 in 1996; 46,795 in 1997; 53,260 in 1998; and 65,727 in 1999; and peak northern pintail numbers include 28,920 in 1993; 21,061 in 1998; 21,835 in 2000; and 35,497 in 2003. Other duck species contributing to duck totals included American black duck, mallard, gadwall, American wigeon, northern shoveler, wood duck, scaup, ring-necked duck, ruddy duck, and hooded merganser.

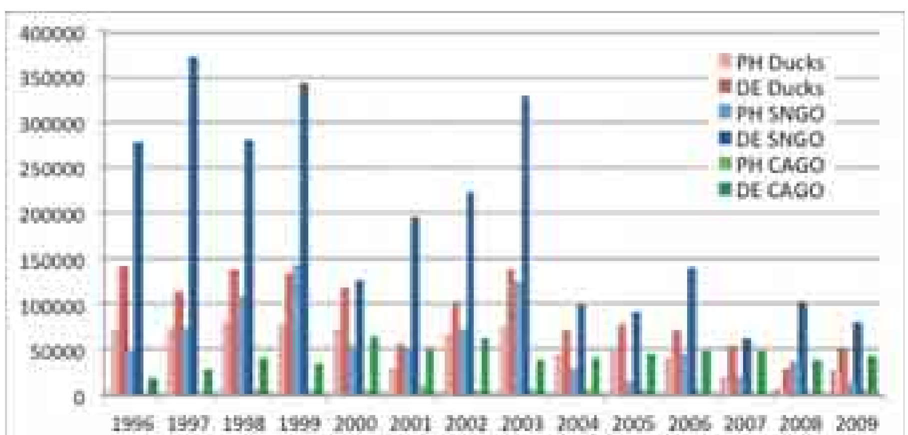
By means of marsh rehabilitation and integrative moist-soil management techniques through water level manipulation strategies, Prime Hook NWR has demonstrated considerable success in increasing both waterfowl and shorebird use of the refuge's wetland habitats simultaneously. Fredrickson and Laubhan (1994) described how intensive wetland management strategies are the keys to enhancing biodiversity in the face of continuing wetland degradation and loss throughout all landscape scales.

The basic premise of intensive wetland management is producing a diverse array of plant and animal food resources that can feed a greater abundance of target species of waterfowl and shorebirds on smaller patches of marshland. Intensive wetland management has demonstrated improvement in wetland productivity and biodiversity when the correct combination of water level manipulations and other habitat management techniques are applied at the appropriate times for an array of target wetland species (Fredrickson and Laubhan 1994).

The general strategy of intensive wetland management is predicated on knowing the life history requirements of target waterfowl and shorebird species, annually creating abundant native plant and animal food resources consistently, and making these annually produced food resources available to target species at the right time of the year.

Annually from 1995 to 2005, Prime Hook NWR attempted to match the chronology of particular biological events such as molting, migration, and reproduction requirements of target waterfowl and shorebird species with specific water level drawdown and reflood regimes conducted asynchronously between the refuge's three impoundment units. Concurrent waterfowl and shorebird habitat management can be accomplished each year by producing abundant invertebrate food resources and then linking drawdowns to local migration phenology. Management success is reflected in the bird use data (Figure 3-19).

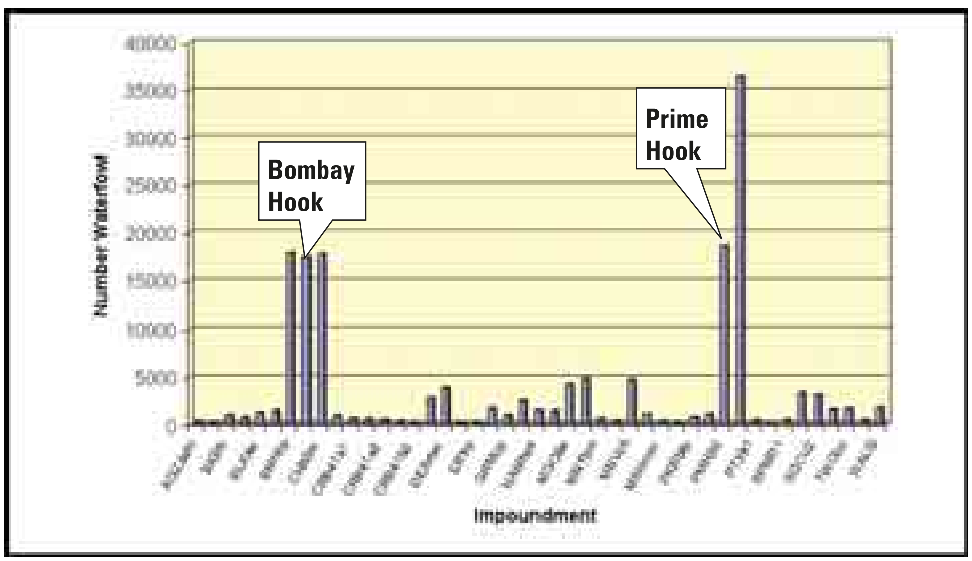
Figure 3-19. Average Waterfowl Use during the Integrative Wetland Management Era



Managed wetlands provide a broad spectrum of resources to migratory birds throughout the annual cycle. Successful conservation and management of waterfowl, shorebirds, and waterbirds depend on integrated approaches. Few managed wetlands have the capability to provide habitat during both spring and fall migration. Whether management actions are designed to benefit spring or fall migrant shorebirds, hydrologic regimes will also impact waterfowl and other waterbirds, primarily through changes to invertebrate and plant communities. With this in mind, the refuge participated in a 3-year, multi-regional wetland management study from 2005 to 2007 to understand the differential impacts of spring versus summer/fall drawdowns on the vegetation structure, invertebrate communities, and use of impoundments by waterfowl, shorebirds, and other waterbirds (USGS 2005). The refuge used study areas in Unit III (PMH3D) and Unit IV (PMH4A).

Preliminary analysis of study results (Green et al 2007) after two seasons of field data (2005 and 2006) indicated that early spring drawdowns conducted in PMH3D to prepare habitat conditions for spring migrating shorebirds, also yielded excellent waterfowl use in mid-November in the same wetland, with more than 20,000 ducks and geese recorded using the area. During the same timeframe Unit IV (PMH4A) experienced a late summer drawdown targeting fall migrant shorebirds which also generated excellent waterfowl use with a peak of 15,000 birds using the same wetland by the first week of November. Of the 22 national wildlife refuges from regions 3 and 5 participating in this study, most refuges recorded waterfowl use in the tens and hundreds range while Prime Hook and Bombay Hook recorded waterfowl numbers in the thousands of birds range, indicating the importance of the Coastal Delaware NWR Complex to waterfowl resources (Figure 3-20). A final analysis and study report will soon be released by the U.S. Geological Survey.

Figure 3-20. Relative Abundance of Waterfowl Using Refuge Impoundments Enrolled in Multi-Regional Impoundment Study. Note importance of Delaware refuge impoundments.



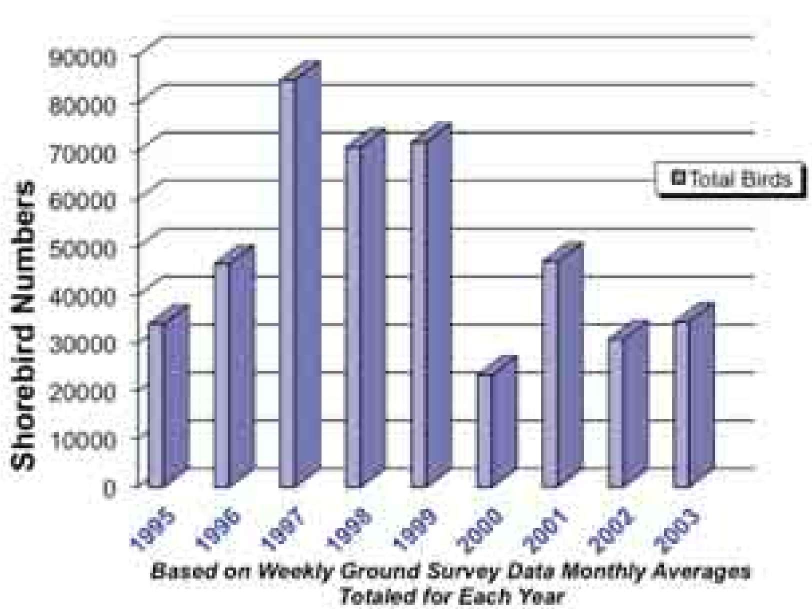
Shorebirds, Gulls, Terns, and Allied Species

The refuge provides diverse fresh and saltwater marsh and impoundment habitats that support 54 species of shorebirds, gulls, terns, and allied species. Most species are migrants, but 13 of these species breed on the refuge (black rail, clapper rail, king rail, Virginia rail, sora, common moorhen, American coot, killdeer, black-necked stilt, willet, spotted sandpiper, American woodcock, and Forster's tern), while 12 species winter in marsh habitats (sanderling, killdeer, American woodcock, willet, greater and lesser yellowlegs, western sandpiper, dunlin, common snipe, ring-billed, herring, and lesser black-backed gulls). Common terns, least terns, and black skimmers seasonally utilize refuge habitats; these three bird species are on the State's endangered species list.

Refuge saltwater marsh, sandy beach, and impoundment habitats support a shorebird migration that has worldwide ecological significance. Abundance of invertebrate foods is recognized as an important determinant of habitat quality for migrant shorebirds. High densities of chironomid larvae are common in the diets of breeding, migrating, and wintering shorebirds (Batzer et al. 1993). As previously mentioned, intensive management of Prime Hook NWR's seasonally flooded impoundments for migrant shorebirds has been a part of the refuge's habitat management strategies by incorporating methods to increase annual invertebrate biomass production. It is possible to successfully manage for such macroinvertebrates as chironomids and other short-cycle invertebrates, purposefully for shorebird consumption, using water level manipulations to produce invertebrate densities of at least 100 individuals per square meter (Baldassarre and Fisher 1984, Helmers 1992). The essence of successful shorebird management within impounded wetland habitats is based on the seasonal production of high densities of macroinvertebrates and their availability at critical times of the year for spring and fall shorebird migrants (Rundle and Fredrickson 1981, Elridge 1992).

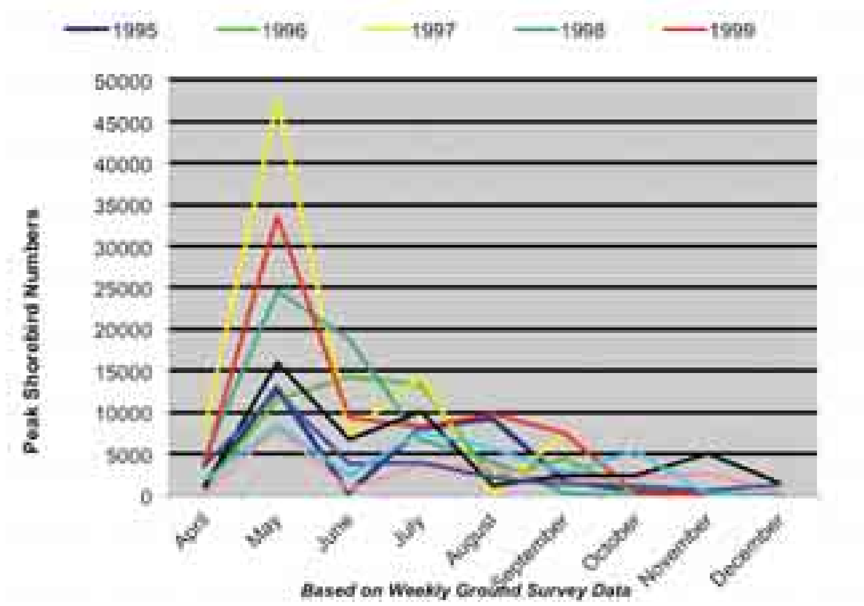
Manipulating water levels at the appropriate times to create areas with a mosaic of open mudflats with shallow water levels (between 1.0 and 10.0 cm deep) and invertebrate densities of at least 100 individuals/M2 have yielded excellent results on the refuge. A decade of shorebird ground surveys were conducted weekly from April to December on Prime Hook NWR's impounded marsh units (Figure 3-21).

Figure 3-21. Refugewide Shorebird Use of Prime Hook NWR's Impoundments



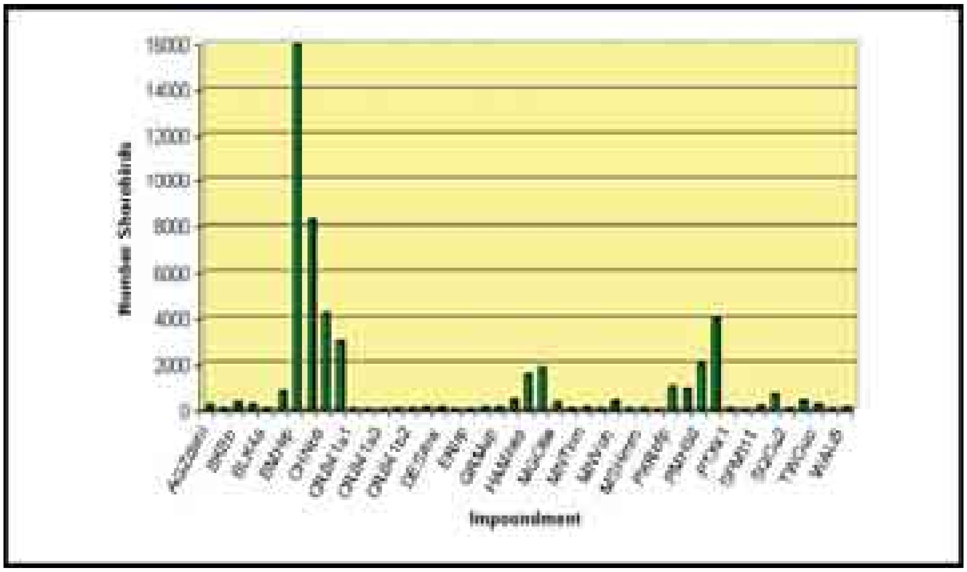
Dominant shorebird species contributing to shorebird numbers on Prime Hook NWR from weekly ground surveys included the following spring migrants: semipalmated sandpipers, short-billed dowitchers, dunlin, sanderlings, and red knots; and fall migrants: short-billed dowitchers, semipalmated plovers and sandpipers, dunlin, least sandpipers, and yellow-legs. Chronology of use information for the years of 1997, 1998, 2000, 2001, 2002, and 2003 shows that spring migrants start arriving by mid-April and peak during the last two weeks of May, while fall migrants start arriving by the last week of June and peak during the first two weeks of July. Local spring migrants arrived 2½ weeks later in 1996 and peak fall migrant numbers were three weeks later in 1995 and 1999 (Figure 3-22).

Figure 3-22. Chronology of Shorebird Use at Prime Hook NWR



As previously mentioned in the waterfowl section, the refuge participated in a multi-region refuge cooperative research impoundment study, whose primary objective was to monitor management actions that created shallow water and mudflat habitat for shorebirds either for the northward or southward migration. While management actions targeted shorebird habitat creation within the impoundments, we also simultaneously monitored the responses of waterfowl and wading birds in addition to shorebirds. The preliminary shorebird monitoring results (Green et al. 2007) suggest that both early spring drawdowns and late summer drawdowns generated greater numbers of fall migrants (peak about 4,000 birds) using Units III and IV impounded study sites, compared to spring migrants (peak about 1,500 birds). Chronology of use plots suggest that the first week of September was when the greatest shorebird use occurred (about 3,000 birds) in Unit III during 2005 and 2006; fall migrant shorebird use in Unit IV occurred in mid-August, and again September 1st and mid-September (about 4,000 birds for all 3 plot peaks) during the same timeframe as Unit III. Preliminary results suggest that refuge impoundments are more important for the southward migration. Overall, impoundments at Prime Hook NWR, as well as Bombay Hook NWR also in Delaware, are clearly important to migratory shorebirds, relative to other impoundments evaluated in the study (Figure 3-23). A final study report is pending that will analyze and compare study results of 22 national wildlife refuges representing regions 3 and 5.

Figure 3-23. Relative Abundance of Shorebirds Using Refuge Impoundments Enrolled in Multi-Regional Impoundment Study. Note importance of Delaware refuge impoundments.



Marsh and Water Birds

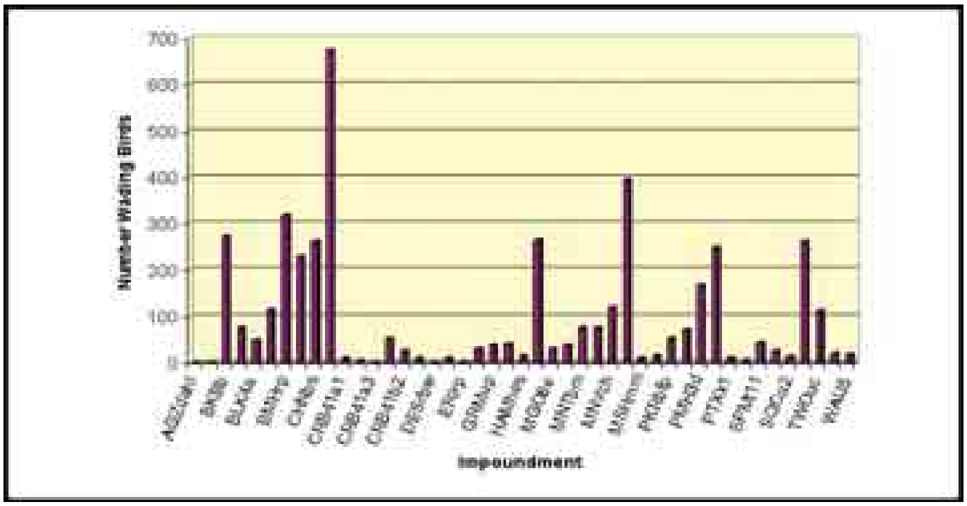
Freshwater impoundments, brackish marsh, and salt marsh wetland areas provide excellent feeding and resting areas for 30 species of marsh and water birds. Pied-billed grebe, least bittern, and green herons all nest on the refuge. Pied-billed grebes are on the State endangered species list and American bitterns and little blue herons use refuge habitats for portions of the year. These three species are ranked as (S1) species of special conservation concern in the Delaware Wildlife Action Management Plan (2005).

The most important heron and egret rookery in Delaware is located in the middle of Delaware Bay Estuary on a 310-acre island named Pea Patch Island. Located about 54 miles north of the refuge, it is the largest heronry on the East Coast north of Florida. It is a resource of both regional and national significance. Ten species of herons, egrets, and ibises nest on this isolated island, which supports 3,000 nesting pairs of wading birds. Many of these birds spend the months of August and September feeding on diverse and plentiful fish resources found in refuge habitats. Of particular note are the black-crowned and yellow-crowned night herons found on the refuge during this timeframe which are listed as State endangered bird species of Delaware.

The Mid-Atlantic/New England/Maritime Waterbird Conservation Plan (2006) has identified the highest priority species in need of immediate conservation action. Highest priority species that breed or migrate through the refuge include pied-billed grebe, American bittern, least bittern, snowy egret, little blue heron, tricolored heron, black-crowned night heron, glossy ibis, black rail, least tern, gull-billed tern, common tern, black skimmer, yellow rail, sora, black tern, and Forster's tern.

An integrated wetland management approach to create optimal shorebird habitats at appropriate times for spring and fall shorebird migrants can also provide a broad spectrum of resources for marsh and water birds. This group of birds was also targeted for monitoring during the Refuge Cooperative Research Program Region 3/5 Impoundment Study previously mentioned in the waterfowl and shorebird sections of this chapter. The objective of conducting management actions to create shallow water and mudflat habitats for shorebirds and monitor the subsequent responses of invertebrate populations and plant communities also included monitoring water bird use of the various seasonal habitat conditions that were generated during the study in two designated study areas (PMH3D and PMH4A). Preliminary data analysis (Green et al. 2007) indicated that marsh and water birds utilized impounded wetland study sites throughout the year, with peak use occurring during mid-August and September during the 2005 and 2006 field seasons. Peak water bird use in Unit PMH4A occurred in late August (approximately 350 birds) and peak use in PMH3D (approximately 250 birds) occurred during the first week in September (Figure 3-24).

Figure 3-24. Relative Abundance of Wading Birds Using Refuge Impoundments Enrolled in Multi-Regional Impoundment Study.



Landbirds

The conservation of birds is a primary purpose of the National Wildlife Refuge System, and refuges provide important breeding and migrating habitats for a variety of landbirds, many of which are of state, regional and national management concern (USFWS 2008a, DWAP 2005, BCR 30 and PIF 44 plans). The term landbirds generally refers to the smaller birds (exclusive of raptors and upland game birds) not usually associated with aquatic habitats. This group refers to songbirds (Family Passeriformes) also known as passerines. These include resident songbirds that breed on refuge lands, such as corvids, chickadees, and nuthatches, and short and long-distance neotropical migrants such as flycatchers, swallows, wrens, thrushes, vireos and warblers.

Many landbird species require large forest areas to breed successfully and maintain viable populations. This diverse group includes songbirds (tanagers, warblers, and vireos), which breed in North America and winter in Central and South America, and residents and short-distance migrants, such as woodpeckers, owls, hawks, and eagles. According to breeding bird survey data since 1966, there has been a 60 percent decline in occurrence of individual birds of landbird migrant species in Maryland and an 83 percent decline in Delaware from 1980 to 2007 (Sauer et al. 2008).

Baseline information about Prime Hook's landbird community during the breeding season is necessary for planning management activities that will contribute to the conservation of targeted resources of concern. A standardized point count survey route for breeding landbirds was established on Prime Hook NWR in 1998 using 40 points all located in fragmented upland forested habitats throughout the refuge.

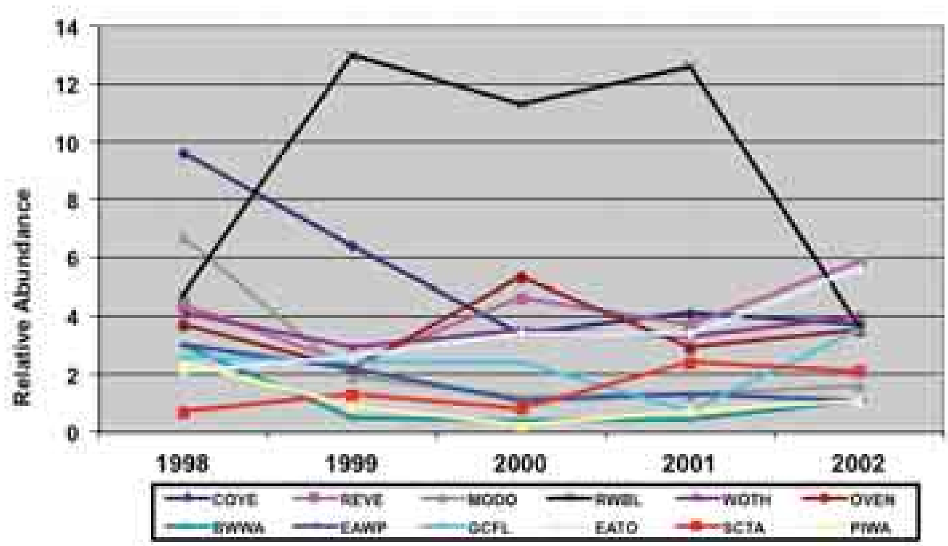
Information gathered from landbird breeding surveys conducted from 1998 to 2005 on Prime Hook NWR showed a wide variety of landbird species utilizing refuge habitats. Monitoring data was archived in the wildlife inventory census database and analyzed. Of the 40 points surveyed on the refuge landbird monitoring route, 70 species were recorded in 1998, 53 in 1999, 64 in 2000, 47 species in 2001, and 49 species in 2002. Monitoring data reflected only 36 points surveyed in 2001 and 32 points in 2002.

Data analyses were conducted separately for each individual species detected during each annual breeding landbird survey. The parameters used for each landbird species during the breeding season were species occurrence (presence/absence), frequency of occurrence, and relative abundance. The frequency of occurrence was calculated using species occurrence values at each point and was represented by the percentage of sampled points of the whole survey route in which the species was detected. The top 12 most abundant species with the greatest distribution across the refuge monitored from 1998 to 2002 are listed below:

Breeding Landbird Species	Frequency of Survey Points
COYE (Common Yellowthroat)	(31 – 71%)
REVE (Red-Eyed Vireo)	(28 – 68%)
MODO (Mourning Dove)	(16 – 27%)
RWBL (Red-wing Black Bird)	(28 – 48%)
WOTH (Wood Thrush)	(31 – 48%)
OVEN (Ovenbird)	(25 – 48%)
BWWA (Black and White Warbler)	(8 – 37%)
EAWP (Eastern Wood Pee-wee)	(9 – 37%)
GCFL (Great-Crested Flycatcher)	(11 – 38%)
PIWA (Pine Warbler)	(2 – 32%)
EATO (Eastern Towhee)	(30 – 53%)
SCTA (Scarlet Tanager)	(10 – 33%)

The relative abundance was calculated as the mean number of individual species detected per point on the refuge during a sample year. This variable provided an index for comparing the abundance of different species and for quantifying the rate of population change of a single landbird species across years on the refuge (Figure 3-25).

Figure 3-25. Prime Hook NWR Breeding Landbird Survey Data



Based on relative abundance data, it seems that red-winged blackbirds had good and poor breeding years but the numbers on the refuge do not indicate a significant negative trend. However, compared to National Breeding Bird Survey data sets from 1966 to 2004 for both region 5 and the New England/Mid-Atlantic Coast (BCR 30), significant declining trends are indicated in both R5 (P = -2.2734) and BCR-30 (P = -0.2767) when (P less than 0.1) for this wetland breeding species.

Scrub breeders like common yellowthroat and pine warbler are showing significant negative trends on the refuge along with R5 and BCR-30 data sets. Woodland breeders on Prime Hook NWR, like the eastern wood peewee, black and white warbler, and ovenbirds showed declines in breeding numbers, while red-eyed vireos and wood thrush numbers were stable on the refuge for the past five years. However, these five landbird species have demonstrated significant negative trends in the breeding bird survey data trend sets (Sauer et al. 2005).

Cavity nesters such as great-crested flycatcher and woodland nesters such as scarlet tanager showed no significant trend declines on the refuge, but trend data from regional data sets revealed slight declines for these two species. Although not present in high numbers (five occurrences or less), records of short-distance and long-distance neotropical migrants breeding on the refuge and captured in these landbird surveys included American redstart, northern parula, Acadian flycatcher, blackpoll warbler, black-throated green warbler, summer tanager, chestnut-sided warbler, prairie warbler, hooded warbler, prothonary warbler, yellow warbler, blue-wing warbler, yellow-rumped warbler, eastern phoebe, cerulean warbler, worm-eating warbler, yellow-breasted chat, and yellow-billed cuckoo.

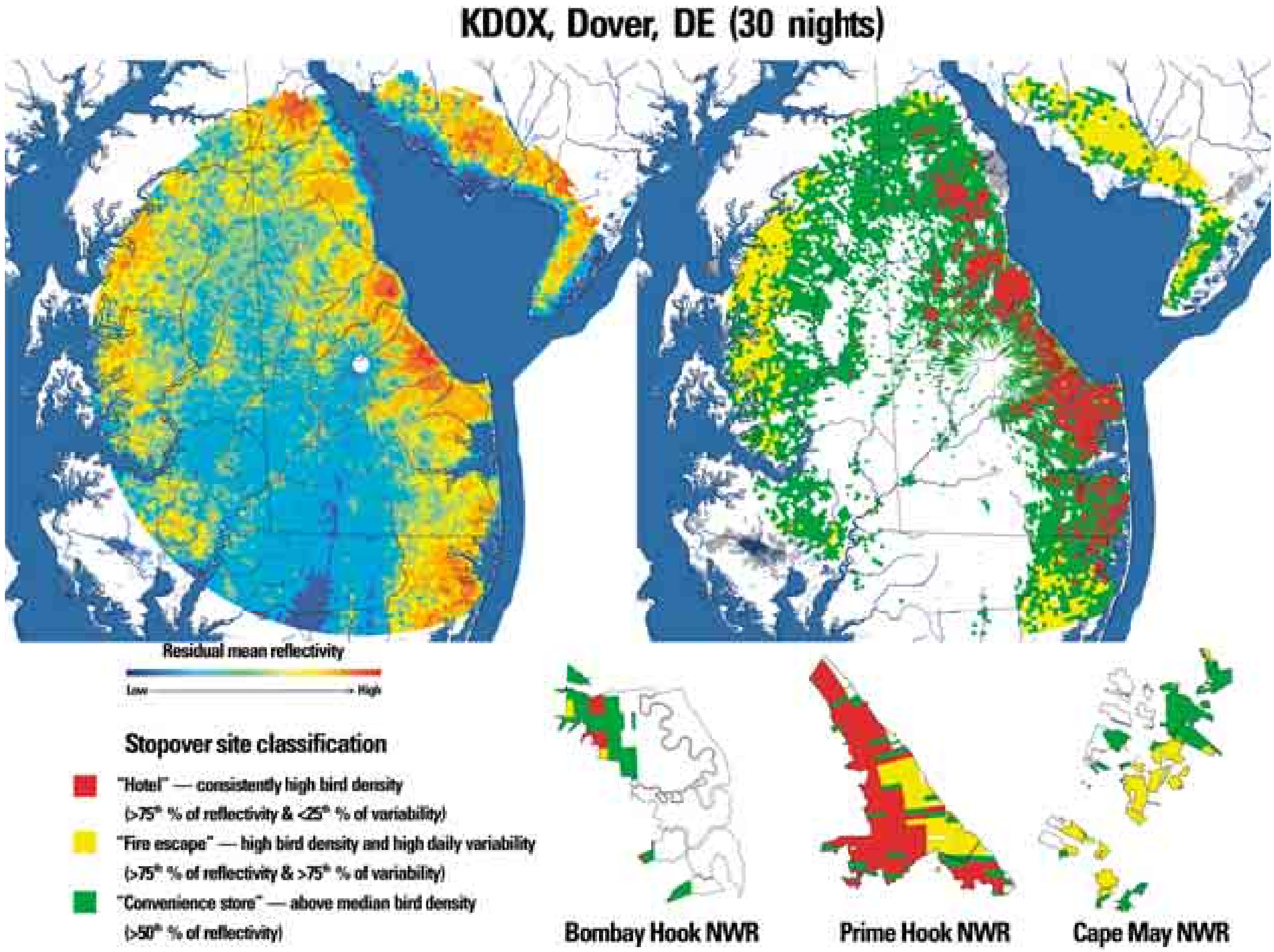
Between May 2001 and October 2003, the Service, in partnership with U.S. Geological Survey, conducted a study of grassland-breeding bird abundance and diversity in some of the largest grassland fields existing on 13 refuges in region 5, including Prime Hook NWR (Runge et al. 2004) Each refuge evaluated at least two fallow fields (e.g., abandoned agricultural fields or old pastures maintained by mowing or burning) at least 12 to 16 ha in size, in a surrounding non-wooded landscape of 25 ha. Grassland bird density differed substantially among refuges ranging from a low of 0.04 obligate birds/ha at Eastern Neck NWR (Maryland) to 4.77 obligate birds/ha at Missisquoi NWR (Vermont). The density of obligate grassland birds detected at Prime Hook NWR was 0.19 birds/ha. While many of the refuges showed the potential to sustain densities of obligate grassland birds that were at least comparable to midwestern habitats, Prime Hook NWR showed some of the lowest densities, much less than midwestern habitats or other refuges in the region. For all of the refuges, fields planted with warm-season grass did not support much higher densities of obligate grassland birds than their cool-season or fallow counterparts.

The abundance of grassland birds supported on the fields enrolled in the study shows a similar pattern to the density. These results are affected by the area of the fields, and thus demonstrate a better measure of the relative contributions each refuge could make. The refuges along the Delaware Bay (Supawna Meadows NWR, Bombay Hook NWR, and Prime Hook NWR), and upper Eastern Shore of Maryland (Eastern Neck NWR), have the lowest abundance of grassland birds and the lowest relative contributions of obligate grassland birds in fallow fields among refuges in the Northeast. In terms of species composition, the refuges on the Mid-Atlantic Coastal Plain also show a distinctive community composition, dominated primarily, and almost exclusively, by grasshopper sparrows. The species detected at Prime Hook NWR, albeit in very low numbers, were mostly grasshopper sparrows and horned larks, as well as eastern meadowlarks and sedge wren.

Very few terrestrial species are resident or reproduce in vegetated portions of the harsher environments of salt marshes (Greenberg et al. 2006). However, obligate salt marsh passerines, such as seaside sparrows, thrive on the refuge salt marsh areas. These salt marsh obligate species can serve as indicators of healthy salt marsh habitats because of their strong relationship with ecosystem structure and function, and because they are easier to sample compared to other environmental health parameters (DeLuca et al. 2004). The refuge monitors their presence and, as staff and resources permit, their breeding productivity.

The refuge also serves as critical stopover habitat for migrating landbirds. Researchers have been reporting for decades on the particular importance of wooded habitats along the Atlantic coast to migrating songbirds for cover and food sources at this vulnerable stage in their life cycles. Preliminary analysis of National Weather Service Doppler radar data (Dawson and Buler 2010), has underscored the importance of forested wetland cover on Prime Hook NWR to migrating songbirds (Figure 3-26). Forested wetlands on the refuge are consistently used by songbirds in very high densities during migration periods, as are a number of large, forested patches outside the refuges. Birds were detected as they left daytime stopover sites at dusk to resume nocturnal migratory flight.

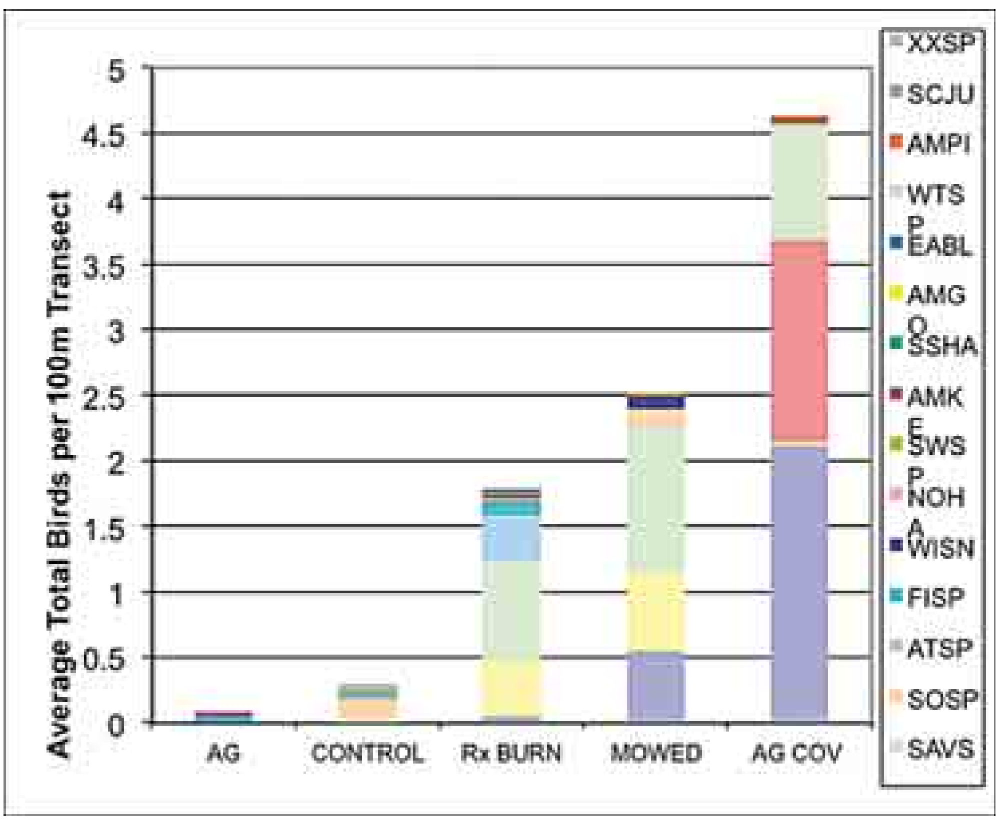
Figure 3-26. Residual mean radar reflectivity (i.e., relative bird stopover density) and stopover site classification during fall 2008 and 2009 in the area sampled by radar station KDOX, located roughly 35 km S of Dover, DE. Figure taken Dawson and Buler (2010).



The refuge may also be providing valuable overwintering habitat for landbird species of conservation interest, such as grassland specialists. In 2003 to 2004, the refuge participated in a pilot wintering grassland bird survey. The primary objective of the survey was to evaluate survey techniques, timing, and duration. Wintering grassland birds are difficult to survey because they are less abundant, less vocal and active and often patchily distributed and spatially and temporally unpredictable (e.g., found in flocks that move throughout suitable habitat). The pilot surveys provided baseline data regarding the abundance and species composition of grassland birds using some of the managed open fields on the refuge.

The pilot study involved a series of survey transects in each sampled field, across 2 to 4 days, once per month (December 2003, January 2004, and February 2004). Five fields with varying cover types or recent management history were surveyed during the pilot study: Field 202A (mowed), Field 321 (burned), Field 332 (control - unmanaged fallow), Field 318 (agricultural), and Field 202B (agricultural with winter wheat cover crop). Seventeen species were detected in the fields over the course of three separate survey bouts. Because the total length of transects surveyed varied with field size and transect configuration, survey results were calculated as the average number of birds detected per day, per 100 meters of transect sampled. In general, Field 202B had the highest average number of birds, which was driven primarily by a large number of horned larks and red-winged blackbirds using that field, especially during the February survey bout. The greatest species diversity was found in Field 332, the unmanaged fallow field (control), and Field 321, the burned grassland field. Savannah sparrows and eastern meadowlarks preferred Fields 202A and 321, the two managed grassland fields (Figure 3-27).

Figure 3-27. Average number of birds detected per 100 meters of transect surveyed in five fields at Prime Hook NWR during winter 2003 to 2004.



Finfish and Shellfish

Refuge fishery resources are extensive and very diverse. The broad goals of refuge fishery management have been to maintain and improve the quality of aquatic habitats for a well-balanced community of fish and other aquatic species, provide fish passage for anadromous fish species, and offer quality recreational fishing opportunities compatible with the refuge's purposes. Current refuge aquatic environments support 52 species of fishes, 4 species of shellfish, and nursery habitats for elvers, striped bass, river herring and other anadromous fish species, and blue crabs.

Early surveys of refuge fishery resources (1969) indicated that 23 species of fishes utilized refuge waters and that largemouth bass, chain pickerel, black crappie, pumpkinseed sunfish, and bluegill were the predominant game fishes of freshwater habitats. Rough fishes such as common carp, creek chubsucker, and gizzard shad were also abundant. Updated surveys conducted in the late 1990s and salt marsh research studies conducted from 2000 to 2004 have supplemented refuge fishery inventory data. See appendix D for a list of the fishery resources found on the refuge.

In its State Wildlife Action Plan (2005), Delaware has identified species of greatest conservation need and placed them in a two-tier system based on endangered and threatened status, significant/sensitive Delaware populations, State and global rankings, highest BCR 30 rankings, and American Fish Society vulnerability rankings. Tier 1 species found on the refuge include blue crab, mud sunfish, and yellow bullhead. Tier 2 species include comely shiner, banded sunfish, fourspine stickleback, and hickory shad.

In 1994, an assessment of the refuge's fishery resources and water quality was conducted by the Service's Gloucester Office of Fisheries Assistance. The purpose of the study was to collect qualitative fishery data on all managed refuge waters. The assessment had two objectives: to evaluate fish species distribution and site specific utilization and to measure water quality at each site and assess suitability to resident fish reproduction, growth, and health.

Baseline information on abundance, species diversity, and water quality parameters was collected in early June of 1994. Data analyzed from refuge waters demonstrated that the area supports a healthy sport fish population whose quality varies among the different creeks and impoundments sampled. Water quality parameters were generally within the optimal ranges for good fish growth and survival, with the exception of extremely high pH values in Goose Pond (Swihart et al. 1994).

During the 1994 fish survey, abundant juvenile striped bass were collected below the water control structures in Unit III. Recommendations were made to install fish passages on the structures. It was noted by the Service's personnel that juvenile striped bass were congregating at the water control structure and were easily caught by fishermen in this popular fishing and crabbing spot. Although the striped bass were small, that did not stop the anglers from keeping them. Many anglers could not distinguish the juvenile striped bass from the numerous white perch they were catching.

The recommendation made to curtail the illegal take of juvenile striped bass in the fishable waters of Petersfield Ditch was to post signs to increase public awareness concerning striped bass regulations, stating size limits, catch limits, and fishing seasons. Based on the results of 1994 survey data, it was also concluded that the Unit III impoundment (2,500 acres) presented a good balance between fisheries and waterfowl management, and that the fisheries in this area were self-sustaining, no further management efforts were suggested at that time for anadramous fish.

Other problems identified included fishery management in Turkle and Fleetwood Ponds. Age, size, and weight class data collected from these sites indicated heavy fishing pressure had resulted in overfishing. The recommended solution was to reduce fishing pressure by staggering the days each pond is opened to fishing, stagger the years in which each pond is opened to fishing, or implement a catch-and-release fishery for all species with the exception of the abundant sunfishes and the predatory chain pickerel.

In 1996, the water control structures in place to impound Unit II and III marshes were retrofitted with vertical slot weirs to provide passage of anadromous, catadromous and estuarine fish species into and out of impoundment habitats. A major focus of the Service is to provide greater spawning and nursery habitat for interjursidictional fish species by eliminating blockages on rivers and streams. Upon the urging and recommendation of the Chesapeake Bay Field Office and Gloucester Fishery Resources Office, fish weirs were installed in Unit II, which opened 3 miles of Slaughter Creek to fish passage, while fish weir installation in Unit III opened up 8 miles of Prime Hook Creek from Petersfield Ditch.

The Gloucester Fishery Resources Office staff returned to the refuge in 1997 to conduct an evaluation of the fish weirs installed at three locations that flowed into the refuge's marshes. Funds were obtained from the Delaware River/Delaware Coastal Ecosystem Team for this interjurisdictional fish study. The purpose of the evaluation was to determine the effectiveness of the fish weirs in permitting the passage of anadromous and catadromous species through the water control structures into the impoundment habitat and upstream reaches of Units II and III. Baseline fish sampling data collected in 1994 prior to fish weir installation was used for comparisons. Particular attention was given to river herring as river herring stocks (e.g., alewife and blueback) along the Atlantic coast are severely depressed from habitat degradation, overfishing, and exclusion from historic spawning grounds due to stream blockages. Results from this study would show if river herring are passing through the weirs and determine if alewife and blueback are using this additional habitat created as a result of recent weir installation for spawning. Study results would also be used to develop improved fish sampling protocols for future comprehensive studies.

Fish weir evaluation was conducted during March, April, and June 1997. Sampling for migrating fish through the vertical slot fish weirs was accomplished using hoop nets. Each hoop was 24 inches in diameter by 8 feet long and made up of 1 ¼ inch sized nylon mesh. All fish passing upstream through the weir that were large enough not to get out of the netting (greater than 1 ¼ inch) were captured in the hoop net. Sampling of the fishways was done over five sampling periods: March 18 to 20, March 27 to 29, April 2 to 4, April 23 to 25, and June 16 to 18. A total of 24 net sets were made totaling 526 hours of fishing.

Fourteen species of fish, blue crabs, and one otter used the fishways. Species of special concern, such as alewife, blueback herring, and American eel were collected. Alewife were collected on six trap nights, for a total of 21 specimens. Four blueback herring were collected on two trap nights. White perch (2,666) were the most numerous species collected, followed by brown bullhead (261), carp (168), gizzard shad (114), pumpkinseed sunfish (45), striped killifish (43), alewife (21), bluegill (11), American eel (5), black crappie (5), blueback herring (4), striped mullet (2), white catfish (2), and largemouth bass (1). Large quantities of elvers were found in the nets when they became partially clogged with vegetation during the March and April sampling bouts.

The vertical slot fishways installed in the Units II and III impoundments appear to adequately allow the passage of any fish, from 1-inch elvers to 24-inch carp, wishing to travel upstream into impoundment marsh habitats. The study demonstrated that river herring stocks and other anadromous and catadromous fish species can successfully access fish habitats in Units II and III refuge impoundments, thereby addressing the conservation and protection of a Service resource of high priority, e.g., interjurisdictional fish.

Tidal waters on the refuge include Slaughter Canal, Slaughter Creek, Petersfield Ditch, and Prime Hook Creek. Up until calendar year 1999, the State of Delaware classified the entire length of Prime Hook Creek, which includes all of its tributaries and associated ponds, as tidal waters despite the placement of water control structures on the Prime Hook Creek outlet and the Petersfield Ditch. However, a large portion of the fishery resource in this waterway consisted of freshwater species. After 2000, the State changed its designation, which prompted the requirement for anglers to have freshwater fishing licenses to fish these areas.

Bank fishing and crabbing along tidal waterways are restricted to areas designated off roadways to prevent disturbance to waterfowl during spring and fall migrations. These areas include Headquarters Ditch, Slaughter Canal, and Petersfield Ditch. Access to waterways by boat is provided at Waples Pond, Headquarters Ditch, and Slaughter Canal at Fowler Beach Road. Blue crabs are most abundant in tidal streams, canals, and ditches and provide an important sport fishing resource. Fiddler crabs and mud crabs, which are important food resources for birds, mammals, and fish, are abundant in tidal marshes along the Broadkill River and Slaughter Canal.

Mammals

During the settlement of North America and heavy exploitation of the land, nearly all the native mammal species of what is now the eastern U.S. suffered radical declines in numbers. Several species are threatened and endangered. Of notable exception is the white-tailed deer, which has done well in recent years due to extirpation of larger predators coupled with unnatural subsidies of rich food resources in the form of agricultural crops. The white-tailed deer is the most important big game animal in Delaware and the eastern U.S. In Delaware over 15,000 deer are reported in annual harvests and the refuge kills about 130 deer per year.

Prime Hook provides habitats for 37 species of mammals. Thirty-four are native to Delaware and four are exotic. Four of the native mammalian species are ranked as rare and uncommon in the State and include the Delmarva fox squirrel, (both Federal and State-listed as an endangered species), American beaver (S-3), marsh rice rat (S-3), and American mink (S-3). Three species ranked as (S-4) are secure in present habitat conditions are woodland vole, northern river otter, and star-nose mole. Four species are ranked as (SU), their status is uncertain but they are usually uncommon species believed to be of conservation concern, but data are inadequate to determine the degree of rarity. These SU species include the silver-haired bat, eastern red bat, and hoary bat. The remaining species are ranked as (S-5) common species and defined as secure in the State under present conditions.

Of the four exotic species found on the refuge, nutria causes the most concern. The only member of the family Myocastoridae, they are native to Brazil and Chile and were introduced in California in 1899 and during the 1930s in the Southeast. Nutria are denizens of freshwater or brackish marshes and compete for habitat with muskrats. In the 1960s the annual take of nutria pelts (used mostly in trim and lining) and the meat (for pet food) was more than $1 million.

Harvest and values of pelts declined drastically in the mid-1980s to early 1990s. The decreasing harvest resulted in concomitant increase in nutria damage to marsh habitats, levees, and agricultural crops. The first appearance of nutria on Prime Hook NWR marshes occurred in 1991. At the manager's request, a refuge trapper harvested any nutria encountered during the 1991 muskrat trapping season. A nutria was preserved as a museum sample for educational purposes at the refuge.

Adult nutria weigh about 26 kg (12 lbs) and eat about a quarter of their own weight in food per night. They are entirely vegetarian and generally prefer more common aquatic plants found in the habitats where they live. Nutria will also opportunistically feed on corn or other crops if adjacent to their marsh homes. Like muskrats, marsh plants are their favorite foods especially rushes, spikerush, pickerelweed, cattail, arrowhead, and smartweeds.

The presence of nutria on the refuge today is confirmed by anecdotal observations of animals seen along the peripheral edges of Units II and III marshes. However, nutria populations have not exploded or even significantly expanded on Prime Hook NWR since 1991. A nutria meeting was held at the refuge in February 2004 to assess the current status of Prime Hook NWR's nutria population, by Dan Murphy of the Maryland Nutria Project from the Chesapeake Bay Field Office and in attendance were Stephen Kendrot, the Nutria Project Field Supervisor, his staff, including trained nutria dogs, and several State DNREC employees.

In the past, refuge areas of confirmed nutria sightings were visited in an attempt to capture some animals. No nutria were found after four hours in the field. It was concluded that the present refuge wetland habitat management techniques (water level manipulations) have created insufficient habitat to support large numbers of nutria. Based on data from Blackwater NWR and other Delmarva areas with large populations, nutria are associated with large contiguous stands of *Scirpus*, which does not exist on Prime Hook NWR. In addition, the very shallow freshwater wetland systems readily freeze-up every winter, further stressing nutria and hampering proliferation.

In 2011, USDA APHIS Wildlife Services conducted delimiting surveys to establish the distribution of nutria throughout the Delmarva Peninsula, focusing first on watersheds that have historically been occupied, even if only sporadically. Wildlife Services identified habitats and divided them into four zones. Prime Hook NWR was mapped in zone 3, identified as an area where nutria exist in small isolated populations; Wildlife Services habitat assessments prioritized zone 3 areas for more intensive ground searches. Twelve Wildlife Services personnel conducted nutria population delimiting surveys on the refuge from several boats in navigable waters along the shoreline edges. They also conducted ground surveys by foot in wetland and woodland habitats. Delimiting surveys were conducted from September 21 to 27, 2011 throughout the entire refuge; and no nutria were detected.

Refuge Endangered Species Management: Delmarva Fox Squirrel Population

The Delmarva Peninsula fox squirrel (*Sciurus niger cinerus*), generally called the Delmarva fox squirrel, was listed as federally endangered in 1967 because of concerns about a reduction in distribution to only 10 percent of its historic range. The original recovery plan for the squirrel was approved in 1979 with a first revision in 1983. These plans emphasized two action objectives: identify optimum habitat conditions for the squirrel and translocate squirrels into suitable habitat outside currently occupied areas into new locations within their historical range.

The Delmarva fox squirrel was extirpated in Delaware in the 1800s. The recovery team decided to reintroduce fox squirrels throughout the Delmarva area and beyond. Sixteen translocations of Delmarva fox squirrels occurred from 1979 to 2000, including 11 in Maryland, 2 in Virginia, 2 in Delaware, and 1 in Pennsylvania. Delaware's sites were restricted to Sussex County; the first was a State wildlife management area (Assawoman) and the second site was on the refuge.

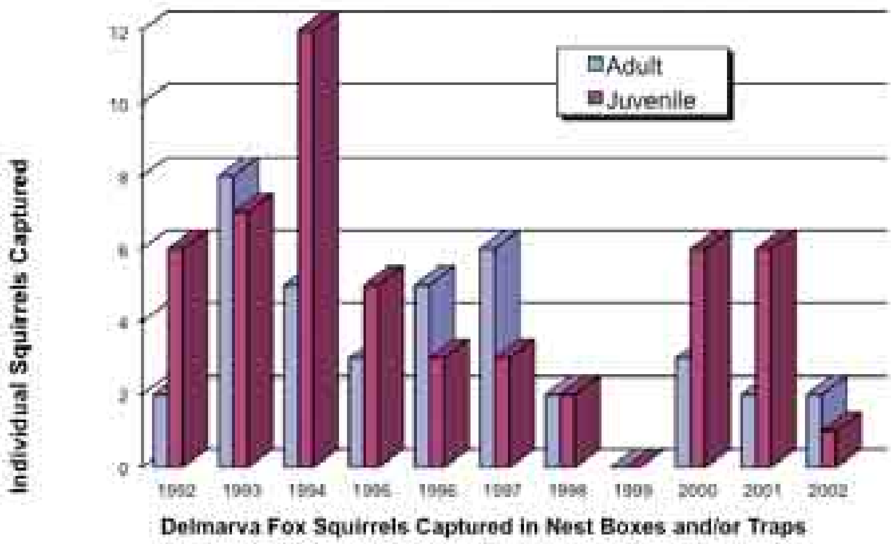
Prime Hook's translocations occurred in 1986 and 1987. A founder Delmarva fox squirrel population of 17 individuals, 4 from Dorchester County, Maryland, and the remainder from Blackwater NWR, was introduced onto the refuge. Two radio-collared squirrels were lost to predation during their first week on the refuge. The remaining squirrels settled into suitable forested habitats, mostly within Unit III.

By 1993, the Prime Hook translocations were deemed successful as per the 1993 second recovery plan, which defined success when a new reproductive population established on or near the original release site had persisted for at least 5 years and increased beyond the original group size (USFWS 1993). However, after 20 years the refuge population remains very small eliciting concerns of founder effects and genetic drift issues, and doubts about long-term viability of the refuge's population. Recent changes in land use surrounding the refuge (i.e., development), the small scale of available habitats on Prime Hook NWR and climate change and sea level rise modeling data, all suggest poor prospects for long-term viability and persistence for the refuge Delmarva fox squirrel population.

Moncrief and Dueser (2001) had recommended that a minimum of 30 squirrels would provide a sufficient number of founder individuals for reintroduced populations at specific sites to reflect enough variation present from a source population. More conservatively, Soule (1987) recommended a minimum of 50 individuals to avoid founder effects or decreased genetic diversity. The founding Prime Hook population may have been established at a disadvantage due to its small size (n = 15) from the beginning, which may warrant considering additional translocations of fox squirrels to augment the refuge population in the future.

Population monitoring and censusing is also more difficult on very small-sized populations. Annual nest box checks and live trapping efforts have provided some refuge trend data. Thirty nest boxes were established by the State of Delaware on Prime Hook NWR in the late 1980s for monitoring purposes. In 1992, the refuge added 45 more nest boxes for a total of 75 boxes, which samples an effective area of about 250 acres in 4 different locations. Calculating refuge fox squirrel population estimates based on traditional mark-recapture techniques for population size (Lincoln-Petersen Index) is imprecise due to small {n} numbers and few recaptures. However, refuge monitoring data does provide evidence of annual recruitment for 10 of the 11 years monitored (Figure 3-28).

Figure 3-28. Delmarva Fox Squirrel Nest Box Monitoring on Prime Hook NWR (1992 to 2002)



Refuge Delmarva fox squirrel population occurrence information from 2003 to present is based on sightings, trapping data, nest box checks and documentation from photo-monitors. In 2004, photomonitoring cameras were placed at 10 trap sites throughout the refuge in suitable squirrel habitat. During a 3-week sampling period, Delmarva fox squirrel visited five traps, four of which failed to capture squirrels. On May 26 and 30, 2004 two adult females were caught in traps and ear-tagged (H. Neiderriter, unpublished data). In 2005 and 2007, nest box checks resulted in zero squirrels captured and in 2008, photomonitoring efforts resulted in no observed or trapped fox squirrels. The long-term viability of the refuge's population is presently unknown (H. Neiderriter, personal communication).

Reptiles and Amphibians

A diversity of refuge natural communities provides for a variety of herpetofauna (38 species) on Prime Hook NWR. Common and scientific names for genus, species, and subspecies descriptions listed in this section are based on Crother et al. 2000. From 1999 to 2002, anuran (frog and toad) call surveys were conducted on selected tracts of Prime Hook NWR to assess overall quality and health of anuran habitats through time and to monitor the distribution of this sensitive group throughout Prime Hook. Twelve species were recorded from these surveys, of which one species is State listed – carpenter frog (S1). The carpenter frog is found in

Refuge Anuran Call Count Survey – Species Detected

American toad	*Bufo a. Americana*
Fowler's toad	*Bufo fowleri*
Eastern cricket frog	*Acris c. crepitanus*
Green treefrog	*Hyla gratiosa*
Northern spring peeper	*Pseudacris c. crucifer*
Pickerel frog	*Rana palustris*
Northern gray treefrog	*Hyla versicolor*
Southern leopard frog	*Rana sphenocephala utricularia*
Carpenter frog	*Rana virgatipes (S1)*
Wood frog	*Rana sylvatica*
New Jersey chorus frog	*Pseudacris feriarum kalmi*
American bullfrog	*Rana cateseiana*

freshwater wetland forest and emergent wetland ecosystems around the Prime Hook Creek drainage. It is a very rare amphibian species in Delaware and the refuge's population is only one of two in the State (Heckscher 2003).

Two local herpetologists have significantly contributed to the surveying, inventorying, and understanding of the refuge's herpetofauna. Joseph "Mick" McLaughlin began surveying anurans of the refuge from 1999 to 2002 by conducting anuran call surveys with the refuge biologist. He has been studying and monitoring the distribution of reptiles and amphibians in Delaware since the mid-1960s and continues critical work with the federally threatened/State endangered bog turtle, contributing much to the State's survey information. James F. White, Jr., herpetologist with the Delaware Nature Society, has conducted occupancy surveys and published several articles about Delaware's amphibians and reptiles. He conducted surveys on the refuge during the 2004 and 2005 field seasons, contracted by the Delaware Natural Heritage Program, as part of the refuge's CCP preplanning inventorying efforts.

State-identified reptile and amphibian species of greatest conservation need in Delaware (DWAP 2005) found on the refuge as a result of survey efforts include the following:

Tier 1
Carpenter frog
Cope's gray treefrog
Spotted turtle
Northern diamondback terrapin
Corn snake
Milk snake

Tier 2
Eastern spadefoot
Rough green snake
Eastern ribbon snake

Amphibians, which are a unique group of vertebrates with more than 6,000 known species, are threatened worldwide. A global amphibian assessment group (Stuart et al. 2004) has found that nearly one-third (32 percent) of the world's amphibian species, representing 1,856 species, are threatened. Amphibians have existed on earth for about 300 million years, but just in the past two decades nearly 168 species have gone extinct and at least 2,469 (43 percent) are declining in numbers as environmental threats continue to escalate.

Due to the especially high incidences of frog abnormalities reported in Minnesota and Vermont, the Service began assessments in region 5 (Northeast) and region 3 (Midwest) in 1997 to document the extent of abnormal frogs on refuges. Scientific literature suggests that abnormalities in amphibians occur normally at low frequencies (0 to 2 percent) in wild populations; therefore the Service set greater than or equal to 3 percent abnormality level as the trigger point for greater study effort (USFWS 2003a).

A malformed frog survey was conducted on Prime Hook NWR during the 1998 field season. The goal was to sample 50 to 100 frogs of the most abundant species. Two sites were sampled: Turkle Pond and Black Farm Pond. Turkle Pond proved to harbor too many amphibian predators which precluded catching a significant sample size (n=9). Black Farm Pond was ideal. One hundred twelve frogs were captured and examined, including 48 percent southern leopard frogs, 44 percent Eastern cricket frogs, 7 percent Fowler's toads, and 1 percent northern spring peeper (Williams 1998).

A low number (less than 2 percent) of cricket frogs were found missing eyes, which placed abnormality levels below the trigger point. Deformed tadpoles and frogs were also noted in the lead shot cleanup site, and remediation and future monitoring is addressing this frog issue on the refuge.

Invertebrate

Invertebrates are the most diverse and abundant animals in natural ecosystems, but their importance in sustaining those systems is not commonly understood or appreciated. Invertebrate conservation and management depends on sound knowledge of the distribution, biology, and food web dynamics of individual species and ecosystem interrelations which all have far-reaching implications for migratory bird management. E. O. Wilson (1987) elegantly referred to them as "the little things that run the world." Both terrestrial and aquatic invertebrate communities are very important components within the Delmarva Coastal Plain ecosystem and more than outweigh all the taxa combined in species richness, abundance, and biomass.

Invertebrates serve vital functions as pollinators and detritivores (facilitating decomposition of matter and returning nutrients to the soil), and are critical food resources for birds, insectivorous mammals, fish, reptiles, and amphibians. They play predominant roles in all ecosystem processes and are necessary links in all food webs in refuge biological communities. Invertebrates represent critical elements of biological integrity, diversity, and environmental health and are essential to the maintenance of ecosystem services.

Invertebrate surveys for State-rare insects were conducted in 2004 and 2005. Insect surveys included numerous nights of blacklighting and baiting for nocturnal Lepidoptera (moths). In addition to noctural moths, fireflies, tiger beetles, and Odonata (damselflies and dragonflies) were also surveyed on Prime Hook based on the high probability that the refuge harbors several uncommon species directly linked to a high diversity of habitat types. Diurnal Lepidotera (butterflies and skippers) were also surveyed in 2005.

Of the animal inventories of refuge biological resources, insect surveys focused on species of conservation concern for which adequate information regarding conservation status (local, regional, global) are available. The objective of these invertebrate surveys was to complete an inventory of the refuge to reveal rare and uncommon species.

Thirty-one species of State conservation concern (S1, S2, SU, State records, county records, and new to science) were found during this sampling period, including 18 S1 species, 8 S2 species, 3 State records, 1 county record, and 2 new species unknown to science. All invertebrate species listed in the final report (McAvoy et al. 2007) are represented by voucher specimens that have been placed in the University of Delaware and/or Delaware Natural Heritage Program insect collections.

The great purple hairstreak is an insect species of very high concern in Delaware (DWAP 2005). This butterfly's host plant is mistletoe *(Phoradendron flavescens)*; a large concentration of this parasitic plant occurs on the refuge. Adjacent fallow fields and open wetland areas where adult nectar plants occur, such as milkweed, several species of goldenrods, and buttonbush, provide important food resources for this and other lepidopteran species (McAvoy and Heckscher 2007).

Hydrangea sphinx was found in several locations throughout the refuge's freshwater shrub and swamp communities; it is very rare across the Delaware landscape. The last confirmed State record prior to the refuge discovery in 2004 and 2005, was in 1886 (Heckscher 2003, Jones 1928). Host plants for this species are buttonbush *(Cephalanthus occidentalis)* and water willow *(Decodon verticillatus)*.

Praeclara underwing populations were found in red maple/seaside alder along Prime Hook Creek coastal plain depression swamp, and coastal loblolly pine wetland forest. The host plant for this species is red chokeberry *(Aronia arbutifolia)*. Due to its rarity in the State landscape Delaware Natural Heritage Program suggested making this species and its host plant a conservation target on the refuge. Red chokeberry is also a known host plant for *Catocala pretiosa*. Although not found during 2004 and 2005 surveys on the refuge, if it is found in future years, its discovery would warrant consideration as an extremely high conservation target, as only a few secure populations are known worldwide (Heckscher 2003).

The rare marbled underwing was found in the swamp cottonwood coastal plain pond community, and considered highly notable by the Delaware Natural Heritage Program. It is State, regionally, and globally rare and an uncommon species in Delaware (S1, Tier 1, G3). The species was found with its suspected host plant swamp cottonwood *(Populus heterophylla)*. This species is the largest underwing moth in eastern North America and is confirmed from only one other location in the State of Delaware. From a global perspective, the marbled underwing is the rarest animal species recorded by the Delaware Natural Heritage Program with the possible exception of State record firefly species *(Photuris pyralomimus)* and *Delphacid* species new to science, a plant hopper secured from the refuge's peat bog community currently being studied for taxonomic classification.

Mosquito Management on Refuge Wetlands

In the early 1900s, people became aware of the mosquito's role in disease transmission and recognized that controlling the mosquito would check diseases such as malaria. East coast tidal marshes were targeted for ditching as a means to drain marshes to control mosquitoes. From 1905 to the mid-1930s a general pattern of ditching known as parallel ditching was established. Ditches (greater than 36 inches) were run in a grid system, about 100 to 150 feet apart, across the surface of the marsh. This activity was carried out whether or not various marsh sites were heavy mosquito-breeding areas. Such drainage patterns resulted in the rapid removal of water from the marsh surface. Progress was evaluated in miles of ditches dug each year (Daiber 1986).

Parallel grid-ditching reached its peak during the depression years of the 1930s, when Federal and State agencies hired people to dig ditches by hand. Prior to Federal ownership, most of the refuge's marshes were parallel grid-ditched by Civilian Conservation Corps (CCC). CCC workers also widened the Prime Hook Creek that drained into the Broadkill Sound in 1933, near the current location of the second water control structure in Unit III (map 3-1).

Parallel grid-ditching was concerned only with the elimination of mosquito breeding with little to no consideration to other consequences. People with wildlife interests began to express concern about plants and animals associated with these drained marshes. This drainage technique significantly lowered the ground water table and replaced species of the low marsh zone *(Spartina alterniflora)* with less desirable species from the high marsh zone like salt marsh fleabane (*Pluchea odorata*) and salt marsh aster *(Aster subulatus)* followed by brushy vegetation particularly *Iva frutescens* and *Baccharis halimifolia* that invade dredged material piles. Lowered water table levels and shifts in vegetation become less desirable for waterfowl and other marsh birds due to the reduction in invertebrate populations as a food resource (Daiber 1986).

The Delaware Mosquito Control Section (MCS), under Service permits, has controlled mosquitoes on the refuge since its establishment in 1963. The refuge has worked with the section to reduce the quantity of insecticides used on refuge lands and ensure activities are consistent with the Service's policies. Mosquito management is a complicated issue for the refuge. Prime Hook NWR is adjacent to residential beach communities where mosquito nuisance issues are amplified.

The control of mosquitoes is a State priority and a reality of management of salt marshes in the State of Delaware, and therefore on the refuge as well. There are three techniques currently employed to control mosquito populations on the refuge within salt marsh habitats: use of the chemical adulticide, naled, source reduction using the chemical larvicides, Bti and Methoprene, and biological control facilitated by open marsh water management.

Adulticides
Adulticides are inherently non-specific, i.e. they kill non-target species, as well as mosquitoes. The adulticides used on the refuge most recently include naled products such as Dibrom and Trumpet EC. Naled is a EPA Toxicity Class I (Highly Toxic) general-use pesticide, having the signal word "Danger" on the specimen label (Amvac 2005a). Based on acute toxicity data, the EPA considers the active ingredient naled, to be moderately to highly toxic to birds, moderately toxic to mammals, highly toxic to honey bees, moderately to very highly toxic to freshwater fish, and very highly toxic to freshwater aquatic invertebrates (EPA 2002). It is a fast-acting organophosphate adulticide licensed for the purpose of controlling aphids, mites, flies, and mosquitoes. Naled is a cholinesterase inhibitor; cholinesterase is an enzyme important for proper nervous system functioning in animals, including mammals, birds, fish, and other insects.

Larvicides
Like other varieties of the natural soil bacterium, *Bacillus thuringiensis* (Bt), *Bacillus thuringiensis israelensis* (Bti) is a stomach poison that must be ingested by the larval form of the insect in order to be effective (Extoxnet 1996a). This soil bacterium contains crystalline structures containing protein endotoxins that are activated in the alkaline conditions of an insect's gut. These toxins attach to specific receptor sites on the gut wall and, when activated, destroy the lining of the gut and eventually kill the insect. The toxicity of Bt to an insect is directly related to the specificity of the toxin and the receptor sites. Without the proper receptor sites, the Bt will simply pass harmlessly through the insect's gut. Several varieties of Bt have been discovered and identified by the specificity of the endotoxins to certain insect orders. *Bacillus thuringiensis* var. *kurstaki*, for example, contains toxins that are specific to lepidopterans (butterflies and moths), while Bti is specific only to certain primitive dipterans (flies), particularly mosquitoes, black flies, and some chironomid midges. Bti is not known to be directly toxic to non-dipteran insects (Extoxnet 1996a).

Methoprene is an EPA toxicity class IV general use pesticide, considered slightly to practically nontoxic (EPA 2001). Methoprene is a synthetic mimic of a naturally produced insect hormone, juvenile hormone (JH). All insects produce JH in the larval stages, with the highest levels occurring in the insect's early developmental stages. As an insect reaches its final stage of larval development, the level of JH is very low. This low level of JH triggers the development of adult characteristics. When an insect is exposed to methoprene, a hormonal imbalance in the development of the insect results, and it fails to properly mature into an adult. The insect eventually dies in the pupal stage. The most susceptible stages of development to methoprene are the later instars (for mosquitoes, third and fourth instars). In mosquito control applications, methoprene is applied to the larval breeding habitat. Methoprene is a non-specific contact insecticide that does not need to be ingested like Bti (Tomlin 1994). Larvae will continue to feed and may reach the pupal stage, but will not emerge as adults.

Due to the potential adverse effects of methoprene on non-target insects, Bti is the first chemical of choice for use on the refuge. However, the refuge recognizes that Bti exhibits limited efficacy under certain conditions; under those conditions methoprene would be the prudent alternative. Only formulations with short-term residuals (5 to 10 days) have been used for larval mosquito control. Use of methoprene products with long term residuals, such as Altosid XR-G, 30-Day Briquettes, or XR Briquettes, will not be permitted.

Mosquito control chemicals have been applied using handheld, backpack, and aerial dispersal methods. The Mosquito Control Section conducts surveillance and carry out methods, including dip samples, light/CO2 traps, and landing rates. *Bacillus thurigiensis* and methoprene are applied following limitations included in the product EPA label, an annual Fish and Wildlife Service pesticide use proposal, and an annual refuge special use permit.

Areas Currently Permitted for Larvicide Treatments
In accordance with an annual larvicide SUP, up to 8 larvicide applications per year (byground or air) can be made to any given marsh site, involving the following areas:

Unit I—no larviciding is allowed, but none was requested by the DMCS. Open Marsh Water Management (OMWM) work, was undertaken in Unit I in the 1990s with additional treatments in the early 2000s. Reduced saltmarsh mosquito production in this unit is low enough that the DMCS has had no need to request any larviciding in this unit for a decade or so.

Unit I—up to 1637 acres within what use to be until about 2009 a heavily-vegetated freshwater wetland impoundment (prior to recent bayfront breaching) can be larvicided. However, relatively little larviciding actually occurred in this unit during the past decade, due to its former freshwater impoundment habitat conditions having reduced saltmarsh mosquito production. The impounding of this unit did not eliminate all saltmarsh mosquito production, but it occurred in a more diffuse manner over widespread areas within the unit, that in aggregate can occasionally produce large numbers of adult mosquitoes.

Unit III—up to 2117 acres within what use to be until about 2009 a heavily-vegetated freshwater wetland impoundment (prior to recent bayfront breaching) can be larvicided. But for reasons similar to Unit II above, relatively little larviciding actually occurred within this unit for the past decade.

Unit IV—this unit received extensive OMWM treatment in the late 1980s and early 1990s, which greatly reduced saltmarsh mosquito production. DMCS is currently permitted to treat up to 371 acres that were missed by the original OMWM work, or which weren't mosquito production areas at the time of treatment, but have since naturally become such. Approximately 90 acres of formerly OMWM-treated areas are currently dysfunctional requiring maintenance, for a total of 461 acres that are currently permitted for larvicide treatments.

Areas Currently Permitted for Adulticide Treatments
In accordance with an annual adulticide SUP, DMCS is currently permitted to aerially adulticide over a 600 ft wide strip of refuge lands immediately behind or landward of the 3 bayfront communities of Slaughter Beach, Primehook Beach, and Broadkill Beach, up to 6 times per year for any given site. The northern portion of this strip in Unit I, located behind the south end of Slaughter Beach, totals 58 acres; the southern portion of this strip in Units II, III and IV, located behind Primehook Beach and Broadkill Beach, totals an additional 169 acres, for a total of 227 acres.

Larvicide use on-refuge
From 2007-2011, aerial larvicide applications on-refuge (by fixed-wing aircraft or helicopter) averaged 1.2 applications per year (range = 0 to 3 applications), and involved an average total of 188 acres per year (range = 0 to 880 acres. Ground larvicide applications on-refuge (by hand or backpack sprayer) averaged 4.6 applications per year (range from 2 to 8 applications), and involved an average total of 11 acres per year (range = 5 to 19 acres).

Adulticide use on-refuge
Aerial adulticide applications on-refuge (by fixed-wing aircraft or helicopter) consistently averaged 1 application event per year over the 5-year period examined (from 2007-2011), involving an average of 227 acres per application event (range = 55 to 227 acres).

Open Marsh Water Management
By the 1960s, a different form of water management for mosquito control advocated the use of biological control rather than mechanical drainage. This concept, which became known as quality ditching was fostered to replace parallel grid-ditching. Quality ditching has since been transformed into what is known as open marsh water management (OMWM) and is based on the following assumptions (Daiber 1986):

- Not all parts of a tidal marsh breed mosquitoes.
- Mosquitoes are greatly reduced or absent from portions of the marsh where tidal action circulates water over the surface and removes excess water.
- Biological control in the form of predation by marsh fishes will reduce mosquito populations.
- Permanent pools of water on the marsh surface serve as reservoirs for mosquito-eating fish, which can forage on the surface of the marsh among *Spartina alterniflora* stems during high tide cycles.

OMWM is a method for controlling salt marsh mosquitoes using physical alternations of marsh habitat. Ponds and ditches are selectively excavated in order to create unsuitable environs for mosquito production while creating suitable habitat for larvivorous fishes. This method is intended to mimic natural wetland features, such as pools and channels, more closely than the dense parallel grid-ditching techniques used in the 1930s. OMWM biological controls are effective in reducing mosquito production by 95 percent in treated areas (DNREC 2008).

In 1980 special use permits were issued to DNREC to start a refuge OMWM study that included a 6-acre control site and 6-acre treatment site in tidal salt marsh habitats in Unit IV. From 1982 to 1986 study data was collected and analyzed on the effectiveness of OMWM on the refuge to control mosquitoes. Four years later, a 90 to 99 percent reduction in mosquito production was recorded by the State in the treatment site and was deemed as a good technique to use to reduce the use of insecticides to control mosquitoes on the refuge, an environmental assessment was completed in 1987 to treat about 960 acres in Unit I and 430 acres in Unit IV salt marsh areas. In subsequent years other areas in Units II and III were identified as breeding areas where OMWM systems should be used. From 1989 through 1995, approximately 1,290 acres were treated with the construction of OMWM systems (closed ponds with sumps, radial ditches, plugs, and sills connecting existing parallel grid ditches), essentially removing about 1,800 acres from the spray program. In 2001 an additional 10.2 acres

(3.2 acres of ponds and 7.0 acres of radial ditches) were treated with OMWM construction, removing an additional 362 acres from the spray program.

Socioeconomic Environment

Demographic data ranks Delaware's human population (830,364) as 45th in the nation. State land area covers 1,982 square miles compared to 3,537,438 (U.S.), with a population density of 401 persons per square mile compared to 80 nationwide. Delaware is 96 miles long and varies from 9 to 35 miles in width. Its chief products are manufacturing, mining, fish industry, and agriculture. Agriculture is one of Delaware's major industries, with 470,000 acres currently in croplands. Delaware ranks 5th in the nation in percentage of land under cultivation, with a total of 39 percent of the total land cover in croplands.

Half of Delaware's 25 miles of seashore beach habitats are State parks. Prime Hook NWR is located in Sussex County 22 miles southeast of Dover. Refuge headquarters are located 12 miles southeast of the town of Milford and 10 miles northwest of the town of Lewes, both of which are also located in Sussex County.

Population and Demographic Characteristics

Sussex County is somewhat less ethnically diverse than the State or nation, with nearly 68 percent of its residents being white persons not of Hispanic origin (U.S. Census Bureau). The poverty rate in Sussex County in 2007 was 9.7 percent, lower than the rates for both the State and nation. Median value of owner-occupied homes in Sussex County is $220,100, which is higher than the national median home value of $181,800 (American Community Survey). More than a quarter of all housing units in Sussex County are for seasonal or recreational use (American FactFinder, Census 2000 Summary File 1).

The largest town in Sussex County is Milford (population 7,201), part of which is in Kent County. Shipbuilding was the major industry of Milford through World War I. During much of the 20th century Milford served primarily as the commercial center for much of southern Delaware's large agricultural community.

Other large towns in Sussex County include Seaford (population 6,997), Georgetown (4,643), Lewes (2,932), Millsboro (2,360), and Milton (1,657). The primary industry in the area surrounding Seaford was agriculture, particularly the cultivation of tobacco, and the style of living was plantation. In 1925, the poultry industry became important as new methods of housing and feeding were introduced. The nature of farming changed from truck crops to grains and corn for chicken feed as Sussex County became the largest chicken-producing area in the world. In 1939, the DuPont Company chose Seaford as the site of the first nylon plant in the world *(www.seafordde.com;* accessed February 2012).

Georgetown is the county seat of Sussex County and contains the county's regional airport (Georgetown Local News, 2006). The town is home to a large chicken processing plant owned by Perdue Farms. The plant employs a sizeable number of immigrants from Haiti and Guatemala. In fact, in 2000, 21.6 percent of Georgetown residents were of Guatemalan heritage, representing the highest percentage of Guatemalan Americans anywhere in the country (Georgetown Local News, 2006) and giving Georgetown a more international feel than one would expect from a colonial-era town.

The town of Lewes was founded as a Dutch whaling colony in 1631, giving it the distinction of being the first town in the first State, making Sussex County the oldest county in Delaware. Lewes is named after the town of Lewes in England, which also is situated in a county named Sussex (from which Sussex County, Delaware, takes its name), and has the same seal as its English counterpart. Lewes is a vacation and resort spot popular with residents of Washington, D.C. and the surrounding suburbs. Even though the city technically sits on the lower reach of the Delaware Bay, it is nonetheless considered an ocean resort, particularly as the ocean is nearby at Cape Henlopen. Lewes is the home of the Zwaanendael Museum, which features exhibits about Delaware's history. Fisherman's Wharf is a dock that stretches along the Lewes and Rehoboth Canal. It features multiple restaurants and bait shops, and in season the dock hosts hundreds of boats. The Lightship Overfalls, moored there, is owned by the Overfalls Maritime Museum Foundation and is one of seven surviving lightships at museums in the United States.

The great mainstays of the local economy of Millsboro since the 18th century have been agriculture and timber, though both have changed significantly. Thriving businesses that began in the early 20th century include the manufacture of holly wreaths, cultivation of strawberry, and tomato canneries. Poultry production became a dominant industry in the Millsboro area, as in most other parts of Sussex County, beginning in the early 1930s *(www.millsborochamber.com;* accessed Feburary 2012).

The town of Milton, originally settled in 1672, is a quaint little Victorian shipbuilding village centered around the headwaters of the Broadkill River, that today it is a growing tourist attraction. For a small town, Milton has a remarkably large number of historic buildings and homes. It has a diversity of historic architecture and boasts 198 homes on the National Historic Register. Milton hosts several annual celebrations co-featuring Prime Hook NWR, most notably the Lower Sussex Bass Masters Youth Fishing Event and the Annual Horseshoe Crab and Shorebird Festival; the latter is a unique day of fun to raise awareness of horseshoe crab conservation and the critical link to healthy shorebird populations. The refuge also has a featured link on the Milton Chamber of Commerce home page.

Employment and Income

As the home to industry, agriculture, and numerous seaside resorts and small towns, Sussex County is diverse in both its natural resource assets and its lifestyles. The county is classified as a recreation and retirement destination, with an economy largely dependent on service industries . Tourism is responsible for employing more than 10,000 people in Sussex County with an estimated economic contribution exceeding $709 million annually (Delaware Economic Development Office, 2008). Sussex County has abundant beaches and inland bays, beautiful state parks, and quaint historical towns. There are 16 public and private golf courses, with 2 additional courses currently under construction.

Today, western Sussex County is the center of Delaware's agricultural industry with more acres of land under cultivation than anywhere else in the State. There are 205 agricultural preservation districts now in Sussex County. Currently, Delaware leads the nation in the percentage of protected farmland with 5.2 percent of the total land area and 11.3 percent in farms permanently preserved through agricultural easements.

Economic Benefits of Refuge Visitation and Management to Local Communities

National wildlife refuges enrich people's lives in many ways. Some benefits are relatively easy to quantify and some are not. Ecotourism is one method to derive economic benefits from the conservation of wildlife and habitats. It is important to quantify the economic effects of ecotourism to assist in refuge planning and facilitate the interaction of refuges and local communities (Caudill and Henderson 2005).

> *"In a world where money counts, the land needs value to give it a voice."* *—(Frances Cairncross/Banking on Nature 2004)*

Economic impacts at the refuge have been evaluated through several analyses over the past several years. Caudill and Henderson (2005) evaluated the economic benefits of the refuge to local communities in 2004 through the Banking on Nature study discussed in this section. Sexton et al. (2007) reported visitor trip spending of non-consumptive visitors and big game hunters using 2004 to 2005 data as part of a visitor and community survey for the refuge (discussed in the “Community Attitudes and Opinions about Prime Hook NWR” section). Koontz (2010) provided regional economic impacts of current and proposed management alternatives for the refuge (appendix I).

Banking on Nature Study by Caudill and Henderson (2005)
Refuge visitors pay for recreation through entrance fees, lodging near the refuge, and purchases from local businesses for items to pursue their recreational experience. This spending generates economic activity throughout the local economy. Some of the money leaks out of the local area (leakage), and some is recycled through the local economy (multiplier). Spending by non-residents must be separated from spending by local refuge visitors. In the data below, total visitor spending is evaluated to show its significance to the local economy.

Daily visitor expenditures for both residents and non-residents were developed in four categories (food, lodging, transportation, and other expenses) for six activities: freshwater fishing, saltwater fishing, migratory bird hunting, small game hunting, big game hunting, and non-consumptive activities. Visitor days were factored in, and the total expenditures by category of spending for each activity were determined. The area economy of the local surrounding area was characterized by population growth, employment, and per capita income (Caudill and Henderson 2005).

Although Prime Hook NWR is located in Sussex County, New Castle and Kent Counties provide significant sources of numbers of refuge visitors. The area had a population of 818,200 in 2003, an increase of 15.8 percent from 1993, compared to a 12 percent increase nationwide. Total area employment increased by 19.4 percent from 1993 to 2003 compared with an 18 percent increase in the U.S. Per capita personal income increased in the area by 17.7 percent in the same timeframe. This compares with a 15.6 percent increase in the U.S (see table 3-16 for summary of these data: source from U.S. Department of Commerce 2003).

Table 3-16. Summary of Area Economy, 2003
(Population and Employment in thousands; Per Capita Income in 2004 dollars)

	Population		Employment		Per Capita Income	
County	2003	Percent change 1993-2003	2003	Percent change 1993-2003	2003	Percent change 1993-2003
New Castle	515.1	11.4%	342.1	16.4%	$39,679	17.8%
Sussex	168.4	33.5%	85.9	29.5%	$27,556	17.8%
Kent	134.6	14.1%	77.4	22.4%	$27,152	17.4%
Area Total	**818.2**	**15.8%**	**505.4**	**19.4%**	**$35,123**	**17.7%**
United States	290,789.0	11.9%	167,174.4	17.9%	$32,322	15.6%

Prime Hook NWR had a total visitation of 106,525 during 2004 (table 3-17). The majority of recreation visits (108,611) were for non-consumptive activities and 63 percent of all recreational visits were undertaken by area residents.

Table 3-17. Prime Hook NWR 2004 Recreation Visits

Activity	Residents	Non-Residents	Total
Non-Consumptive:			
Nature Trails	30,077	20,052	50,129
Observation Platforms	5,264	3,509	8,773
Other Wildlife Observation	25,916	17,277	43,193
Beach /Water Use	0	0	0
Other Recreation	3,910	2,606	6,516
Hunting:			
Big Game	345	518	863
Small Game	71	4	75
Migratory Birds	1,100	367	1,466
Fishing:			
Freshwater	5,357	282	5,639
Saltwater	3,572	188	3,760
Total Visitation	***75,612***	***44,802***	***120,414***
Total Visitors			***106,525***

The regional area for the refuge is defined as Sussex, New Castle, and Kent counties of Delaware. In 2004, total Prime Hook NWR visitor recreation expenditures were $1,043,600 with non-residents accounting for $795,000 or 76 percent of the total refuge visitor recreational expenditures. Dollars spent by non-consumptive users totaled $771,900, fishing expenditures accounted for $222,100 or 21 percent of the total, and hunting expenditures ($49,700) or 5 percent of total recreation expenditures (table 3-18).

Table 3-18. Prime Hook NWR: 2004 Visitor Recreation Expenditures (in thousands)

Activity	Residents	Non-Residents	Total
Non-Consumptive:	$165.2	$606.6	$771.9
Hunting:			
Big Game	$3.3	$18.9	$22.2
Small Game	$0.3	—	$0.3
Migratory Birds	$7.5	$19.7	$27.2
Total Hunting	$11.0	$38.6	$49.7

Activity		Residents	Non-Residents	Total
Fishing:				
	Freshwater	$36.2	$100.6	$136.9
	Saltwater	$36.1	$49.1	$85.2
	Total Fishing	$72.3	$149.8	$222.1
Total Expenditures		**$248.6**	**$795.0**	**$1,043.6**

Table 3-19 quantifies the local economic effects associated with 2004 recreation visits. The data focuses on the final demand (see glossary), employment income, and tax revenue dollars generated by Prime Hook NWR's recreational visitors. In addition to the economic effects of refuge hunting and fishing programs to local economies, it measures the dollar impact of ecotourism, which is the recent phenomenon of large numbers of people traveling substantial distances to take part in non-consumptive uses of the natural environment, to capture the total economic impacts associated with refuge visitor spending.

This total final demand was calculated as $1,456,000. This amount reflects the total monetary value of economic activity generated in the three county area by Prime Hook NWR visitor spending. In turn, the final demand generated 13 jobs (both full-time and part-time) with a total job income of $419,400. Total tax revenue generated (county, State, and Federal) amounted to $291,000 (table 3-14).

Table 3-19. Local Economic Effects Associated with 2004 Recreation Visits

	Residents	Non-Residents	Total
Final Demand	$346,400	$1,110,200	$1,456,600
Jobs	3.0	9.8	12.8
Job Income	$99,400	$320,000	$419,400
Total Tax Revenue	$69,700	$221,300	$291,000

The total economic effects (total recreation expenditures plus net economic value) are compared with Prime Hook NWR's budget for 2004. Net economic value is defined as an individual's total willingness to pay for a particular recreation activity minus his or her actual expenditures for that activity. The figure for economic value is derived by multiplying net economic values for hunting, fishing, and non-consumptive recreation use (on a per day basis) by estimated refuge visitor days for that activity and combining that number with the estimate of total expenditures, and dividing by the refuge budget for 2004. Caudill and Henderson (2005) estimated that the total economic effect is $1.85, meaning that for every $1 of budget expenditures, $1.85 of total economic effects are associated with these budget expenditures (table 3-20). This ratio provides a basis to compare the magnitude of economic effects resulting from refuge visitation to budget expenditures.

Table 3-20. Summary of Local Economic Effects of Recreation Visits (2004)

	FY 2004 Budget	Recreation Expenditures	Net Economic Value	Total economic effects per $1 budget expenditure
Prime Hook NWR	$1,290,700	$1,043,600	$1,344,400	$1.85

Regional Economic Impacts of Current Management for the Refuge by Koontz (2010)
The U.S. Geological Survey-Fort Collins Science Center estimated the direct and total economic impacts of refuge management activities in Sussex County.

Refuge management activities of economic concern included refuge purchases of goods and services within the local community, refuge personnel salary spending, revenues generated by the refuge Revenue Sharing Program, and spending in the local community by refuge visitors. The economic impacts in this study were estimated using the impacts analysis for planning regional input-output modeling system. Refuge management activities directly related to refuge operations generate an estimated $2.7 million in local output, 25 jobs, and $742 thousand in labor income in the local economy. Including direct, indirect, and induced effects, refuge activities would generate total economic impacts of $3.9 million in local output, 33 jobs and $1.1 million in labor income.

More specifically, non-consumptive use directly related to refuge operations would generate an estimated $2.1 million in local output, 21.3 jobs, and $602.7 thousand in labor income in the local economy. Including direct, indirect, and induced effects, non-consumptive use would generate total economic impacts of $3.1 million in local output, 29.3 jobs and $875.6 thousand in labor income.

Fishing activities directly related to refuge operations would generate an estimated $180.4 thousand in local output, 1.8 jobs, and $50.4 thousand in labor income in the local economy. Including direct, indirect, and induced effects, fishing activities would generate total economic impacts of $252.5 thousand in local output, 2.1 jobs, and $72.1 thousand in labor income.

Overall hunting activities directly related to refuge operations would generate an estimated $73.5 thousand in local output, 0.6 jobs, and $21 thousand in labor income in the local economy. Including direct, indirect, and induced effects, overall refuge hunting activities would generate total economic impacts of $103.5 thousand in local output, 0.9 jobs and $30.1 thousand in labor income. A further breakdown of hunting activities on the refuge, including direct, indirect, and induced effects, reveals that big game hunting on the refuge would generate total economic impacts of $45.5 thousand in local output, 0.4 jobs, and $13 thousand in labor income. Waterfowl hunting on the refuge would generate total economic impacts of $56 thousand in local output, 0.5 jobs, and $16.6 thousand in labor income. Small game hunting on the refuge would generate total economic impacts of $2.0 thousand in local output, 0.02 jobs, and $500 in labor income.

Recreation and Tourism

According to the 2009 State of Delaware Comprehensive Outdoor Recreation Plan, 91 percent of Delaware residents indicate that outdoor recreation had some importance in their lives. When asked about facility needs, survey respondents in Sussex County identified as high priorities walking and jogging paths, bike paths, beach access, fishing access, and open space/passive recreation. According to the 2003 State of Delaware Comprehensive Outdoor Recreation Plan, the majority of Delaware residents surveyed think that there is too much development and not enough forests or open spaces in the State. Nearly half think there is too little farmland in the State, while one-third think there are too few wetlands in the State.

The National Survey of Fishing, Hunting, and Wildlife Associated Recreation collects information about anglers, hunters, and wildlife watchers in the U.S. (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2006). The 2006 survey found that 395,000 Delaware residents and non-residents 16 years old and older participated in wildlife-associated recreation in Delaware. While the total number of participants[1] has fallen since 2001, the number of *days* spent participating in wildlife recreation has risen (table 3-21), as has expenditures on such recreation. In 2006, State residents and nonresidents spent $299 million on wildlife recreation in Delaware, compared to $148 million in 2001.

[1] The sum of anglers, hunters, and wildlife-watchers exceeds the total number of participants in wildlife-related recreation because many individuals engaged in more than one wildlife-related activity.

Table 3-21. Wildlife-Related Visitors in Delaware

	Visitors (Resident and Non-Resident)		Visitor-Days (Resident and Non-Resident)		% Non-Resident Visitor-Days
Activity	**2001**	**2006**	**2001**	**2006**	**2006**
Wildlife Viewing	232,000	285,000	722,000	855,000	16%
Fishing	148,000	159,000	1.4 million	1.8 million	33%
Hunting	16,000	30,000	226,000	654,000	22%

Source: U.S. Fish and Wildlife Service and U.S. Census Bureau (2006)

Wildlife Viewing

Abundant opportunities for wildlife viewing are available throughout Delaware. Wildlife viewing includes the activities of observing, identifying, and photographing. These activities can be done for formal educational purposes or general recreational enjoyment.

In 2006, trip-related and equipment-related expenditures associated with birding nationwide generated more than $82 billion in total industry output, 671,000 jobs, and $11 billion in local, state, and Federal tax revenues, impacting local, state, and national economies (USFWS 2009a).

Wildlife-watchers spent $131 million on wildlife-watching activities in Delaware in 2006 (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2006). The majority ($110 million, or 84 percent) of wildlife-watching expenditures were for equipment. Trip-related expenditures, including food, lodging, transportation, and other trip expenses such as equipment rental, made up $13 million, or 10 percent of all wildlife-watching expenditures. Other items purchased by wildlife-watching participants, such as magazines, membership dues and contributions, land leasing and ownership, and plantings, made up the remainder.

Accounting for the multiplier effect of these direct expenditures, wildlife-viewing generated a total of $203 million in economic activity and supported 1,975 jobs in Delaware in 2006 (Leonard 2008), comprising 0.34 percent of the State's GDP (Bureau of Economic Analysis) and 0.36 percent of all jobs in the State (USA Counties).

Preliminary findings from the 2011 National Survey of Fishing, Hunting, and Wildlife Associated Recreation report no significant change in wildlife watching from 2006 to 2011 and a nine percent increase from 2001 to 2011 in overall wildlife watching participation (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2012).

Hunting

Total expenditures for all hunting activities nationwide (big game, small game, migratory birds, and others) totaled $22.9 billion in 2006 (USFWS and U.S. Dept. of Commerce 2006). A more detailed analysis conducted for waterfowl hunting nationwide, found it generated over $2.3 billion in total industry output, 27,618 jobs, and $347 million in state and Federal tax revenues, impacting local, state, and national economies (USFWS 2008b).

Preliminary findings from the 2011 National Survey of Fishing, Hunting, and Wildlife Associated Recreation report that overall hunting participation has increased nine percent from 2006 to 2011 (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2012). In 2006, hunting participation nationwide was decreasing; however, it was increasing in Delaware (U.S. Fish and Wildlife

Service and U.S. Census Bureau, 2006). In 2006, the majority (57 percent) of hunting was for big game, with the remainder being for migratory birds (29 percent) and small game (14 percent) (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2006). All hunting-related expenditures in Delaware totaled $41 million in 2006 (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2006). Equipment made up the largest proportion of hunting expenditures ($25 million, or 60 percent). This was followed by trip-related expenses, such as food and lodging, transportation, and other trip expenses, which made up one-third of all hunting expenditures. The purchase of other items, such as magazines, membership dues, licenses, permits, and land leasing and ownership, made up the remainder of all hunting expenditures.

A more detailed analysis conducted for waterfowl hunting in Delaware, found it generated more than $3.9 million in total industry output and $679,000 in State and Federal tax revenues (USFWS 2008b).

Fishing

Total expenditures for all fishing activities nationwide totaled $42 billion in 2006 (USFWS and U.S. Dept. of Commerce 2006). Preliminary findings from the 2011 National Survey of Fishing, Hunting, and Wildlife Associated Recreation report that the number of anglers increased eleven percent from 2006 (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2012). In 2006, fishing participation nationwide was decreasing, but it was increasing in Delaware (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2006). Fishing-related expenditures in Delaware totaled $97 million in 2006 (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2006). Trip-related expenditures, including food and lodging, transportation, and other trip expenses, totaled $49 million—half of all fishing expenditures. This was followed by expenditures on equipment, which totaled $39 million (41 percent of all fishing expenditures). The purchase of other items, such as magazines, membership dues, licenses, permits, stamps, and land leasing and ownership, made up the remaining 9 percent of expenditures.

Recreation in Sussex County

According to the 2007 Sussex County Visitor Profile Study (Delaware Economic Development Office, 2008), nearly 3.2 million visitors traveled to Sussex County in 2007, a 6 percent increase over 2006 and a 20 percent increase over 2005. The majority of trips to Sussex County were for leisure (78 percent), increasing nearly 2 percent over 2006. On the other hand, business travel to the County declined by 2 percent. After Delaware, most visitors came from Maryland and Pennsylvania. Personal auto travel remained the dominant form of transportation to Sussex County, accounting for 69 percent of person-trips in 2007.

The average age of visitors in to Sussex County in 2007 was 45 and the median income of households visiting Sussex County was over $75,000, significantly higher than the median household income in Sussex County ($50,132). Average total trip spending was $405, a decrease of 7 percent from 2006. The average length of trip for Sussex County visitors was approximately 1.7 nights. Approximately 41 percent of overnight visitors stayed in a home/apartment/condo, while 30 percent stayed in a hotel/motel/resort and 19 percent stayed in a private home. Dining was the most popular activity for Sussex County visitors (42 percent), followed by visiting the beach/waterfront (41 percent), shopping (32 percent), entertainment (27 percent), touring/sightseeing (22 percent), hunting/fishing (13 percent), and visiting national/State Parks (10 percent).

Agriculture

As previously stated, Sussex County is the center of Delaware's agricultural industry. In 2007, 1.4 percent of all farmland in Sussex County was enrolled in Conservation Reserve, Wetlands Reserve, Farmable Wetlands, or Conservation Reserve Enhancement Programs.

According to the census of agriculture, farmland made up 41 percent of Delaware's land area in 2007. The majority of this farmland (81 percent) was used for growing crops, while 9 percent was woodland, 1.3 percent was pastureland, and the remaining was house lots, ponds, roads, and wasteland. In line with national trends, the average farm size in Delaware has been increasing, while total farmland has been decreasing. The average farm size in Delaware in 2007 was 235 acres, compared with the national average of 418 acres. Major crops grown in Sussex County are soybeans, corn for grain, wheat, barley, and corn for silage.

Community Attitudes and Opinions about Prime Hook NWR

The U.S. Geological Survey also estimated visitor trip spending and reported visitor and community attitudes and preferences about Prime Hook NWR (Sexton et al. 2007). The full report may be viewed at: *http://pubs.er.usgs.gov/usgspubs/ofr/ofr20071239;* accessed February 2012.

This extensive public use study was commissioned by the Northeast Region of the Service in support of the comprehensive conservation planning at Prime Hook NWR. The research was conducted by the Policy Analysis and Science Assistance Branch (PASA) of the U.S. Geological Survey/Fort Collins Science Center in order to determine how current and proposed CCP planning strategies for Prime Hook NWR could affect:

- Visitor use
- Visitor experiences
- Visitor spending
- Community residents' perceptions and opinions

Data for this study were collected using a survey administered to visitors to Prime Hook NWR and individuals living in the communities surrounding the refuge. 1,859 surveys were randomly distributed to two groups—to on-refuge visitors and to residents of surrounding communities, both consumptive (participating in fishing, hunting, or crabbing) and non-consumptive users. The stratified random sample of community residents, weighted with U.S. Census Bureau data to correct for age, gender, and community proportionality, had a +/- 4.4 confidence interval and the visitor survey had a +/- 5.4 confidence interval. Most refuge visitation is from repeat visitors, with visitors coming about 12 times a year and residents about 16 times per year. The study explicitly focused on whether there were statistically significant differences between the consumptive and non-consumptive users. About 72% of the total refuge visitors were from the local area and about half of them engaged in consumptive activities. 89% of the nonlocal visitors were classified as non-consumptive users. The non-consumptive users were more likely to be older (60s), retired, and female (54%). The consumptive users were more likely to be in their late 40s, employed, and male (97%). Other demographic factors were not significant differentiators between the visitor and community residents.

Wildlife observation was listed as the primary reason for both the visitor and community residents' visits, drawing 54% of the respondents' visits, regardless of whether they otherwise engaged in consumptive or non-consumptive activities. The refuge visitor group engaged in hunting more frequently than the community resident group and ranked it at a higher level of importance. The community residents more frequently participated in driving for pleasure and observing wildlife from or close to, their vehicles. The community residents also participated in various festivals, the National Fishing Day event, and organized lectures or birding trips to a larger extent than the refuge visitors did. Consumptive users primarily engaged in hunting (80%) and fishing (30%) and the non-consumptive visitors identified bird watching (73%), nature/wildlife viewing (64%), hiking/nature trails (56%), and special events, environmental education, and guided interpretive tours (collectively 68%) as their primary activities, although both groups did engage in the other activities. Proximity to the roads was of key importance to both the consumptive and non-consumptive users, but presumably for different reasons--the consumptive users use roads to access areas for hunting and fishing; many of the non-consumptive users, being older, remain in or near their cars while viewing birds on or near the water. However, non-consumptive visitors also placed the roads as important for viewing forest birds and paddling. Both the community residents and the visitors placed being in natural, undeveloped lands, experiencing a serene environment, using hiking/nature trails, and viewing birds on or near water as the activities of highest importance to them. Overwhelmingly, both consumptive and non-consumptive users held similar views of the refuge as providing attachment or meaning to their sense of place and identity and for family tradition or heritage.

Both groups expressed strong support for the level of services and features presently being provided by the refuge. In almost all categories of refuge services or opportunities, "Leave As Is" received the highest or close to the highest view (as compared to those wanting "More" or "Less" of some attribute.) Both consumptive and non-consumptive users indicated that refuge improvements could include increased wildlife viewing opportunities, improved environmental education and interpretive exhibits, increased hiking/nature trails, a new wildlife observation tower, and additional roadside pull-offs. Both consumptive and non-consumptive users highlighted only one area of services as important and poorly served by existing refuge management; this was media coverage/information, i.e. brochures and publications.

Local consumptive-use visitors rated the hunting and fishing programs as important and satisfactory, non-consumptive, especially non-local visitors, perceived the hunting programs as relatively unimportant and as "possible overkill" (a term not related to killing, but to the degree of program emphasis provided for that activity.) One statistical difference between the consumptive and non-consumptive users is that the non-consumptive users preferred to have more areas restored to natural conditions, more hiking trails, and more interpretive exhibits. When asked to rate five potential future services, the non-consumptive users rated an observation tower overlooking the marsh, road-side pull-offs, more walking trails around refuge headquarters, and more scheduled guided interpretive walks as far more important to them than the consumptive users rated such increased services. Non-consumptive users also wanted to have less hunting or level amounts of hunting, whereas the consumptive users overwhelmingly requested increased access for hunting and areas where they could set up their own blinds or deer stands.

Attitudes about certain aspects of visitor activities and refuge management revealed some areas of strong agreement amongst the respondents and some areas of clear polarization. Most habitat management options (restoration of natural habitats, use of fire to reduce risk and improve wildlife habitat, elimination of invasives) generated agreement amongst all respondents. The "continue farming/cease farming" issue was highly polarized when the survey was conducted in 2004-5, with non-consumptive visitors far more supportive of restoration of natural habitats than the consumptive users. Continued land acquisition from willing sellers was strongly supported by both groups, of both private lands currently managed as farmland or of beachfront. Mosquito control generated strongly disparate opinions, again polarizing non-consumptive users who tended to favor limited spraying, but this group still accepted spraying when mosquito numbers are excessively high or when a public health emergency was declared. Since the survey was conducted before the breach of the barrier island east of Unit II, concerns about beach and marsh management did not generate public comments.

In contrast to the farming and mosquito control issues, hunting and other consumptive uses did not generate such disparities in attitudes between the non-consumptive users and the consumptive users. About 55% of the non-consumptive users were content to leave hunting 'as is' or to have it be increased. But the survey also included an open-ended response option regarding views about whether some activities should not be allowed/should be allowed on the refuge and about one quarter of the respondents provided some point of view. Some community residents stated the desire to have increased areas open for off-trail non-hunting use in addition to having more trails in areas now open to hunting. About 10% of the respondents expressed general opposition to hunting as an allowed refuge activity, but these comments did not reflect an understanding that hunting and fishing are identified by law as a priority public recreation wildlife-dependent use.

Spending associated with refuge recreational activities such as wildlife viewing and hunting can generate considerable tourism activity in the local Sussex County economy. On average, non-consumptive visitors spent 2 to 3 days in the local area with approximately three people in their group sharing expenses. Most of the non-local deer hunters were from other counties in Delaware; about half spent the night locally while the other half drove home after hunting. The current level of non-consumptive use and big game hunting nonlocal visitor days accounts for more than $983,500 of spending annually in the local communities near Prime Hook NWR. Direct and secondary effects generate more than $1.21 million in local output, $447,700 in personal income, and 19.4 jobs annually in Sussex County.

Currently, there is no fee to visit Prime Hook NWR. Survey results indicate residents and visitors do not feel that they should have to nor would they be willing to pay to visit the refuge. Responses were divided among agreement, disagreement, and uncertainty regarding this issue, although visitors were more willing to pay a fee than community members. While opinions regarding fees sometimes change once implemented, more study would be needed if implementation of fees were to be considered at Prime Hook NWR in the future.

Respondents were asked about their participation in natural resource decisionmaking (civic engagement) and ways in which they commonly obtain information on these topics, as well as their level of trust in both the refuge and the U.S. Fish and Wildlife Service. Understanding individuals' civic engagement and their trust in the managing organization aids in public communication efforts.

Visitors to Prime Hook NWR rely heavily on friends and neighbors for news and information about the refuge. Local residents rely mostly on newspapers, followed by friends and neighbors, for news and information about the refuge. There appears to be some emerging use of the Internet for refuge information by visitors and community residents. These results support the importance of targeting communication strategies and outlets to different user groups of the refuge to convey important messages.

Community residents and visitors to the refuge have been quite engaged in natural resource decisionmaking in the past 5 years, engaging in passive activities, such as signing a petition, and active activities, such as joining a special interest group. On average, visitors and community residents have engaged in half the activities listed in the survey. The most common activities include attending a public meeting (59 percent of visitors and half of community residents), signing a petition (59 percent of visitors and 45 percent of community residents), and joining a special interest group (about half of visitors and 41 percent of community residents).

Another factor important in public involvement in decision making is trust in the managing agency. Visitors and community residents appear to have moderate trust in Prime Hook NWR staff and the Service. However, nearly a quarter are unsure about their level of trust in the agency and the refuge. A planning process such as development of the CCP is an opportunity to build relationships and improve trust not only with visitors and community residents with whom the refuge has established relationships, but also with those who are less familiar with the refuge or have not engaged in the process due to lack of trust in the agency or uncertainty of their role in the process.

The study has been a key tool for the Service as it developed the CCP and many of the actions and initiatives incorporated into alternative B reflect the perspectives expressed by the survey respondents, including increasing the extent of trails open both to consumptive and non-consumptive users, increasing habitat restoration efforts, and expanding environmental education and interpretation programs, informational brochures, internet information, etc. Some of the issues which were identified in 2004-2005 may be less confrontational now, such as increased recognition of the national policies about unacceptable farming practices (requiring use of non-genetically modified seed.) However, some issues which did not surface at the time of the survey, such as barrier island management and maintaining the fresh-water impoundments in light of climate change and sea level rise have generated controversy more recently. While many more non-local residents than local visitors did not engage in consumptive activities or felt that hunting should be reduced, slightly more than 50% of the non-consumptive users accepted hunting at existing levels or were supportive of an increase in this use. Only about 10% of the survey respondents felt that hunting should not be allowed at all, and it is possible that some of these visitors did not understand that Congress has already determined that hunting and fishing are to be facilitated as well as wildlife observation, photography, or environmental education. Since hunting, fishing, and crabbing have been a key aspect of Delaware history and culture, the results of the random survey support the conclusion that the refuge has appropriately allocated its resources amongst all of its priority public recreation users, and that increasing opportunities for shared public access of areas which were previously closed to any public access will be perceived as beneficial by both consumptive and non-consumptive visitors.

Refuge Administration

Prime Hook NWR Staffing

Through the implementation of a regional workforce plan in 2007, Prime Hook NWR was merged with Bombay Hook NWR to form the Coastal Delaware Refuge Complex. As part of the plan, some staff positions were deleted or reassigned to different positions. The approved staffing chart indicates five full-time employee equivalent positions (table 3-22).

Table 3-22. Prime Hook NWR Staffing levels (over the past 10 years)

Fiscal Year	FY 03	FY04	FY05	FY06	FY07	FY08	FY09	FY 10	FY11	FY12
Funded FTEs	9	8	8	8	7	7 (2 temps)	5 (1 temp)	5 (2 temps)	5 (2 temps)	5 (1 temp)
Approved FTEs	9	8	8	8	7	5	5	5	5	5

Facilities and Maintenance

A 3,920-square-foot headquarters building houses the refuge administrative staff. The building was constructed in 1997 and provides space for staff, a friends group sales outlet, public restrooms, and an auditorium that can accommodate 45 persons. Adjacent to the refuge office building is an office trailer that houses two employees. A larger building is needed to accommodate all staff in one building and increase auditorium seating capacity. Located in the headquarters area is a self-service boat ramp and a 12,350-square-foot parking area. The boat ramp provides access to Prime Hook Creek. There are two additional boat ramps on the refuge. In 2004, a 4,500-square-foot maintenance facility was constructed that allows for the storage and repair of refuge heavy equipment. The building has a full shop, which allows the maintenance staff to perform a wide range of tasks. A 3,200-square-foot pole style pavilion was constructed in 2006 to provide an area for festivals and educational programs to be held. In 2008, an additional pole shed was constructed to store equipment. The environmental education pavilion was replaced and relocated closer to the refuge office in 2010. Three county roads are found within the refuge. They are maintained by the Delaware Department of Transportation.

The refuge has several informational kiosks, a photography blind, an accessible observation tower, and several hunting stands (96) and blinds (28) that are maintained for recreational uses. Walking trails cover a distance of approximately six miles. The refuge manages 4,200 acres of impounded marshes to provide feeding and resting areas for migrating birds, particularly waterfowl and shorebirds. Through a series of dikes and water control structures, the refuge controls water levels to manage for waterfowl and shorebirds. Three water control structures within the impoundments contain fish weirs. To access these areas and structures, there are paved, earthen, and graveled roads and parking areas.

Operating Budget

Table 3-23 summarizes the budget for the refuge over several recent years.

Table 3-23. Recent Refuge Budgets

	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY11
Operation	370,527	609,678	216,845	301,956	318,489	697,093	320,397	295,722
Maint.	910,171	109,215	138,507	125,985	113,716	263,848	118,828	97,176
Visitor services	–	–	203,722	184,593	156,837	158,172	164,171	158,850
Planning	–	–	132,415	132,415		–		
Other	177,321	159,684	96,962	22,658	19,662	41,426	35,451	41,547

* *Funds in "Other" category can be carried over from year to year; therefore, they do not necessarily represent new funds.*

Refuge Visitor Services Program

A visitor services review of the refuge was conducted in October 2004 by regional office visitor services professionals to serve as a tool for refuge staff to use as they continue to develop their visitor services program and consider new possibilities in the various alternatives of the CCP (USFWS 2004a). A great deal of background information and recommendations from this review have been used to summarize the affected environment of the visitor services program at Prime Hook NWR.

Public use objectives at Prime Hook NWR are to provide wildlife-oriented recreational opportunities compatible with habitat and wildlife objectives. Current management at Prime Hook NWR provides for all six of the priority wildlife-dependent recreational opportunities, which are wildlife observation, wildlife photography, hunting, fishing, environmental education, and environmental interpretation. Long-term focus for the refuge, recommended in the review, suggests that emphasis should be placed on hunting, wildlife observation, and photography, and encourages the staff to continue to work toward providing and developing strong, high-quality programs in these areas in particular, and balancing the emphasis placed on these three uses.

The refuge's affected audiences include hunters, anglers, birders, wildlife enthusiasts, photographers, beach tourists, and retirees. The refuge has dealt with a number of controversial issues over the years that have strained its relationship with the community. Past and current issues include land condemnation, management and protection of the endangered Delmarva fox squirrel, farming, hunting, dune overwash, lead shot contamination, and water management. However, refuge staff continues to work with diligence and patience to secure the community's trust and understanding.

Service employees, volunteers, concessionaires, and other cooperators conform to the following standards when planning, conducting, and evaluating all visitor service activities and facilities at refuges, as described in Part 605 Wildlife Dependent Recreation of the U.S. Fish and Wildlife Service Manual.

Visitor Services Plan
To date, visitor planning at Prime Hook NWR includes the public use management plan, which was prepared in June 1993. Currently, no updates or revisions have been made to the 1993 plan. In addition, the refuge has also prepared a sign plan (1992), a station management plan (1987), a safety plan (1986), a fishing plan (1986), a hunt plan (1987), a crowd control plan (1971), an occupant emergency plan (1983), a fire management plan (2003), a furbearer/trapping plan (1987), and an interim land use plan (1967). A visitor services plan is scheduled to be completed following the completion of the CCP.

Welcoming and Orienting Visitors
Eastern Sussex County, Delaware, is a major summer tourist attraction and receives several million visitors per year. A portion of those tourists visit Prime Hook NWR. Visitation at the refuge is growing as more people move into the area and as visitors traveling on Route 1 and 16 observe directional signing that clearly identifies the location of refuge headquarters. Increasing public use is expected to continue well into the future, bringing large numbers of first-time visitors in need of basic refuge orientation and information. Records going back to 1968 indicate a low of about 5,900 visits per year and a high of about 106,525 visits in 2004. Since 1995, the average number of visitors is approximately 81,000.

The visits at Prime Hook NWR fall into several seasonal categories. Throughout the year, visitors use Prime Hook by hunting, fishing, birding, canoeing/kayaking, wildlife photography and observation, and participating in environmental education programs, refuge special events, and interpretive programs. Summer visits primarily include tourists, education visits occur during the spring and fall, and outreach initiatives provide refuge information to visitors during the spring, summer, and fall through display booths at dozens of offsite events.

Refuge staff have not conducted formal surveys of annual visitation as limited funding and staffing along with numerous refuge access points have proved challenging. However, for the purpose of the CCP/EIS, annual visitation has been estimated based on a variety of sources, including a traffic counter located at the refuge headquarters area, hunt permits, visitor facility counts, group counts, and general observations by refuge personnel. Offsite interpretive exhibit numbers are based on either an estimate of total event attendance or the number of people visiting the refuge's exhibit.

During fiscal year 2012, over 85,000 people were estimated to have visited Prime Hook NWR. Onsite interpretation, special events, visitation at the headquarters office/visitor facility, nature observation, and photography accounted for majority of the visits; environmental education accounted for more than 400 visits; hunting visits numbered 1,520; fishing visits numbered 8,693; and other recreation accounted for an additional 1,929 visits.

The refuge has one primary access point at the refuge headquarters/visitor contact station located on Turkle Pond Road. There are four secondary entrances located at Slaughter Beach, Fowler Beach, Prime Hook, and Broadkill Beach Roads. These are State-maintained roads that cross the refuge and provide access to refuge lands and several beach communities.

The refuge headquarters entrance is the main entrance. A refuge orientation kiosk is located at the hunter check-in station located at the entrance to welcome visitors with refuge information and literature. The entrance sign is appropriately located outside the electronic gate entrance that provides access to the road leading to the refuge headquarters. There is one refuge entrance sign on the northeast tip of the refuge on the Slaughter Beach Road adjacent to the community of Slaughter Beach. The road here aligns with the refuge boundary. The entrance sign is suitably located where it is visible to visitors traveling in either direction along Slaughter Creek Road. Fowler Beach Road bisects the refuge, terminating at Fowler Beach. A refuge entrance sign is well-placed at the west end of the road and refuge entrance signs are located at both ends of this refuge-bisecting road. The entrance sign on the east end of the road is visible to visitors entering the refuge from the Prime Hook Beach community. The entrance sign located on the west end serves travelers who continue east on Prime Hook Road or who turn north onto Cods Road.

One refuge entrance sign combined with a message board for temporary messages is located along Broadkill Beach Road. Although these signs are not situated near the entrance to refuge property on this road, it does not appear to be confusing to visitors. The visibility of refuge boundary signs serves to define the refuge boundary here, and the entrance sign here helps to reinforce the refuge's name while the message board highlights significant refuge events.

Directional signs provided by the Delaware Department of Transportation are located along Route 1 and along Broadkill Beach Road. These signs are fairly new, properly identify the refuge, and include the Blue Goose graphic. Effective and efficient directional road signage continues inside the refuge gate to the headquarters.

Directional signs indicating visitor parking in front of the building entrances are located at the junction of the office parking area and the parking area facing the restrooms and interpretive sign trio. A sign with directional arrows indicates that visitors are to park in front of the office building and boaters are to park on the side of the building.

The visitor information area is staffed exclusively by volunteers. In the event that a volunteer is not available to staff the area, the door to the visitor contact station, which is located next to the refuge office door, is locked. People looking for information enter through the refuge office door where staff assist them with information and gift shop sales. A third door, which is located at the end of the bathroom hallway, exits to the north end of the building to the parking area for boaters.

The refuge headquarters area is the key visitor activity location. By Service standards, the use of the word "center" implies more extensive visitor services and facilities than currently exist here, which actually align more with the Service's concept of a visitor contact station. It was recommended by the review team that this location be identified as a visitor contact station or visitor facility.

Upon entering the main entrance to the refuge headquarters area, there is a sign highlighting the permitted and prohibited activities at Prime Hook NWR. Major permitted activities include wildlife observation and photography, environmental education, hiking, canoeing, hunting, and fishing. Major prohibited activities include camping, horseback riding, firearms, off-road vehicles, and collecting plants and animals. The refuge's boundary is generally well-marked. Refuge staff periodically inspects each boundary sign and replace or clean it as needed.

The refuge does not charge an entrance fee; however, the Prime Hook NWR does participate in the Recreation Demonstration Fee Program through collection and deposit of hunting permit fees and boat launching fees. During fiscal year 2011, the refuge collected $10,843 for hunt permits, with $8,674 returned to the refuge. Boat launch fees and the sale of interagency passports yielded the refuge an additional $656, with $524 returned to the refuge. The review team commented that there did not seem to be a clear reason for charging boat launching fees while not charging fees for use of improvements such as boardwalk trails and observation platforms and recommended that the refuge explore developing a more equitable process for determining the imposition of user fees.

Information kiosks are located throughout Prime Hook NWR – at the headquarters, adjacent to all entrance signs except on Broadkill Beach Road, and near Slaughter Canal on Fowler Beach Road. Kiosks include flyers announcing upcoming refuge events and other information. Refuge orientation maps are included at some of the kiosks and would be a good addition to those kiosks currently lacking this map. Refuge volunteers regularly inspect and update kiosk information.

The review stated that the refuge seems to be in compliance with ADA requirements. Wheelchair accessibility is available on trails, an observation platform, bathrooms, the visitor contact station and refuge office, fishing pier on Fleetwood Pond, and deer and duck hunting blinds. Benches are placed in several refuge locations, including the fishing access areas at Turkle and Fleetwood Ponds and along refuge hiking trails.

Parking is available at the refuge headquarters, Turkle and Fleetwood Ponds, Black Farm Trail, Fowler Beach, Prime Hook Wildlife Area, Brumbley Family Park, and at several temporary areas during the hunting season. According to the review, parking at the refuge's HQ/VCS is generally adequate. Exceptions occur during special events like festivals and during duck hunting seasons; however, overflow space is available on nearby refuge lawns.

Refuge publications are available in the refuge headquarters office, the hallway to the public restrooms, in the visitor facility, near the trailhead and launch area off the headquarters parking lot, and at the kiosk at the entrance to the refuge. The restroom entrance door near the soda machine remains unlocked, offering visitors the opportunity to obtain brochures after office and visitor facility hours. Refuge hunting information is also available at all times at the hunt check station at the main refuge entrance.

Prime Hook NWR provides up-to-date information about refuge management activities and visitor opportunities. It can be viewed at *http://www.fws.gov/northeast/primehook/;* accessed September 2012.

Refuge lands and outdoor facilities are open for public use half an hour before sunrise until half an hour after sunset. The refuge headquarters and visitor facility are open Monday to Friday, 7:30 a.m. to 4:00 p.m. The visitor facility is also open on weekends from 10:00 a.m. to 4:00 p.m. during April through November, and occasionally on weekends during the off-season. Staffing of the visitor facility is provided largely by refuge volunteers. It is sometimes difficult ensuring that volunteers are available, particularly on the weekends when safety concerns heighten with the absence of refuge staff. During open hours at the headquarters and visitor facility, the telephone is answered by a live person. The after-hours message on the answering machine offers facility schedules and emergency contact information. A general email address is posted on the refuge's Web site for visitors to inquire about Prime Hook NWR.

Hunting Opportunities

Prime Hook NWR hosts one of the largest hunting programs of all East Coast refuges within the National Wildlife Refuge System. Hunting is a historic, traditional, and very popular activity in the Prime Hook area and in other parts of the Delmarva Peninsula. Prime Hook NWR is open to hunting of deer, waterfowl, and upland game. The primary objectives of the refuge hunting program are to offer high-quality opportunities for hunting white-tailed deer, waterfowl, upland game, and webless migratory birds, and to manage wildlife populations, where appropriate. The two most popular forms of hunting at Prime Hook NWR are for waterfowl and white-tailed deer. During the 2011-2012 hunting season, 513 deer hunters and 908 duck hunters participated in refuge hunts, harvesting 66 deer and 1,050 waterfowl. Along with State hunting regulations, Prime Hook has refuge-specific regulations at 50 C.F.R. § 32.27. Not all of these regulations are presented in this overview.

Section 605 (FW 1.10 F1) of the U.S. Fish and Wildlife Service Manual states: "Refuge managers should offer wildlife-dependent recreation programs consistent with staff and funding resources needed to develop, operate, and implement the program safely and with quality standards." The refuge's existing hunting program is complex and requires a considerable amount of staff resources. The review (USFWS 2004) found our hunt program to be "out of balance with other priority refuge needs and services." Another important quote from the review that confirmed the refuge staff's own evaluation of the hunt program was, "the amount of station resources going into this activity (hunting) seem to far exceed what is necessary to provide for a quality hunting program." The review also mentioned that the "care and maintenance of refuge blinds and tree stands….put an undue burden on staffing resources. Consideration should be given to eliminating this service, increasing the user fees for hunters, and either contracting this work out or hiring a temporary employee to conduct the maintenance."

Administrative burdens of the existing program have included excessive compensatory time accumulations and staff burnout. The hunt program is out of balance with staff time used on other priority refuge needs and services, and the amount of station resources going into the program seem to far exceed what is necessary to provide for a quality hunting program. Administrative changes were made to the 2006 to 2007 program in collaboration with the Delaware Division of Fish and Wildlife to ease some of these administrative burdens on staff. These changes continued to be implemented during the 2011 to 2012 hunting season and included instituting self check-in procedures and hunter-facilitated morning drawings for blind and stand vacancies on lower use hunting days, and instituting a first-come, self-serve system for deer firearms hunts after the morning standby lottery drawings are conducted (this allows hunters to arrive throughout the day until 2:00 pm to check out any available stand; a similar procedure was already in place for waterfowl hunts).

To relieve staff from conducting the standby lottery drawings on the mornings of scheduled hunts, standby hunters were charged with the task of facilitating a drawing in the absence of staff on days other than opening hunt days. This system has proven to be reliable with few minor problems or complaints; however, the success of the program is dependent upon the hunters cooperating and monitoring each other, some staff monitoring, and law enforcement compliance checks. A few of the problems encountered with this system included failure of hunters to flip over their blind/stand tags, not following proper procedures for fee collection, and not properly filling out the permit information.

All hunters must possess a permit to lawfully hunt. Permits are issued by self-service for hunters wishing to pursue upland game, webless migratory birds, and deer by archery. Hunters wishing to pursue deer using firearms or waterfowl in refuge impoundments may participate in a daily standby lottery drawing for vacant stands or blinds on days open to hunting. On opening days, it is common for 80 or more waterfowl hunting parties (maximum of 3 people per party) to be present at the daily drawing for 26 blinds (including 1 handicapped-accessible blind), and more than 100 deer hunters trying for 89 stands (including 11 accessible blinds) when all hunting areas are open. Deer hunters may also enter into a preseason lottery drawing for stands. In 2011, nearly 700 applications were submitted for the pre-season lottery drawing for deer stands. No pre-season drawing currently exists for waterfowl hunting.

The issuance of permits through the daily lottery requires a staff member to be at the check station as early as 2:50 am to check in pre-selected deer hunters or to sign-in waterfowl hunters for the lottery drawing. The current hunter facilitated drawings have decreased the number of days required by staff members to be present. Standby lottery drawings take place two hours before legal shooting time. Refuge staff operating the morning standby drawings consisted of an administrative assistant, visitor services manager, tractor operator, refuge manager, and deputy manager. After the morning standby lottery drawings, deer hunters may obtain permits by self-service until 2 pm and waterfowl hunters until 12 noon. All hunters must return their permits and harvest information to the hunt check station following their hunt.

Prior to implementing the administrative changes during the 2006 to 2007 hunting season, standby lottery drawings were conducted in 2004 by staff on a total of 49 days from October 2004 through January 2005. Stated another way, 40 percent of all the days from October through January required staff to be at the refuge early in the morning, therefore allowing them to leave for the day as early as 11:30 am, or stay and incur compensatory time to meet other required obligations. The program caused compensatory time accumulations of 90 hours or more, staff burnout, and inefficient use of management time to run the hunt. The total of 49 days breaks down into 13 deer days, which also included a daily stand-by drawing at noon for stand vacancies, and 36 waterfowl days. After the lottery drawing, vacant blinds for waterfowl hunting were issued on a first-come, self-serve basis until noon. There were also days when both deer and waterfowl hunting occurred, which required refuge staff to conduct two separate drawings each morning.

In past years, the refuge hired temporary positions to assist in conducting the daily drawings. From October through mid-December 2005, the check station was operated by a volunteer couple who were not from the local area. The use of temporary positions involves a considerable amount of training by refuge staff while not guaranteeing that the hired individual will remain throughout the hunting season before leaving for another position. Refuge staff has experienced the scenario in which the individual was just trained and left at the start of the hunting season. The use of local volunteers is not recommended, as it has led to accusations of special privileges and affected the integrity of the program.

The annual cost of conducting the 2004 to 2005 hunting program was approximately $43,050. Hunter use fees accounted for estimated revenue of $17,535, of which $14,028 was returned to the refuge to offset the cost of the hunt. Still, the refuge recovered less than one-third the costs required to carry out its hunting program through the existing Recreation Demonstration Fee Program. After administrative changes were implemented, the cost of the 2011 to 2012 hunting season was $34,482, which is $8,568 less than during the 2004 to 2005 season. Hunter-use fees for the 2011 to 2012 hunting season accounted for an estimated revenue of $10,973, of which $8,778 was returned to the refuge. Expenses include planning, materials for stands/blinds, publications, hunt operations, law enforcement, processing applications, fuel/electricity, inquiries, and toilet rentals. All permit funds received from hunters are deposited into the fee account for use in supporting the hunting program and other visitor services related needs. Senior citizens (age 62 and older) are entitled to a 50 percent discount with an interagency senior passport. Citizens who have been medically determined to be permanently disabled are also entitled to a 50 percent discount with an interagency access passport. Refuge staff follow the guidelines of the interagency passport program. The interagency senior passport can be purchased in person for $10 and the interagency access passport is free of charge at the refuge headquarters during office hours.

Refuge managers have taken reasonable steps to facilitate hunting through user fee programs and cooperative efforts. Refuge staff are very active in seeking and nurturing cooperative relationships with the State Delaware Division of Fish and Wildlife and refuge volunteers. State personnel from the Assawoman State Wildlife Area work cooperatively with refuge staff to cut and grass the waterfowl hunting blinds located on refuge, on the Prime Hook Wildlife Area, and at the Assawoman Wildlife Area. In addition to our 17 blinds, we also administer the State's 8 blinds located in the Prime Hook Wildlife Area through the daily standby lottery drawing for waterfowl hunting. Besides conducting the daily lottery drawings, refuge staff, along with considerable assistance from volunteers, construct and maintain 115 combined deer and duck blinds, expending considerable human and financial capital. A small group of volunteers in 2011 donated over 500 hours in this area alone.

Deer Hunting Stands and Waterfowl Hunting Blinds
Permanent elevated deer hunting stands have been used on the refuge since 1983, when 20 stands were donated by the Delaware Division of Fish and Wildlife. By 1989, the use of these stands became mandatory. The majority of these stands were placed along the edges of agricultural fields of corn and soybean, which are attractive to deer. Since the cooperative farming program ceased in 2006, these fields have been maintained in early succession, which limits the ability of deer hunters to see and harvest deer from these permanent stands. Since 2006, refuge staff have been criticized for a decrease in the quality of their hunt because hunters are confined to these stands that do not offer any flexibility for movement. Relocating nearly 100 stands is not feasible due to lack of space within currently open areas, and time and budget restraints. Free roam areas for deer hunting are available to hunters in Unit I of the refuge, where hunters in groups of 2 to 10 can access four zones using boats (one is accessible by foot). Demand for these areas is low and the use of boats is a limiting factor. Free roam hunting of deer was permitted in all deer hunting areas between 9am and 3pm up until the 2002-2003 hunting season, but was prohibited due to complaints of unethical hunting behaviour such as harvesting deer from the stands of other hunters.

Permanent waterfowl hunting blinds have been used on the refuge since the hunting program was first established in the 1960s. These structures are rectangular frames enclosed with plywood and mounted on a platform over refuge marshes. Every year, these blinds are camouflaged with switch grass. The variability from year to year in the vegetation surrounding these blinds may affect the naturalness or effectiveness of the camouflage. With current changes in marsh vegetation due to sea level rise and dune overwash issues, a majority of these blinds may be isolated in open water, minimizing their effectiveness. Hunters complain about the amount of grass on the blinds and current blind location, and many offer their preferences on how to improve the construction of the blinds to better meet their needs.

Both waterfowl and deer hunters have inquired about having greater flexibility to enhance the quality of their hunt by scouting, choosing their own hunting locations, and using portable hunting stands/blinds (boat blind, pop-up blind, tree climbers, etc.). For example, waterfowl hunters would like to have the flexibility to adjust their hunting locations for changing weather conditions. Waterfowl hunters have also stated that allowing them to camouflage themselves in the location of their choice will allow birds to get closer, thereby reducing crippling loss. Skybusting, or shooting at birds flying out of range, leads to more crippled birds and has been a constant complaint from refuge hunters.

Provision of elevated deer stands, and to a lesser degree waterfowl blinds, is relatively unique to Delaware. There are many areas on the Delmarva Peninsula, other than Prime Hook NWR, that offer public hunting opportunities in free-roam areas where the hunter is required to provide the blind or stand, if desired.

The Service conducted a web-search for public lands within the three states making up the Delmarva Penninsula in order that we evaluate the prevalence of permanent waterfowl blinds or deer stands on public hunting lands. A wide assortment of ownership and management regimes was evident across 215 tracts managed or described by 19 different designations, e.g. State Park, National Park Service, State Forest, Chesapeake Forest Lands, Natural Resources Management Area. For waterfowl hunting, 131 of the 215 tracts examined permitted waterfowl hunting. Of the 131, only 36 provided either a pit or standup blind somewhere on the tract. The Service makes this qualifying statement because some areas, Tuckahoe State Park for example, provide four pit blinds but also allow free roaming along the Tuckahoe River. Of the 36, 28 were located in Delaware, 8 in Maryland, and none in Virginia. Twenty tracts required hunters to hunt at a stake or within some designated distance from a blind site where the hunter would provide the blind (if desired), including nine in Delaware, 11 in Maryland, and none in Virginia. A total of 84 tracts permitted free-roam hunting where the hunter would provide the blind (if desired), 17 in Delaware, 60 in Maryland, and seven in Virginia.

For deer hunting, of the 215 tracts examined, 181 permitted some form of deer hunting. Unfortunately, the Service did not make a distinction between the various methods, i.e. some tracts may be limited to bow hunting only. Of the 181 tracts, 95 were located in Delaware, 77 in Maryland and nine in Virginia. A total of 51 of the 181 tracts required hunters to use stands that were provided, all of which were located in Delaware. Free-roam hunting was permitted on 165 tracts, including 80 in Delaware, 76 in Maryland, and nine in Virginia. The Service acknowledges that some free roam areas were for bow hunting only, however such a distinction would only apply in Delaware; all deer hunting tracts in Maryland and Virginia permitted free-roam hunting regardless of hunting method.

For the 85 tracts located in Maryland and Virginia where no stands are provided, only two require an elevated stand, which the hunter must provide. For areas immediately adjacent to the building complex on Blackwater NWR, the hunter must use an assigned blind site where the hunter erects a stand with a platform minimum of eight feet above the ground. All other tracts on Blackwater NWR are free-roam where ground-hunting is permitted.

The second site where elevated deer hunting is required is on Chincoteague NWR, around the tour loop. Here the hunter must erect his/her own stand with a platform minimum of 14 feet above the ground. All other areas on Chincoteague NWR permit free-roam hunting.

The Service should also add that rifle hunting, as well as deer drives, are permitted on most public hunting lands on the lower eastern shore of Maryland and the eastern shore of Virginia.

Refuge's Disabled Hunting Program
The refuge currently provides hunting opportunities for those individuals with a permanently disability as defined by the interagency access passport guidelines. However, up until the 2005 to 2006 hunting season, the refuge offered hunting areas with accessible ground blinds only for individuals permanently confined to wheelchairs to participate in a limited number of days for archery, firearms deer hunting, and waterfowl hunting. A disabled hunter who was not permanently confined to a wheelchair and who was denied access to these accessible blinds filed a complaint to the Washington Office. As a result, the decision was made that refuges could not segregate individuals with certain disabilities from others wanting to use the program's accessible sites, unless there is a justifiable reason established by the agency as a policy, which there is not.

Based on this decision, the refuge opened its wheelchair only hunt area and structures to all individuals with any permanent disability and the disabled hunt area was required to remain open for all scheduled hunts on the refuge. This additional hunting pressure on this small area has led to increased wildlife disturbance and has decreased the quality of the hunt for all disabled hunters, which is indicated by the number of deer observed and harvested by hunters. Furthermore, the guidelines of the interagency access passport require refuge staff to rely on the honesty of the applicant and do not require medical proof of the disability. The Privacy Act prevents refuge staff from asking for proof of disability.

Since this change has been made, frustrations have been running high for staff and wheelchair-bound hunters. Hunters confined to wheelchairs have limited mobility and there are no opportunities on the refuge to hunt unless refuge staff provide them with accessible infrastructure such as ground blinds and vehicular access to them. These hunters don't have the option to hunt other areas, as they are limited by the accessibility that the refuge provides them.

Additional Information on Refuge Hunting Program
The refuge prepares one-page sheets or booklets on hunting information. These publications outline general provisions, permit information, and general requirements, such as hunting areas (including maps), seasons, shooting times, use of boats, youth and disabled hunting requirements, bag limits, safety requirements, stand/blind requirements, and other special conditions of the hunt.

Hunting areas and blinds are identified by numbered markers and referenced on hunting maps. Upland game hunting areas are not signed, but areas are referenced on hunting maps. Specifically designated parking areas are clearly identified on the refuge.

Use or possession of alcoholic beverages on hunt areas is prohibited. Youth must be accompanied by a hunting or non-hunting adult who is 18 years or older. It is recommended that the adult be licensed to hunt in the State of Delaware. Deer hunters are required to display a minimum of 400 total square inches of blaze orange material on their head, chest, and back. Deer hunters may only have loaded weapons while in their assigned deer stand or when actively in pursuit of a crippled deer. Designated safety zones have been established.

Hunting is a traditional activity in this area and little opposition has been encountered by refuge staff. Occasionally, adjacent neighbors complain about shooting noise and the close proximity of hunters to their property, particularly residents in the Broadkill area. Hunters must make a reasonable effort to recover wounded game and may not shoot toward the refuge boundary or into private property.

Most hunting occurs in areas of the refuge usually closed to the general public. During the two days each year that the headquarters area is open to deer hunting, it is closed to all other public uses. Impact of this closure on the visiting public is minimal. Canoeists and anglers are not permitted to launch at the office boat ramp to access the easternmost 3 miles of Prime Hook Creek from October 1 to March 15 to lessen disturbance to migrating and feeding waterfowl and potential conflicts with hunters. Earlier closures have also been necessary to accommodate the hunting of teal in September on the adjacent State-owned Prime Hook Wildlife Area and ensure the safety of refuge visitors. There are no commercial hunting guides operating on the refuge.

Certification of hunter safety education is a requirement to receive a State hunting license. The refuge has partnered with the State of Delaware to provide hunter education courses on the refuge, including the young waterfowlers course.

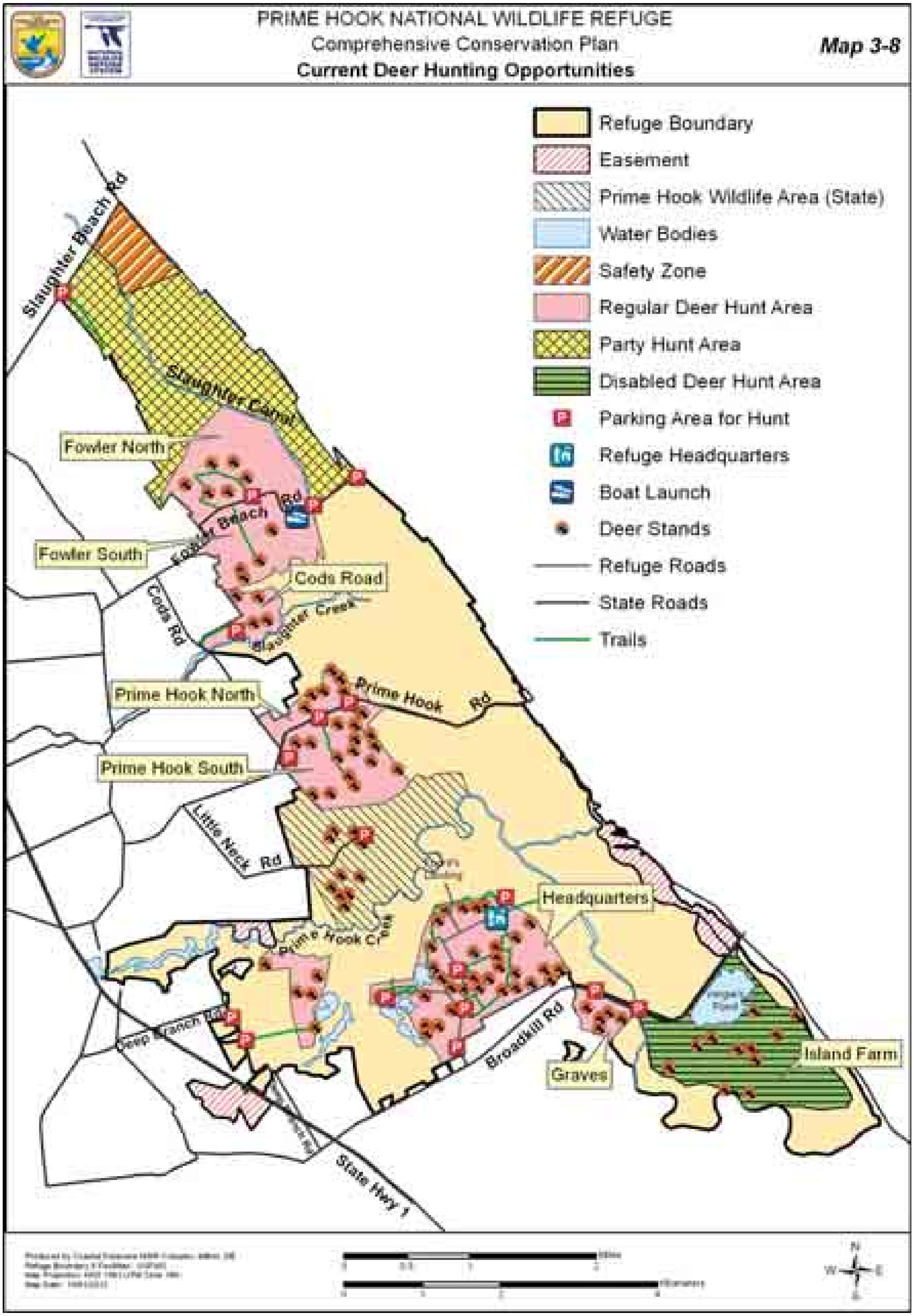
Hunting for White-Tailed Deer

During the 2011 to 2012 deer hunting season, Prime Hook NWR was open for 53 days of deer hunting from September 1 to January 28. The refuge was open for archery, muzzleloader, and shotgun hunting. Approximately 39 percent of refuge lands (4,020 acres) are available for deer hunting. Areas open to deer hunting are Prime Hook North, Prime Hook South, Fowlers North, Fowlers South, Cods Road, Jefferson-Lofland, Slaughter Canal, Island Farm, Headquarters, and Graves Tract (map 3-8).

The 2011 to 2012 deer hunting program resulted in a total harvest of 66 deer, which includes 26 (39.4 percent) male deer and 40 (60.6 percent) female deer. Deer harvested in 2011 to 2012 were not inspected by refuge personnel for weight and age. The State has eliminated deer checking stations, opting for local vendors to check deer for them. A youth hunt was conducted on November 5 with a total of nine young people removing four deer. In addition, disabled hunters made a total of 46 visits and harvested six deer. The refuge maintains 78 elevated deer stands, which include 32 for use in the headquarters area, primarily through volunteer assistance. An additional 11 wheelchair-accessible ground blinds are available to disabled hunters.

Deer hunters using firearms may enter into a preseason lottery drawing for stands. An application fee of $3.00 is charged for each hunt for which a hunter applied. Currently there are six total hunts. Successful applicants may claim a permit for their stand reservation at the check station on the morning of the hunt. Successful participants in the standby lottery drawing for stand vacancies may also receive a permit. A daily fee per hunter of $10.00 is charged for all firearm hunts and a daily fee per hunter of $2.00 for all archery hunts. For archery hunting, hunters may obtain permits by self-service at the check station. In accordance with State regulations, hunters may take buck and antlerless

Map 3-8. Current Deer Hunting Areas



deer – their license allows them to take two does and two antlerless deer. They may purchase a $10.00 tag for an antlered buck and additional doe tags may be purchased for $10.00 each. Only one buck may be taken on the refuge per hunter per year.

Except for the two days when the headquarters area is open to hunting, the refuge remains open to other users during the hunting season. Other than the headquarters area, hunting occurs in areas closed to other visitor uses. Scouting is permitted on Sundays from late August through late January. The refuge does not permit the use of dogs or off-road vehicles. No field trials are permitted and there are no shooting ranges open to the public on the refuge.

The Jefferson-Lofland Tract was closed to scouting and hunting in January to minimize disturbance to endangered Delmarva fox squirrel. Stands 9 and 10 in the headquarters area were closed during the late shotgun season to minimize disturbance to bald eagles. The headquarters area was not open during the statewide youth deer hunt to lessen administrative workload, reduce hunting pressure to maximize deer harvest during the hunt in November, and avoid conflict with adjacent landowners who are hunting waterfowl.

Deer hunters have been free roam hunting in Unit I of the refuge for years and upland game hunters free roam hunt in areas in Unit I, Unit II, and Unit III. Free roam hunting of deer was permitted in all deer hunting areas between 9am and 3pm up until the 2002-2003 hunting season, but was prohibited due to complaints of unethical hunting behaviour such as harvesting deer from the stands of other hunters.

Upland Game and Webless Migratory Bird Hunting
During the 2011 to 2012 season, upland game hunting was permitted from September 1 to January 13, providing 80 total hunting days (this includes other migratory birds such as mourning doves). Squirrel hunting was closed on the refuge due to lack of interest and to safeguard endangered Delmarva fox squirrel. Upland game hunting is permitted on 19 percent (1,995 acres) of refuge land at Prime Hook North and South, Fowlers North, and zones I to IV of Slaughter Canal; however, the southern portion of zone IV was closed to dove hunting. Although the refuge permits hunting of ring-necked pheasant, bobwhite quail, and woodcock, populations of these species are low in areas open to hunting and there is no hunter interest. Rabbits are most frequently hunted. A voluntary self-service permit process at the check station is used. In 2011 to 2012, 100 permits were issued resulting in 76 rabbits, one woodcock, and nine dove taken during 422 hours in the field. Interest in upland game hunting is limited due, in part, to the non-toxic shot requirement for small game. A fee of $2.00 per hunter is required. Hunters obtain permits by self-service at the check station.

The refuge remains open to other users during the upland game and webless migratory bird hunting season. The use of dogs is permitted for flushing and retrieving small game. Hunters must make a reasonable effort to recover wounded game and may not shoot toward the refuge boundary or into private property. Prime Hook NWR is closed to upland and small game hunting during all firearms seasons for deer, except the handgun season for deer in early January and the antlerless season in October.

Waterfowl (Duck) Hunting
The 2011 to 2012 waterfowl hunting framework permitted Delaware a duck season of 78 days of hunting, including two additional days for a special youth waterfowl hunt. Delaware also offered a 64-day late snow geese season from February 1 to April 14, 2012. Prime Hook was open for a total of 41 days, which

includes one of the Statewide youth waterfowl hunts. The refuge was closed for hunting of resident Canada geese and late season snow geese due to low hunter use and low harvest. Refuge staff facilitated the morning lottery drawing on January 14, 2012, for only the State blinds (refuge blinds were closed due to a deer hunt in the headquarters area). Hunting of snow geese was also permitted on the refuge during the duck season. A liberal bag limit of 15 snow geese per day was permitted. Hunting of migratory Canada Geese was permitted during the 2011 to 2012 season, with a daily bag limit of two.

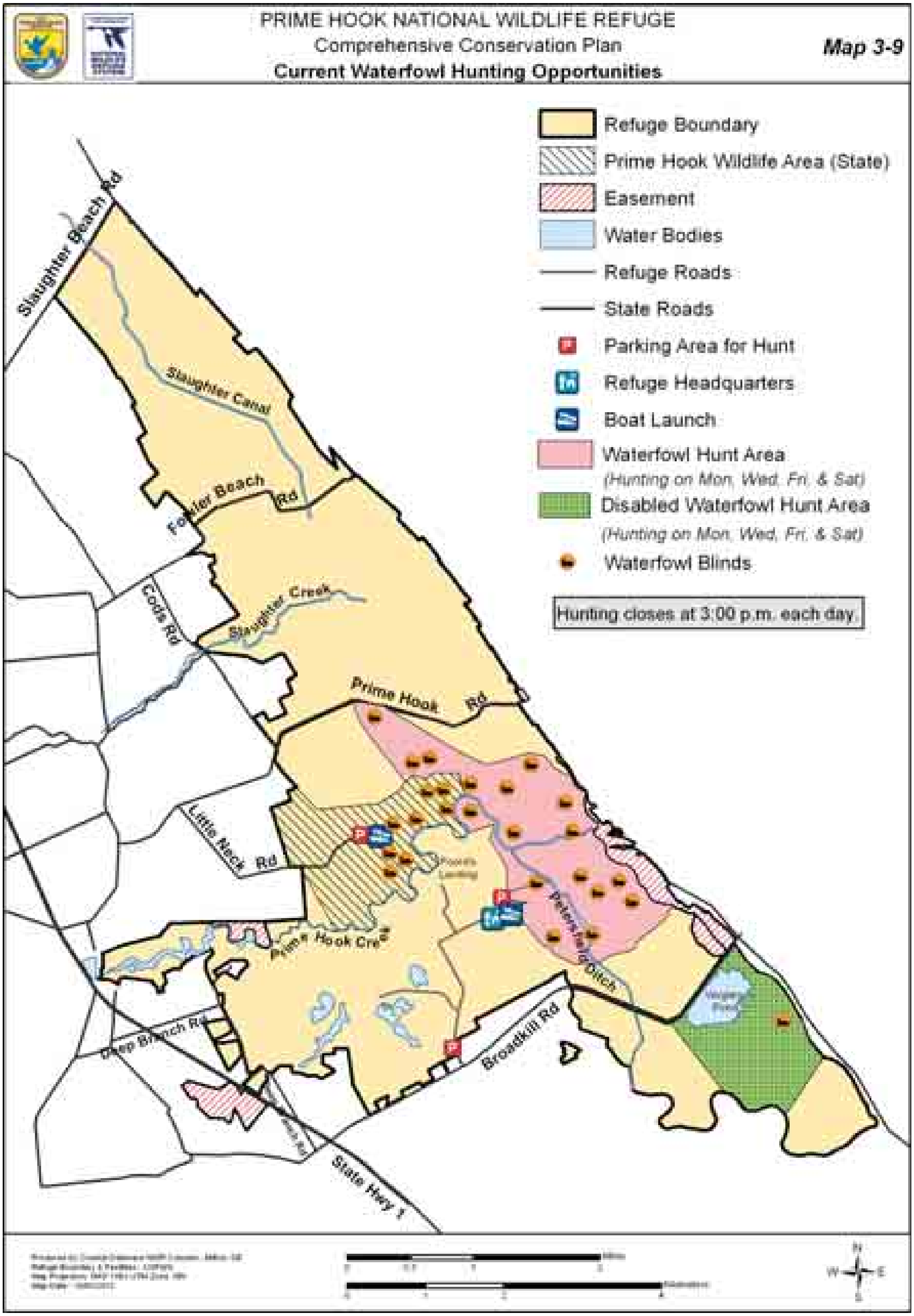
A total of 25 marsh blinds and 1 wheelchair-accessible blind were available for hunting on Mondays, Wednesdays, Fridays, and Saturdays throughout the State duck hunting season. Refuge staff administered the morning standby lottery drawings on the first two opening days of all three seasonal splits. On all other days open to duck hunting on the refuge, including the youth waterfowl hunt, hunters facilitated the morning stand-by lottery drawings themselves. Hunting was permitted until 3:00 pm. Overall hunter use for all hunts was slightly higher in 2011 (908) than in 2010 (874). In 2011, hunters harvested 1,050 birds; 1,604 birds were harvested in 2010.

The refuge remains open to other users during the waterfowl (duck) hunting season. The use of dogs is permitted for retrieving downed birds. Shooting outside an assigned blind is prohibited except in active pursuit of crippled waterfowl. The exception to this regulation is when hunting from a temporary blind in ponds 25 or 27. See map 3-9 for an illustration of the waterfowl hunting area.

The refuge is closed to resident Canada goose hunting in early September for the following reasons: low hunter use, low harvest, and the closure of Prime Hook Creek for hunting conflicts with other wildlife-dependent recreational opportunities involving canoers, kayakers, and fishermen on Prime Hook Creek. Since 2001, when the refuge began hunting for resident Canada geese, hunter visits and harvests have averaged 13 hunters and 9 birds a year. Only 3 to 4 days have been hunted each year. Managing this hunt involves closing the easternmost 3 miles of Prime Hook Creek, which limits access for kayakers and fishermen for selected days during early September. The intermittent closure of Prime Hook Creek for a handful of hunters with minimal harvest numbers does not appear to warrant limiting access for fishermen and wildlife observers when this portion of the creek will be closed from October 1 (sometimes earlier) through March 15 for waterfowl hunting and to minimize disturbance. The intermittent closure of Prime Hook Creek for this hunting season also led to confusion among kayakers and fishermen and poses a safety risk for those who fail to see or read the temporary closure signs.

The refuge closed the late season snow goose hunting from late January to early March for the following reasons: low hunter use, low harvest, and no agricultural cover crops. Since 2001 when the refuge began hunting for late season snow geese, hunter visits and harvests have averaged 17 hunters and 16 birds a year. Eight days, on average, have been hunted. Hunters are permitted to sign out hunting zones (fields) and set up their own temporary hunting blinds. Since agricultural crops are not being planted, opportunities for upland snow goose hunting are very limited. With limited use and harvest during the season, continuing this hunt to provide opportunities for a few hunters does not appear to be warranted but will be continually evaluated. Opportunities to harvest snow geese are still available during the 35 days open to waterfowl hunting on the open marsh from October through January.

Map 3-9. Current Waterfowl Hunting Opportunities



Turkey Hunting

Turkey hunting was initiated on the refuge in 1993. After two seasons of hunting and only one harvested turkey, the opportunity was discontinued. In recent years, hunter and staff observations indicate that a huntable population of turkeys may exist on the refuge, particularly in the headquarters area and in areas near Deep Branch Road. Limited opportunities exist on public lands to hunt turkey and the refuge may be able to contribute in providing additional opportunities.

Fishing Opportunities

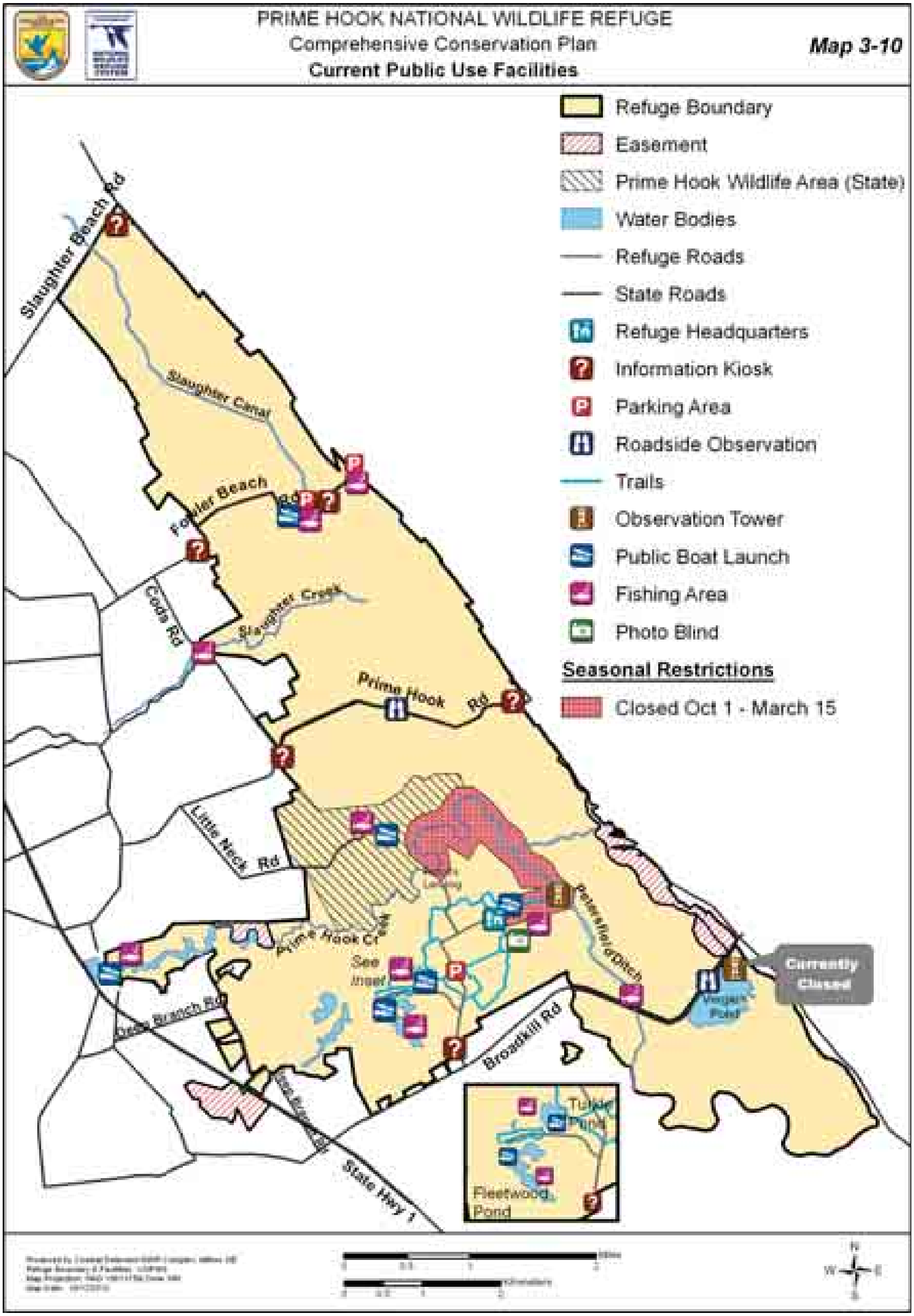
Freshwater fishing on Prime Hook is permitted along the Headquarters Canal in Prime Hook Creek, Turkle and Fleetwood Ponds, and Slaughter Creek at Cods Road (map 3-10). These freshwater marshes and ponds are popular fishing areas for largemouth bass, pickerel, white perch, crappie, and other species. Boats up to 30 horsepower are permitted in Prime Hook Creek and Slaughter Canal. Only electric or hand-propelled boats are permitted in Turkle and Fleetwood Ponds. Water control structures at Fowler Beach, Petersfield Ditch, and Slaughter Canal support brackish tidal waters that are popular for fishing for white perch and crabbing from shore. Bank fishing is restricted to designated areas off State maintained highways at these locations. Surf fishing at Fowler Beach along the Delaware Bay shoreline provides opportunities to catch estuarine species such as weakfish, striped bass, and flounder. During fiscal year 2012, the refuge estimates 8,693 fishing visits, including crabbing.

Signs that address fishing regulations can be found at the Headquarters Canal in Prime Hook Creek, Fleetwood Pond, and Turkle Pond. The signs outline refuge fishing regulations, ask visitors not to park on the boat ramp, identify October 1 (sometimes earlier) through March 15 as a time when access to Prime Hook Creek is by permit only, and direct visitors to gain access for canoeing and fishing from Waples Pond. There is a daily ramp fee to launch a boat from Turkle Pond, Fleetwood Pond, and the Headquarters Canal at a cost of $1.00 per boat. The Prime Hook Wildlife Area also provides a boat launch into Prime Hook Creek. At Fowler Beach and Slaughter Creek, there are water control structures where crabbing and fishing are popular. An unimproved boat launch is located at the Fowler Beach water control structure site. A boat launch is located at both Turkle and Fleetwood Ponds and signs outline the fishing regulations and designate it as public fishing area. A refuge boat launch is also located at the Brumbley Family Park; however, visitors must cross the Brumbley property to reach the refuge boat launch and the owner charges a $4.00 fee per boat. No signs designate the area as a launch site, although refuge boundary signs are posted on each side of the ramp.

All roads, parking, and trails associated with the launch sites are fairly rustic except for the road and parking facilities associated with the Headquarters Canal ramp and dock. There is a ramp and a dock at the Headquarters Canal, and ramps located at Turkle Pond, Fleetwood Pond, the Prime Hook Wildlife Area, Slaughter Creek near Fowler Road, and Brumbley's Family Park. A wheelchair-accessible fishing pier is located on Fleetwood Pond. A boat ramp is located about midway on Prime Hook Creek at Foord's Landing and is closed to all public entry.

Prime Hook NWR has a one-page information sheet that highlights fishing areas, boating information, permits, boat launching, fishing hours, and special conditions for fishing on the refuge. In addition, the refuge includes a short passage in its general refuge brochure concerning fishing, canoeing, and boating. The refuge has also produced a brochure for its canoe trail that addresses certain launching sites available on the refuge. No fishing guides operate on the refuge.

Map 3-10. Current Public Use Facilities



Canoeists and anglers are not permitted to launch at the office boat ramp to access the easternmost 3 miles of Prime Hook Creek from October 1 (sometimes earlier) to March 15 to lessen disturbance to migrating and feeding waterfowl and lessen potential conflicts with hunters. Designated beach dunes and overwash areas are closed from March 1 through September 1 due to nesting State endangered least terns and American oystercatchers, and the potential for use by federally endangered piping plovers. Areas may be re-opened if no nesting activity occurs or when nesting ends for the season.

The refuge has partnered with the Lower Sussex Bass Masters in Milton to host a fishing event for kids the first Saturday in June. The event is held at the Milton Community Park and hosts 200 youngsters and their parents. The event includes fishing along the Broadkill River, exhibits, fish tanks, fish printing, and prizes to promote the recreation of fishing.

Wildlife Observation and Photography Opportunities
The refuge currently does not offer an auto tour route. Refuge staff recognize that an opportunity exists, but concerns about sign vandalism in remote areas of the refuge and the over-proliferation of interpretive signs were two reasons discouraging a signed route. Roadside vehicle pull-outs are located on Prime Hook Beach Road and along Broadkill Beach Road to provide increased opportunities for wildlife observation and photography along refuge impoundments.

Prime Hook NWR currently has approximately six miles of hiking trails, 7 miles of canoe trail, roadside pull-offs along State roads transecting the refuge, two observation platforms, one photography blind, two ponds, nine information kiosks, trailhead kiosks, a visitor contact station, five boat ramps, benches, and parking areas (map 3-10). The majority of the refuge's developed visitor use improvements are located near the refuge headquarters. A separate map of this area identifies the specific locations of each facility. An accessible wildlife observation platform is located on the Dike Trail, which overlooks a vast marsh and offers exceptional opportunities for wildlife viewing and photography. The Boardwalk Trail shares an entry off the headquarters parking lot and meanders through uplands and marsh. Both the Dike and Boardwalk Trails offer signs interpreting refuge habitats, wildlife, and history. The Black Farm Trail includes an extension to a photography blind overlooking a pond. Pine Grove Trail loops through a pine and hardwood forest habitat. The Blue Goose Trail serves to connect the four existing trails and features upland fields, forest, marsh, and several wildlife observation areas. An uncompleted trail is located on the southside of Broadkill Beach Road overlooking Vergee's Pond.

The refuge offers at least 15 miles of canoe access, including the 7-mile brochure-interpreted Canoe Trail. Access to Canoe Trail and its associated marsh habitat is located on the east end near the refuge headquarters parking lot, at a mid-point in the Prime Hook Wildlife Area, and on the west end at the Brumbley Family Park. Canoeists and anglers are not permitted to launch at the office boat ramp to access the easternmost 3 miles of Prime Hook Creek from October 1 (sometimes earlier) to March 15 to lessen disturbance to migrating and feeding waterfowl and lessen potential conflicts with hunters. The review team (USFWS 2004a) agreed that serious consideration should be given to removing the boat ramp at the Brumbley Family Park, developing a special use permit for the landowner who benefits from charging for access, or exploring alternative sites for a ramp where the refuge would have more control.

Vital support from the refuge's Friends group has allowed the refuge to offer outstanding programs and special events. Since 2004, the refuge has hosted the

Evening at the Hook Lecture Series on the second Thursday of each month. Topics focus on natural resource conservation, wildlife-dependent recreation, and cultural resources.

Also since 2004, the Vandegrift Memorial Series has been sponsored through an endowment received by the Friends of Prime Hook NWR. These lectures/performances take place once a year. A small fee is charged, typically less than $10 per person. Previous events have featured the BBC film Eggs on Coast; Case Hicks, a Theodore Roosevelt impersonator; and Kiawani Lee, a Rachel Carson impersonator. These programs have taken place at off-refuge sites, including a local church and the Milton Theatre.

Prime Hook NWR offered its Fifth Annual Waterfowl Festival in 2006, and has seen attendance grow from around 50 in the first year to 1,200. The event included a very successful nature photography contest and featured live music, guided walks, fish and wildlife-related demonstrations, exhibits, food vendors, and a silent auction sponsored by the Friends of Prime Hook. It was made possible by the Friends of Prime Hook Refuge in partnership with the local tourism bureau, the town of Milton, local bass fishing clubs, State resource agencies, Ducks Unlimited, and the Delaware Department of Corrections. Due to reduced staffing at Prime Hook NWR, the refuge was forced to discontinue this popular event after 2006.

The Friends of Prime Hook NWR host a nature photography contest that illustrates the talents of local photographers, highlights the natural resources and scenery of the Delmarva Peninsula, and promotes the wildlife-dependent recreation of photography. Last year’s event featured more than 300 entries from nearly 80 people. A reception is held to announce the contest winners and kick off a month-long exhibition of all photograph entries for visitors to enjoy.

Since 2004, Prime Hook NWR has partnered with the town of Milton in the Annual Horseshoe Crab-Shorebird Festival in celebration of International Migratory Bird Day to offer special interpretive activities at the refuge and other activities in town. Refuge activities include guided canoe trips, bird walks, plant walks, pond seining, refuge tours, and field trips. This event has grown to 1,500 people.

Designated beach dunes and overwash areas are closed from March 1 through September 1 for nesting State endangered least terns and American oystercatchers, and the potential use by federally endangered piping plovers. Areas may be reopened if no nesting activity occurs or when nesting ends for the season.

Environmental Education Program

Informing local students about nature, wildlife, habitat, the seasons of change, and how places like Prime Hook NWR play a role in their well-being has been ongoing for many years since the refuge’s early beginnings. The refuge has in the past provided limited field trips to teachers by offering programs on requested topics, offered teacher workshops, and participated in programs such as the Sister Shorebird workshop. More recently, efforts have been made to align our efforts with the curricula in the local school districts and develop key partnerships that provide better opportunities for environmental education at Prime Hook.

The refuge conducts environmental education programs as funding and staff time allow. The demand for programs from local schools, scouting, and other groups far exceeds our ability to provide them. We must rely on support from the Friends of Prime Hook NWR and volunteers to plan and implement these programs.

Currently, there are no facilities specifically designated for environmental education. The refuge currently uses the auditorium and small pavilion located near the refuge office for discussion areas and for field studies.

Over the past several years, refuge staff and the Friends of Prime Hook NWR have been working to develop an environmental education program to better meet the needs of both the refuge and the local school districts (Cape Henlopen and Milford). The Friends of Prime Hook NWR have taken an active role in its development, creating an environmental education committee. Refuge staff and the education committee partnered with the science coalition specialist at Cape Henlopen School District to develop an insect program for second grade students, which has been very successful since 2005. The partnership started with the topic of insects, something tangible and familiar to students and the volunteers leading the groups. In 2008, a watersheds program was developed for seventh grade students through the assistance of a grant by MBNA. The refuge is currently planning a birding program.

Teacher workshops have been offered in the past but without success due to time restraints on the teachers. Refuge staff and volunteers occasionally go to schools to provide programs to classes of various age groups. Based on the definition of environmental education, which identifies any environmental education program as one that addresses a class's academic standards, the review (USFWS 2004a) concluded that most of the off-site school programs may fall into the category of environmental interpretation.

Current evaluation methods include up-front evaluation (coordinating with the field trip leader on what is expected of the trip) and informal follow up with teachers, students, and chaperones.

Interpretation of Key Resources and Issues

Key resource topics or interpretive themes of Prime Hook NWR focus on the awareness and importance of the conservation of waterfowl and other migratory birds, the endangered Delmarva Peninsula fox squirrel and other threatened or endangered species, and their associated habitats. No specific interpretive themes or messages have been developed at this time. Currently, key issues affecting the refuge are climate change/sea level rise, mosquito control, the cooperative farming program, and the beach overwash/Fowler Beach Road repair issue.

Personal services interpretation includes guided birding trips, a monthly lecture series, an annual Vandegrift Memorial Lecture, and an annual nature photography contest. The refuge also partners with the Milton Chamber of Commerce to co-host the annual Horseshoe Crab-Shorebird Festival and with the Lower Sussex Bassmasters to promote youth fishing.

The refuge headquarters building includes a small visitor information area. The visitor information area includes an information desk and sales area, display cases, and a 45-person multi-purpose room that is used for special exhibits, training, and special programs.

The refuge has a large number of brochures and handouts available to the public. Some of the materials are refuge-specific, some specific to the local area, and some are generic to the Service. Information is provided to orient refuge visitors and educate them about refuge resources and regulations.

Traveling or portable exhibits have been developed for the refuge that highlight habitat management, wildlife, public use opportunities, volunteers, and the friends group. These exhibits are used at several local events to provide information about the refuge to participants.

The refuge maintains an audio/visual library, including a professionally produced 12 minute video that highlights Prime Hook. Self-guided interpretive facilities and materials, including signs, maps, and kiosks, are available for the Blue Goose Trail, Photography Blind Trail, Dike Trail, Black Farm Trail, Pine Grove Trail, Boardwalk Trail, and Canoe Trail.

Current compatible uses on the refuge include sport fishing; commercial fishing; commercial trapping of muskrat, raccoon, etc.; turtle trapping; public hunting of waterfowl; public hunting of other migratory birds; public hunting of big game-turkey; public hunting of big game-deer; public hunting of upland game; environmental education; canoeing; walking, hiking, and jogging; wildlife/wildlands observation; photography, picnicking; 5k road race; research; special use permit of the FAA VORTAC tower; beekeeping; waterfowl retrieval permits; and mosquito control.

All commercial and economic uses will adhere to 50 CFR, Subpart A, §29.1 and Service policy which allow these activities if they are necessary to achieve the Refuge System's mission, or refuge purposes and goals. Allowing these activities also requires the Service to determine appropriateness and prepare a compatibility determination and an annual special use permit outlining terms, conditions, fees, and any other stipulations to ensure compatibility.

Communicating Key Issues with Offsite Audiences
Key resource topics or interpretive themes of Prime Hook NWR focus on the awareness and importance of the conservation of waterfowl and other migratory birds, endangered Delmarva Peninsula fox squirrel and other threatened or endangered species, and their associated habitats. Currently, key issues affecting the refuge are climate change and sea level rise, mosquito control, the cooperative farming program, and the beach overwash/Fowler Beach Road repair issue.

The refuge's affected audiences include hunters, anglers, birders, wildlife enthusiasts, photographers, beach tourists, and retirees. The refuge has dealt with a number of controversial issues over the years that have strained its relationship with the community; however, refuge staff continue to work with diligence and patience to secure the community's trust and understanding.

Public comments have been collected during public scoping meetings and from visitor and community surveys through planning efforts for the CCP. The proposed alternatives in the CCP will provide the public with a future management direction for the refuge, and additional public meetings will provide greater opportunities to communicate and gather public opinion.

Volunteer Programs and Partnerships with Friends Organizations

Approximately 100 active volunteers participate in a range of services and activities in the areas described below:

Visitor Contact Station: training and mentoring; greeting and informing visitors; answering telephone inquiries; sales outlet ordering; stocking brochures; miscellaneous clerical and office projects; and miscellaneous administration duties.

Biological: horseshoe crab sampling; weekly bird surveys; water level readings and management; shorebird and osprey banding; volunteer bluebird nest box monitoring program; constructing and placing monitoring boxes for the endangered Delmarva Fox Squirrel; and vegetation transects and surveys.

Maintenance: trail maintenance; equipment maintenance; maintenance, repair, and construction of deer stands and duck blinds; designing and installing directional signs for deer stands and duck blinds; designing and constructing trails; building construction; building and installing information kiosks; volunteer patrol for litter cleanup and providing refuge information to visitors; mowing grass and assisting with herbicide spraying; changing and installing boundary signs; landscaping around refuge office; assisting with Department of Correction crews; repairing gates; routine office building cleaning; washing vehicles; and miscellaneous office repairs.

Public Use: planning, organizing, and staffing annual Horseshoe Crab-Shorebird Festival and annual nature photography contest; organizing the annual Vandegrift Memorial Series; maintaining databases on newspaper clippings; planning and implementing environmental education programs; designing and maintaining friends group newsletter; conducting birding field trips; holding monthly lecture series and supplying refreshments; completing and submitting monthly reports; conducting tours for groups; staffing information booths at local events; promoting fishing to children at the Lower Sussex Bass Masters Annual Youth Fishing Event; distributing visitor use surveys for the CCP; updating the friends group Web site; designing and coordinating a refuge library of reference materials; applying for miscellaneous grants; maintaining a database; and organizing and coordinating other volunteers.

Volunteers are managed in a three-tier system. The refuge's visitor services manager serves as the station's volunteer coordinator. A volunteer serves as assistant volunteer coordinator, screening potential applicants and assisting the manager with the administrative aspects of the program. Several other volunteers coordinate specific activities such as trail maintenance, outreach, landscaping, etc. The visitor services manager receives feedback from staff and volunteers on work performance.

Over the past several years, Prime Hook NWR has developed a partnership with the Georgetown facility of the Delaware Department of Correction, which supplies a volunteer prison work crew to the refuge throughout the year. In prior years, the typical 13-person crew visited the refuge on a weekly basis; more than 16,000 hours of maintenance-related work has been provided to the refuge since 2003. Projects have included removing deer stands, rebuilding duck blinds, facility maintenance, mowing, carpentry, painting, and more.

Volunteer contributions have increased considerably over the last several years, from 2,257 hours in 1998 to a high of 11,963 hours in 2006. In fiscal year 2012, 103 volunteers contributed 6,487 hours. Refuge staff praise and thank volunteers for their work. During conversations with refuge volunteers, the review team stated that it was very clear the volunteers felt appreciated by the refuge staff. The refuge also organizes two volunteer recognition and appreciation events each year. In late summer, the refuge hosts a volunteer barbeque and in late winter or early spring, a volunteer recognition event. Due to large numbers, the refuge rents the Milton Fire Hall for the latter eventwhich includes a formal recognition ceremony and catered dinner.

Volunteer gifts are distributed at the recognition event. A program was established to award volunteers with recognition items such as pins, patches, coffee mugs, etc., based on their cumulative hours. The refuge staff also recognize volunteers who provide considerable hours during the calendar year, including the prestigious "Blue Goose Award" for the volunteer with the highest amount of hours. This is a wooden sandblasted plaque with a painted blue goose and engraved plate.

Prime Hook NWR has developed informal partnerships with a number of community organizations and State agencies including: Lower Sussex Bass Masters; R.S.V.P.- Retired Seniors Volunteer Program; Town of Milton; Chambers of Commerce in the towns of Milton, Lewes and Milford; Southern Delaware Tourism; Delaware Department of Corrections; Sussex Bird Club; Ducks Unlimited; U.S. Geological Survey; Delaware Division of Fish and Wildlife; Delaware Natural Heritage Program; local Boy Scout troops; Milton Development Corporation; Milton Theatre; Cape Gazette; Delaware Forest Service; M.R. Designs, Inc; Centex Home Builders; Delaware Division of Parks and Recreation; University of Delaware; and many more.

The Friends of Prime Hook NWR, a 150-member non-profit grassroots membership organization, supports the refuge in many ways. The Friends operate a bookstore and gift shop, serve as refuge volunteers, enhance public use opportunities, provide public outreach for the refuge, seek out and apply for grant opportunities, and much more. This group has been instrumental in supporting the visitor services program by leading guided walks, establishing an environmental education committee to assist the refuge in the developing an environmental education program, sponsoring the Vandegrift Lecture Series and nature photography contest, and assisting with the refuge's various special events. They coordinate the refuge offsite exhibits at local festivals and promote refuge messages to the community.

The Friends of Prime Hook NWR function as the cooperating association of the refuge, managing a gift shop at the refuge's visitor facility. Sales items include natural resource-related products such as t-shirts, stuffed animals, jewelry, and books. The gift shop is open weekdays from 7:30 am to 4:00 pm, weekends from April through November from 10:00 am to 4:00 pm, and occasionally on weekends during the off-season. The refuge has no concessionaires at this time.

Chapter 4


Chuck Fullmer

Scarlet tanager

Alternatives Considered, Including the Service-preferred Alternative

- Introduction
- Developing Alternatives, Including the No Action Alternative
- Formulating Alternatives Using Refuge Resources of Concern (ROCs) and Focal Species Management
- Actions Considered but Eliminated from Detailed Analysis
- Actions Common to all Alternatives
- Alternative A. Current Management
- Alternative B. The Service-preferred Alternative
- Alternative C. Historic Habitat Management

Introduction

This chapter presents:

- Our process for formulating alternatives.
- Actions common to all alternatives.
- Descriptions of the three alternatives we analyzed in detail.

The alternatives considered, including the Service's preferred alternative, are:

- Alternative A—Current Management. This alternative fulfills the NEPA requirement for a no action alternative, one that proposes no change in the current management of the refuge. Alternative A is to continue to manage the refuge as we do at the present time.
- Alternative B—Preferred Alternative. This alternative will focus on focal species with proactive habitat management and expanded public use. Based on comments we received on the draft CCP/EIS, we made several changes to alternative B. This modified alternative B is our preferred alternative and the action that we recommend for final selection.
- Alternative C—Historic Habitat Management. This alternative proposed to return to habitat management programs which were conducted on the refuge for several decades, but had been stopped in recent years for various reasons. Reestablishment of such programs would require substantial refuge action. This alternative includes some modifications to public use programs.

At the end of this chapter, a matrix compares how each alternative addresses significant issues, supports major programs, and achieves refuge goals and objectives.

Developing Alternatives, Including the No Action Alternative

We developed management alternatives after identifying a wide range of possible management objectives and strategies that could achieve refuge goals. These alternatives can be described as packages of complementary objectives and strategies designed to meet refuge purposes and the Refuge System mission and goals as described in chapter 1, and stepped down into refuge-specific goals used as the framework for each alternative. Management objectives and strategies developed for each alternative respond to public issues and opportunities identified during the planning process and public scoping meetings.

In this chapter, we fully analyze three alternatives that characterize different ways of managing the refuge over the next 15 years. We believe they represent a reasonable range of alternative proposals for achieving the refuge purpose, vision and goals, and addressing the issues described in chapter 1. Unless otherwise noted, all actions would be implemented by refuge staff. The three alternatives are summarized in a matrix at the end of this chapter (table 4-5).

The environmental baseline: It is important to understand that while the CCP/EIS was under development, there were major habitat changes within the refuge. As explained in chapter 3, the formerly freshwater impoundments in Units II and III (particularly in Unit II) have undergone significant change, due to breaches in the barrier island allowing for the free exchange of saltwater in the formerly maintained freshwater marshes. The rapid inundation of saltwater killed substantial amounts of freshwater vegetation and has increased the salinity of brackish waters but, to date, has not brought in sufficient sediment to overcome the sediment deficit incurred over the decades of freshwater management. The refuge continues to assess the biological, chemical, and geological impacts of these changes, specifically exploring whether the underlying peat layers, which were not increasing during the decades of freshwater management, have recently experienced increased subsidence or other biochemical changes. Therefore, while the environmental baseline for these habitats is difficult to fully assess, for this analysis we assume that the baseline is the condition of the refuge as of mid-2012. Thus, alternative A assumes little or few future proactive efforts and assumes that future habitats will evolve on the template of past natural events and earlier human manipulations of the marshes. Alternative B assumes that the Service will undertake future proactive measures, geared to restoration of a more natural system with the goal of limiting its actions to those that will result in more naturally sustainable future conditions (i.e. "fix it, and then let it be"). Alternative C proposes to return the refuge to former management conditions, including restoring and maintaining freshwater impoundments. This alternative recognizes that, in order to sustain freshwater marshes in light of sea level rise and climate change, the refuge would need to work with partners to build extensive engineering. This would include constructing a substantial sand barrier, as well as continued and perpetual sand renourishment. Similarly, for upland management, since the refuge has not been engaged in active farming for 6 years, Alternative A assumes that incremental vegetation changes will result in the gradual development of bushes, thickets, and ultimately woodlands, which the Service will not actively manage other than to remove invasives. Alternative B will bring these areas into a forested condition more rapidly by planting certain desired trees and other species. Alternative C anticipates a return to active farming.

Alternative A satisfies NEPA requirements for a no action alternative. It describes the refuge's existing management activities and serves as a baseline for comparing and contrasting alternatives B and C. Implementing alternative A would continue current habitat management regimes and maintain public use programs in their present format.

Alternative B, the Service-preferred alternative, combines actions that we believe would most effectively achieve refuge purposes, vision and goals, and respond to public needs. Alternative B also incorporates the principles of strategic habitat conservation and focal species management, as both reflect the most recent advances in the fields of conservation science and delivery of conservation actions on the ground by the Service. Under alternative B, the refuge would implement manipulative management tools and interventions that mimic natural processes to enhance habitat restoration where deemed most appropriate. At the same time, the refuge would strategically reduce the use of management actions that are contrary to the directions of the biological integrity, diversity, and environmental health (BIDEH) policy, such as artificial maintenance of extensive freshwater wetlands that are vulnerable to sea level rise, but can pursue careful sediment placement or marsh restoration to enable sediment-deficient salt marshes to subsist in light of sea level rise. Alternative B would include a combination of passive and active management approaches to foster or achieve more ecologically sustainable habitats than occur on the refuge at present.

In alternative B, the habitat condition objectives and general management strategies include the following:

- Managing for natural range of conditions in upland habitats (native forest, early successional grassland, and shrubland habitats) to restore lost elements of BIDEH for priority resources of concern.

- Managing the refuge's wetland marsh systems consistently with BIDEH, and considering their sustainability in light of sea level rise and climate change.

- Developing wetland restoration efforts to restore salt marsh communities in portions of the refuge's impounded wetland complex to promote adaptation in the face of sea level rise.

- Restoring mature upland forested habitats, through planting and active forest management, to manage for priority resources of concern—such as the federally endangered Delmarva fox squirrel and forest interior-dwelling birds—and improving the environmental health of connecting waterways and wetland habitats.
- Increasing the diversity and abundance of targeted focal bird species.
- Increasing and enhancing native plant resources that conserve invertebrate resources and pollinators that support avian conservation objectives.
- Reducing chemical use associated with nontarget negative effects on invertebrates and pollinators.
- Using certain bird, fish, and insect species as umbrella or indicator species.

Alternative B will enhance visitor services through a proposed expansion of access facilities and new trails open for wildlife observation, photography, interpretation, environmental education, hunting, and fishing. The hunting program is being modified for greater administrative efficiency. Additional areas of the refuge will be opened for the hunting program, with careful consideration of public safety and balancing this expanded use with other options for non-consumptive wildlife-dependent public uses.

Our preferred alternative in the CCP/EIS is to expand some aspects of the hunting program to include additional days and acres throughout the hunting seasons established by the state. Deer hunting acreage would increase from 4,020 to 5,221 acres, waterfowl hunting from 1,722 to 3,432 acres (which meets the 40% "inviolate sanctuary" rule of the total 10,144 acres in the refuge), upland game & migratory bird (excluding waterfowl) hunting remains at 1,995 acres, and turkey hunting is added, from zero to 3,729 acres. However, we would only issue no more than five turkey hunting permits, and only after annually evaluating the status of the wild turkey population on the refuge. Hunting will be permitted if State and refuge personnel determine that the turkey population in the area is sufficient to support hunting on the refuge. The vast majority of the refuge would remain open to wildlife observation and other non-consumptive uses during the 4-week turkey hunting season (mid-April to mid-May), with hunting lasting until 1:00 p.m. on designated hunt days. Furthermore, we are providing 3,185 acres of sanctuary area (no-disturbance areas) for waterfowl and other wildlife. Given the dominant role of the refuge in the Atlantic Flyway migration corridor, this closed area system was established to provide waterfowl with a network of resting and feeding areas and to disperse waterfowl hunting opportunities on the refuge. Specific descriptions of these sanctuary areas can be found in chapters 4 and 5 of the CCP/EIS, but are roughly Unit II, the lower half of Unit III, and Unit IV.

We believe that the proposed hunting expansions will provide a more quality hunt for hunters, and will not occur in areas or times currently allowed to other non-consumptive users. Many of the proposed "new" hunting areas are currently open to some type of hunting or have been previously open either under refuge management or private ownership. Our mandate is to provide high-quality opportunities for priority uses when they are compatible with refuge purposes, goals, and other management priorities. The Refuge Improvement Act does not establish a hierarchy among the six priority uses, but requires the Service to facilitate them when they are compatible and appropriate. In fact, we maintain or enhance opportunities for all six priority public uses in our preferred alternative. In other words, expansion of hunting opportunities at the refuge does not come at the expense of other priority public uses.

The refuge will be open to at least one form of hunting for 8 ½ months out of the year; however, the vast majority of the hunting will occur during the main hunting season, which typically runs for 5 months from September through January. The actual season length, including starting and ending dates, will vary annually, and the actual number of huntable days will vary annually as well. For example, the Federal framework only permits a maximum of 60 days hunted during the waterfowl season, but because of additional restrictions imposed by the refuge (e.g., only allowing waterfowl hunting 4 days a week rather than 6 days a week), the regular duck season on the refuge will actually be approximately 40 days, and only to 3 p.m. on those days. These restrictions help to reduce disturbance to waterfowl feeding patterns. Literature reviews of visitor use and its relationship to disturbance to waterbirds support the time restriction and are reflected in the hunting regulations of other refuges, particularly in the Southeast Region of the Service (DeLong 2002). Hunting during the snow goose conservation order, which will occur for 2 ½ months from late January through mid-April, will take place mostly in the wetland areas, leaving the upland areas open to other uses. This late season is not anticipated to bring large numbers of hunters, but is beneficial to the species and other wildlife due to overpopulation of snow goose on the refuge. The headquarters area remains available without hunting for 363 days a year for non-consumptive uses; during the two days each year that the headquarters area is open to deer hunting, it is closed to all other public uses. For potential turkey hunting in the headquarters area, the entire headquarters area would not be closed; only a portion of the area, and only until 1p.m. on designated dates during the state turkey hunting season. Most other areas of the refuge are open on every Sunday during the hunting seasons.

In an effort to improve the hunting experience through advanced scouting and allowing hunters to choose their preferred location, permanent deer stands (78 total) and duck blinds (25 total) will be phased out over a five year period. Providing elevated deer stands, and to a lesser degree waterfowl blinds, is part of the burdensome and inefficient existing hunting program which is inconsistent with the hunting programs for most of the national wildlife refuge system outside of Delaware. There are many areas on the Delmarva Peninsula, other than Prime Hook NWR, that offer public hunting opportunities in free-roam areas where the hunter can use their own blind or stand, if desired. We would recommend and encourage the use of portable deer climbing stands, but will not require it. For hunters who may be unable to climb trees using portable deer stands or who may wish to hunt from permanent deer stands or duck blinds, the State-owned Prime Hook Wildlife Area, which adjacent to the refuge, will continue to provide these opportunities.

Deer hunters will be able to freely roam in designated hunting areas to have greater access to where the deer are located. Waterfowl hunters in regular hunting areas will have the ability to set up, where desired, for changing weather conditions or bird use on a first-come, first-serve basis. In the lottery hunting area, waterfowl hunters will be restricted within a defined hunt zone identified by a blind site marker. Hunters may use their own portable stands/blinds, but they must be removed daily. The numbers of hunters that would be on the refuge at any time is not unlimited; the number of deer hunters that can free roam at any time would be limited by the capacity of the 13 parking areas found on or near the refuge that total approximately 72 vehicle spaces, which we estimate would total no more than 150 hunters. Areas and blinds will continue to be maintained for disabled hunters permanently confined to wheelchairs to ensure that these individuals have quality opportunities for deer and waterfowl hunting. Other disabled, yet ambulatory hunters, may hunt anywhere within the free roam areas and choose how far they are willing to travel to hunt.

Alternative C habitat management emphasizes a return to habitat management programs that were conducted on the refuge through most of its existence, but which were stopped in recent years for a variety of reasons (e.g., changes in the environment, court decisions, updates in Service policy). These historic habitat management programs include the use of cooperative farming in upland refuge fields, and management of freshwater wetland impoundments, both conducted for the benefit of migratory birds. Under this alternative, the refuge, with partner assistance would conduct infrastructure and duneline enhancements to reestablish management of freshwater impoundments. Upland fields previously enrolled in the cooperative farming program would once again be managed through farming practices with the cooperation of local farmers. Alternative C would match alternative B in that initiating adult mosquito control will be triggered by documented mosquito-borne disease activity near the refuge. Appropriate documentation of a high risk to public health and safety would include adult mosquito monitoring data from the refuge, or areas near the refuge that show an increase in the rate of disease-infected mosquitoes. Disease surveillance means pathogen presence in mosquito pool(s), wild birds, sentinel chicken flock(s), horses, or humans has been documented with its flight range of vector mosquito species present on the refuge. These conditions in combination with adult mosquito populations above established thresholds would trigger consideration of a more aggressive treatment strategy, including the use of adulticides. A threat is to be defined as detection of a mosquito-borne virus using any virus surveillance method of DMCS' choosing.

Under this alternative, public use programs would be modified somewhat from current management, but not as extensively as in alternative B. Compared to alternative A (current management), for visitor services programs and refuge uses, alternative C would expand opportunities for hunting and have a greater emphasis on public outreach and education. Fishing, wildlife observation, and wildlife photography would be similar to alternative A (Map 4-25). Compared to alternative B, proposals for hunting in alternative C would decrease the amount of hunting areas and opportunities.

Under alternative C, we would further enhance local community outreach and partnerships, continue to support a Friends Group, and continue to provide valuable volunteer experiences. We would also promote research and the development of applied management practices through local universities to sustain and enhance natural composition, patterns and processes within their range on the Delmarva Peninsula.

Formulating Alternatives Using Refuge Resources of Concern (ROCs) and Focal Species Management

Relating Resources of Concern to Goals, Objectives, and Strategies

Refuge goals and objectives define each of the management alternatives identified below. As described in chapter 2, the first step in our planning process was to map out the refuge's resources of concern and prioritize focal management species that were used in developing goals and objectives. Goals are intentionally broad, descriptive statements of the desired future condition for the refuge's resources of concern. By design, they are less quantitative and more prescriptive in defining the future desired habitat conditions of our management.

Our goal statements include the principal elements of the refuge purposes and Refuge System mission and refuge-specific habitat vision statement developed by the public. All these inputs provided the framework for stepping down specific management objectives and strategies.

Our goals are common to all of the alternatives, but objectives and strategies vary between alternatives.

A rationale accompanies each objective to explain its context and why we think it is important. We will use the objectives in the alternative selected for the final CCP in writing refuge step-down plans. We identified strategies for each of the objectives. These are specific actions, tools, techniques, or a combination of these that may be used to achieve the objective. Respective lists of strategies under each objective represent a potential suite of actions to be implemented in step-down plans that will achieve the desired future habitat and wildlife outcomes.

The balance of this chapter is organized as follows. Actions common to all alternatives are described first. Each alterative considers each of the six goals set out in chapter 1 (preservation, restoration, and enhancement of BIDEH in four key habitats, public use, and outreach and public partnerships) and describes the different objectives and strategies that we will use to achieve that goal.

Actions Considered but Eliminated from Detailed Analysis

Refuge Boundary Expansion

Prime Hook's 4,000 acres of impoundments represent approximately 40 percent of the total 10,000 acres of impoundments in the State of Delaware and 78 percent of the freshwater impoundments within the State. However, the refuge's impoundments are extremely vulnerable to sea level rise due to their position immediately behind a dynamic coastal barrier, as described in chapter 3. In the last decade, this sand dune system has been breached several times, resulting in the deposition of sand and saltwater into the Unit II impoundment during storm tides. Storms have also created inlets south of Fowler Beach Road, resulting in constant tidal regime. Consequently, the freshwater impoundment created to provide habitat for migratory birds in Unit II has converted to an open water system, which has also impacted the management of the Unit III impoundment. It would be extremely difficult, costly, and unsustainable to reestablish freshwater impoundment management in these units.

Under the preferred alternative, described later in chapter 4, these impoundments will eventually be restored to a natural salt marsh or brackish wetland complex, with a cessation or significant reduction in communities of freshwater annual plants resulting from impoundment management on the refuge. Although salt marsh and brackish wetlands provide valuable migratory bird habitat, conversion of refuge impoundments creates the potential for significant reduction of waterfowl numbers and loss of shorebird habitat. With the loss of Prime Hook's impoundments, 78 percent of the freshwater impoundments within the State of Delaware will have a reduced function and value as habitat for migratory waterfowl. Since freshwater wetlands have greater diversity than saltwater wetlands, State rare plants are vulnerable due to saltwater intrusion, resulting in the refuge's loss of biodiversity.

Radar research indicates how important the refuge's forests are during the migration of neo-tropical migrants (Dawson and Butler 2010). However, surveys show that the refuge contains 125 to 150 acres of dead, dying, or stressed woodland habitat due to saltwater intrusion. Mitigating for the loss of this critical and habitat is an important step toward the refuge purpose as envisioned under the Migratory Bird Conservation Act.

As rising sea levels prompt changing habitat conditions along the refuge coastline, salt marsh and brackish wetlands will migrate landward, which is a natural response mechanism. In order to continue providing valuable impoundment and forest habitats, the refuge must consider expanding the refuge boundary toward the west. The refuge currently owns 10,144 acres and has approval to acquire an interest in 1,101 additional acres. It is prudent for the refuge to continue acquiring lands within the approved acquisition boundary from willing sellers, and to manage newly acquired land in a manner consistent with management proposed in this CCP. However, ultimately the refuge will need to pursue and expand the acquisition boundary westward to permit the purchase of additional lands inland from willing sellers. This would enable the refuge to pursue forest management and the potential creation of new freshwater impoundments. Land acquisition, however, is increasingly expensive.

As described in chapter 3, some 9,000 years ago the Delaware shoreline was about 3 miles east of its current location east. Since the shoreline of the refuge has retreated some 500 feet over the past 80 years, it is inevitable that the westward migration of land and saltwater will continue.

Expansion of the refuge's acquisition boundary is a necessary future step to meet habitat needs for trust species such as migratory waterfowl, shorebirds, and neotropical migrants, and to contribute to the network of conservation lands and wildlife resources in the regional landscape. However, with input we received from the public during scoping, coupled with reduced land acquisition funding, we are not planning any major refuge boundary expansion as part of this CCP/EIS. Approval to explore refuge boundary expansion comes from the Service's Director, and then expansion requires development of a Land Protection Plan (LPP). We will continue to consider minor acquisitions adjacent to the refuge from willing sellers if the lands are determined to be biologically important, or provide connections with other protected lands. Land protection efforts that emerge outside of this planning process will include significant public involvement in decision-making, involve partners in the protection effort, and will use a full range of protection methods, including management agreements, conservation easements, and fee acquisition. Any new LPP developed in the future will incorporate these features and contributors.

Shoreline Stabilization

Most oceanfront and bay shorelines in the Northeast have been eroding over the last 10-20,000 years, in part as a natural process and in part as a process exacerbated and accelerated by human activity. Beaches erode naturally due to physical processes (wind, waves, tides, sea level rise, and subsidence). Higher intensity coastal events such as nor'easters, hurricanes, and storm surges accelerate beach erosion or can reconfigure areas of sediment accumulation and erosion. During storms, sand from the visible beach submerges to form storm bars that protect the beach. During milder weather, sediments moved off shore can move landward, so an eroded beach with substantial submerged sand surrounding it may recover naturally.

Human activities and alterations on the coast can also be as catastrophic as hurricanes, but generally over a longer time interval (Kraft et al. 1975, GSA 2009). Human construction activities have caused substantial erosion on the beach face of barrier islands or along sandy shoreline strands (littoral cells) adjacent to a sandy harbor, like in Lewes, Delaware. Today coastal beaches are eroding for several reasons, such as human-induced changes in sediment transport processes, sand supply, sea level rise, and increased storminess. Eroding beaches generally migrate landward, which is a natural coastal process even under more recent (5-7,000 years) historic rates of sea level rise.

An ecologically ideal and sustainable management response is to allow natural retreat. However, urbanization of beaches and their associated shorelines have resulted in residents of adjacent coastal communities advocating that State or Federal agencies actively intervene through hard armoring or soft engineering solutions that temporarily halt the migration of shorelines. Neither solution is free of negative ecological consequences (Komar 1998a). Increased storminess is a predicted consequence of global climate change and will likely result in significant annual changes to the refuge's sandy beach and bayshore habitats. The roles of both traditional hard and soft armoring methods to stabilize sandy beach shorelines have been considered during the development of the CCP/EIS.

Hard Engineering Methods to Stabilize Shorelines
Hard engineering methods are often positioned in marine environments to offset erosion in sediment-deficient areas, or to prevent accretion in dynamic areas such as inlets. Hard engineering methods to stabilize shorelines include groins, sea walls, revetments, rock armoring, and bulkheads. Often, hard armoring techniques implemented to solve coastal erosion problems result in accelerated erosion rates and measures used to reduce coastal erosion at one location will often create coastal erosion problems at other coastal locations more removed from the armored areas.

Delaware coastal scientists have noted that if there is an inadequate supply of sand in a given location, hard armoring cannot control erosion (DNREC 2004, Maurmeyer 1978, Kraft et al. 1975). In the absence of an adequate sand supply, hard structures such as seawalls, bulkheads, and revetments placed in the area of wave action may be effective in protecting properties in the upland, but often at the expense of the sandy beach ecosystem and back-barrier island habitats, by curtailing and cutting off sediment flow. Disruption or changes in the littoral drift and flow of sediment negatively impacts sediment budgets of natural dune and beach ecosystems. These engineering techniques also impede the natural landward migration of the shoreline (Kraft et al. 1975).

From the 1920s to the late 1970s, shoreline hardening techniques were used in Delaware. For example, groin fields were established on Broadkill Beach in tandem with beach nourishment to protect beach houses. Similar shoreline hardening combined with soft hardening techniques were used from the 1940s through the 1970s in Slaughter Beach, where groin fields, bulkheads, and riprap, coupled with beach nourishment had been historically employed to stabilize Delaware Bay shorelines immediately north and south of the refuge (DNREC 2004). However, it is pointed out by DNREC coastal scientists that it is the sand and sediment that ultimately serves best to temporarily protect beach properties, not the groins or other shoreline hardening techniques used in the past.

Importantly, if a hard structure diverts the existing sediment supply from other areas, it will be necessary to perpetually add sediment into the system to compensate for such impacts. Thus, this approach does not meet one of the fundamental parameters for a satisfactory alternative (i.e., that the alternative be sustainable ecologically).

Since the late 1970s, the State of Delaware has no longer included shoreline hard armoring of ocean or bay shorelines as part of its primary coastal management strategies. Additionally, Federal coastal scientists suggest that, before using either hard or soft stabilization of any shoreline, the effect of these coastal management techniques on the local sediment budget must be appropriately analyzed to eliminate or reduce adverse environmental problems and negative impacts on barrier beach island integrity and functioning (NOAA 2011).

Shoreline transgression is necessary to maintain the biological integrity, diversity and environmental health (BIDEH) of Barrier Beach Island and salt marsh habitats in the face of rising rates of sea level and climate change. Hard armoring is also a very expensive technique with little to no capability of stemming coastal erosion in the long term. Hard armoring was eliminated as an alternative from detailed analysis in this CCP because of its adverse impacts, its lack of sustainability and the probably need for perpetual sand replenishment to address its like adverse impacts, its inconsistency with BIDEH policies, and the fact that its high cost.

Soft Engineering Methods to Stabilize Shorelines
Beach scraping involves mechanically moving sand from the intertidal zone to the dune or upper beach. Beach scraping is intended to mimic natural beach recovery processes, but at an increased recovery rate, and is regarded by some as being suitable only under certain circumstances for coastal protection, such as when there is sufficient material in the intertidal zone to sustain the beach profile (Wells and McNinch 1991). Beach scraping can have negative consequences on the beach biota (Peterson et al. 2000) and in some situations can worsen shoreline erosion (Kerhin and Halka 1981). Beach scraping is not suitable for severely eroding beaches (Wells and McNinch 1991). In 2010, the community of Primehook Beach was denied a State permit for beach scraping on the basis of several concerns, including the potential for increased erosion (DNREC 2010).

Shoreline stabilization using onsite material can also be accomplished by mechanically moving sand that has washed landward from the dunes back onto the duneline. The material can be reconfigured to create berms and dunes and provide shoreline stabilization without using sand from the intertidal zone as is done with beach scraping. Such stabilization was conducted along Unit II in the fall of 2010, following the preparation of an Environmental Assessment (USFWS 2010). The project had been delayed by litigation, and by the time it was conducted Hurricane Irene had washed away much of the material that was to be utilized for the stabilization. The resulting project was smaller than originally planned and lasted only a short time before the closed inlets were opened again during a high tide event. For this reason, this approach has been dismissed from further consideration. There is no longer enough sandy sediment along the Unit II shoreline to make this technique feasible.

No Hunting

An alternative that would have closed the refuge to all hunting was considered but dismissed from detailed analysis. A “No Hunting Alternative” would not accomplish the purposes we seek to accomplish by the adoption of this CCP, as described in the “purpose and need” section of this EIS. Closing the refuge to hunting would conflict with the Refuge Improvement Act, which provides that hunting is an appropriate and priority use of the Refuge System, shall receive priority consideration in refuge planning and management, mandates that hunting opportunities should be facilitated when feasible, and directs the Service to administer the Refuge System so as to “provide increased opportunities for families to experience compatible wildlife-dependent recreation, particularly opportunities for parents and their children to safely engage in traditional outdoor activities, such as fishing and hunting” Furthermore, “no hunting” would conflict with Executive Order #13443: “Facilitation of Hunting Heritage and Wildlife Conservation.” The order directs the Department of the Interior and its component agencies, bureaus and offices “to facilitate the expansion and enhancement of hunting opportunities and the management of game species and their habitat.” Finally, the CCP’s stated purpose and need is to ensure that management of the refuge will best respond to four key areas of concern, including "abide by and contribute to the mission, mandates and policies of the U.S. Fish and Wildlife Service and the National Wildlife Refuge System, and meeting refuge's goals." One of the goals of the Refuge System is to "provide and enhance opportunities to participate in compatible wildlife-dependent recreation (hunting, fishing, wildlife observation, photography, environmental education and interpretation)." An alternative that failed to provide any opportunity to participate in hunting activities, where such activities are compatible with the purposes of the Refuge System, would fail to meet the goals of the Refuge System.

Reduced Hunting

An alternative that would have considerably reduced existing hunting opportunities was considered but dismissed from detailed analysis. The fundamental mission of the Refuge System is wildlife conservation: wildlife and wildlife conservation must come first. Biological integrity, diversity, and environmental health are critical components of wildlife conservation. According to Section 3.14 601 FW 3 "Biological Integrity, Diversity, and Environmental Health" the Service is mandated to manage populations to maintain and restore biological integrity, diversity, and environmental health by "… cooperation and coordination with State fish and wildlife management agencies in setting refuge population goals and objectives. To the extent practicable, our regulations pertaining to fishing or hunting of resident wildlife within the System are consistent with State fish and wildlife laws, regulations, and management plans." Hunting helps achieve the purposes of the refuge and the Refuge System.

Overabundant deer and snow goose populations have created negative impacts on the refuge, including economic losses, agricultural and landscape damage, habitat degradation and destruction, and deer-vehicle collisions. White-tailed deer cause significant damage to agricultural crops. DNREC (2010) found that 75% of Delaware farmers surveyed experienced some form of damage related to deer.

Along with agricultural crop damage, excessive numbers of white-tailed deer also damage the native flora and fauna of Delaware. Numerous studies have indicated that intensive deer browsing related to overabundant deer populations can change the forest species composition and the associated wildlife (DeCalesta 1994, Waller and Alverson 1997). This change would not only affect the forest composition but would also negatively affect the wildlife species that live within these forest communities. Deer overabundance can affect native vegetation and natural ecosystems and has been well-studied (Tilghman 1989, Nudds 1980, Hunter 1990; Behrend et al. 1970). White-tailed deer selectively forage on vegetation (Strole and Anderson 1992), and thus can have substantial impacts on certain herbaceous and woody species and on overall plant community structure (Waller and Alverson 1997). Over-browsing by deer can decrease tree reproduction, understory vegetation cover, plant density, and plant diversity (Warren 1991). High densities of deer have also been recognized as vectors for spreading exotic or invasive species like Japanese stiltgrass. Delaware's natural ecosystems are often threatened by exotic plants that find the habitat and climatic conditions favorable. According to the Delaware Division of Fish and Wildlife's "Delaware Deer Management Plan" (2010), "active management of deer is a necessity in Delaware today to maintain populations at levels compatible with the varied interests of the citizens of the state as well as ecological concerns….. Presently, non-lethal management techniques such as contraceptives and non-hunting mortality (i.e. disease, injuries, predation, and roadkills) are not sufficient in maintaining deer populations at satisfactory levels. Lethal control of deer via the regulated deer hunting season is required to effectively regulate the deer population." We believe that annual harvesting of 60-100 white-tailed deer on the refuge will likely have a beneficial localized impact toward the biological integrity and biological diversity of the refuge.

Both Canada goose and snow geese cause damage to refuge habitats. Canada goose herbivory during the growing season is a relatively new impact upon wetlands. In 2002, a research study conducted at neighboring refuges, Bombay Hook and Chincoteague NWRs, suggested that higher levels of use by geese may cause a long-term change in wetland community structure (Laskowski et al. 2002). Biomass of several species of vegetation was significantly adversely impacted by feeding resident Canada geese at both refuges. Resident geese directly damage agricultural resources by eating grain crops and trampling spring seedlings. Heavy grazing by geese can result in reduced yields and in some instances a total loss of the grain crop (Allen et al. 1985, Flegler et al. 1987). Grubbing for rhizomes, especially in salt marshes, results in areas denuded of vegetation, typically referred to as eat-outs. However, where eat-outs occur within salt marsh habitats, snow geese often return each winter to the same areas to feed. Such impacts have been observed at the refuge. It is also speculated that during the time snow geese are feeding in a salt marsh, much of the soil and sediment may be loosened and placed into suspension. In fact, recently analyzed water quality samples from the refuge impoundments have found extremely high sediment concentration in the water during times of extensive snow goose browsing on the refuge. This material may then be washed away during high or flood tide periods. After several years of successive erosive eat-outs at the same location, the lower ground elevation may further prevent the return of vegetation, causing a more long-term impact to vegetation community on the site. Constant harassment, habitat alterations, and hunting are the most effective long-term solutions to reduce goose problems. With limited staff resources and the potential negative consequences to habitat and other wildlife, harassment is not a feasible option at Prime Hook NWR. Thus, we believe that reducing snow goose numbers on the refuge through a regulated hunt will best reduce the impacts of Canada goose and snow goose herbivory on salt marsh habitats.

Hunting on the Delmarva Peninsula is a traditional outdoor past time and is deeply rooted in American and Delaware heritage. Opportunities for public hunting are decreasing with increasing private land development. Therefore, refuge lands have become increasingly important in the region as a place to engage in this activity. Hunting is an existing use on the refuge and has provided the public compatible use since 1963. Experience has proven that time and space zoning (e.g., establishment of separate use areas, use periods, and restrictions on the number of users) have been effective in eliminating potential conflicts between user groups. The refuge has an excellent safety record.

The Service had a randomized public opinion survey conducted when it began the CCP process. Both visitors to the refuge and residents of nearby communities were sent surveys and the results met statistical standards for demographic proportionality and had high confidence levels. Among a wide range of topics (see chapter 3), survey questions were designed to identify similarities and differences of opinion between consumptive (hunting, fishing, and crabbing) users and non-consumptive users. Both groups were highly supportive of the opportunities for wildlife observation and appreciated the serenity and natural environment which the refuge provides. Overwhelmingly, both consumptive and non-consumptive users held similar views of the refuge as providing attachment or meaning to their sense of place and identity and for family tradition or heritage.

Both the consumptive and non-consumptive users of the refuge reported visiting the refuge frequently, generally about 12-16 times per year. The non-consumptive users were more likely to be older (60s), retired, and female (54%). The consumptive users were more likely to be in their late 40s, employed, and male (97%).

The consumptive users overwhelmingly felt that opportunities for hunting should be increased. About 55 % of the non-consumptive users accepted hunting at existing levels or were supportive of an increase in this use. The non-consumptive visitors identified bird watching (73%), nature/wildlife viewing (64%), hiking/nature trails (56%), and special events, environmental education, and guided interpretive tours (collectively 68%) as their primary activities.

Proximity to the roads was of key importance to both the consumptive and non-consumptive users, but presumably for different reasons--the consumptive users use roads to access areas for hunting and fishing; many of the non-consumptive users, being older, remain in or near their cars while viewing birds on or near the water. However, non-consumptive visitors also placed the roads as important for viewing forest birds and paddling. One statistical difference between the consumptive and non-consumptive users is that the non-consumptive users preferred to have more areas restored to natural conditions, more hiking trails, and more interpretive exhibits. About 45% favored reducing hunting. Only about 10% of the survey respondents felt that hunting should not be allowed at all, and it is possible that some of these visitors did not understand that Congress has already determined that hunting and fishing are to be facilitated on refuges as well as facilitating wildlife observation, photography, or environmental education. When asked to rate five potential future services, the non-consumptive users rated an observation tower overlooking the marsh, road-side pull-offs, more walking trails around refuge headquarters, and more scheduled guided interpretive walks as important to them, far more than the consumptive users rated such increased services.

In developing the hunting and public access plan for the CCP, the Service determined that increasing the totality of opportunities to engage in priority wildlife dependent public uses could best address the concern raised by both groups. Therefore, the number of trails has been increased and additional areas are being opened to both consumptive and non-consumptive users; these areas and trails were previously closed to all public uses. By increasing opportunities for wildlife viewing for non-hunters while also increasing hunting opportunities, the Service believes it is responding to the views expressed by both groups. Reducing the hunting opportunities would not as effectively address the purposes and goals of the CCP as expanding all opportunities for increased wildlife dependent public uses. Thus, the Service feels that it has developed a far more reasonable approach to allocating wildlife dependent public use options than reducing hunting options alone.

In developing the CCP, the Service is required, to the maximum extent practicable, to consult with State conservation agencies and coordinate development of the plan with the relevant state conservation plan. For Prime Hook NWR, DNREC requested that hunting opportunities not be reduced below existing levels. A reduced hunting alternative would also conflict with Executive Order #13443 to "… facilitate the expansion and enhancement of hunting opportunities." It would also conflict with Congress' mandate to "provide increased opportunities for…compatible wildlife-dependent recreations…such as fishing and hunting." 16 U.S.C. 668dd(a)(4)(K)

Although there are other methods available to reduce overabundant deer, Canada goose, and snow goose populations, hunting remains an efficient, traditional, and compatible wildlife/habitat management tool that provides an excellent recreational opportunity for many outdoor enthusiasts. Eliminating or reducing the hunt program at the refuge would be contrary to the establishing purpose, and the mission of the Refuge System.

Actions Common to all Alternatives

All of the alternatives share some common actions. Some are required by law or policy, or represent NEPA decisions that have recently gone through public review and are binding in many of our decisions. Others may be administrative actions that do not require public review, but are highlighted in this public document. They may be actions crucial to achieving refuge purposes, vision, and goals. There are at least 17 components of refuge management that are common to all alternatives and are described below. They include:

- Conducting adaptive resource management.
- Managing invasive species.
- Monitoring and abatement of diseases affecting wildlife and forest health.
- Control of pest animals.
- Removing unnecessary structures and site restoration.
- Coordinating with the State regarding the Prime Hook Wildlife Area.
- Maintaining regional and community partnerships.
- Community relations.
- Conducting appropriate use and compatibility determinations.
- Facilitating and conducting biological research and investigations.
- Commercial and economic uses.
- Providing opportunities for wildlife-dependent recreation.
- Protection of cultural resources.
- Refuge wilderness review.
- Refuge staffing and administration.
- Distributing refuge revenue sharing payments.

Adaptive Resource Management

In all of the alternatives, CCP goals and objectives are supported by rationales and management strategies which were developed after a thorough assessment of available science derived from scientific literature, onsite refuge data, expert opinion within and outside the Service, and sound professional judgment. Biological objectives describe desired future conditions for wildlife and refuge habitats.

In all the alternatives, it is assumed that we employ adaptive resource management as a strategy to ensure a quick and efficient response to new information and events. The need for adaptive management is compelling because our present knowledge and information on refuge habitats and species is incomplete, provisional, and subject to change as new information is acquired. Adaptive management is a proactive process of learning what works on the ground by constantly adjusting strategies to respond to new information, spatial and temporal changes, and environmental and climatic events, whether foreseen or unforeseen, measured against a clearly defined goal or set of conditions.

On March 9, 2007, the Secretary of the Interior issued Order No. 3270 that provides policy on the procedures for implementing adaptive management in DOI agencies. A published guidebook for managers and practitioners defines adaptive management and the conditions under which we should consider it, and the process for implementing and evaluating its effectiveness. You may view this reference at the following site: *http://www.doi.gov/initiatives/AdaptiveManagement/documents.html* (accessed February 2012). As it relates to refuge management, adaptive management promotes flexible decision-making through an iterative learning process to deal with uncertainty, resulting in more effective decisions. At the refuge level, monitoring habitat management actions and outcomes and key resources of concern will be critical to the process.

Climate change is expected to exacerbate the current rate of habitat fragmentation and loss, change habitat composition and structure, simplify ecosystem function, increase the prevalence of weed and disease species, degrade water quality, and alter hydrology. It will be especially important to continually evaluate management activities and the status of the refuge's resources in order to respond to negative impacts in a meaningful way as quickly as possible.

At the refuge level, monitoring and assessing management actions and outcomes, and tracking critical resources and indicators of environmental health will be very important. The refuge will be responsible for changing management actions and strategies if they do not produce the desired conditions. Significant changes in management actions and strategies from what we present in our final CCP may warrant additional NEPA analysis and public comment. Minor changes will be documented as an important element of the adaptive management process when NEPA analysis and public comment are not warranted.

Many of our alternatives' objectives identify increased monitoring elements. If monitoring activities are conducted by non-Service personnel, these activities must be determined compatible by the refuge manager in a compatibility determination. Our future habitat and species inventory and monitoring plan will detail how and what we monitor and will also incorporate an adaptive management approach to support the goals and objectives of the refuge.

Managing Invasive Species

The establishment and spread of invasive species, especially invasive plants, is a major problem that reaches across all refuge habitat cover-types. We use the definition of invasive species found in the Service Manual (620 FW 1.4E):

> *Invasive species are alien species whose introduction does or is likely to cause economic or environmental harm, or harm to human health. Alien species, or non-indigenous species, are species that are not native to a particular ecosystem. We are prohibited by Executive Order, law and policy from authorizing, funding, or carrying out actions that are likely to cause or promote the introduction of invasive species in the United States or elsewhere.*

The unchecked spread of invasive plants threatens the biological integrity, diversity, and environmental health of all refuge habitats. In many cases, invasive species have a competitive advantage over native plants and outcompete them, reducing the availability of desirable native food and cover plants for wildlife. Invasive plants reproduce rapidly over large areas of the landscape and have few or no natural controls to keep them in check. Invasive vegetation usually spreads aggressively by runners or rhizomes, produces large numbers of seeds, and disperses seeds through various means such as wind, water, wildlife, or people. Invasive wildlife is best held in check through alert monitoring; if found, appropriate techniques need to be matched to the particular species of concern.

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

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

Potential management strategies for preventing invasive species, prioritizing control efforts for established invasive species, and controlling invasive species are described in detail below. Prior to the initiation of invasive species control efforts, refuge staff must understand the biology of the species to be controlled. A number of resources are available on the internet to assist with this. Some sources are included below (all accessed February 2012):

- National Invasive Species Information Center: *http://invasivespeciesinfo.gov/index.shtml*

- USGS Invasive Species Program: *http://biology.usgs.gov/invasive/*

- Weeds Gone Wild: *http://www.nps.gov/plants/alien/index.htm*

Refuge staff should conduct appropriate and applicable pest detection, environmental surveillance, and monitoring before, during, and after any management activity to determine whether pest management goals are achieved and whether activity caused any significant unanticipated effects. The lowest risk, most targeted approach for managing invasive species should always be used.

Early Detection and Rapid Response

Where prevention is not possible, early detection and rapid response are the next best strategies. Success will depend in part on participation by all refuge staff, contractors, volunteers, and visitors in efforts to report and respond to invasions. The refuge manager must have access to up-to-date reliable scientific and management information on species that are likely to invade. The Delaware Invasive Species Council of the Delaware Department of Agriculture (DDA) is an important source of information: *http://www.delawareinvasives.net* (accessed February 2012).

For some species, an active monitoring protocol may be established to facilitate early detection. For example, artificial substrates may be suspended in waterbodies and checked regularly for the early detection of zebra mussel on the refuge. When small plant infestations are spotted, they should be eradicated as soon as possible. Sites must then be monitored for the appropriate time period considering the species involved to ensure the control was effective.

Prioritizing Invasive Plant Species Control Efforts

The first step in prioritizing invasive species control efforts is to determine the abundance and distribution of invasive species on the refuge or management unit. However, control efforts should not be delayed to collect statistically rigorous survey data. Baseline data regarding the location of many invasives on the refuge already may be available from observations of staff, volunteers, contractors, and refuge visitors. These observations should be documented and mapped on refuge GIS. If a more formalized mapping procedure is desired, the North American Weed Management Association (*http://www.nawma.org*; accessed February 2012) has information on mapping procedures.

There are a number of ranking tools to assist land managers with the daunting task of prioritizing their invasive plant control efforts (Morse et al. 2004, Hierbert and Stubbendieck 1993, APRS Implementation Team 2000). The “Fulfilling the Promise” team recommends using the following order of priority to determine appropriate actions: smallest scale of infestation, poses greatest threat to land management objectives, and greatest ease of control.

When limited resources prevent the treatment of entire populations, the following order of priority is recommended: treat the smallest infestations (satellite populations), treat infestations on pathways of spread, and treat the perimeter and advancing front of large infestations.

To prevent the spread of invasives along transportation corridors, maintain invasive species-free zones along trails, around parking lots and boat launches, and at other related facilities. These areas will be inspected often, and new infestations will be controlled immediately. Minimize the number and size of roads on the refuge. Remove all mud, dirt, and plant parts from all equipment between projects or when equipment is moved from one location to another.

Incorporating Invasive Species Prevention in Impounded and Other Emergent Wetland Areas
To minimize infrastructure development in managed wetland units we will remove or revegetate dikes, waterways, and access roads found to be unnecessary for meeting management objectives. These often are sources of infestation and provide pathways for the spread of invasives. We will plant native grass mixes that establish quickly to stabilize banks and dikes and prevent the establishment of invasive species. Native grass mixes should include annual ryegrass *(Lolium perenne)* so bare soil is not exposed to erosion or invasive plant seeds and rhizomes. This nonnative plant will establish quickly and then drop out of the mix after 1 or 2 years.

Timing water manipulation activities, such as flooding and drawdowns, to minimize the germination and spread of invasive plant seeds and encourage the growth of native species. Prolonged flooding can be used to stunt the growth of some invasive species. Water level management can also be used to control invasive plants. Robust plants such as *Phragmites* (common reed) require air pockets (carbon dioxide) to survive. Flooding the impoundment through all or part of a growing season, particularly after mowing or chemical application, discourages vegetative re-growth of robust invasives like *Phragmites*.

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

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

Herbicides
There are many chemicals available to control invasive plants. They may work in different ways and be very target-specific, or affect a wide range of species. Herbicides may be pre-emergent (i.e., applied prior to germination to prevent germination or kill the seedling) or post-emergent and have various modes of action (auxin mimic, amino acid inhibitor, mitosis inhibitor, photosynthesis inhibitor, lipid biosynthesis inhibitor). Products may come in granular, pelleted, dust or liquid forms. Common application methods include foliar spray, basal

bark, hack and squirt, injection, and cut stump. The timing of applications is critical to achieve good control, as the growth stage at which an invasive plant will be most effectively controlled varies with different species. All pesticides must be mixed, loaded, and applied in accordance with label specifications and all applicators must be certified with the Delaware Department of Agriculture or working under the supervision of a certified applicator.

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

Within refuge lands, all chemicals, including adjuvants designed to enhance effectiveness are covered by Service and Departmental regulations, and a pesticide use proposal (PUP) is required for all pesticide applications. Attention to protective gear, licensing requirements and other regulations is essential.

Prescribed Burning
Fire is a critical tool for managing ecosystems. It recycles vital nutrients, stimulates growth, and provides quality habitat for a variety of species, especially when it is used to control invasive plants like *Phragmites*, in conjunction with other techniques like herbicides and mechanical removal. Regular fires also help check the risk of catastrophic fire by reducing accumulation of hazardous fuels by clearing underbrush and dead vegetation.

Over 90 percent of hazardous fuels reduction on the refuge has been accomplished through strategic use of fire in conjunction with herbicides to reduce large stands of *Phragmites*. A comprehensive monitoring plan was established in 2002 with 45 transects spread across all four management units as part of the initiation of a large wildland urban interface project conducted in 2002 through 2004. These established transects continue to be monitored to track *Phragmites* control in relation to original 2002 treatment sites in all alternatives considered. Maps and the monitoring plan can be located in the refuge's 2009 fire management plan.

Biological Control
Biological control is the use of animals or disease organisms that feed upon or parasitize the invasive species target. Usually, the control agent is imported from the invasive species' home country, and artificially high numbers of the control agent are fostered and maintained. There are also conservation or augmentation biological control methods in which populations of biological agents already in the environment (native) are maintained or enhanced to target an invasive species. The advantages of this method are that it avoids the use of chemicals and can provide relatively inexpensive and permanent control over large areas. Appropriate control agents do not exist for all invasive species. Petitions are submitted and approved by the USDA Technical Advisory Group on weed biological control before any proposed biological control agent can be released in the United States.

Methods are in development to biologically control two of our most invasive plant species—common reed *(Phragmites australis)* and mile-a-minute *(Persicaria perfoliata)*. Biological control organisms for common reed are still in the experimental stages; therefore that strategy cannot yet be explored. However, mile-a-minute biological control organisms are closer to being ready for field use. Biological control of invasive species is not being pursued under this CCP, but may be explored in the future, pursuant to NEPA compliance at that time.

Mile-a-minute is an annual vine of Asian origin that infests refuge forested areas, roadsides, and drainage ditches. In areas in full sun, by early spring it rapidly outgrows and outcompetes native plants, and is often the first colonizer in refuge areas that have been reclaimed from *Phragmites* dominance. It is a weed that poses a particularly strong threat to forest regeneration and could potentially provide considerable setbacks in reforestation and forest enhancement projects.

A biological control program targeting mile-a-minute weed was initiated by the Forest Service in 1996, with field surveys and laboratory host specificity tests conducted in China and subsequent testing continuing under quarantine conditions in Delaware. A stem-boring weevil, *Rhinoncomimus latipes*, was determined to be host-specific to mile-a-minute (Price et al. 2003, Colpetzer et al. 2004), and a permit application for field release was approved in July 2004. Development of a rapid germination protocol and field successes in Delaware have been documented (Colpetzer et al. 2004, Hough-Goldstein et al. 2008).

Of the 426 plant taxa listed for the refuge, 45 are non-native; among those are considered invasive on Prime Hook NWR are:

- *(Centaurea bieberstei)*—spotted knapweed
- *(Cirsium arvense)*—Canada thistle
- *(Hydrilla verticillata)*—hydrilla
- *(Lonicera japonica)*—Japanese honeysuckle
- *(Ludwigia leptocarpa)*—water willow
- *(Microstegium vimineum)*—Japanese stiltgrass
- *(Phalaris arundinacea)*—reed canary grass
- *(Phragmites australis)*—alien common reed
- *(Polygonum perfoliatum)*—mile-a-minute
- *(Pueraria montana)*—kudzu
- *(Rosa multiflora)*—multi-floral rose
- *(Sorghum halepense)*—Johnsongrass
- *(Elaeagnus umbellata)*—autumn olive

Spotted knapweed, Canada thistle, and Johnsongrass are mostly found on roadside areas, agricultural fields, and early successional habitats throughout the refuge. Water willow, which is not native to Delaware, but is native in areas further south, dominates about 100 to 200 acres within the Unit III impounded emergent marsh along Prime Hook Beach Road. Japanese stiltgrass (approximately 50 acres) is restricted to Oak Island, where it dominates the herbaceous layer. Japanese honeysuckle is ubiquitous on the refuge in wooded habitats. Reed canary grass, another species native in areas south of Delaware, dominates old field habitats also located in Unit III.

By far, the most problematic invasive plant historically and currently on the refuge is *Phragmites*. Its proliferation in the refuge's marshland and upland interface is a signature of man-made wetland alternations and activities creating constant habitat disturbances (water level management actions, open marsh water management excavations, and eutrophication from off-refuge nutrient sources). These disturbances have made it an annual requirement to monitor and treat *Phragmites.* In 1983, the refuge conducted an environmental assessment on the marsh vegetation rehabilitation and chemical control of *Phragmites.*

A fundamental concern to control *Phragmites* on the refuge is the grave fire hazard it presents as a potential danger to local beach communities adjacent to refuge lands. A second concern is the reduction of environmental health and biodiversity that occurs when native plant species are replaced by aggressive exotics. Competitively superior exotic genotypes have displaced former indigenous *Phragmites* populations in North America, especially in the mid-Atlantic through heavy shipping channels from European trade (Saltonstall 2002). Commensurate with a shift to an exotic *Phragmites* monoculture is an unhealthy reduction in avian, insect, and other important floral and faunal assemblages.

The biggest invasive problems and accumulation of hazardous fuel-loading has occurred in the refuge's marsh areas. Marsh management practices preceding refuge establishment and lack of funding since contributed to a build-up of highly flammable *Phragmites* fuels on refuge lands immediately adjacent to three private beach communities. Dense stands over 15 feet high with accumulation of dead canes created severe fuel hazards, as these canes can persist for up to four years. The exotic m-haploid type prevalent in the mid-Atlantic can grow over 14 feet tall annually and primarily spreads by the growth of rhizomes that can extend 150 feet from a single cane stem per season. The plant can also reproduce via seed; seeds dispersed by wind or water from off-refuge sites are quickly establishing on refuge sites that have high water tables or are seasonally flooded. By the end of the 1999 and 2000 growing seasons, more than 3,000 acres of *Phragmites* persisted on the refuge.

Within the context of Federal wildland fire policy and wildland urban interface protection concerns and habitat conditions on the refuge, it became evident that wildland urban interface fire protection and prevention required immediate attention. The major focus occurs along the refuge's eastern boundary; Prime Hook Beach and Broadkill Beach were identified in 2002 by the Delaware State Forester and included in the vicinity of Federal lands published in the *Federal Register*. In three beach communities, approximately 750 homes are at risk. Periodic arson-set fires also increase fire risks to these communities, each with poor access and lack of defensible space.

The use of fire in invasive species control of *Phragmites* for public safety and natural resource protection is fully addressed in our updated fire management plan, which will be implemented under all three alternatives. The use of prescribed fire and full suppression of all wildfires occurred under previous refuge management. Prescribed fire was used by managers to reduce fuel hazards, achieve resource management objectives, and simulate natural fire processes. Natural ignitions or human caused wildfire will not be allowed to burn without suppression.

In addition, a program for continued monitoring and treatment of hazard fuel zones near the three wildland urban interface communities is now formally included in the refuge's fire plan (2009). This continues fuel management practices initiated in 2001 in primary treatment zones (zero tolerance zones, approximately 800 acres) and secondary treatment zones (limited tolerance zones, approximately 2,000 acres) to continue reduction of hazard fuels to reduce risks and threats to nearby communities.

Monitoring and Abating Wildlife and Plant Diseases

We derive guidance on wildlife and plant diseases from the Refuge Manual and directives from the Service Director or the Secretary of the Interior. The Refuge Manual (7 RM 17.3) lists three objectives for the prevention and control of disease:

- Manage wildlife populations and habitats to minimize the contraction and contagion of disease.
- Provide for the early detection and identification of disease mortality when it occurs.
- Minimize the losses of wildlife from outbreaks of disease.

Disease prevention is far more cost-effective and resource protective than disease control. However, when disease outbreaks do occur, aggressive and responsible control activities can save considerable numbers of wildlife (7 RM 17.5).

In 2006, the Service instructed all refuges to prepare an avian influenza (AI) surveillance and disease contingency plan specific to their sites following the criteria established by the national plan. The goal of the national interagency AI plan was to structure a unified national system for the early detection of Asian H5N1-HPAI in migratory birds. Data collected throughout the country were assimilated and used from a national database.

The refuge's approved AI plan (2006) describes local wild avian ecology and management practices and the known risk factors for H5N1-HPAI adjacent to Prime Hook NWR in Sussex County. The poultry industry in Delaware is the most important agricultural business in the State. Delaware ranks tenth in the nation in broiler production (approximately 243,000,000 birds). Statewide, the industry is represented by 900 chicken farms, with the largest portion located in Sussex County (Delmarva Poultry Industry 2008 Factsheet–*http://www.dpichicken.org/faq_facts/*; accessed February 2012).

Avian influenza sampling of migratory shorebird and waterfowl bird species found on and near the refuge has been ongoing since 2005 in several collaborative efforts with Maryland and Delaware State agencies, universities, and with USDA Wildlife Services. Specific AI disease surveillance and monitoring actions and outbreak responses (bio-containment, work practices, and sanitation protocols) are all described in the refuge's AI surveillance and disease contingency plan. Management actions are the same for all three alternatives.

In Delaware, chronic wasting disease (CWD) is another prevalent wildlife disease of concern. CWD is a spongiform encephalopathy of deer and elk in North America. It is a rare, fatal, and transmissible disease of the central nervous system caused by abnormal prion proteins. CWD is spread by direct contact between infected animals and indirectly through contaminated environments.

The Service recognizes that CWD presents a threat to refuge deer populations and deer populations in the surrounding area. The refuge's approved Chronic Wasting Disease Surveillance and Contingency Plan (2008) provides a mechanism for early detection of CWD on the refuge through collaboration with the State of Delaware in detecting and controlling CWD by assisting DNREC with monitoring.

In addition to wildlife diseases, we will be attentive to diseases that affect forest health. Since we place high value on oak hardwood forests on the refuge, diseases pertaining to oaks are of special concern. Oak trees in the U.S. are affected by more than 80 documented insects and diseases, with escalating international trade likely to introduce new pests. Impacts of these pests range from minor defoliation to rapid mortality. In some years, pests cause the loss of a major portion of the acorn crop, impeding oak regeneration. A few pests have altered or may alter eastern U.S. oak forests on a broad scale. For example, the spread of the introduced gypsy moth, a defoliator, has been aided in the last few decades by the accidental transport of egg masses by humans.

General strategies for disease prevention and control include:

- Continue to conduct disease surveillance in conjunction with other field work.
- Cooperate with State agencies, particularly Delaware Division of Fish and Wildlife and the U.S. Forest Service, in conducting surveillance, providing access for sampling, and following protocols in the event of an outbreak.
- Inform volunteers and others who work in the field about the dangers of Lyme disease and measures to avoid contracting the disease.
- Monitor forests and other habitats for indicators of increased occurrence of pests or disease. For example, note changes in flowering or fruiting phenology, physical damage, decay, weakening, sudden death, particularly of canopy and source trees of major host species. Note changes in wildlife use of habitats such as the absence of breeding birds that used to be seen regularly.
- Use silvicultural practices such as thinning, prescribed burns, and stand improvements that may relieve stress; and.
- Follow protocols outlined in national, State, and refuge-specific disease prevention and control plans.

Control of Non-Native and Other Pest Animals

Many exotic animals, and at times native animals, can interfere with management objectives. The Refuge Manual (7 RM 14.4A) defines an animal pest as "any terrestrial or aquatic animal which interferes, or threatens to interfere, at an unacceptable level, with the attainment of refuge objectives or which poses a threat to human health." In order to meet management objectives under all alternatives, pest animals will be controlled on the refuge to maintain acceptable population sizes. Acceptable population sizes vary with species and management situation. The impacts of specific pest animal species or groups are described further below.

In controlling animal pests, whether alien or native species, we use an integrated approach. Integrated pest management is defined as "a dynamic approach to pest management which utilizes a full knowledge of a pest problem through understanding of the ecology of the pest and ecologically related organisms and through continuous monitoring of their populations. Once an acceptable level of pest damage is determined, control programs are carefully designed using a combination of compatible techniques to limit damage to that level." We will use integrated pest management to control pests, which is a sustainable ecosystem-based decision-making process for managing invasive species, pests, and diseases through a combination of biological, physical, cultural, chemical, and other practices. The goal of integrated pest management is to remove or reduce only the target organism(s) with the least possible risk to other organisms. Pest animals that present problems to refuge management include overabundance of resident Canada geese, mute swans, nutria, beaver, muskrat, and furbearers, such as raccoons and foxes and birds such as gulls and crows, that can cause unacceptable levels of predation on migrating and breeding shorebirds.

We will use the following strategies in animal pest management:

- Determine the need for site-specific control based on the potential to negatively affect wildlife and habitat management objectives on the refuge.

- Employ integrated pest management techniques when a species is having a significant impact on an area resulting in major habitat replacement or damaging rare species.

- Monitor results to ensure that pests do not exceed acceptable levels.

- Use predator management as one of several actions to support State and federally endangered or threatened migrating birds and to increase the productivity of breeding federally listed and State-listed bird species.

Although we will employ an adaptive management approach to pest animal problems, we also expect that lethal control or removal of individual animals will be required. Unfortunately, establishing general thresholds for lethal action is difficult. Instead, a case-by-case analysis and specific site characteristics will be used to determine the best solutions as needed to fulfill habitat and wildlife management objectives. For example, an annual predator management program would be used to increase the productivity of State-listed endangered and threatened shorebird species and protect migrating shorebird species using refuge beach habitats. In the case of lethal control of resident Canada geese for habitat protection, the appropriate permits are acquired annually from the Service Migratory Bird Office.

Trapping or lethal control of mammals will be relied on as a management practice to control predators and manage pest animals that negatively impact refuge habitats or impoundment infrastructure (e.g., nutria or muskrat that burrow in refuge dikes). Trapping to control beaver, muskrats, or nutria can help to protect desirable vegetation, achieve desirable interspersion of wetland vegetation, and protect rarer species. Reasons for using trapping as a major tool for controlling animal pests on the refuge include protecting migratory birds and threatened or endangered species, habitat or wildlife population management, and rare vegetation communities and associated invertebrate species. Trapping is also useful for surveys and monitoring of some species, facilities protection, research, feral animal control, disease control, and public health and safety.

Resident Non-Migratory Canada Geese
Herbivory by resident Canada geese during the growing season impacts wetland vegetation, rendering the resident individual of this species as a pest at that time of the year. Research at nearby refuges has shown a reduction in the amount of plant biomass that would be available to migrant birds at the end of the growing season (Laskowski et al. 2002). To address well-documented concerns regarding the impacts of resident Canada geese on habitats and public property, the Service-issued new regulations for control of non-migratory resident geese (71 FR 45964).

Mute Swan
Similarly, the non-native mute swan's feeding behaviors pose a threat to the ecological integrity of wetland habitats. Introduced to North America in the 1800s, mute swans escaped captivity and established wild populations, which have grown exponentially in recent decades (Atlantic Flyway Council 2003). Mute swans can consume large quantities of submerged aquatic vegetation, damaging sensitive wetland areas, and reducing food availability for native bird and fish species. They can exhibit aggressive territorial behavior toward native bird species and humans. The Atlantic Flyway Council Mute Swan Management Plan (Atlantic Flyway Council 2003) recommends that the U.S. Fish and Wildlife Service and other land managers actively control this species. The species was

removed from Federal protection by the Migratory Bird Treaty Act Reform of 2004 and is excluded from State protection under State regulation, permitting their control as the refuge deems necessary. Any apparent invasion of mute swan on refuge lands or waters will warrant an immediate lethal removal program.

Nutria

Nutria are native to South America and were first introduced into the United States to California in 1899 and then to southern states in the early 20th century for fur farming and weed control. Nutria use marsh vegetation to create resting platforms and consume whole plants, including roots and tubers, creating holes in the marsh which eventually become open water when sediment erodes with tidal action (Harris and Webert 1962, Foote and Johnson 1993, Linscombe and Kinler 1997). Since their introduction, nutria have contributed to the destruction of more than 7,000 acres of marsh on Blackwater NWR (TCBNWG 2003). Fortunately, at this time, there have been limited sightings of nutria in the State of Delaware, though they have become a serious pest in the Maryland portions of the Chesapeake Bay, and may yet find easy access to Delaware through the Choptank and Nanticoke River drainages. The refuge will be monitored for nutria. Any apparent invasion of nutria into refuge marshes will warrant an immediate lethal removal program.

Beaver and Muskrat

Beaver and muskrat are native aquatic rodents and as such, are an important component of the refuge ecosystem. However, at times both species do pose a nuisance for human and refuge management infrastructure. When nuisance animals are impacting refuge management capabilities, they may be trapped and removed.

Red Fox, Raccoon, Gulls and Crows

Red fox, raccoon, gulls, and crows have been documented as predators upon nesting birds, eggs, and chicks. Predation is a natural process and is not normally considered a management issue for the continued productivity and survival of species across a biologically diverse and healthy landscape. However, some habitats have been so fragmented and reduced by human impacts that intervention is considered critical for the continued survival of some species. Some shorebirds, such as the federally threatened piping plover and colonial beach nesting bird populations, are especially vulnerable to loss of suitable nesting habitat due to high sensitivity to human disturbance.

Given the plight of migratory birds requiring beach or island nesting habitats, the refuge may utilize a predator management program for the benefit of these species. The program would entail lethal removal of animals that frequent specific tracts or habitats where birds would likely nest (i.e., problem predators). Removal will be conducted by refuge staff or contractual employees, immediately prior to or during the nesting season.

Maintaining Regional and Community Partnerships

Partnerships are essential for this refuge to accomplish natural resource conservation mandates and meet wildlife, habitat, and visitor service objectives. Working in partnership encourages broader cooperation between the Service and local communities, interest groups, and other agencies. The Service can be a resource to the community in providing valuable technical assistance to area conservation groups. Sharing resources where mutually compatible conservation objectives are apparent is cost-effective and in the best interest of the Service, the partner organization, and the public.

All the alternatives would maintain the existing partnerships identified in chapter 3, while also seeking new ones consistent with refuge goals and objectives. The Delaware Division of Fish and Wildlife, Ducks Unlimited, the

Nature Conservancy of Delaware, the Conservation Fund, U.S. Geological Survey, Southern Delaware Tourism, local Chambers of Commerce, and many others have been particularly important and valued partners. These relationships are vital to our success in managing all aspects of the refuge—conserving land, managing habitats and protecting species, outreach and education, and providing wildlife-dependent recreation.

Under all alternatives, we will continue to work cooperatively with the Delaware Division of Fish and Wildlife to develop a management plan for wildlife management and public recreational use of this area and associated waters, including Prime Hook Creek. We will also work with them to complete a memorandum of understanding to coordinate activities within the State boundary.

We will continue to work closely with other offices within the Service on mutually important issues and seek new opportunities to find cooperative solutions to problems that affect the refuge but are beyond the ability of the refuge alone to address. One important example is the management of snow goose populations, which will require cooperation with the Migratory Bird Office, as well as State agencies and private landowners. On this issue, we will work with State and local partners on outreach, and with regional and Migratory Bird Office biologists on monitoring and developing population targets.

Citizen involvement is critical to the well-being of the Refuge System and the natural resources that depend on those lands. When local citizens and other stakeholders of a refuge can see firsthand our conservation work, they become an informed constituency on behalf of conservation.

The Friends of Prime Hook National Wildlife Refuge, Inc. (Friends Group) and refuge volunteers have been extremely helpful in promoting an appreciation of natural and cultural resource conservation and facilitating the implementation of priority refuge projects. The Friends Group is instrumental in conducting outreach about the refuge and its opportunities to the community and in accomplishing many programs through their hard work, dedication, and fundraising efforts. Refuge volunteers are instrumental in refuge management activities including maintenance, habitat management, visitor services, and outreach programs.

Refuge volunteers and the Friends Group play a vital role in the conservation and management of our natural and cultural resources. The refuge currently has an active volunteer program involving more than 100 citizens. These volunteers contribute 6,000 hours annually, assisting with a full range of administrative, biological monitoring, invasive species control, and visitor services tasks. The nurturing and use of volunteers will continue as a vital component of many of the objectives outlined in the CCP/EIS. The Friends of Prime Hook, a citizen-based Friends Group, also raises funds for needed projects, conducts special programs which support the goals of the refuge and the mission of the Refuge System, and works to educate the public. Like volunteers, the Friends Group will play an important role in the strategies to achieve many of the objectives outlined in this document.

Strategies Common to All Alternatives

- Continue to maintain the collaborative relationship with Federal, State, and local governmental agencies to meet natural resource mandates and objectives. Examples include providing office space for USDA Wildlife Services; coordinating the waterfowl hunting program on the adjacent Prime Hook Wildlife Area of the Delaware Division of Fish and Wildlife; accomplishing refuge projects with the aid of crews from the Delaware Department of Corrections, water level management projects with Ducks Unlimited, land acquisition with The Conservation Fund and The Nature Conservancy of Delaware, and biological and visitor surveys with U.S. Geological Survey.

- Work with conservation partners to achieve commons goals; establish memorandums of understanding (MOU), memorandums of agreement (MOA), and cooperative agreements as appropriate.

- Share resources, equipment, and/or expertise with State and private landowners.

- Continue to support and offer guidance to the Friends of Prime Hook National Wildlife Refuge organization.

  - Work with the Friends Group to continue to seek outside support for refuge projects, develop public use programs, coordinate refuge projects, operate the sales outlet, plan and conduct public events, conduct community outreach, promote national Service initiatives as they develop, and respond to public inquiries about the refuge.

- Continue to partner with the Friends of Prime Hook, refuge volunteers, and other partners to assist with maintenance of trails, observation platforms, photography blinds, and benches and to promote opportunities in wildlife observation and photography.

- Continue to partner with the Friends of Prime Hook to host the nature photography contest and exhibition.

  - Continually update the memorandum of agreement between the Friends Group and the Service.

  - Continue to provide a primary liaison between the Friends Group and the Service.

  - Continue to support the Friends Group newsletter, distributed to their membership by regularly providing information, articles, and photos about refuge management and visitor services programs.

  - Continue to work with the Friends Group on a regular basis to seek alternative funding sources and partnerships for various projects to benefit the refuge.

- Continue to offer volunteer opportunities to assist with accomplishing projects in the refuge's biological, maintenance, and visitor services program areas and in carrying out the mission of the Service and Refuge System.

  - Continue to implement volunteer recruitment, training, and appreciation/recognition events.

  - Continue to implement the resident volunteer work-camper program.

  - Continue to maintain and observe tree swallow and bluebird nest boxes for public viewing, pending volunteer support.

  - Continue to provide refuge-sponsored guided birding field trips by volunteers.

- Continue to collaborate with educational institutions to conduct research and investigations seeking answers to important natural resource issues on the refuge and within the Refuge System, and contribute our basic understanding of important natural resource issues worldwide.

Community Relations and Outreach

Community Outreach

From the results of a refuge visitor and community survey conducted in 2004 and 2005 by U.S. Geological Survey (Sexton et al. 2007), nearly a quarter of the community members and refuge visitors are unsure about their level of trust in decisions that the Service makes about managing the refuge. The community surrounding the refuge is aware of and engaged in natural resources decision making in both passive activities, such as signing a petition, and active activities, such as joining a special interest group or attending a public meeting. It is important, if we are to be a valued part of the communities we serve, that we communicate often with our local citizens. News articles and personal appearances inform our neighbors about what we are doing and why, which we hope will lead to increased understanding, appreciation, and support of our programs. Feedback we receive from these outreach efforts allows us to better understand issues that are important in our communities, and how our management may affect them. A planning process such as development of the CCP is an opportunity to build relationships and improve trust not only with visitors and community residents with whom the refuge has established relationships, but also with those who are less familiar with the refuge or have not engaged in the process due to lack of trust in the agency or uncertainty of their role in the process.

Strategies Common to All Alternatives

- Continue to conduct outreach in conjunction with refuge interpretive programs highlighted under goal 5.

- Continue to work within community forums such as the Milton, Milford, and Lewes Area Chambers of Commerce; Southern Delaware Tourism; town meetings; State Fish and Wildlife Advisory Council meetings; and other venues.

  - Continue to co-host or partner with local Chambers of Commerce and the Friends of Prime Hook NWR to conduct the following annual community events: horseshoe crab-shorebird festival in May, youth fishing tournament in June, nature photography contest in October, and the Vandegrift memorial series in summer/fall. While the main venues for some of these programs are in town, onsite programs are included when staffing and funding are available.

- Continue to issue news releases on significant accomplishments and to promote special events and announce major initiatives.

- Continue to maintain the refuge's website and post information on refuge kiosks.

- Continue to honor requests for speaking engagements by local community and civic organizations to inform members about refuge purposes and activities.

Private Landowner Assistance

Our *Phragmites* control and education program, in conjunction with the wildland urban interface program, is one example of our successes in working with private landowners. We have partnered with more than 150 private landowners to control hundreds of acres of *Phragmites* on the refuge. We hope to continue this effort over time to keep this invasive plant from increasing its territory, and to use it as a model to assist landowners in controlling other invasive plants on private lands. We believe there are many landowners adjacent to the refuge boundary area who would gladly take on more responsibility to manage their lands to benefit wildlife whether for invasive species control or habitat restoration and enhancement, if they had assistance to get started. Under any of the alternatives we will continue to utilize the Service's wildland urban interface program and seek assistance from the Service's private lands biologist.

Strategies Common to All Alternatives

- Continue our current level of *Phragmites* control and other invasive plant initiatives on private land through programs such as wildland urban interface.
- Continue to provide technical assistance to private landowners on invasive species identification and control, wetland protection, and habitat restoration and management.
- Seek grants and other funding sources to assist private landowners.

Appropriateness and Compatibility Determinations

Chapter 1 describes appropriate refuge uses policy (section 1.422) and specific requirements necessary to prepare written compatibility determinations (section 1.423). Appendix E includes draft appropriateness records and compatibility determinations to support the activities in alternative B, the Service-preferred alternative. The final CCP will include the approved refuge-specific compatibility determinations for the alternative selected.

Compatibility determination analyses must consider impacts of the use analyzed. The compatibility determination section titled Anticipated Impacts of the Use summarizes the short- and long-term and cumulative impacts of the use and how the use will affect:

- Refuge purposes(s) and the Refuge System mission.
- Refuge goals, objectives and management strategies.
- Fish, wildlife, plants and their habitats.
- Biological integrity, diversity, and environmental health of the refuge and Refuge System.
- Other refuge uses.
- Public safety.

As previously noted, hunting, fishing, wildlife observation and photography, and environmental education and interpretation are priority wildlife-dependent uses of the Refuge System. The refuge manager has determined that all six priority public uses are compatible, although some have stipulations as detailed in each determination. As priority uses, they will receive preferential consideration in refuge planning and management before the refuge manager analyzes and considers other recreational opportunities for appropriateness and compatibility.

Permitted non-priority uses common to all alternatives are discussed later under Other Recreational Uses found in the Wildlife-Dependent Recreational Programs section.

Activities Not Allowed
We have reviewed prior uses and evaluated recent requests for non-priority, non-wildlife-dependent activities. Activities evaluated by the refuge manager, and determined not to be appropriate or compatible on refuge lands, include recycling trash using State-sponsored recycle containers located on the refuge, ice skating, camping, horseback riding, geocaching/metal detecting, off-road and mountain biking, off-road vehicles including ATVs, operation of model boats and airplanes, swimming and sunbathing, waterskiing, personal watercraft, air thrust boats, soliciting of funds (per 50CFR 27.97 for private operations and per 50CFR 27.86 for begging), and other activities identified in 50CFR part 27. Of these uses, the only one with a documented appropriateness finding is “recycling trash using State-sponsored recycle containers on the refuge.” The recycler dumpsters were placed on the refuge to allow the general public, not just refuge users, to dispose of their recyclable materials. The increased traffic, unsightly dumpsters, and the trash around the area subsequently resulted in a finding of not appropriate by the refuge manager. In addition, two other recycling centers were within five miles of the refuge. From our review of the refuge files, the other uses listed here were never formally evaluated or conducted, and therefore we are taking this opportunity to review them in accordance with all compliance procedures. Appendix E documents the refuge manager’s decision on their appropriateness. Most of these activities are provided elsewhere nearby, so the lack of access on the refuge does not eliminate the opportunity. According to Service policy 603 FW 1, if the refuge manager determines a use is not appropriate, it can be denied without determining compatibility.

Specialized Uses
These uses require specific authorization from the Refuge System, often in the form of a special use permit. We make appropriateness findings for specialized uses on a case-by-case basis. Before we consider a specialized use, we must make an appropriateness finding as defined in section 1.11A(3) of the appropriate refuge use policy. For example, in addition to the six priority recreational and educational uses, we have determined that several other activities are appropriate and compatible under certain conditions. These include research, allowing the State to collect rare plant species seeds to benefit the Delaware Division of Fish and Wildlife’s Landowner Incentive Program, mosquito population monitoring and limited use of chemicals to control mosquitoes, and operation of a Federal Aviation Administration tower. All of these activities require a special use permit and adherence to specific conditions to ensure the compatibility of these uses.

Facilitating and Conducting Research and Investigations
The Refuge Manual and the Service Manual both contain guidance on conducting and facilitating biological and ecological research and investigations on refuges. The Service published three objectives in the Refuge Manual 1982) for supporting research on units of the Refuge System (4 RM 6.2):

- To promote new information and improve the basis for, and quality of, refuge and other Service management decisions.
- To expand the body of scientific knowledge about fish and wildlife, their habitats, the use of these natural resources, appropriate resource management, and environmental health.
- To provide the opportunity for students and others to learn the principles of field research.

In 2006, the Service Manual provided further guidance on the appropriateness of conducting research on refuges in part 603, the appropriate refuge uses policy. It states that:

> *We actively encourage cooperative natural and cultural research activities that address our management needs. We also encourage research related to the management of priority public uses. Such research activities are generally appropriate. However, we must review all research activities to decide if they are appropriate or not as defined in section 1.11. Research that directly benefits refuge management has priority over other research.*

All research conducted on the refuge must be determined in writing to be both appropriate and compatible, unless we determine it to be an administrative activity. Research projects must contribute to a need identified by the refuge or the Service. In the past we have conducted many research projects on the refuge and expect additional research opportunities to arise under all the alternatives we propose in this draft CCP. Non-Service organizations and personnel conducting research on the refuge must provide the Service with a copy of all data collected and/or reports. The research organization/agency in conjunction with the Service will retain the use and ownership of all data and reports. In determining the appropriateness and compatibility of future research activities, we will follow Service policy guidance and employ the following objectives:

- Seek qualified researchers and funding to help answer refuge-specific management questions.
- Participate in appropriate multi-refuge studies conducted in partnership with USGS.
- Facilitate appropriate and compatible research by providing temporary housing and equipment, if available, for persons conducting fieldwork.
- Pursue peer-reviewed publications of research and ensure the Service is acknowledged as a contributor in research conducted on the refuge by others.

Commercial and Economic Uses
All commercial and economic uses will adhere to 50 CFR, Subpart A, §29.1 and Service policy which allow these activities if they are necessary to achieve the Refuge System mission, or refuge purposes and goals. Allowing these activities also requires the Service to determine appropriateness and prepare a compatibility determination and an annual special use permit outlining terms, conditions, fees, and any other stipulations to ensure compatibility. The following policies and regulations were consulted:

- Appropriate use policy
- Compatibility policy
- 5 RM 17 (Refuge Manual)
- 16USC668dd, 50 CFR 27.97 Private Operations: Soliciting business or conducting a commercial enterprise on any national wildlife refuge is prohibited except as may be authorized by special permit.

- 16USC668dd, 50 CFR 27.86 Begging: Begging on any national wildlife refuge is prohibited. Soliciting of funds for the support or assistance of any cause or organization is also prohibited unless properly authorized.

- 16USC668dd, 50 CFR, subpart A, 29.1 Allowing Economic Uses on National Wildlife Refuges: We may only authorize public or private economic use of the natural resources of any national wildlife refuge, in accordance with 16 U.S.C. 715s, where we determine that the use contributes to the achievement of the national wildlife refuge purposes or the National Wildlife Refuge System mission.

- Proposed standardized fee schedule for special use permits—Memorandum 4/19/93 ARD Donald Young—finalized in 8/93

A fee will be required for appropriate and compatible commercial uses, except for fee exemptions specified in the USFWS Refuge Manual 5 RM 17.9C. Fees will be required for commercially guided canoeing, birding, or nature tours, and commercial photography. Examples include interpretive guided tours on refuge waterways and guided birding trips by non-profit organizations (e.g., Chambers of Commerce). Fees will be waived for guided tours (with or without fees) that are sanctioned as continuing education from a recognized organization, and public use of the auditorium for wildlife-dependent oriented organizations. Examples include bus tours, classes from Sussex Academy of Lifelong Learning, Elder Hostel, etc. A fee may be required if the cost to the Service in preparation for the activity is unreasonable. See the compatibility determination for additional detail.

For commercially guided recreational uses, a non-refundable administrative fee of $100 will be charged, comparable to fees issued by refuges in other regions. This fee is based on the salaries, plus 22 percent overhead, for a GS-13 refuge manager ($37.22 an hour at Step 1) and a GS-6 administrative assistant ($15.88 an hour at Step 1), plus a proportionate share of the average cost to operate the refuge (including construction cost, utilities, maintenance, equipment, vehicles, supplies, travel, and training), which is estimated at approximately $40.00. The staff is required to determine fair market value and cost recovery or to conduct competitive bids. In determining the fee, the staff could easily exceed the $100 administration fee. In addition to the administration fee, the permit fee will be 5 percent of gross revenues or $50, whichever is greater. Guides will be required to meet certain conditions before they are permitted to guide on the refuge. These conditions include certifications in an organization such as the American Canoeing Association, first aid/CPR, State or Federal licenses, and interpretive guide certification. Liability insurance will also be required for all commercial operations.

Wildlife-dependent Recreational Programs

The National Wildlife Refuge System Improvement Act of 1997 designated six priority public uses that are to receive enhanced consideration on national wildlife refuges: hunting, fishing, wildlife observation, photography, environmental education, and interpretation. We will strive to meet the criteria for a quality wildlife-dependent recreational program on the refuge as specified in the Service Manual (605 FW 1) and as stated in chapter 1.

The term "quality" is often used when discussing the various wildlife-dependent recreational opportunities on the refuge. This is a subjective term since there is a substantial diversity in what people are seeking in outdoor recreation. A quality experience to one visitor may be completely different to another. However, the term "quality" is emphasized in Chapter 605 FW 1, General Guidelines for Wildlife-dependent Recreation by stating that, "The overarching goal of our wildlife-dependent recreation policy is to enhance wildlife-dependent recreation opportunities and access to quality visitor experiences on refuges while managing refuges to conserve fish, wildlife, plants, and their habitats."

Throughout the CCP, the Service uses the term “quality” to emphasize enhanced opportunities or access, realizing that each visitor will enjoy them in their own unique way.

The refuge provides opportunities for all six priority recreational uses. We believe we are offering quality programs that meet public demand and our wildlife population and habitat goals. In chapter 3 (affected environment), we described in detail the facilities and programs we offer to support these uses. As always, we look to our partners, Friends Group, and volunteers to assist with our public use programs. We will provide these opportunities in ways that do not adversely impact wildlife resources.

A detailed visitor and community survey and final refuge report conducted by U.S. Geological Survey in 2007 indicated that hunting, photography, and wildlife observation were highly desired in the area. Although all the priority public uses are important and the refuge offers them to some degree, hunting, wildlife observation, and photography will receive the greatest emphasis in prioritizing refuge resources for visitor services. Our Regional Visitor Services Program Team identified hunting as an “area of emphasis” for this refuge, followed by wildlife observation and photography as a tool to assist refuge managers and staff in a declining budget environment and to direct attention to what refuges do best. In 2006, each refuge in the region was assigned a first and second priority area of emphasis based on many criteria such as refuge purposes, local interest in the recreational activity, opportunities for unique experiences, and opportunities to attract National/international exposure. One of the uses of these areas of emphasis is to support CCP teams as long-range goals, objectives, and alternatives are developed.

Below we provide a summary of the public use strategies common to all alternatives. However, other public use strategies differ between the three alternatives. Table 4.6 at the end of this chapter shows the differences among the alternatives in the hunting and wildlife observation opportunities.

In addition to published 50CFR regulations and State regulations, refuge-specific regulations also apply and are highlighted below in the following strategies and throughout each alternative.

Strategies Common to All Public Use Programs in All Alternatives

- Evaluate newly acquired refuge lands for potential quality wildlife-dependent recreational opportunities, if deemed compatible.

- Provide effective outreach and communication for and about the refuge’s existing public use programs

  - Coordinate with State and other partners to develop or participate in host programs that encourage new user groups, e.g., Becoming an Outdoors Woman, youth hunts, youth fishing event with Lower Sussex Bassmasters in Milton to celebrate National Fishing Week.

  - Monitor and evaluate the public use programs through staff observation and visitor contact.

  - Continue yearly review of refuge public use regulations with staff and State partners to ensure clarity and address any emerging issues or concerns.

  - Continue to work toward developing one brochure for hunting regulations and one brochure for all other public use regulations to inform the public of public use opportunities and refuge-specific regulations.

- Ensure public notification of public use program changes through news releases and other means.

- Provide adequate law enforcement to enforce regulations, and continue to collaborate with enforcement officers from the Delaware Division of Fish and Wildlife.

- Maintain existing infrastructure, including accessible facilities, to support wildlife-dependent recreation. These include hiking and canoeing trails, roadside pull-offs, observation platform, photography blind, wheelchair-accessible fishing pier, visitor contact station, parking areas, boat ramps, boardwalks, kiosks, roads, and benches.

- Provide access to launch boats, canoes, and kayaks at the headquarters boat ramp, Turkle Pond, Fleetwood Pond, and Slaughter Canal at Fowler Beach Road. Additional access provided at the Prime Hook Wildlife Area and Brumbley's Family Campground near Waples Mill Pond (the ramp at this location is on Service lands; however, access and parking are through the campground).

- Evaluate the future management of the Prime Hook Wildlife Area with the Delaware Division of Fish and Wildlife. Refuge staff have issued waterfowl hunting permits for the Prime Hook Wildlife Area, which is managed by the Delaware Division of Fish and Wildlife, through the refuge's permitting system. State and Federal personnel maintain the facilities (duck blind construction and grassing) yearly. A portion of Prime Hook Creek borders both the refuge and Prime Hook Wildlife Area, which is used by anglers, wildlife observers, hunters, and photographers. No formal agreement exists. An evaluation of the cooperative management of the State area should occur and, if necessary, a formal agreement should be developed.

- Days open or closed to either consumptive and nonconsumptive users are subject to change by the refuge manager for management reasons, changes in hunting seasons, or for unexpected circumstances.

- General regulations common to all public use programs in all alternatives

  - Except for hunting, the refuge is open from one-half hour before sunrise to one-half hour after sunset except all boats must be off the water at sunset.

  - Areas may be closed on the refuge without prior warning.

  - Boat motor restrictions

- The maximum permitted motor on Prime Hook Creek and Slaughter Canal is 30 horsepower.

- Air thrust boats and jet skis are not permitted.

- A slow no wake zone of one-half mile has been established on the Headquarters Ditch.

- Except for hunting, only electric motors or manual propulsion is allowed on Turkle and Fleetwood Ponds

  - All boaters are required to operate their craft and possess all safety equipment in accordance with Delaware State and U.S. Coast Guard regulations.

  - ✷ Designated beach dunes and overwash areas will be closed from March 1 through September 1 due to nesting State-endangered least terns and American oystercatchers, and the potential for use by federally endangered piping plovers. Areas may be reopened if no nesting activity occurs or when nesting ends for the season.

- ■ Beach access will only occur on refuge-owned lands on the sandy part of the beach from the toe of the dunes to the Delaware Bay (mean high water demarcation to mean low water demarcation). One parking lot with a dune crossover provides access to the beach. Access on the dune and adjacent marshes is prohibited.

  - ✷ Overnight camping and open fires are prohibited.

  - ✷ Dog walking is not permitted on the refuge.

Hunting
Hunting on the Delmarva Peninsula is a traditional outdoor pastime and is deeply rooted in our American and Delaware heritage. Off-Refuge opportunities for public hunting are decreasing with increasing private land development. Refuge lands have become increasingly important in the region as a place to engage in this activity. Hunting has and will continue to be an integral component of the public use program at the refuge engaged in by many visitors each year. When managed responsibly, this activity can instill a unique understanding and appreciation of wildlife, their behavior, and habitat needs, as well as their role in the surrounding environment. General hunting information can be found in chapter 3, Affected Environment, Refuge Administration—Refuge Visitor Services Program.

Section 605 (FW 2) of the Fish and Wildlife Service Manual states that hunting programs will be compatible, provide quality experiences, and to the extent practicable, be consistent with State fish and wildlife laws and regulations. After careful review and consideration, we have determined that the refuge's previous hunting program was inefficient and overly complex, requiring a significant amount of staff resources. A recently conducted regional visitor services review found the hunt program to be "out of balance with other priority refuge needs and services," such as habitat management, maintenance, and public use programs such as environmental education. Another finding from the review identified that "the amount of station resources going into this activity (hunting) seems to far exceed what is necessary to provide for a quality hunting program." The review also mentioned that the "care and maintenance of refuge blinds and tree stands….seems to put an undue burden on staffing resources." In other words, a major portion of refuge staff time and operating budget are currently devoted to the hunting program's fee-based permit system, the continued replacement and upkeep of over 100 permanent waterfowl blinds and elevated tree stands, and administration of all hunts and associated lotteries.

The opinions by the visiting public and community landowners were surveyed in 2004 and 2005 by the U.S. Geological Survey on behalf of the refuge (Sexton et al. 2007). About 35 percent of visitor respondents indicated that they hunted on the refuge and had been hunting there an average of 11 years. When asked about the importance of hunting activities, more than half of the responses rated it as moderately to very important, and most hunters (85 percent) feel the refuge provides a quality hunting experience. Dove hunting and upland game hunting appear much less important than other hunting activities, and hunting ducks and hunting deer with muzzleloader and shotgun were more important than other hunting activities.

In the survey, hunters were also asked about the desirability of changing some hunting services or regulations, but did not appear to be very interested in making changes. Most hunters seemed to prefer the refuge to maintain or improve the elevated tree stands, and the waterfowl blinds. The most desirable of the suggested changes was the provision of more areas where portable deer stands could be used as well as areas where individuals could set up their own waterfowl blinds. Some were only slightly interested in adding a preseason drawing for waterfowl hunting. Consumptive-use visitors asked to see increases in hunting and fishing areas and access.

Strategies Common to All Alternatives

- Continue to provide hunting opportunities for deer, waterfowl, upland game (rabbit, quail, pheasant) and webless migratory birds (mourning dove, snipe, and woodcock).
  - Continue to provide deer and waterfowl hunting opportunities for disabled hunters.
- Maintain waterfowl sanctuaries (no hunting) in Unit II impoundment to provide undisturbed areas for feeding and resting.
- Clearly sign all areas closed to hunting.
- Enforce general regulations for all hunting programs.
  - The refuge will follow all State youth hunting requirements.
  - No vegetation may be cut on the refuge for shooting lanes, camouflaging, etc.
  - The use of natural vegetation for camouflaging a blind is prohibited.
  - Practice or target shooting on the refuge is prohibited.
  - Hunting blinds/stands must be portable and removed at the end of each day.
  - No hunting is permitted in designated safety zones.
  - Non-toxic shot is required for all hunting except lead slugs are permitted for deer.
  - The refuge manager will monitor, evaluate, and make necessary adaptations to the hunting program to ensure that the refuge is meeting resource management objectives and continuing to offer quality experiences. The refuge manager has the authority to extend or close hunting opportunities on the refuge within the established hunting seasons of the Delaware Division of Fish and Wildlife, while ensuring compatibility.

White-tailed Deer Hunting

In addition to being a traditional outdoor pastime, deer hunting aids statewide efforts to control deer populations and complements habitat management on the refuge. We intend to consult with the Delaware Division of Fish and Wildlife to maintain the deer population at a level commensurate with available habitat, to maintain the health of the herd and prevent the habitat degradation that accompanies overpopulation.

Strategies Common to All Alternatives

- The refuge will continue to participate in all State hunting seasons and bag limits except the October antlerless deer season and January handgun season. State hunting seasons and harvest limits for deer are based on guidelines found in the Delaware Deer Management Plan 2010 to 2019 (Rogerson 2010), written by the Delaware Division of Fish and Wildlife.

    - The refuge will consider participating in the October antlerless season if the refuge can provide a quality hunting experience, if an overabundance of deer arises as determined by the Delaware Division of Fish and Wildlife and concurrence by the refuge, and potential conflicts are minimized with other user groups.

- The refuge will participate in the Statewide youth deer hunt.

- The driving or pushing of deer is prohibited on the refuge.

Waterfowl Hunting

Much of the rationale for waterfowl hunting is discussed under Hunting in the section for each appropriate alternative.

Strategies Common to All Alternatives

- The refuge will participate in the Statewide youth waterfowl hunts.

Upland Game and Webless Migratory Bird Hunting

Much of the rationale for upland game and webless migratory bird hunting is discussed under Hunting in the section for each appropriate alternative.

Strategies Common to All Alternatives

- The hunting of squirrel is prohibited due to presence of the endangered Delmarva fox squirrel on the refuge.

Wildlife Observation and Photography

Wildlife observation constitutes the majority of the use on the refuge throughout the year, with refuge staff estimating that 90 percent of visitors engage in this activity. Wildlife observation is the primary reason both visitor and community residents visit the refuge, as indicated by the survey conducted on behalf of Service (Sexton et al. 2007). The survey also found that being in a natural, undeveloped area and experiencing a serene environment are equally important to the refuge experience as are the trails that afford this opportunity (Sexton et al. 2007). Both visitors and community residents (consumptive and non-consumptive users) appear satisfied with the level of services or features currently offered by the refuge; however, a number of respondents indicated that they would like to see increases or improvements in wildlife viewing opportunities, environmental education, interpretive exhibits, and hiking or nature trails (Sexton et al. 2007).

Strategies Common to All Alternatives

- Continue to provide wildlife observation and photography opportunities

    - Refuge headquarters area

        - Maintain six miles of hiking trails that include the Blue Goose Trail, Photography Blind Trail, Dike Trail, Black Farm Trail, Pine Grove Trail, and Boardwalk Trail.

        - Maintain the photography blind on the Photography Blind Trail and observation platform (wheelchair accessible) on the Dike Trail.

        - Provide canoeing and kayaking access on Turkle and Fleetwood Ponds.

        - Maintain the visitor contact station at refuge headquarters and allow the sale of refuge approved items by the Friends of Prime Hook through a signed memorandum of agreement.
        - Area open year-round except when closed for deer hunts.
    - Prime Hook Creek (includes mainstem of creek and Headquarters Canal)
        - Maintain the 7-mile Canoe Trail and associated boat ramps for canoeing and kayaking
    - Slaughter Canal
        - Provide opportunities along the canal from Fowler Beach Road to Slaughter Beach Road. Access is by boat only.
    - Fowler Beach
        - Continue to permit use by the general public on beach except during seasonal closures.
    - Prime Hook Beach Road and Broadkill Beach Road
        - Maintain and enhance existing roadside pull-offs
        - Area is open year-round
    - Water control structures at Petersfield Ditch, Slaughter Canal, and Cods Road are open year-round.

- Enforce general regulations for wildlife observation and photography
    - No refuge-specific permits are required.
    - Visitors must stay on the designated trail routes.
    - Bicycling is allowed only on roads open to public vehicular traffic.
    - The visitor contact station is open weekdays from 7:30 am to 4:00 pm and seasonally on weekends.

Recreational Fishing and Crabbing
Fishing and crabbing on the Delmarva Peninsula are traditional outdoor pastimes and are deeply rooted in our American and Delaware heritage. Fishing accounts for 10 percent of the total visitation to the refuge (or nearly 10,000 annual visitors). Fishing has and will continue to be an integral component of the public use program at the refuge.

The opinions by the visiting public and community landowners were surveyed in 2004 and 2005 by US Geological Survey on behalf of the refuge (Sexton et al. 2007). About 20 percent of visitor respondents indicated that they fished on the refuge and had been fishing there an average of 11 years. When asked about the importance of fishing activities, all of the responses rated it as moderately important, and most anglers (89 percent) feel the refuge provides a quality fishing experience. Fishing on Prime Hook Creek was slightly more important than fishing at the water control structures and at Fleetwood and Turkle Ponds. Very few comments regarding improvements were made. A few respondents mentioned water levels, better access to some fishing areas, and providing catch-and-release fishing areas.

Strategies Common to All Alternatives

- Continue to provide fishing and crabbing opportunities in accordance with the State of Delaware fishing, crabbing, and boating regulations and seasons to include the following areas:

  - Slaughter Canal between Fowler Beach Road and Slaughter Beach Road (boat access only)

  - Slaughter Creek at Cods Road and water control structures at Petersfield Ditch and Slaughter Canal (shore access only; boats are not allowed at Slaughter Creek and Petersfield Ditch) open year-round

  - Prime Hook Creek (boat access only; includes mainstem of creek and Headquarters Canal)

  - Turkle and Fleetwood Ponds in headquarters area (boat and shore access): open year-round except when closed for deer hunts

  - Fowler Beach (surf fishing from shore only)

- Provide information about fish consumption advisories and water level management on refuge waterways at the refuge office, refuge kiosks, and on the refuge's Web site.

- Harvest information is not required.

- Restrict bank fishing (where permitted) to designated areas off of State-maintained highways at Petersfield Ditch, Slaughter Creek, and Slaughter Canal.

- No check-in/out required.

Environmental Education and Interpretation

Interpreting the resources and challenges of the refuge to the general public and incorporating these topics into school curricula are important ways to influence the future well-being of the refuge and the Delmarva Peninsula. Only through understanding and appreciation will people be moved to personal and collective action to ensure a healthy refuge for the future. Interpretation and environmental education are also key to changing attitudes and behavior, which affect the refuge through off-refuge land-use decisions and on-refuge conduct and use.

The refuge provides onsite and offsite environmental education and interpretive programs to visitors of all ages and abilities. Programs include structured educational field programs tied to national and State education standards, guided interpretive canoe and hiking trips, special events, lecture programs, self-guided interpretive hiking trails, interpretive signs and displays, the visitor contact station/Friends Group sales outlet, refuge website, and refuge brochures. The refuge also conducts interpretive programs to local civic organizations and displays refuge information at numerous offsite events. We estimate that our environmental education and interpretation programs reach over 5,400 people a year. Refuge volunteers and Friends Group members play a considerable role in the success of these programs, which would not be possible without their assistance. Interpretive refuge themes focus on the awareness and importance of the conservation of waterfowl and other migratory birds, the endangered

Delmarva fox squirrel and other threatened or endangered species, and their habitats.

Strategies Common to All Alternatives

- Conduct environmental education and interpretive programs in the following areas of the refuge: Headquarters Area including but not limited to hiking and canoeing trails, visitor contact station, Turkle and Fleetwood Ponds; Fowler Beach; and at roadside pull-offs along Prime Hook and Broadkill Beach Roads.

- Continue to facilitate educator-led environmental education programs that focus on refuge key resources and messages for local schools, scout troops, and other organized education-oriented groups.

  - Integrate existing Service national education programs into the refuge's education program. In particular, consider the Shorebirds Sister Schools program, especially in combination with the Delaware Aquatic Resources Center's Green Eggs and Sand program. Other programs to consider include Hands on the Land and the Nature of Learning.

  - Continue to partner with local educational institutions, refuge volunteers, Friends of Prime Hook, and other partners to plan, develop, and implement environmental education programs. This network would act as supporters of the refuge, advocates for environmental education, and as a liaison to the community.

  - Continue to respond to requests for onsite and offsite environmental education and interpretive programs when staffing and funding allows.

- Continue to enhance detailed environmental education and interpretive programs for the refuge.

- Continue to provide interpretive materials and programs explaining the historic, cultural, and natural resources of the refuge to gain public awareness and understanding of their value.

  - Develop a tear sheet with public use regulations and a map that includes fishing information.

  - Develop a hunting brochure containing regulations and associated maps, which will be available at the refuge office or on the refuge's website.

  - Develop a new general refuge brochure.

  - Develop an annual schedule of interpretive activities.

  - Provide regularly guided field trips for nature, birding, fishing, photography, etc.

  - Continue "An Evening at the Hook" monthly lecture series.

  - Continue partnership with Friends of Prime Hook in hosting the Vandegrift memorial lecture series and annual nature photography contest and exhibition.

  - Continue to provide self-guided interpretive facilities and materials, including signs, maps, kiosks, etc., for the Blue Goose Trail, Photography Blind Trail, Dike Trail, Black Farm Trail, Pine Grove Trail, Boardwalk Trail, Canoe Trail, and the trail and observation platform off Route 16 near Vergie's Pond.

  - Continue to provide information to the public through the refuge's website.

  - Continue to partner with Delaware Department of Transportation for maintenance of directional highway signage for the refuge.

  - Continue to maintain a universally accessible full-service visitor contact station with a sales outlet operated by the Friends of Prime Hook. The visitor contact station will continue to include interpretive displays and various mounted species of animals found on the refuge and will be staffed mainly through volunteer support.

  - Participate in national interpretive events such as National Fishing Week and International Migratory Bird Day.

- Continue partnership with Milton Chamber of Commerce in hosting the Horseshoe Crab-Shorebird Festival in May.

- Continue partnership with Lower Sussex Bassmasters to host an annual youth fishing tournament in Milton to celebrate National Fishing Week and promote fishing to youngsters.

- Conduct routine condition reviews of interpretive signs and information kiosks, and complete maintenance and sign replacement as needed.

Other Recreational Use

Public entry and use regulations serve to protect fish, wildlife, plants, and habitat. Public use regulations were last reviewed and amended in 1993. However, the resources and public use of the refuge are dynamic, and periodic review would ensure that regulations are needed, clear, and effective. In addition, new regulations may be required to safeguard resources or address new or emerging problems recognized by managers and law enforcement officers. An annual review would provide a more systematic process than in the past.

Some uses are not dependent on the presence of fish and wildlife; however, these activities are allowed to continue at designated locations in a manner that would give maximum consideration to the fish and wildlife purpose of the refuge and the wildlife focus of each alternative. We estimate that approximately 2,000 visitors a year participate in one of these uses and are not counted in the numbers itemized under the six priority wildlife dependent public uses described above.

Strategies Common to All Alternatives

- Refer to prohibited non-priority uses that are discussed earlier in the Appropriateness and Compatibility Determinations section.

- Allow the following non-priority uses that were found to be compatible on the refuge: research, mosquito control, and public leases of the Federal Aviation Administration tower.

  - Canoeing (includes boat and kayaking), walking, hiking, and jogging are uses allowed across all alternatives. These uses were individually found compatible in alternative A, but were considered as a means of access under the compatibility determinations in alternatives B and C.

- Allow commercially guided tours for wildlife observation (including commercially guided tours for continuing education). Adhere to Commercial Wildlife Observation Guide Program Stipulations found in appendix E and to information found in Specialized Uses in the section titled, Actions Common to All Alternatives.

- Will require a special use permit and appropriate fee and minimal disturbance to wildlife resources and their habitat.

- Will be covered by compatibility determinations for their respective uses (wildlife observation, wildlife photography, etc.)

- Provide the public and State of Delaware ample opportunity to review and comment on any new or substantially changed regulation.

- Use national guidance and *Federal Register* process for codifying any changes and make them a part of the Code of Federal Regulations governing national wildlife refuges.

- Post pertinent regulations at boat landings and other public use areas, such as trailheads, informational kiosks, and the visitor contact station.

- Be proactive with law enforcement to inform and educate the public on refuge regulations and seek their compliance.

Protecting Cultural Resources

As a Federal land management agency, we are responsible for locating and protecting all historic resources, specifically archeological sites and historic structures eligible for, or listed in, the National Register of Historic Places. This applies not only to refuge lands, but also to lands affected by refuge activities, including museum properties. As described in greater depth in chapter 3, Affected Environment, consultation with the Delaware State Historic Preservation Office and regional historic preservation office and data collected from several field investigations and archeological studies (1982, 1984, 2004), indicate that, to date, 14 prehistoric archeological sites and 31 historic sites have been identified at Prime Hook NWR.

Under all the alternatives, we will evaluate the potential for impact on archeological, prehistoric and historical resources, and will consult with the regional historic officer before new refuge activities or actions are planned. We will be especially thorough in upland areas along waterways or areas surrounded by marsh, where the probability of locating new cultural resources is higher. This care will ensure that we comply with section 106 of the National Historic Preservation Act, regardless of the alternative.

Conduct a Refuge Wilderness Review

The Service revised its Wilderness Stewardship Policy in November of 2008, to improve the National Wildlife Refuge System's management of lands considered for designation as wilderness under the Wilderness Act of 1964. The revision provides refuge managers with the first-ever guidance on wilderness review of Refuge System lands and whether areas should be recommended to Congress for wilderness designation.

The updated policy ensures consistency with several new refuge management policies established in recent years including Refuge System mission, goals and refuge purposes, appropriate use and wildlife-dependent recreation, and the Wilderness Act and Refuge Improvement Act. It also reflects other developments in the policy and science of managing the Refuge System and wilderness.

The Service priorities in implementing the wilderness policy consider the following order when conducting wilderness reviews on refuge lands: the Refuge Administration and Improvement Act, the Endangered Species Act, and the Wilderness Act. We first determine what needs to be accomplished to meet refuge purposes, ensure these activities comply with the Endangered Species Act, and ensure these activities comply with the Wilderness Act (610 FW 1.4).

Chapter 610 of the Service Manual addresses wilderness stewardship policy in the Refuge System, where wilderness is defined in 610 FW 1.7:

> *A wilderness, in contrast to those areas where man and his works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean in this Act as an area of undeveloped Federal lands retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with imprint of man substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is sufficient in size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value.*

The Refuge System planning policy requires that we conduct a wilderness review during the CCP process. One of the eight goals stated in this policy is to ensure that we preserve the wilderness character of refuge lands (602 FW 1.5(H)). Part of the CCP planning policy is that we help achieve the goals of the National Wilderness Preservation System (NWPS) and specifically address the potential for any new special designations (602 FW 3.4). We do this by conducting a wilderness review and evaluating any new information about refuge lands that may warrant wilderness study (appendix F). Roadless islands of any size are also eligible for wilderness designation. The wilderness review in Appendix F concluded that three small roadless islands located within Unit II fail to meet the criteria for wilderness designation due to the impacts of human manipulation of the surrounding marsh areas for mosquito control and the impoundments, the proximity of roads and aural impacts of vehicles and boats, and the non-natural fluctuation of water levels and reduced salinity when the barrier was intact thereby creating an artificial freshwater system. The impact of a century of human manipulation of the marsh system has meant that the larger area of the refuge has lost its “primeval character” despite recent natural events which are influencing the system.

Refuge Staffing and Administration

Congress determines the annual budgets that our Washington headquarters and regional offices distribute to the field stations. The activities shared among the alternatives described in this chapter pertain to staffing, administration, and operations that include the integration of Prime Hook NWR with Bombay Hook NWR into the Coastal Delaware National Wildlife Refuge Complex. Implementing any of the listed alternatives and associated activities supports refuge goals and implements habitat and wildlife objectives.

Permanent Staffing and Operational Budgets

Under all the alternatives, our objective is to sustain levels of annual funding and staffing that allow us to achieve refuge purposes, as interpreted by the goals, objectives, and strategies in this CCP. We have achieved our most highly visible projects, like the construction of our headquarters office and visitor center, through special project funds that typically have one- to two-year duration. These funds are important but their flexibility is limited because they cannot be used for any needs that may arise. Funding for land acquisition derives from two sources: the Land and Water Conservation Fund and the Migratory Bird Conservation Fund. These funds are directed toward specific land acquisitions.

In response to declines in operational funding nationwide, Region 5 developed a *Strategic Workforce Plan for the National Wildlife Refuges in Region 5* (2006-2007) to support a base budget approach. Its goal is a maximum of 75 percent of a refuge station budget to cover salaries and fixed costs, while the remaining 25 percent or more will be for operating and maintenance funds. The strategy is to improve the capability of each refuge manager to do project work of the highest priority, and not have the refuge's budgets tied to inflexible fixed costs.

Appendix H lists our refuge operations needs system (RONS) and service asset maintenance management system (SAMMS) construction and maintenance projects currently listed in those databases. We also included new projects not yet in the databases, but proposed under alternative B. Once approved, if funding is not available, we will continue to seek alternate means of accomplishing our projects, for example, through our volunteer program, challenge cost share grants, or other partnership grants and internships. The SAMMS projects include a list of backlogged maintenance needs.

Under all alternatives, and within the guidelines of the new base budget approach, we would seek to fill our currently approved but vacant positions, which we believe are needed to accomplish our highest priority projects. Alternative B also proposes additional staff to provide depth in our biological and visitor services programs. We identify our recommended priority order for new staffing in appendix H. Under alternative B, we also seek an increase in our maintenance staff since they provide invaluable support to all program areas.

Facility and Fleet Management

All of the alternatives include the periodic maintenance and renovation of existing facilities to ensure the safety and accessibility for staff and visitors. Our current facilities are described in chapter 3. They include administrative facilities such as the refuge office, maintenance shop, pole buildings, office trailer, hunter check-in station, biological lab, and several small storage sheds. Visitor facilities to be maintained under all alternatives include visitor contact station (includes auditorium and store), volunteer/Friends Group office, hiking trails, canoe trail, roadside pull-offs along Broadkill Beach and Prime Hook Beach Roads, observation platforms, photography blind, kiosks, boat launch ramps, and numerous interpretive signs. Any new facilities recommended in the final CCP, once constructed, will be placed on the maintenance schedule. All facilities and equipment maintenance and upgrades would incorporate ecologically beneficial technologies, tools, materials, and practices.

Refuge Operating Hours

All of the alternatives will open the refuge for public use from one-half hour before sunrise to one-half hour after sunset, seven days a week, to insure visitor safety and protect refuge resources. However, the refuge manager does have the authority to issue a special use permit to allow others access outside these timeframes. For example, research personnel or hunters may be permitted access at different times, or organized groups may be permitted to conduct nocturnal activities, such as wildlife observation and educational and interpretive programs. Designated areas may be closed for public safety or to avoid conflicts with other user groups, such as the closure of the headquarters area for deer hunts.

Distributing Refuge Revenue Sharing Payments

As we describe in chapter 3, we pay annual refuge revenue sharing payments to Sussex County based on the acreage and appraised value of refuge lands in our jurisdiction. These annual payments are calculated by formula determined by, and with funds appropriated by, Congress. All of the alternatives will continue those payments in accordance with the law, commensurate with changes in the appraised market value of refuge lands, or new appropriation levels dictated by Congress.

Alternative A. Current Management

This alternative primarily portrays current management, representing a "No Action" alternative. . It is the baseline for comparing the other two alternatives. Our habitat management program would continue in its present manner, which involves no active management of wetlands due to recent extensive changes along the refuge shoreline, no active forest management, and no agricultural management of upland fields. This means that natural succession would occur in most upland habitats instead of proactive restoration actions, and that natural ecological processes would be allowed to proceed with no human intervention. In this alternative's scenario, no attempts would be made to manage freshwater impoundments, nor would the refuge conduct any active restoration within impounded wetland areas. While natural resource protection and conservation actions would continue, generally speaking, the only habitat manipulation programs we would conduct would be the removal of invasive species and enhancement actions for federally listed endangered and threatened species.

Current biological program priorities include monitoring waterfowl and shorebird populations and habitats, maintaining habitat for the Delmarva fox squirrel, cooperating with State partners in monitoring bald eagles and fox squirrels, protecting bald eagle and osprey active nest sites from human disturbance on refuge lands, using prescribed fire to reduce fuel hazards near beach communities, simulating natural fire processes on refuge habitats, and conducting wildlife and habitat monitoring. We would continue these conservation actions with the help of volunteers, conservation partners, and refuge personnel as funding and staffing allow. Biological research studies would continue if they benefit the resources and are determined to be compatible by the refuge manager.

The refuge can be described as an elongated coastal strand covering 10,000 acres that lies parallel to the Delaware Bay (Map 1-1).

Map 4-1 through Map 4-5 depict the broad habitat types we predict would result under implementation of alternative A management objectives and strategies. The acreage figures presented in the alternatives matrix at the end of this chapter (table 4-5) are approximations based on GIS mapping from several data sources.

We would continue to offer hunting and fishing opportunities on refuge lands, and respond to requests for interpretive and school programs. The refuge would continue to provide six miles of walking trails, 7 miles of canoe trail, and associated viewing and photography infrastructures. Educational and interpretive programs, such as the monthly lecture series and annual photography contest would also continue. We would continue to partner with the Milton Chamber of Commerce to host an annual community event the Horseshoe Crab-Shorebird Festival, and with the Lower Sussex Bassmasters to host an annual youth fishing event. Map 4-6 depicts the public-use facilities present under current management.

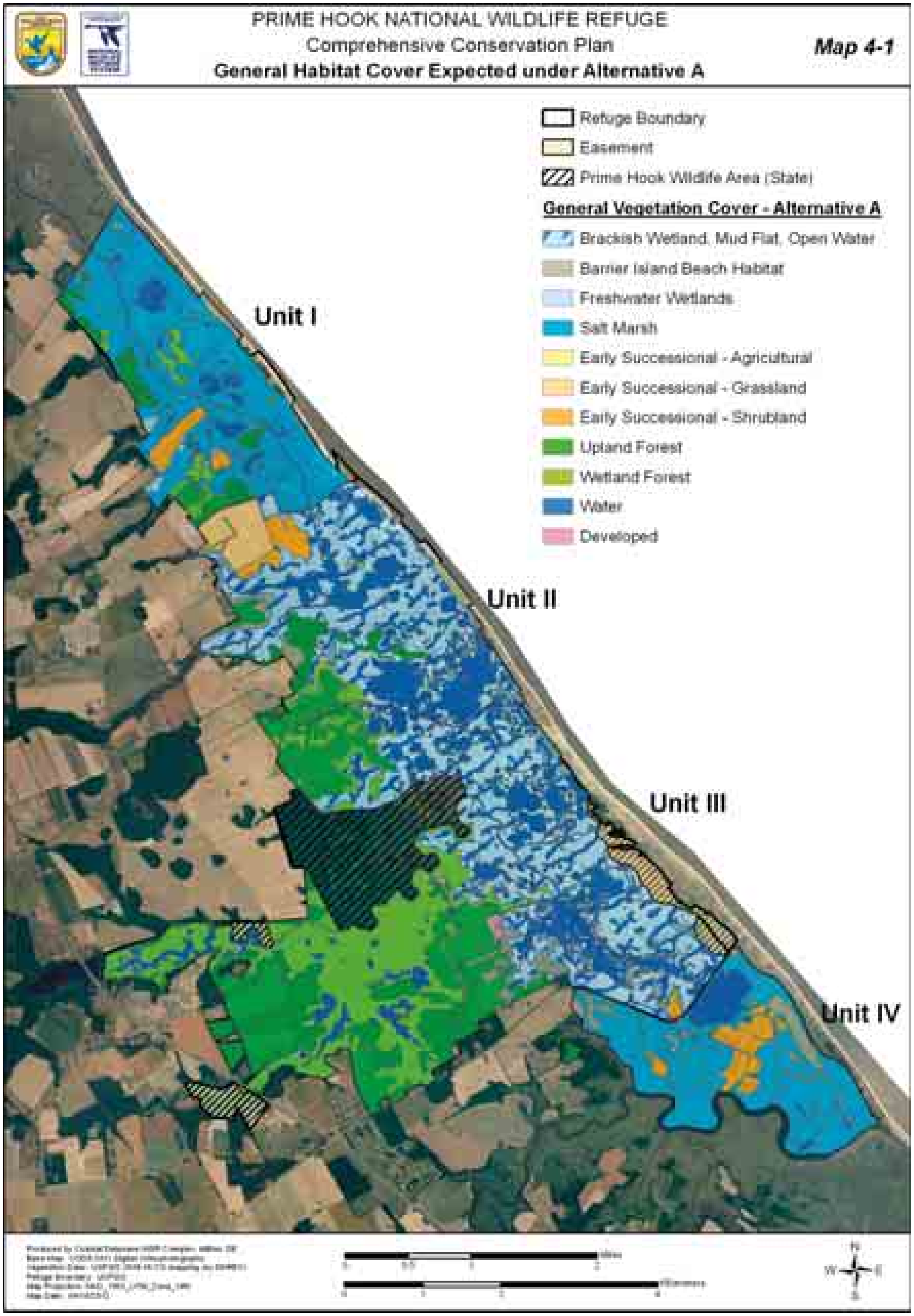
GOAL 1. Barrier Beach Island and Coastal Salt Marsh Habitats

Manage, enhance, and protect the dynamic barrier beach island ecosystem for migratory and breeding shorebirds and other marine fauna and flora. Perpetuate and restore the biological integrity, diversity, and environmental health of North Atlantic low and high salt marsh habitats.

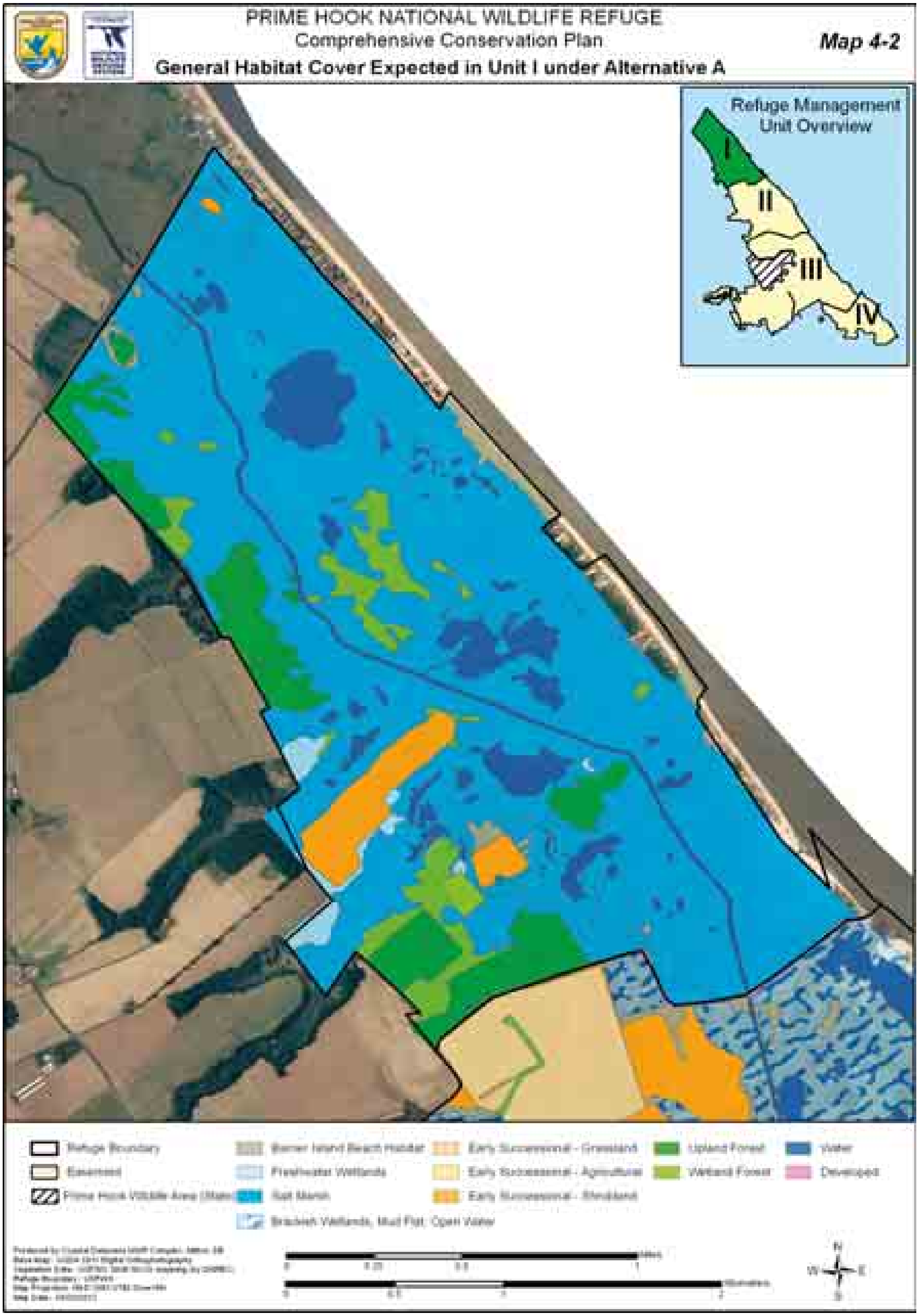
Objective 1.1 Overwash, Dune Grassland and Atlantic Coast Interdune Swale

Allow natural processes to affect the evolution and functioning of coastal landforms and habitats (including sandy beach, overwash tidal flats, dune and grasslands, and mudflats) along nearly 3.5 miles of shoreline in all refuge management units, as they naturally evolve in order to conserve spawning horseshoe crabs, American oystercatcher, and other State and federally listed

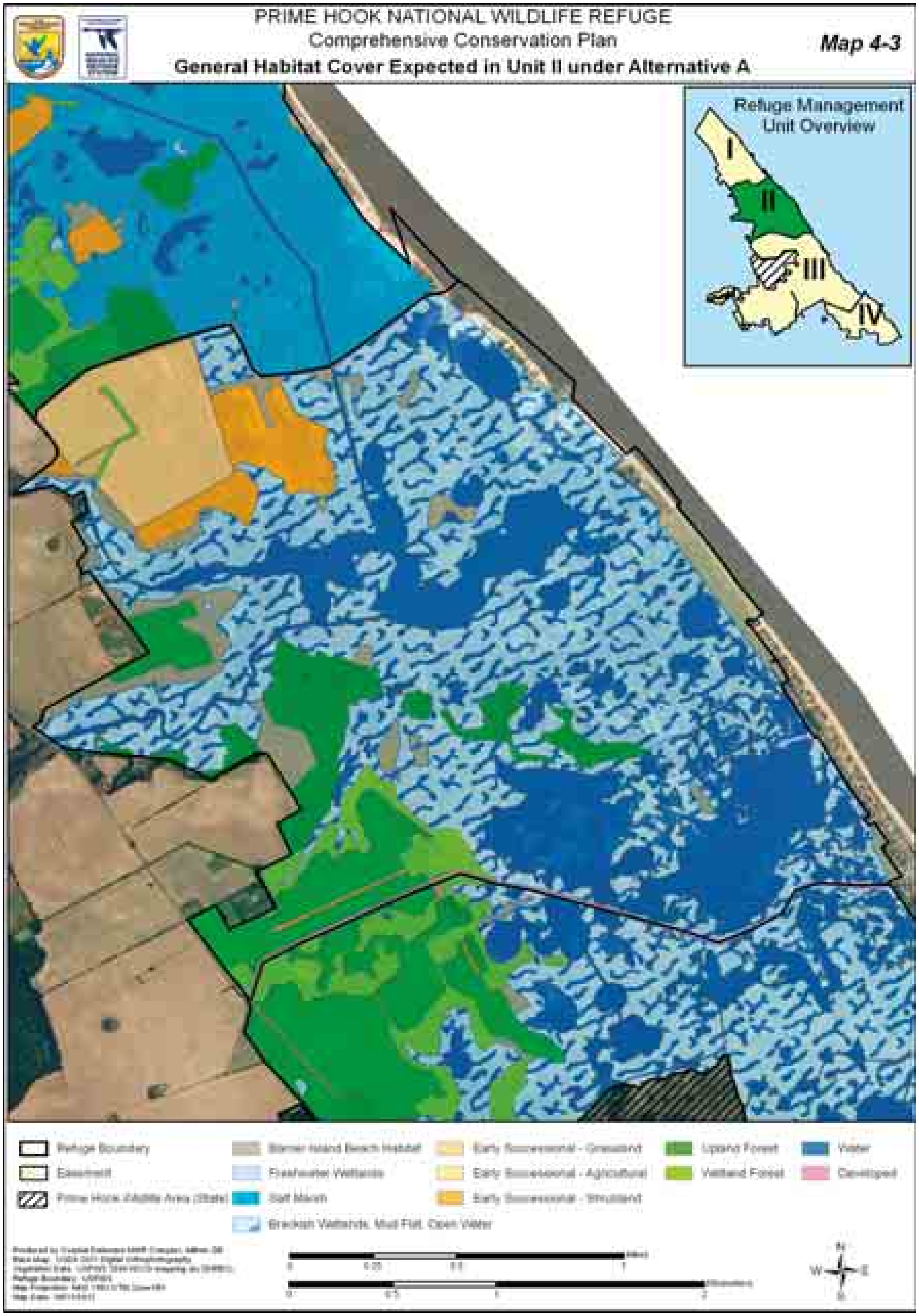
Map 4-1. Overview of general habitat cover under alternative A



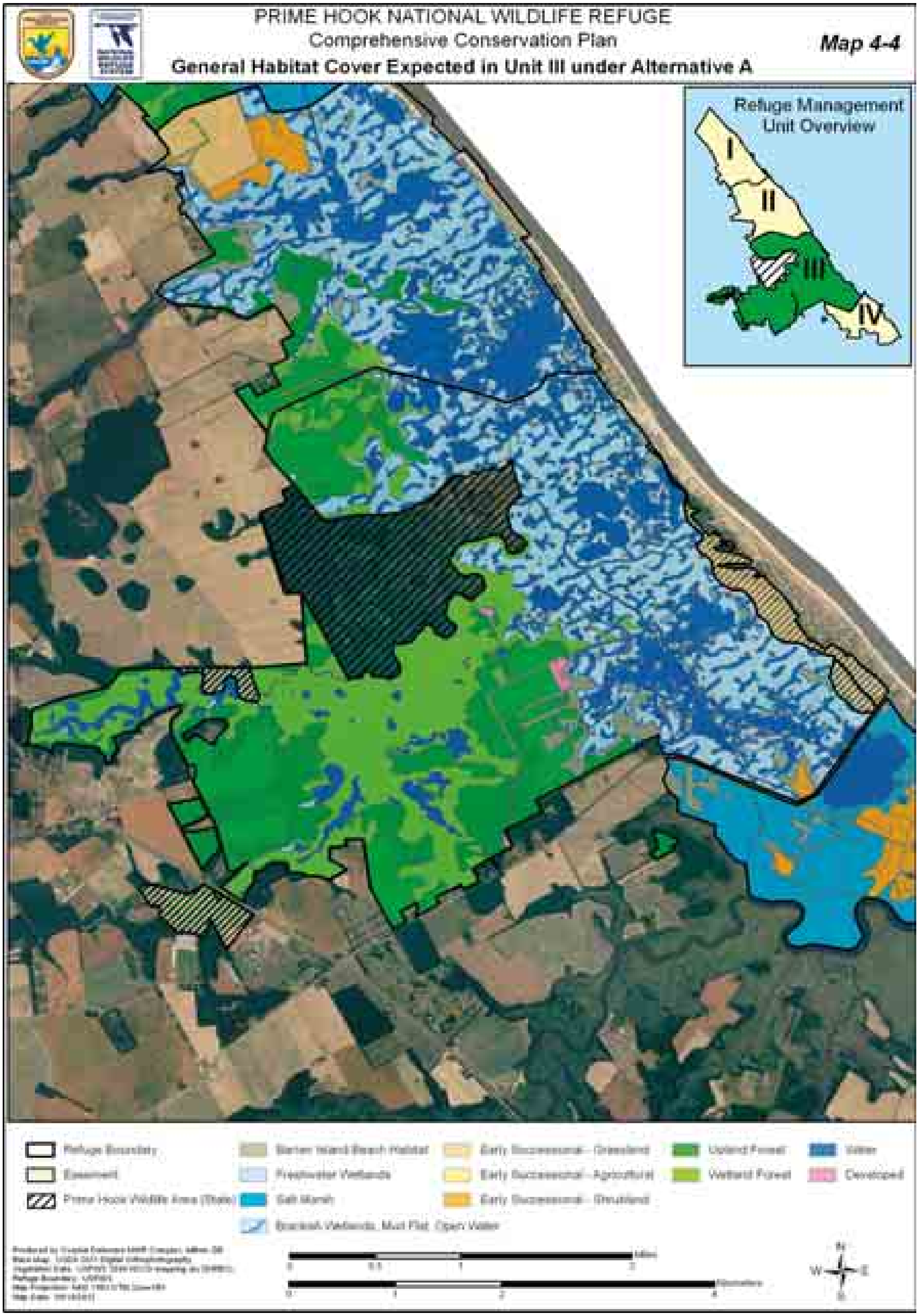
Map 4-2. General habitat cover in Unit I under alternative A



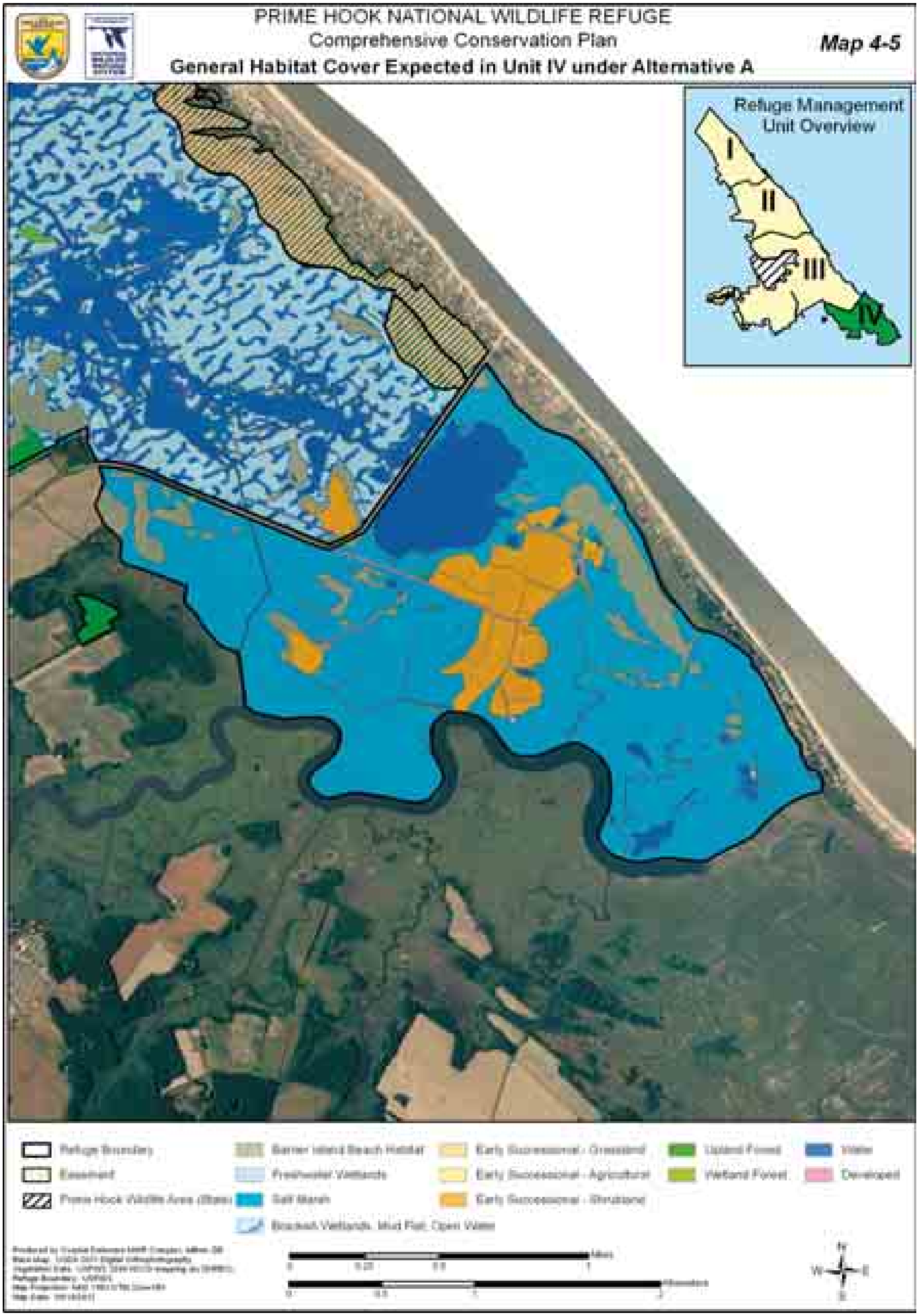
Map 4-3. General habitat cover in Unit II under alternative A



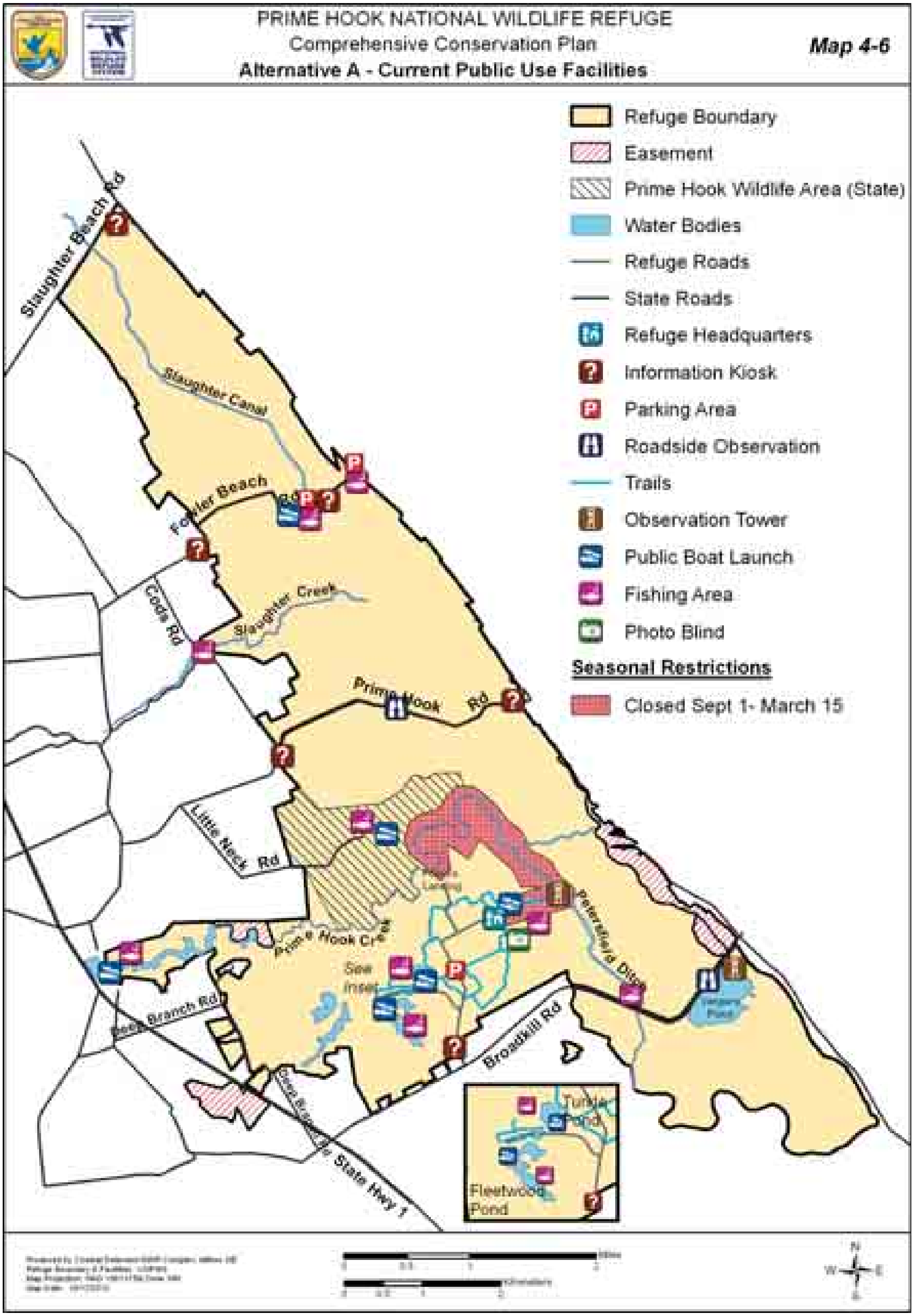
Map 4-4. General habitat cover in Unit III under alternative A



Map 4-5. General habitat cover in Unit IV under alternative A



Map 4-6. Public use facilities under alternative A



beach nesting bird species, and provide feeding and staging habitats for sanderlings, whimbrel—and other migratory shorebirds.

Rationale
The Delaware Bay has been recognized by many scientists and conservation organizations as one of the most important and critical shorebird stopovers in the Western Hemisphere and world (USFWS-Shore Technical Committee 2003). Immediately parallel to the Delaware Bay, Unit I habitats have increasingly become more important for both migrating and breeding shorebirds in the face of beach development along bay shore areas. The highest quality dunes remaining along the Delaware Bayshore occur from Big Stone Beach south to Beach Plum Island (Clancy et al. 1997), with the refuge's barrier beach island habitats located just north of Beach Plum Island. Protecting some of the last undeveloped 3.5 miles of barrier beach island habitats along a critical shorebird migrational hot spot like the Delaware Bay will greatly benefit breeding and migrating shorebirds.

A distinctive dune system with overwash and ephemeral mini-inlets is still found from the last Prime Hook Beach home north to Slaughter Beach. Beach heather *(Hudsonia tomentosa)*, beach plum *(Prunus maritima),* and dune panicgrass *(Panicum amarum)* are interspersed with several overwash habitats along Unit II and Unit I. In 2006, Hurricane Ernesto plus several nor'easter storms of 2007 and 2008 expanded the overwash habitats, flattened most dune areas, and increased tidal flows. These events increased habitat availability for beach nesters and provided greater amounts of invertebrate and fish food resources flowing in daily from the Delaware Bay for nesting and migrating birds. In 2009, fall storms breached the duneline in Unit II, south of Fowler Beach Road, creating two overwashes and inlets.

Refuge sandy beach and overwash dune grassland habitats are recording greater use by spring and fall migrating shorebirds since 2006, and we are consistently noting more beach-nesting attempts by the American oystercatcher, least terns, and common terns.

Both spring and fall migrating shorebirds and nesting shorebirds will benefit greatly if we close beaches from March 1 to September 1. Such beach closures would subject shorebirds to fewer disruptive events that interfere with foraging, preening, resting, and nesting shorebird activity budgets. Protecting these habitats from human disturbance through seasonal closures, not allowing dog walking, and proactively reducing predator problems could increase nesting attempts, improve nesting success, and provide better foraging habitats for red knot, ruddy turnstones, sanderlings, whimbrels, and other migrating birds.

Strategies
- Permit the natural processes of inlet openings and closings, sand migration, and overwash development along Unit I and Unit II.
- Monitor resources of concern and conduct baseline inventories and surveys as funding and staffing allows
- Conduct seasonal beach closures if and when Federal or State endangered shorebird species attempt to nest on refuge overwash habitat

Objective 1.2 Maritime Shrub and Forested Habitats

Continue passive management of approximately 320 acres of existing successional maritime salt shrub and successional maritime forest and maritime red cedar woodland habitats, as well as any such additional habitat that may develop through passive succession within and adjacent to impounded wetland areas.

Rationale
We define passive management as monitoring resources of concern and conducting baseline inventories and surveys as funding and staffing allow. Passive management in this sense would increase our knowledge of the status of refuge resources to improve our information about the healthy ecosystem functioning of barrier beach island and maritime habitats and conserve what currently exists on the refuge.

Due to development, maritime shrub and maritime forested habitats are underrepresented in the State of Delaware. These natural communities are connected to coastal dune systems and are restricted by the natural processes that develop and enhance barrier beach island ecosystems. Maritime shrub and forested habitats are threatened by commercial and residential development, artificial dune stabilization, and lack of recognition that these vegetative communities represent unique communities within northeast coastal beach ecosystems.

Importance to Migratory Landbirds: Widespread population declines of many migratory songbird species are among the most critical issues in avian conservation today. Numerous studies have shown the critical role that maritime shrub, maritime red cedar woodland, and maritime forested habitats play for migrating passerines, especially on the refuge and along the mid-Atlantic and Delmarva peninsula coastal areas (Mizarhi 2006, Clancy et al. 1997, McCann et al. 1993). Conservation of these habitats and the natural resources associated with them is essential to perpetuate the migratory songbird resources of North America.

Strategies
- Control invasive species, especially *Phragmites* when significant patch sizes (more than 5 acres) are noted

- Allow natural processes like inlet formation, sand migration, and tidal flows from inlet formations, etc., to proceed unimpeded to enhance and protect the natural development of maritime shrub and forest habitat in Unit I.

Objective 1.3 North Atlantic High and Low Salt Marsh

Protect approximately 2,200 acres of existing refuge salt marsh resources, primarily in Units I and IV, for the benefit of salt marsh-dependent species, which include a mix of high and low *Spartina* salt marsh, pool panne, and irregularly flooded eastern tidal salt shrub habitats. In addition, permit the natural conversion of up to an additional 4000 acres in Units II and III to a mix of salt marsh, mud flats, and open water.

Rationale
Salt marsh communities along the East Coast are the most degraded of all wetland habitats, and within the mid-Atlantic region a substantial number of salt marshes have been lost or degraded in the last century (Kennish 2001). With the loss of greater than 50 percent of these habitats in the mid-Atlantic, remaining salt marsh areas are critically important for many salt marsh-dependent species that are experiencing major population declines.

Refuge salt marsh habitats were grid-ditched since the 1930s, and are highly altered systems compared to natural salt marsh environments (see HMP in appendix B for detailed history of refuge salt marsh habitat alterations). Current refuge salt marsh habitats consist of approximately 2,200 acres confined in Unit I (1,400 acres) and Unit IV (800 acres). Vegetation cover-types are represented by North Atlantic high salt marsh, North Atlantic low salt marsh, tidal creek shrubland, and salt panne communities dominated by *Salicornia* spp. and salt grasses, with various stands of *Phragmites* scattered around Units I and

IV. The dominant community is North Atlantic low salt marsh consisting of approximately 1,700 acres.

Refuge salt marsh resources provide important breeding habitats for seaside and salt marsh sharp-tailed sparrow, black rail, clapper rail, willet, sedge wren, and wintering black ducks. Principal habitat management activities are vegetation and bird monitoring, invasive species control, prescribed burning, and the use of open marsh water management (OMWM) to control mosquitoes.

In 2009, fall storms breached the duneline in Unit II, south of Fowler Beach Road, creating two overwashes and inlets. These breaches have introduced daily tidal flow directly into Unit II, and therefore into Unit III through culverts that connect it to Unit II. This constant tidal regime resulted in the conversion of previous managed freshwater wetlands to a mix of open water, mudflats, and salt marsh. Over time, under this alternative of no action, additional salt marsh may be established in areas of Units II and III as the impounded wetlands respond naturally to the tidal regime.

Although larvicides and adulticides have been used on the refuge, OMWM is the State of Delaware's preferred method to control mosquitoes as a source reduction technique that reduces the need for chemical insecticide treatments. It is a method for controlling salt marsh mosquitoes through physical alterations of marsh habitats. Ponds and ditches are selectively excavated in order to create an unsuitable environment for mosquito production while creating favorable habitat conditions for larvivorous fishes. Often, OMWM is applied in areas where historic grid-ditching was conducted in an attempt to restore features similar to natural pannes and channels in those areas while also controlling mosquitoes. Such biological controls are effective in reducing mosquito production by 95 percent in treated areas (DNREC 2008).

Extensive OMWM systems have been installed on approximately 1,350 acres from 1980 to 2002, effectively treating all of the refuge's salt marsh habitats. In 1980 a pilot study to demonstrate efficacy was initiated. Four years later a 90 to 99 percent reduction of mosquito breeding was recorded by the State in treatment sites. An environmental assessment to conduct OMWM on the refuge was completed in 1988 to treat 960 acres in Unit I and 430 acres in Unit IV. This work was completed in 1994, removing 1,880 acres from the mosquito spraying program. In 2001, an additional 362 acres were removed from the spray program upon the construction of 3.2 acres of ponds and 7.0 acres of radial ditches.

Strategies

- Control *Phragmites* encroachment onto refuge salt marsh habitats through the use of fire, mechanical means, and herbicides.

- Continue or resume snow goose hunting to discourage snow goose use of salt marsh habitats to prevent destruction of salt marsh vegetation.

- Permit the State of Delaware Mosquito Control Section to maintain existing OMWM systems for source reduction of mosquito breeding to reduce the amount of insecticide treatment on the refuge.

- Permit the use of the larvicides Bti and methoprene, and the adulticide naled, to control mosquitoes.

- Permit the natural development of additional salt marsh, mud flats, and/or open water within Units II and III in response to tidal flow through breaches along the refuge shoreline.

GOAL 2. Forested Habitats

Manage the biological diversity, integrity, and environmental health of refuge upland and wetland forested cover-types to sustain high quality habitats for migratory birds, increase quality habitat for the endangered Delmarva fox squirrel, breeding and wintering landbirds, reptiles, amphibians, and other resident wildlife.

Objective 2.1 Upland Forested Habitats

Continue protecting more than 750 acres of existing oak forest and mixed hardwood cover-types using prescribed fire in appropriate stands to improve habitat conditions for the Delmarva fox squirrel and migratory birds.

Rationale
Extensive upland forest loss and fragmentation provided the impetus for the State to designate upland forested blocks greater than 250 acres in size as key wildlife habitats. Exotic species are another great conservation concern. Of the 115 tree species found in Delaware, only 60 are native species. The loss of native upland forested habitats has taken a large toll on migratory song birds and forest interior dwelling breeding birds that all require large contiguous blocks of forested habitats. These include black-and-white warbler, whip-poor-will, cerulean warbler, hooded warbler, and American redstart. Severe forest loss and habitat fragmentation were also responsible for the extirpation of the Delmarva fox squirrel from Delaware (ELI 1999).

The reintroduction of Delmarva fox squirrels to Sussex County in the mid-1980s included two locations, one of which was the refuge. The purpose of these reintroductions was to restore the squirrel to its historic range. To provide more optimal habitat for the fox squirrel before and after its introduction, increased forest management treatments (low intensity understory prescribed fire and hydro-axe removal of dense understory thickets in mixed hardwood stands) were recommended by recovery team members as good management practices to benefit the squirrel. These conservations actions were performed several times in various timber stands from 1987 to 1995.

The first bald eagle nest was established on the refuge in 1991 on Second Hill. A single bird was produced and banded by State biologists and fledged that summer. The same pair has produced two young and built an additional nest on First Hill in Unit II. The nest on Second Hill was blown away in a storm but the pair produced eggs in 2007 and 2008 in a First Hill nest.

In 2006, a second bald eagle pair established a breeding territory on Horse Island in Unit III adjacent to Turkle Pond and has produced a pair of birds each breeding season up to and including 2008. In 2010 the Unit III nest appeared to be abandoned and remains inactive. Refuge breeding territories have proven successful due to plentiful food supplies, minimal human disturbance, and adequate habitat features. New juveniles recruited each year have increased the numbers of summer roosts on the refuge. Roost sites typically offer isolation and good food resources nearby. Bald eagles remain designated as a State endangered species, despite Federal delisting in 2008.

Strategies

- Use prescribed fire where appropriate to maintain or restore habitat for Delmarva fox squirrel.

- Monitor migratory bird use in forested habitats.

- Perform early detection/rapid response of invasive species and treat accordingly using integrated pest managements strategies.

- Follow the bald eagle management guidelines.

- Support Service and State efforts to monitor local populations.

Objective 2.2 Mixed Hardwood Forest Restoration

In the next 15 years, permit reforestation through natural succession on approximately 500 acres of old fields and cropland areas to increase habitat for the Delmarva fox squirrel and focal forest interior dwelling birds.

Rationale
Same as Objective 2.1

Strategies
- Permit natural establishment of forest vegetation in previously managed refuge fields

- Monitor and treat for invasive plant species.

Objective 2.3 Wetland Forested Habitats

Continue passive management of approximately 1,200 acres of forested wetland cover-types on the refuge.

Rationale
The mid-Atlantic Coastal Plain forested wetlands include a highly diversified gradient of forest types. These habitats are dominated by woody species that are adapted to tolerate saturation of the root zone for varying duration and frequency during the growing season. Nationally and on a State level, forested wetlands have experienced dramatic fragmentation and losses. Much of this loss has been due to clear cutting, filling, or draining of forested wetlands for conversion to agriculture or urban development (Cowardin et al. 1979, ELI 1999) leading to sharp declines in prothonotary warbler, Acadian flycatcher, yellow-throated warbler, and other migratory birds dependent on forested wetlands (PIF 44 and BCR 30 plans).

Strategies
- Monitor bird use.

- Map vegetation communities.

- Monitor and treat for invasive plant species.

GOAL 3. **Refuge Impounded Marsh Complex**

Maintain, create, and enhance the quality of managed wetland habitats within and surrounding the refuge's impoundment complex for migrating shorebirds, breeding rails, wading birds, American black ducks, and migrating and wintering waterfowl. Support obligate amphibians and other native wetland-dependent species, provide fish passage and nursery habitats for anadromous fish species, and protect and conserve rare native flora and fauna dependent on refuge-managed hydrology.

Objective 3.1 Refuge Impoundment Management

Allow natural processes to create wetland and open water habitats across up to 4,200 acres of impounded wetland habitats to meet the needs of a wide variety of wetland-dependent migratory birds, including rails, bitterns, terns, migrating shorebirds, and migrating and wintering waterfowl.

Rationale
Under this "no action" alternative, there is no active management of the refuge impounded wetlands. This alternative permits the system to respond naturally

to ongoing sea level rise and more frequent coastal storms. As described later under alternative B, objective 3.1, the refuge convened a group of world-renowned wetland management and restoration experts from outside Delaware for a meeting with refuge staff and a number of State scientists and managers. It was the conclusion of this group that without the addition of outside sources of sediment, the elevation within Units II and III would require years, perhaps centuries, to fully recover from the impacts of the decades of tidal restriction and the rapid peat collapse that followed the reintroduction of saltwater. Although salt marsh communities have already formed in portions of Unit II, it may be a much longer timeframe before healthy salt marsh communities are established throughout the entire impoundment. Large portions of the wetland complex will persist as open water until salt marsh vegetation returns naturally. Challenges associated with historic freshwater impoundment management are described in detail under alternative B, objective 3.1

Strategies

- Permit natural coastal processes, such as overwash, breaching, and inlet formation, to continue unhindered

- Conduct no management or construction of dunes on private or refuge coastal land.

- Continue to implement some water level management and vegetation control strategies, to the extent conditions warrant and permit.

  - Keep manipulated Unit III water levels, in accordance with deed restrictions, at or below a level of 2.8 ft mean sea level between October and March 10th, as long as the Refuge is able to maintain an artificially-controlled water level system. (Storm events and other high water events may cause uncontrollable higher water levels beyond the refuge's control.)

  - Control invasive species using chemical control, prescribed fire and other techniques as appropriate so that 95 percent native vegetation is achieved. The exact number of acres treated will depend on funding and management capability.

Objective 3.2 Fisheries Resources and Water Quality

Manage impounded wetlands for interjurisdictional fish species and improve water quality to perpetuate fish and migratory bird resources.

Rationale

Because of their wide geographic distribution and migratory patterns, many fish populations are dependent on freshwater, coastal, and marine areas that are managed by multiple states. The Service's Northeast Region Fisheries Program has identified the need to work with partners to restore and manage interjurisdictional fish species along the Atlantic Ocean. The Atlantic State Marine Fisheries Commission manages 22 species of Atlantic coastal fish; several of these species depend on refuge habitats, especially populations of freshwater, coastal, and anadromous fish.

For example, shad and river herring are anadromous fish that spend the majority of their adult lives at sea, only returning to freshwater areas in the spring to spawn. Historically, shad and river herring supported the largest fishery populations in the Atlantic Coast, but due to habitat degradation and impediments of passage to freshwater resources, shad and river herring populations are severely depleted. Other species of management concern include American eel, striped bass, and horseshoe crabs. Maintaining fish passage for spawning and nursery habitats and improving water quality are key management actions to address declines of anadromous fish populations and ensure healthy ecosystems to perpetuate interjurisdictional fish species. Through these actions, the refuge can contribute potential habitat to meet the needs of interjurisdictional fish species that occur throughout the Delaware Bay.

Strategies

- Conduct fisheries inventories and water quality assessments to evaluate resource conservation needs and receive direction from fisheries biologists regarding management recommendations to protect and enhance refuge fish and other aquatic species.

- Maintain fish weir passages in Unit II and III water control structures to allow unimpeded passage of river herring and other anadromous trust species.

- Improve or restore water quality by restoring water circulation within refuge impoundments by ditch cleaning and maintaining approximately 7.5 miles of ditch-network in Unit III and 3,300 linear feet in Unit IV.

GOAL 4. Early Successional Upland Habitats

Maintain and enhance, or restore the native vegetation, biological diversity, and ecological integrity of early successional habitats to create a mosaic of native grassland and herbaceous scrub-shrub habitats mixed with transitional forested areas to conserve migratory birds, breeding landbirds, and endangered species, and to maximize benefits for other priority resources of concern.

Objective 4.1

Within the next 15 years, allow early successional areas representing the historic range of variability for upland transitional communities to occur through natural processes in the absence of active management. Habitats will be dominated by native grassland and shrubland vegetation reflecting assorted cycles of diverse seral stage distributions that mimic historic conditions. Transitional habitats will usually be small in size and imbedded within a habitat matrix dominated by wetland and upland forested habitats.

Allow a continuum of natural habitats to include a mosaic of grassland, transitional, young and old shrublands, and young forest habitats on 2,000 acres undergoing restoration to native vegetation (including those areas previously planted in trees or transitioning through natural succession for Delmarva fox squirrel management purposes). These habitats will support high priority breeding and migrating birds identified in BRC 30, Partners in Flight 44, the State wildlife action plan (2005), and Birds of Conservation Concern (USFWS 2008a), and include prairie warbler, blue-winged warbler, Northern bobwhite, brown thrasher, whip-poor-will, willow flycatcher, eastern towhee, field sparrow, and Henslow's sparrow.

Rationale

Early successional grassland and shrub-dominated habitats were historically widely distributed throughout the Northeast but are rare today. Shrub-dominated habitats are the most rapidly declining habitat type in the Northeast (Litvaitis et al. 1999, Litvaitis 2006). National breeding bird survey data indicate that populations of thicket specialists (thickets are defined as sites dominated by persistent shrubs or seedling-to-sapling sized trees) continue to decline in the Northeast (Askins 1995). Bird species that rely on open grasslands and shrublands for breeding are among the highest priority conservation targets due to the greatest rates in population declines both in the BCR 30 and Partners in Flight 44 regions.

Most early successional habitats are temporary and dynamic in nature, constantly changing as more shade-tolerant trees replace sun-loving shrub species. Given the highly ephemeral and disturbance-dependent nature of these successional communities, many shrubland habitats within the next 15-year time horizon will likely revert to young forest as alternative A will rely mostly on allowing natural succession to dictate the future conditions of refuge habitats. Shrubland cover-types will represent less acreage than alternative B, and naturally succeeding areas will ultimately result in higher acreages of forested habitats on the refuge than alternatives A and B.

Passive management consists of allowing natural succession to occur across the refuge's upland landscape to approximate native plant species composition and natural ecological processes, including natural disturbance regimes characteristic of a mixed forest matrix in the Delmarva Coastal Plain within a natural range of variation. The overall objective of allowing natural succession is to create a diverse mosaic of native upland habitat types to be sustained through natural ecological processes with minimal management intervention.

Strategies

- Develop GIS monitoring layers needed to document natural succession and habitat management conditions as they progress annually by field number, along with refuge management actions database to tract shifting mosaics of transitioning habitats.

- Develop monitoring protocols for targeted breeding and migratory birds dependent on early successional habitat condition assessments, and monitor how natural succession proceeds and how bird use shifts with shift annual habitat conditions in annual habitat wildlife plan.

- Increase shrubland and forested buffered areas adjacent to refuge creeks, emergent wetland, and depressional habitats, and restore prior converted wetlands, with the side benefits of conserving soil resources and improving water quality throughout the refuge.

GOAL 5: Visitor Services

Provide visitors with a place to safely take part in the six priority wildlife-dependent recreational uses established by the Refuge Improvement Act, as well as such other public uses as may be allowed without interfering with refuge purposes and objectives for wildlife.

Objective 5.1 Hunting

Maintain a hunting program that offers high-quality hunting opportunities for white-tailed deer, waterfowl, upland game (rabbit, pheasant, quail), and webless migratory birds (mourning dove, snipe, and woodcock) on the refuge. Use hunting to manage wildlife populations, where appropriate.

Rationale

Same as rationale listed under Actions Common to All Alternatives.

Strategies

In addition to those strategies listed under Actions Common to all Alternatives affecting this program:

- Continue a permit-based hunt program for able-bodied and disabled hunters (see additional program details in Chapter 3, Affected Environment, Refuge Administration—Refuge Visitor Services Program).

- Maintain permit fee structure (per hunter per stand or blind per day—$3 preseason application fee for deer; $10 permit for firearms deer; $5 permit fee for waterfowl; and $2 permit fee for upland game, webless migratory birds, and archery deer). A 50 percent discount is available to interagency senior passport and interagency access passport holders.

- Continue to offer a preseason lottery drawing for deer, daily standby lottery drawings for firearms deer and waterfowl, and daily self-service for upland game, webless migratory birds, and archery deer during designated days and times.

- Continue to require hunters to report their harvest for targeted species.

- Continue to provide 115 permanent hunting structures for deer and waterfowl.

  - Deer—78 elevated stands for able-bodied hunters (32 in headquarters area and 46 in other areas) and 11 wheelchair-accessible ground blinds for disabled hunters in Unit IV.

  - Waterfowl—25 blinds (17 Federal and 8 State-owned), 1 wheelchair-accessible blind for disabled hunters, and 3 blinds for the young waterfowler program.

- Hunters may not be on the refuge any earlier than three hours before shooting time.

Objective 5.1a White-Tailed Deer Hunting

Provide high-quality hunting opportunities for white-tailed deer.

Rationale

Much of the basis for hunting deer under the existing program is described under Actions Common to All Alternatives, and in chapter 3 (Affected Environment).

Map 4-7 depicts deer hunting opportunities and infrastructure under alternative A.

Strategies

In addition to objective 5.1 strategies under alternative A,

- Maintain deer hunting opportunities on 4,020 acres of refuge lands.

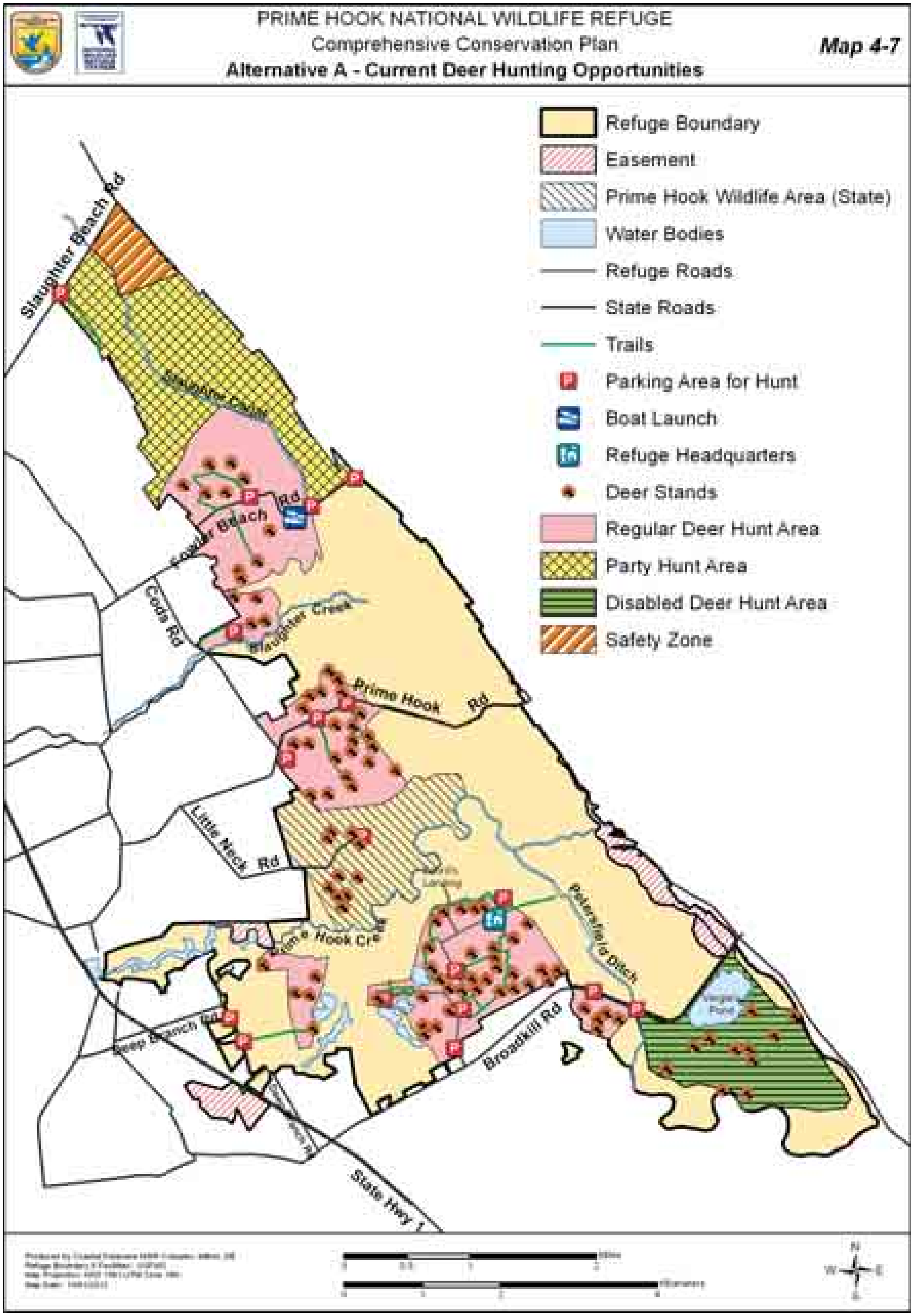
  - Continue to provide opportunities for able-bodied and disabled hunters for approximately 38 archery hunt days from September through January, 12 firearms hunt days including the muzzleloader and shotgun hunting seasons, and 1 youth hunt.

  - In addition to permanent hunting stands, continue to provide free-roam hunting opportunities for hunters in the party zone areas, which allow two to ten hunters to access designated areas to free roam during the archery and firearms hunting seasons. Archery hunters are also permitted to hunt from portable stands on designated dates.

  - Continue to provide opportunities to hunt the headquarters area for two days (one in November and one in January).

  - Continue to allow scouting on Sundays from late August through the end of the hunting season.

Map 4-7. Deer hunting opportunities under alternative A



Objective 5.1b Waterfowl Hunting

Provide high-quality hunting opportunities for waterfowl.

Rationale
Much of the basis for hunting waterfowl under the existing program is described under Actions Common to All Alternatives and in chapter 3 (Affected Environment).

Map 4-8 depicts waterfowl hunting opportunities and infrastructure under alternative A.

Strategies
In addition to objective 5.1 strategies under alternative A:

- Maintain waterfowl hunting opportunities on 1,722 acres of refuge lands.
  - Provide opportunities for approximately 40 hunt days on Monday, Wednesday, Friday, and Saturday throughout the State hunting seasons and two youth hunts. The refuge does not participate in the early teal season.
  - Young waterfowler blinds are only hunted one to two times per year.
  - Shooting hours are limited from one-half hour before sunrise to 3:00 pm.
  - Three people maximum are permitted per blind, and all blinds except for the disabled blind and young waterfowler blinds are accessible only by boat.
- The refuge will participate in all State hunting seasons except the early teal season. Due to history of low hunter use and harvest for resident geese and late season snow geese, the refuge is closed during these seasons.
- Close the eastern end of Prime Hook Creek from Foord's Landing to the headquarters boat ramp from October 1 (sometimes earlier due to hunting of early teal season on state area) through March 15

Objective 5.1c Upland Game and Webless Migratory Bird Hunting

Provide high-quality hunting opportunities for upland game (rabbit, pheasant, and quail) and webless migratory birds (mourning dove, snipe, and woodcock).

Rationale
Much of the basis for hunting upland game and webless migratory bird hunting under the existing program is described under Actions Common to All Alternatives and chapter 3 (Affected Environment). Map 4-9 depicts upland game and webless migratory bird hunting opportunities and infrastructure under alternative A.

Strategies
In addition to objective 5.1 strategies under alternative A,

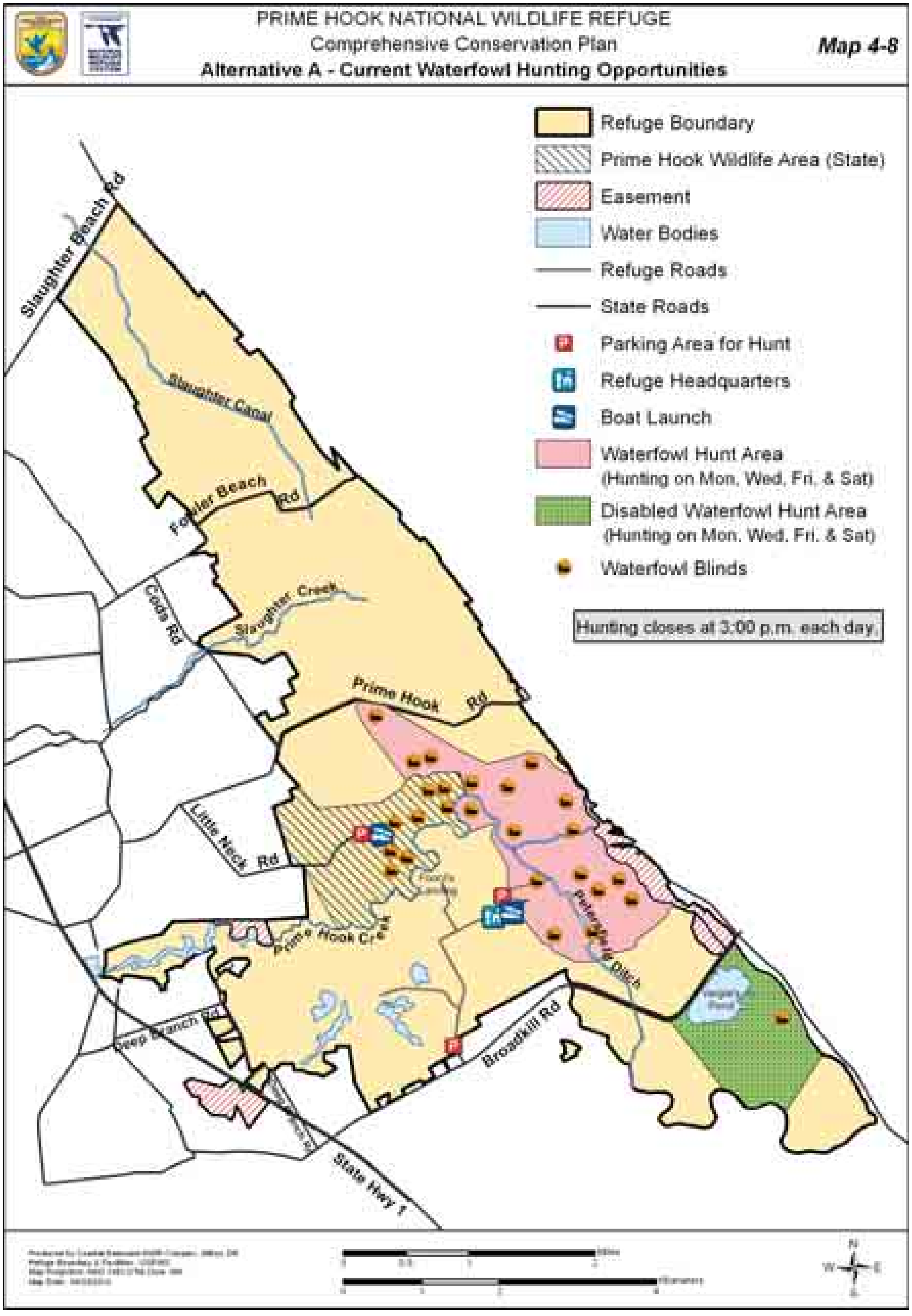
- Maintain upland game and webless migratory bird hunting opportunities on approximately 1,995 acres of refuge lands.
  - Scouting is permitted on Sundays from late August through the end of the hunting season.

Objective 5.2 Wildlife Observation and Photography

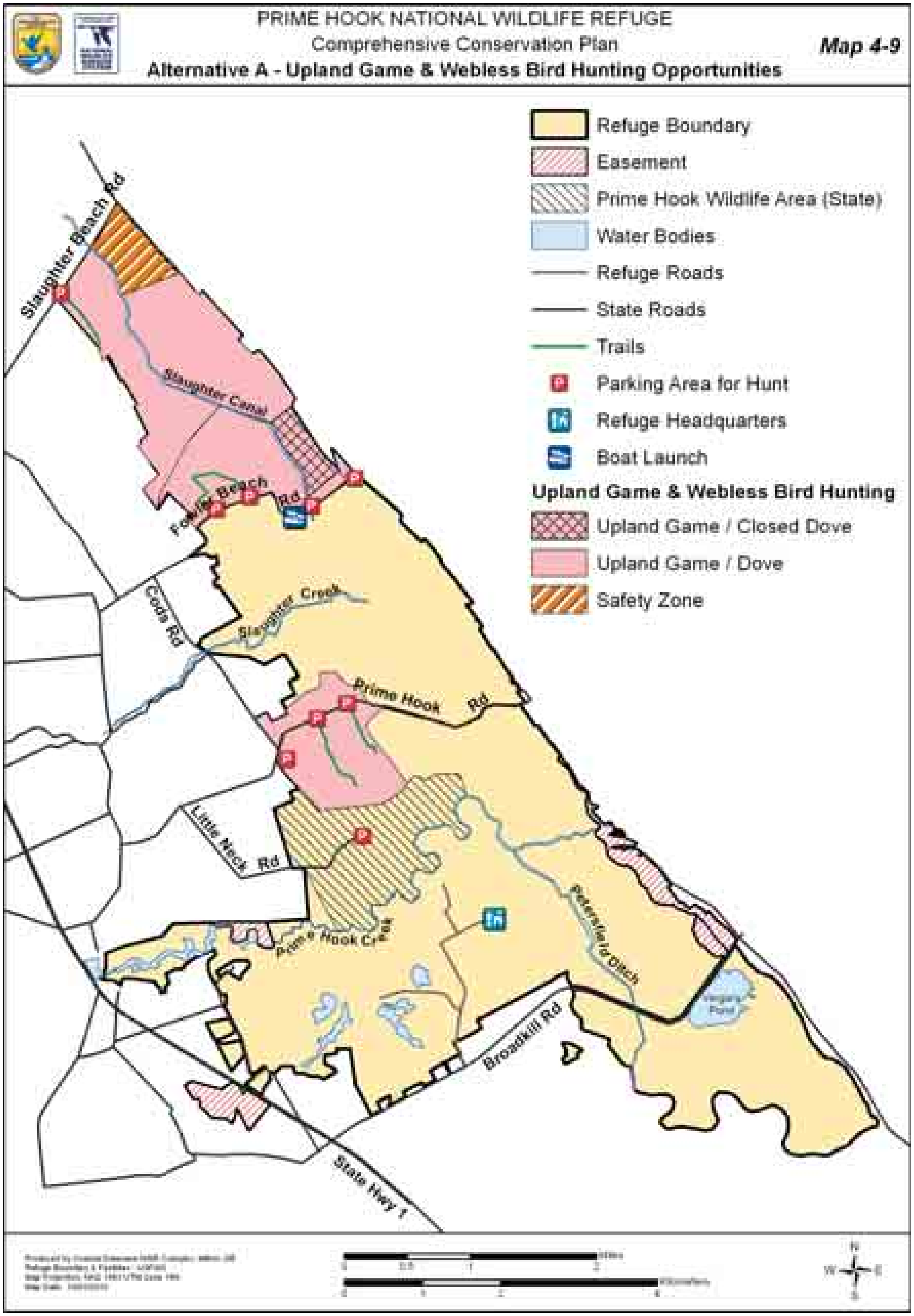
Provide high-quality wildlife observation and photography opportunities.

Rationale
Much of the basis for wildlife observation and photography under the existing program is described under Actions Common to All Alternatives and chapter 3

Map 4-8. Waterfowl hunting opportunities under alternative A



Map 4-9. Upland game and webless migratory bird hunting opportunities under alternative A.



(Affected Environment). Map 4-6 depicts wildlife observation and photography opportunities and infrastructure under alternative A.

Strategies
In addition to those strategies listed under Actions Common to all Alternatives affecting this program:

- The eastern portion of Prime Hook Creek (Unit III) is closed from Foord's Landing to the headquarters boat ramp from October 1 (sometimes earlier due to hunting of early teal season on state area) through March 15.
- Allow visitors to use the existing trail and observation platform overlooking Vergie's Pond on the south side of Broadkill Beach Road.

Objective 5.3 Recreational Fresh and Saltwater Fishing and Crabbing

Provide high-quality fishing and crabbing opportunities.

Rationale
Much of the basis for recreational fishing and crabbing under the existing program is described under Actions Commons to All Alternatives and chapter 3 (Affected Environment). Map 4-6 depicts fishing and crabbing opportunities and infrastructure under alternative A.

Strategies
In addition to those strategies listed under Actions Common to all Alternatives affecting this program:

- No refuge permit is required.
- The eastern portion of Prime Hook Creek (Unit III) is closed from Foord's Landing to the headquarters boat ramp from October 1 (sometimes earlier due to hunting of early teal season on state area) through March 15.
- Maintain the boat launching fee of $1.00 per boat at refuge boat ramps in the headquarters area.

Objective 5.4 Environmental Education and Interpretation

Provide high-quality environmental education and interpretation opportunities.

Rationale
Much of the basis for environmental education and interpretation is described under Actions Common to All Alternatives. Map 4-6 depicts facilities and infrastructure used to support environmental education and interpretation.

Strategies
Refer to strategies listed under Actions Common to all Alternatives affecting this program.

Objective 5.5 Other Recreational Use

Provide opportunities for the public to use and enjoy the refuge for traditional and appropriate non-wildlife-dependent recreation that is compatible with the purpose for which the refuge was established and the mission of the Refuge System.

Rationale
Much of the basis for other recreational use under existing management is described under Actions Common to All Alternatives and in chapter 3 (Affected Environment).

Strategies
In addition to those strategies listed under Actions Common to all Alternatives affecting this program:

- Continue to allow the following non-priority uses that have previously been formally evaluated and documented: commercial fishing, commercial trapping of muskrat, raccoon, etc., turtle trapping, picnicking, 5k road race, beekeeping, and waterfowl retrieval permits.
- The following uses were never formally evaluated and documented under current management: dog walking (required a ten-foot leash), roller blading, competitions or organized group events, non-competitive organized events. It is the professional judgment of current and former refuge staff that these historic uses, if found appropriate and compatible, are allowed.

GOAL 6. Outreach and Community Partnerships

Collaborate with the local community and partners to complement habitat and visitor service programs on the refuge and the surrounding landscape.

Objective 6.1 Community Outreach

Continue to provide community outreach by conducting programs or events each year, and initiate news articles to increase community understanding and appreciation of the refuge's significance to natural resource conservation and its contribution to the Refuge System, and to garner additional support for refuge programs.

Rationale
Much of the basis for community outreach is described under Actions Common to All Alternatives.

Strategies
Refer to strategies listed under Actions Common to all Alternatives affecting this program.

Objective 6.2 Private Landowner Assistance

Continue existing levels of technical assistance to private landowners to enhance their land management to improve wildlife habitat.

Rationale
Much of the basis for private landowner assistance is described under Actions Common to All Alternatives.

Strategies
Refer to strategies listed under Actions Common to all Alternatives affecting this program.

Objective 6.3 Regional and Community Partnerships

Continue existing partnerships with Federal, State, and local government agencies and regional and community organizations to fulfill natural resource conservation mandates and help us meet our wildlife, habitat, and visitor services objectives.

Rationale
Much of the basis for regional and community partnerships is described under Actions Common to All Alternatives.

Strategies
Refer to strategies listed under Actions Common to all Alternatives affecting this program.

Alternative B. The Service-preferred Alternative

Alternative B is the alternative our planning team recommends to our Regional Director for implementation. It includes an array of management actions that, in our professional judgment, work best towards achieving the refuge's purposes, vision and goals, and would make an important contribution to conserving Federal trust resources of concern on the Delmarva Peninsula and in the Northeast region. It is the alternative that would most effectively address the issues identified in chapter 1. We believe it is reasonable, feasible, practicable, and the most timely, sustainable, and efficient alternative within a 15-year timeframe to achieve the desired future habitat conditions for the conservation of the greatest number of fish, wildlife, and plant resources, while enhancing biological resources of Delmarva coastal plain ecosystems. This alternative involves direct human actions and manipulations to restore degraded and manipulated habitats onto a trajectory that will ultimately allow them to persist naturally.

The biological and habitat goals, objectives, and management strategies of alternative B are based on the following underlying hypotheses and assumptions that were used to decide the future management direction for the refuge, including the desired habitat conditions depicted in Map 4-10 to Map 4-14:

- Focal species management would be the best approach to conserve continental migratory bird populations, while maintaining, enhancing, and restoring biological integrity, diversity, and environmental health of refuge lands.

- Managing upland habitats and improving refuge forest management are the best approaches to optimize Delmarva fox squirrel and forest interior bird conservation.

- Increasing avian diversity and abundance on refuge habitats is best accomplished by conserving, protecting and restoring native plant community cover types.

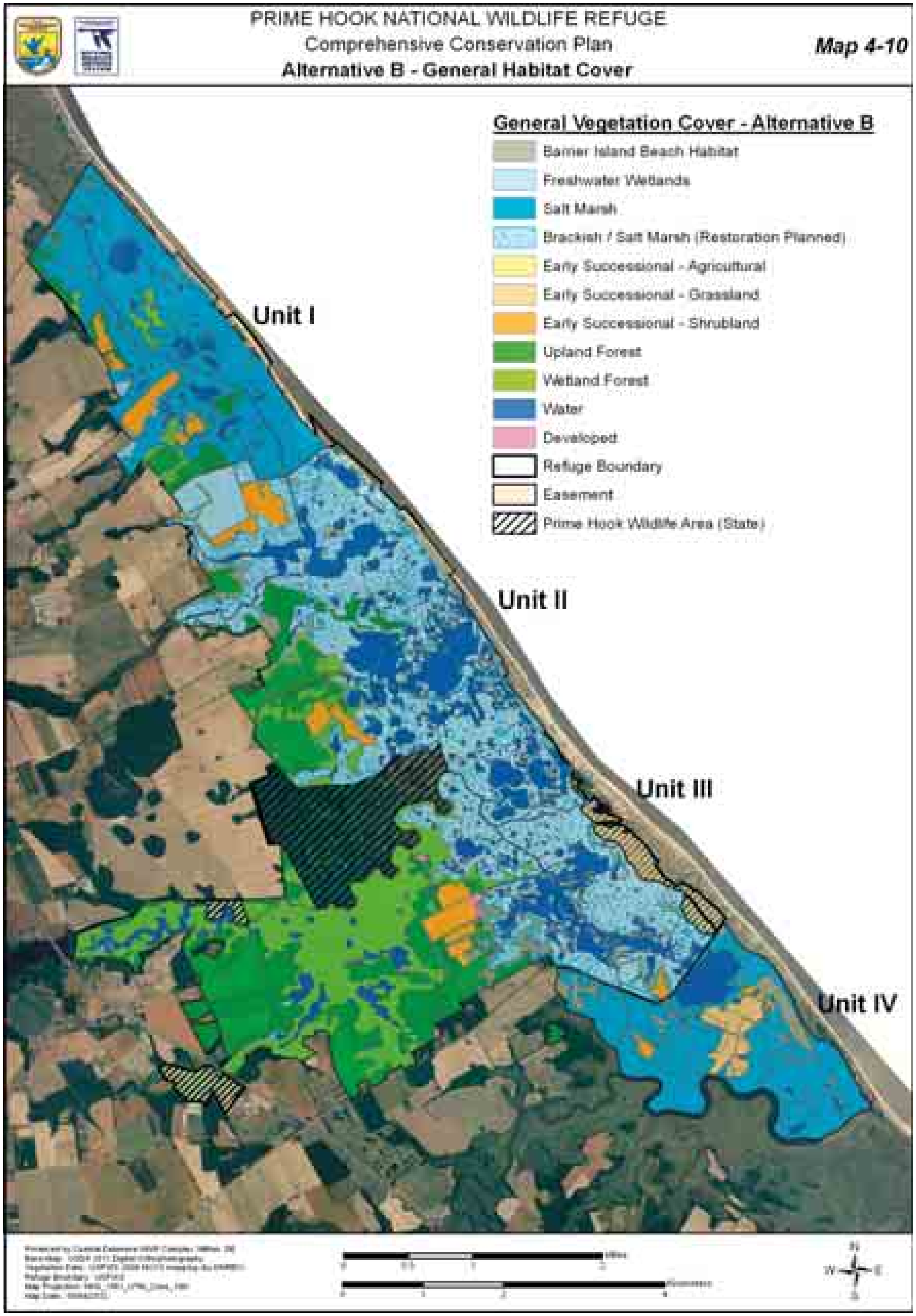
- Selecting certain focal bird, fish, and insect species as indicator and umbrella species and yardsticks to gauge ecosystem function, biological diversity, integrity, and environmental health, improves environmental health monitoring.

- Modify mosquito and integrated pest management (IPM) strategies to advance pollinator conservation and protection and reduce negative non-target impacts on refuge invertebrate resources.

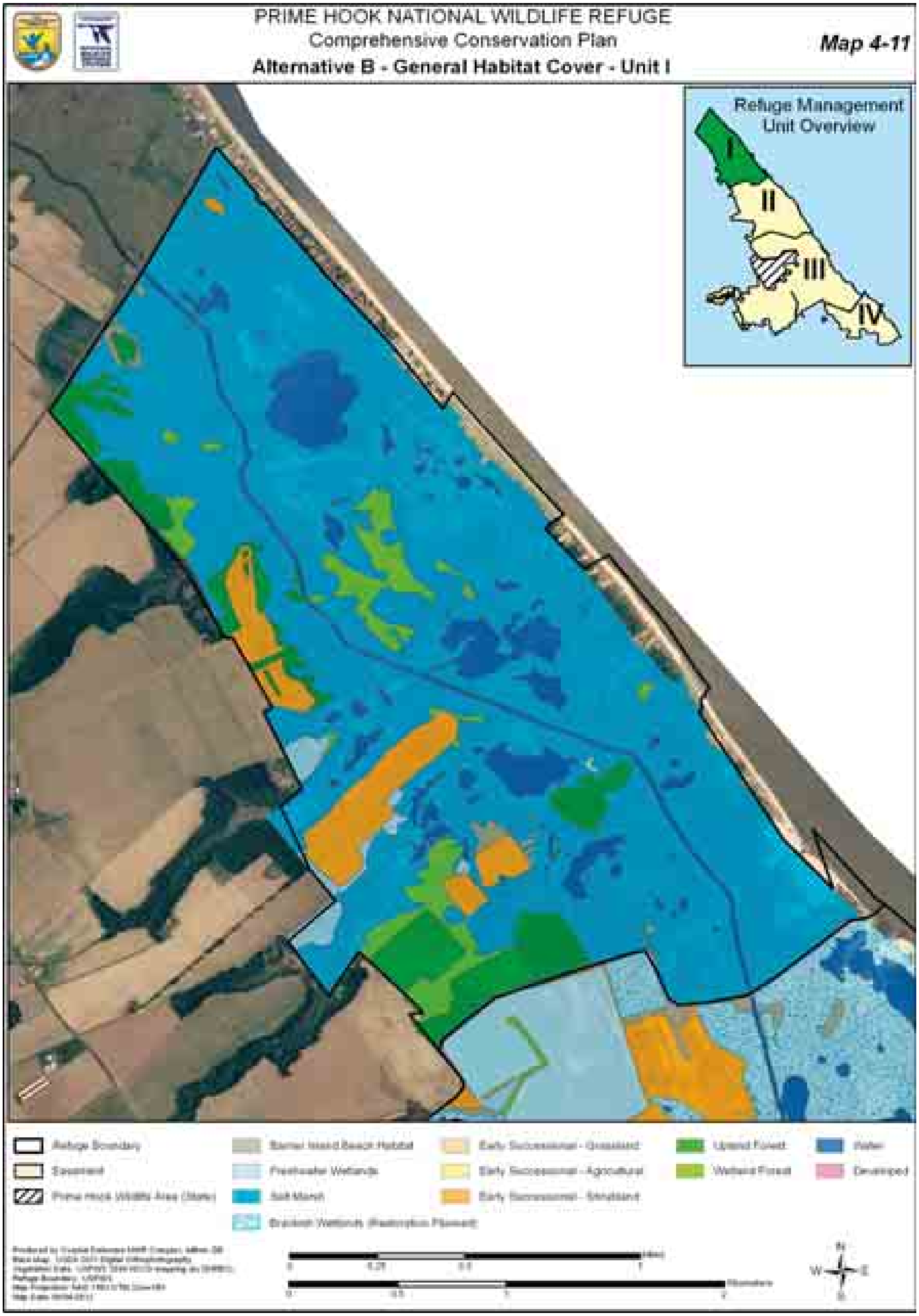
- Restoring healthy salt marsh systems in Units II and III, as well as degraded areas of Units I and IV, along with conserving appropriate vegetation communities in brackish and freshwater areas closer to streams and freshwater sources, will foster sustainable coastal habitats and contribute to biological integrity.

The Service is aware that physical forces in the changing climatic environment, and the biological responses that they generate, are rapidly altering our ability to follow management prescriptions designed just a few years ago. Accelerating climate change and its coastal manifestations—sea level rise, increased coastal storm activity and force, changes in plant and animal population distributions associated with changing temperature regimes—will necessitate revising management strategies for the long term, particularly where management of coastal wetlands and impoundments is concerned. This preferred alternative outlines a proactive habitat management approach in response to these changing conditions.

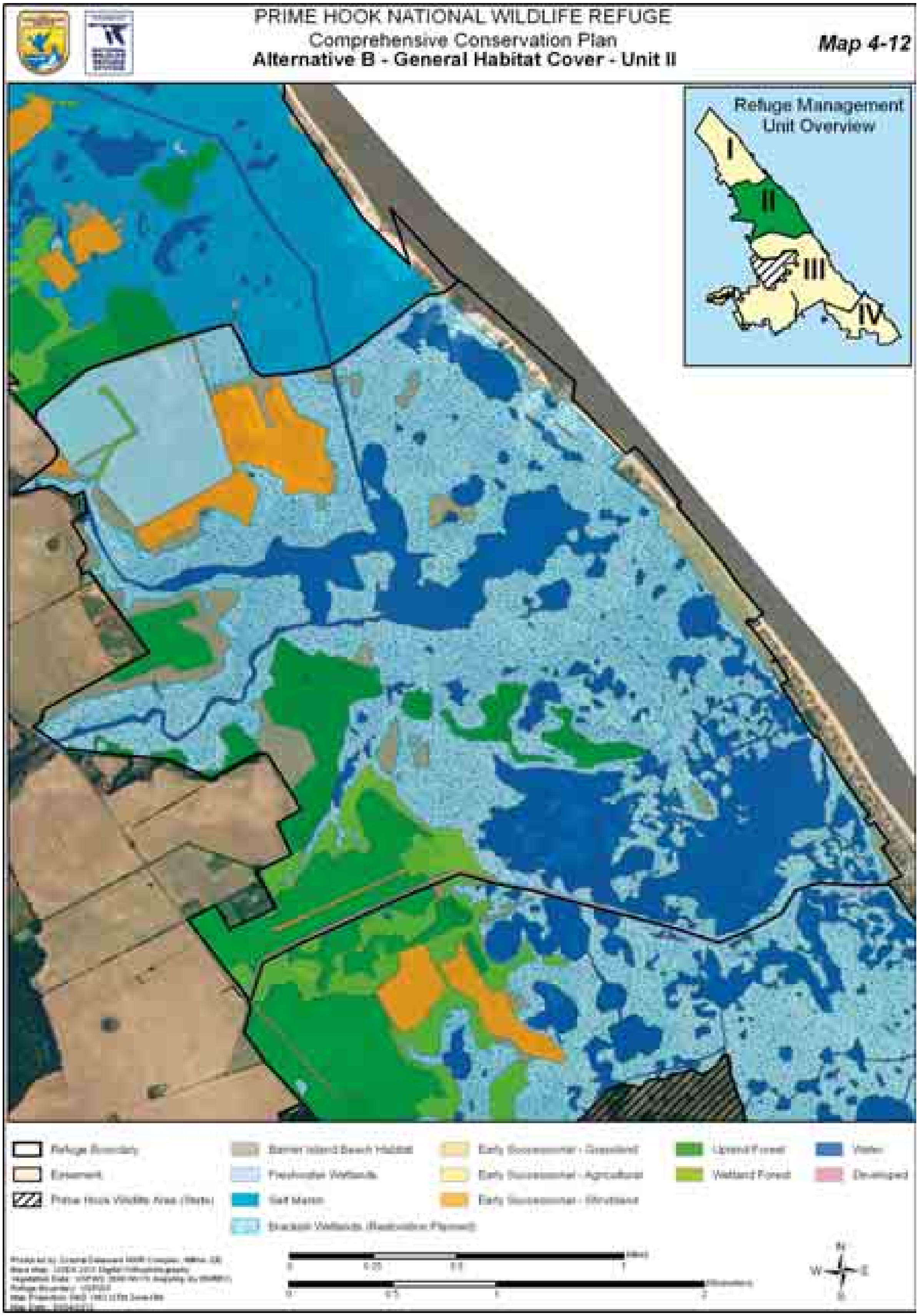
Map 4-10. Overview of general habitat cover under alternative B



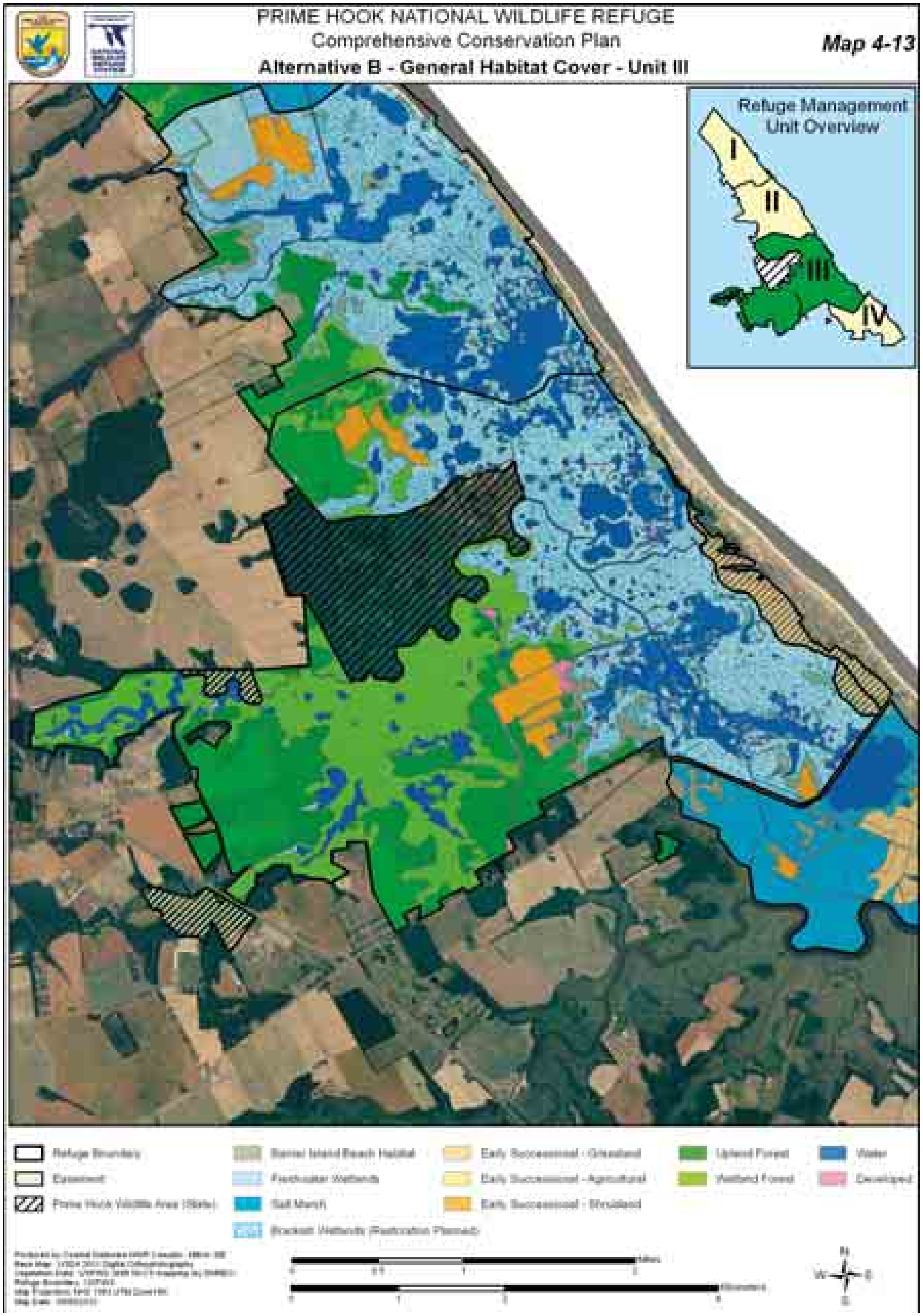
Map 4-11. General habitat cover in Unit I under alternative B



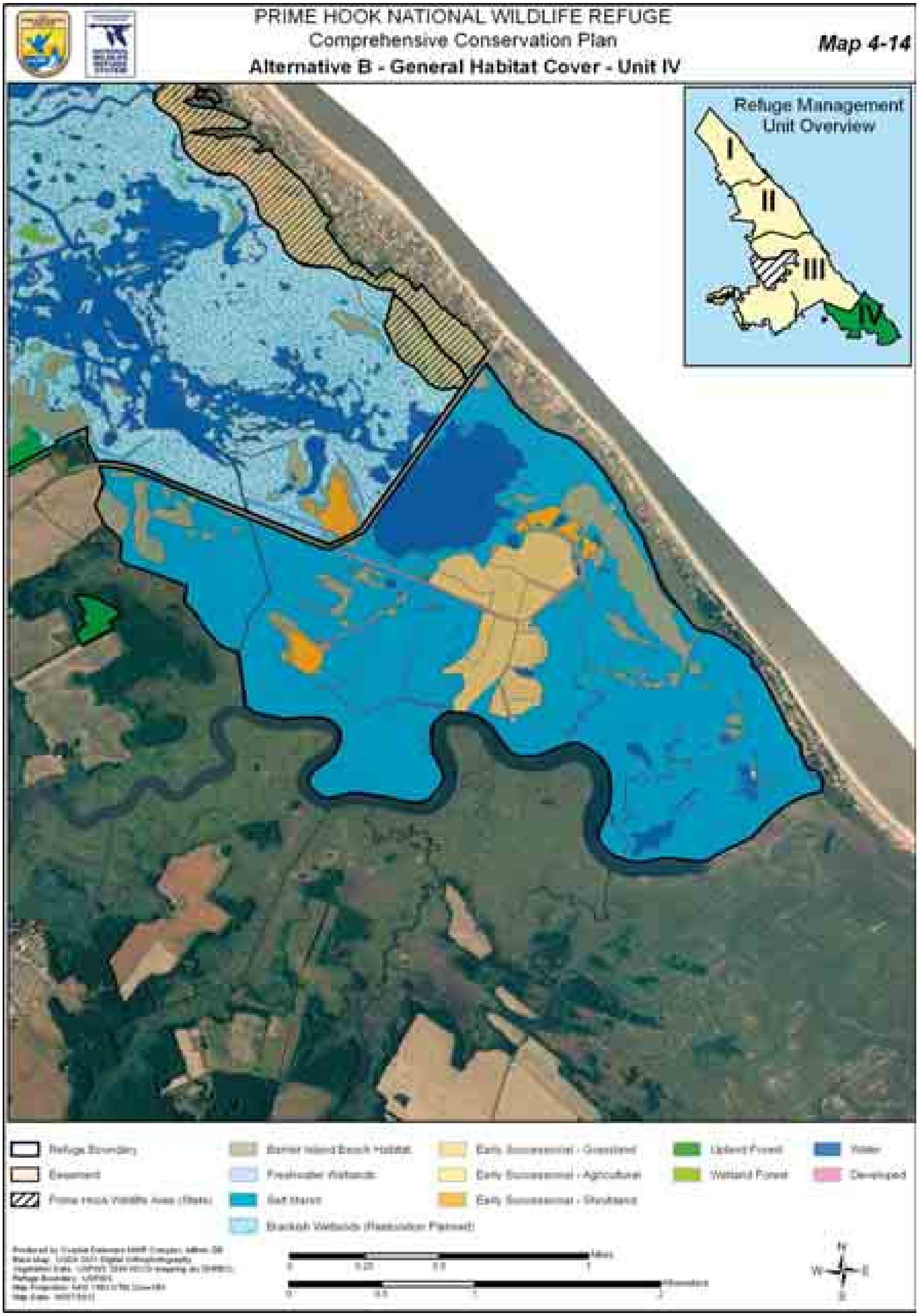
Map 4-12. General habitat cover in Unit II under alternative B



Map 4-13. General habitat cover in Unit III under alternative B



Map 4-14. General habitat cover in Unit IV under alternative B



Most notably, for salt marsh enhancement where intrusion of tidal waters and the collapse of the peat substrate has occurred, we will pursue strategies to compensate for lost marsh platform elevation, in order to support the growth of salt marsh vegetation. This may include the addition of dredged sediment through a carefully planned restoration project, and/or smaller actions to encourage natural accretion of sediment. Additional sediments may also be needed to enhance overwash flats and to potentially create low dunes or islets within the marsh. However, the purpose of these actions is not to rebuild a barrier island in the same alignment as the former barrier island but to allow for a diverse array of maritime habitats which would naturally occur in a mid-Atlantic bay, marsh, and beach/spit system. In upland habitats, there will be an emphasis on restoring native forest cover in previously farmed or otherwise open fields.

For public use under alternative B, we would expand existing opportunities for all six priority public uses, with additional emphasis on hunting and wildlife observation and photography. Map 4-15 depicts the public use facilities proposed under alternative B.

As compared to Alternative A, which represents current hunting and fishing opportunities, opportunities for hunting and fishing will be enhanced under Alternative B. These enhancements consist of expanding fishing and hunting areas, increasing the number of hunt days, reducing the administrative burden of the hunts, eliminating permit hunting fees except for lottery hunts, providing better outreach and information materials, phasing out the permanent hunting structures, and providing opportunities for preseason lottery hunts for waterfowl and deer. We will expand new areas and provide new opportunities for wildlife viewing, photography, and interpretation primarily by opening existing roads and trails and providing new infrastructure. In addition, a photography blind overlooking a restored wetland site is proposed. Furthermore, new visitor infrastructure, including additional building space for environmental education programs, an interpretive auto tour route using advanced technology, and additional guided field trips would be developed.

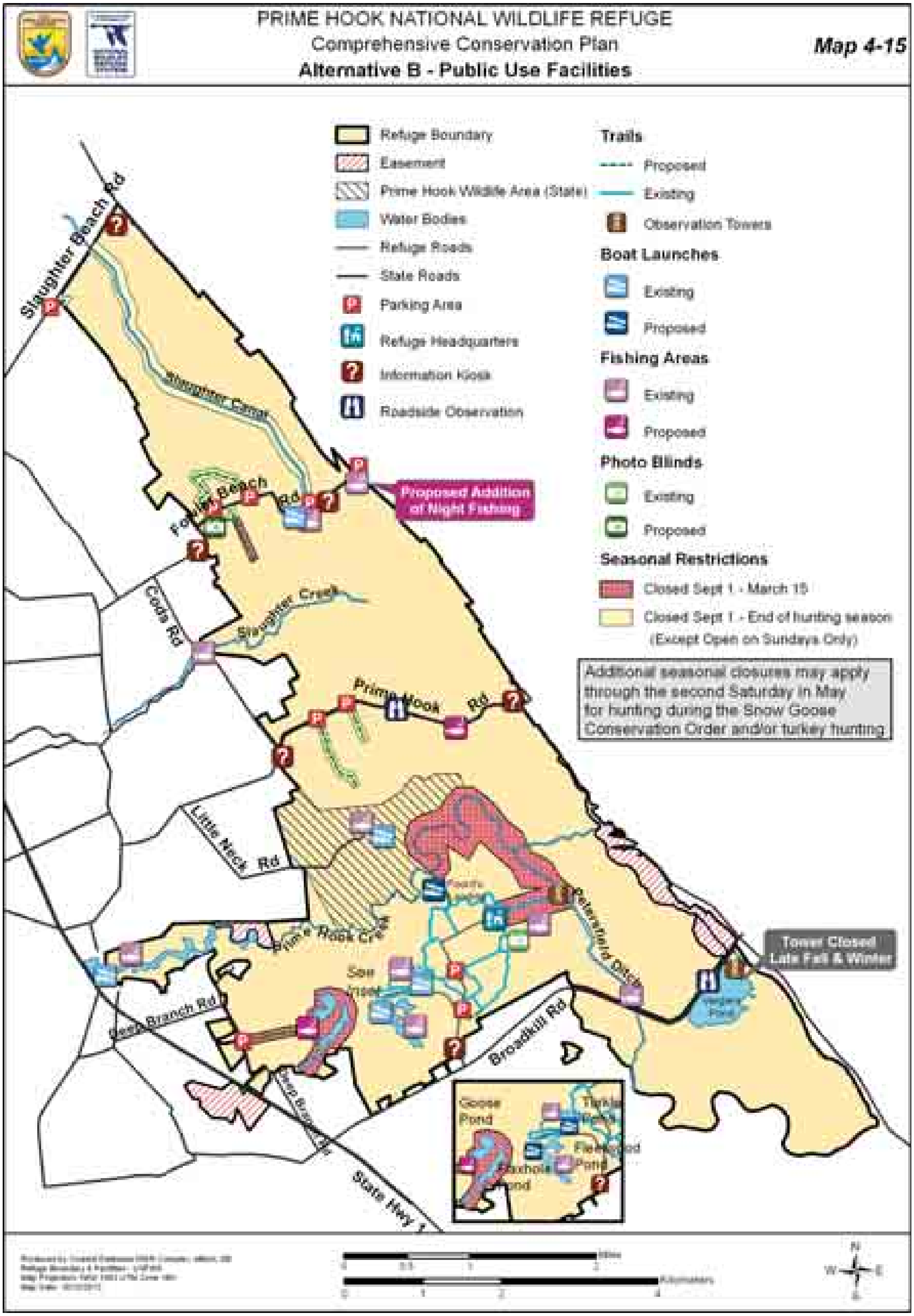
- Concerning other refuge uses, we would continue to allow wildlife observation, wildlife photography, hunting, fishing, environmental education, environmental interpretation, limited mosquito control, research, and use of the Federal Aviation Administration tower. Commercially guided birding and canoeing trips and commercial photography would be permitted with a signed special use permit and fee. Activities evaluated by the refuge manager and determined not to be appropriate on refuge lands can be found in appendix E.

We would also enhance local community outreach and partnerships, continue to support a Friends Group, and continue to provide valuable volunteer experiences. As described under goal 6, we would pursue establishing demonstration areas on the refuge to promote research, and developing applied management practices to benefit the species and habitats identified in this alternative.

Under this alternative, we propose to achieve a staffing level that meets minimum requirements for a refuge of this size and stature, potentially adding five new positions (clerk, biological technician, maintenance worker, law enforcement officer, and public use specialist). Any staffing increases would be based on available permanent funding sources, and would be considered in the context of regional and refuge priorities.

We would seek to expand the current office building to accommodate additional visitors for environmental education and interpretive programs. This office

Map 4-15. Public use facilities under alternative B



expansion would also provide needed space for storage of visitor services, supplies, and biological equipment. We would continue the use of travel trailers, which are used for interns, researchers, volunteers, and temporary employees.

In the discussion that follows, we describe in detail the goals, objectives, and associated rationales and strategies that we would use to implement alternative B habitat management and public use objectives. We have provided additional discussion and strategies specifically regarding our response to climate change and sea level rise.

GOAL 1. Barrier Beach Island and Coastal Salt Marsh Habitats

Manage, enhance, and protect the dynamic barrier beach island ecosystem for migratory birds, breeding shorebirds, and other marine fauna and flora. Perpetuate the biological integrity, diversity, and environmental health of North Atlantic high and low salt marsh habitats.

Objective 1.1 Barrier Beach Communities: Overwash, Sandy Beach, and Mudflat

Permit the natural evolution and functioning of sandy beach, overwash, dune grassland, and mudflat habitats along approximately 1.5 miles of refuge coastline in Unit I to conserve spawning horseshoe crabs and listed BCR 30 migratory bird species. Over time, permit the development of these features and communities along an additional approximately 1.5 miles of the shore of Unit II, as salt marsh restoration is pursued. Barrier beach communities are characterized by the following attributes:

- Plant species typical of overwash grasslands include a mixture of *Cakile eduntula, Spartina patens, Schoenoplectus pungens, Cenchrus tribuloides, Triplasis purpurea*, and scattered *Baccharis halimifolia* seedlings.
- Diagnostic dune grassland species consist of a mixture of *Ammophila breviligulata, Solidago sempervirens, Panicum amarum,* and *Opuntia humifusa*.

In years when piping plovers, American oystercatchers, or least and common terns nest, maintain suitable nesting habitat through beach closures, predator management, and public education to achieve minimum productivity rates as defined within current recovery or management plans. Proposed productivity targets are:

- 1.5 piping plover chicks per nesting pair, on average, over a five-year period
- 0.35 American oystercatcher chicks per nesting pair
- 1 least or common tern chick per nesting pair

Rationale

Barrier beach island and coastal salt marsh habitats are priority conservation habitat types within the Delaware Bay and the mid-Atlantic coastal region. Remaining undeveloped coastal saltwater wetlands in Delaware support the greatest diversity of species of conservation concern, while beach overwash and dunes provide habitats for some of the State’s and region’s most critically rare and threatened species. Saltwater marsh and sandy overwash beach habitats also support a shorebird migration that has worldwide ecological significance.

Despite the heavy loss of habitat, Delaware Bay remains one of the country’s most important migratory stopovers for hundreds of bird species (USFWS 2003d). All remaining beach dune and overwash habitat patches are considered critical habitats regardless of size. These habitats are the most representative of the region, and should receive priority conservation protection on the refuge, especially during the critical breeding and migration periods for highest priority shorebird species identified in BCR 30, BCC 2008, and bird and insect species identified in the DNREC (2005b).

On the refuge, barrier beach island habitats are comprised of five natural community types:

- Overwash dunes
- Beachgrass/panicgrass dune grassland
- Atlantic coastal interdune swale
- Maritime red cedar woodland
- Successional maritime forest

These highly dynamic habitats are closely related to the natural ecological processes of estuarine tidal creek shrubland, *Spartina* low and high salt marsh communities. Processes creating all of these habitat types include tidal salt water flows and eolian actions that contribute to active sand deposition or erosion. Natural ecological processes responsible for shifting mosaics of sandy beach, mudflats, and inland salt marsh habitat migrations have been impeded or altered by human activities within the Delaware landscape.

Storm-maintained ecosystems are critical during breeding and migration periods for the highest priority shorebird species identified in BCR 30 and birds of conservation concern (USFWS 2008a), plus pollinator species, birds, and rare insect species of greatest conservation need identified in Delaware's wildlife action plan (2005). Maintaining natural coastal formation processes provides high quality breeding habitats critical for American oystercatchers, least terns, common terns, piping plovers, black skimmers, beach dune tiger beetles, and seabeach amaranth, which all depend on habitats maintained by coastal storms.

A dune system with overwash and ephemeral inlets, identified as a key wildlife habitat of special conservation concern in the Delaware wildlife action plan and BCR 30 plan, is found from the northernmost private residence on Prime Hook Beach, north to Slaughter Beach. Beach heather *(Hudsonia tomentosa)*, beach plum *(Prunus maritima)* and dune panicgrass (*Panicum amarum*) are interspersed with several overwash habitats along Unit I and Unit II. In 2006, Hurricane Ernesto plus several nor'easter storms of 2007 and 2008 expanded the overwash habitats, flattened most dune areas, and increased tidal flows in the salt marsh. This has increased habitat availability for shorebirds by providing greater amounts of invertebrate and fish food resources flowing in daily from the Delaware Bay for easier exploitation by nesting and migrating birds. Refuge sandy beach and overwash dune grassland habitats have recorded greater use by spring and fall migrating shorebirds since 2006. There has been an increase in nesting attempts by American oystercatcher, least terns, and common terns. Observations of piping plovers staging on the refuge, and spilling over from State-protected breeding piping plover beaches, suggest that refuge barrier beach island habitats could potentially host State and federally endangered nesting shorebird species in the near future.

Immediately parallel to the Delaware Bay, Unit I habitats have increasingly become more important for both migrating and breeding shorebirds in the face of beach development along bayshore areas. The highest quality dunes remaining along the Delaware Bay shore occur from Big Stone Beach (about 7 miles north of the refuge) south to Beach Plum Island (about one mile south of the refuge) (Clancy et al. 1997) and have been identified as a key wildlife habitat of special conservation concern in the State plan and the BCR 30 plan. Beach strand habitats along the bay are migrating landward as a result of storm surges and sea level rise. Storms and high tides deposit wrack composed of algae, vascular plant fragments, assorted mollusk shells, whelk casings, and remnants of clams, crab, and fish. This rich organic debris provides important feeding and breeding sites for a variety of invertebrates. Coupled with spawning sites for horseshoe crabs, wrack lines provide nutritious and plentiful natural food resources for migrating birds year-round and for nesting birds in the spring and summer.

Strategies

- Allow the natural processes of inlet formation, sand migration, and overwash development.

- Avoid artificial dune stabilization where tidal flow from Delaware Bay is naturally restoring Unit I salt marsh habitats or transitioning refuge impoundments into a salt marsh.

- Develop site-specific restoration recommendations for Unit II, with the continued input of a diverse group of wetland management and restoration experts, state and Federal officials, academic scientists, and community representatives for short-term and long-term shoreline management to maximize the success of salt marsh restoration efforts.

- Control invasive plant species (mostly *Phragmites australis* and *Salsola kali*).

- Seasonally protect beach berm, wrackline and associated dune edge, and overwash from human disturbance to protect listed and candidate breeding and migrating shorebirds, establishing and enforcing nesting area closures from March 1st to September 1st.

- Use high visibility law enforcement patrols to implement beach closures.

- Develop a refuge-specific piping plover contingency management plan should piping plovers establish nesting sites on refuge overwash areas.

- Determine the potential number of nesting pairs of American oystercatcher, piping plover, and other focal species that could be supported by available overwash, sandy beach, and dune grassland habitats by 2012, to fine-tune protection prescriptions.

- Fence and post areas annually to protect breeding and migrating shorebird species at critical times from human disturbance. In years when piping plovers, American oystercatchers, or least and common terns nest, maintain suitable nesting habitat through beach closures, predator management, and public education.

- Eliminate dog use of refuge beach strand habitats to protect nesting and migrating shorebirds during the same time frame.

- Assess red fox, raccoon, feral cat, and other predator problems along refuge beach strand habitats and implement predator control in collaboration with USDA Wildlife Services. Work with State and Federal endangered species specialists to determine the number of American oystercatcher, least and common terns, and piping plover that can be supported by these refuge habitats.

Monitoring Elements

Develop a comprehensive monitoring and survey programs to measure our success with respect to our objectives. The results may trigger adjustments to management strategies, or a reevaluation or refinement of our objectives. Details of planned monitoring will be developed in a subsequent inventory and monitoring plan. Examples of monitoring or surveys that we may implement include:

- Determine the number of nesting pairs of American oystercatcher, least and common terns, and piping plover and estimate productivity conduct annual surveys during the breeding and nesting season.
- Prevent new invasive species from becoming established by utilizing early detection rapid response techniques to detect newly established invasive species and immediately address those populations through the appropriate control measure. This approach will incorporate a combination of plant identification and inventories, maintain updates of new invasive species present in the region, and provide knowledge of the appropriate management techniques prior to conducting control efforts.
- Establish annual habitat assessment protocols of overwash areas and mini-inlet openings and closures along Unit I and Unit II beach strand habitats to monitor expansion and contraction of overwash acreages, creation and plugging of mini-inlets, and tidal flow changes feeding Unit I salt marshes using GPS/GIS tools.
- Use presence or absence of the beach dune tiger beetle as an indicator species of healthy overwash, dune grassland, and sandy beach habitats.
- Conduct shoreline position and topography monitoring along the full length of refuge coastline, consistent with National Park Service protocols and in coordination with other Northeast Region refuges.
- Conduct surveys to determine presence or absence of northeastern beach tiger beetles to assess the health of overwash, dune grassland, and sandy beach habitat.
- Develop and implement weekly bird monitoring protocols. Utilize data to document the ongoing effectiveness of water level management activities and adjust management protocols as necessary.
- Continue monitoring of rare flora and fauna and work on establishing BIDEH metrics to evaluate annual habitat condition of barrier beach island habitats on refuge and State lands.
- Monitor habitat impacts from public use and impacts to resources of concern during the spring and summer periods.
- Maintain suitable nesting habitat for beach nesting shorebirds, monitor presence of red fox, raccoon, feral cats, and other predators and implement predator removal measures in collaboration with USDA Wildlife Services.
- Work collaboratively with Delaware's Coastal Programs to set up physical markers on the ground to establish baseline of overwash formations, sea level rise changes, and changes in tidal flow patterns.
- Re-survey and calibrate all refuge water control structures to reflect the true local mean sea level of refuge marshes and water inflows and outlets.
- Reset all gauges to one common vertical datum.

- Establish several tides gauges, starting with locations in Slaughter Canal in Unit I and Broadkill River in Unit IV.

Climate Change and Sea Level Rise Adaptation Rationale
The shoreline on the western side of the Delaware Bay, which includes coastal areas within the refuge boundary, is characterized as a lagoon-barrier-marsh shoreline (Kraft et al. 1976). These shoreline areas occupy a low-lying coastal plain and are part of a larger geological structure known as the Atlantic coastal plain continental geosyncline. Delaware shorelines of both the Atlantic Ocean and Delaware Bay are migrating rapidly in geologic time in a landward direction (Kraft and John 1976b). This is caused by several geological processes:

- The continental shelf and coastal plain are known to be experiencing deep subsidence

- Global sea level rise

- Erosion and redistribution of sediments as shorelines shift in a landward and upward direction in response to the rise in relative sea level.

Inlet formation acts as a safety valve mechanism by adjusting and shifting in size and location in response to each storm event or higher than normal tide cycles. The dynamic nature of inlets means that a stable, deep channel is rarely maintained naturally and inlets are filled after they are formed. Barrier island shorelines are dependent upon storm overwash formations to build shoreline elevation and width, and both inlet and overwash developments are critical processes that allow these sandy beach ecosystems to keep pace with sea level rise. Overwash events also provide sediment inputs, helping coastal wetlands accumulate material reserves—or elevation capital—which increase the marsh elevation and may buffer these systems from rising sea levels (Cahoon and Guntenspergen 2010, Kraft and John 1976a, Drew 1981, Riggs and Ames 2007, Defeo et al. 2009).

Even non-storm tidal surges can produce waves that overtop beach berms on the Delaware Bay shoreline, resulting in overwash fans on the marsh side of the shoreline. Through time, overwash events bury the marshes and associated peat deposits, fill in old inlet channels, or create new ones. During the last 47 years, numerous mini-inlets, various depositional overwash fans and shoreline recessions have occurred on the refuge. These natural processes are driven by hurricanes and nor'easters and are all crucial and integral elements for both short-term and long-term evolution of healthy shoreline habitats (Kraft and John 1976a, Drew 1981, Defeo et al. 2009, Pilkey and Young 2009). Shoreline transgression enables wetlands behind shorelines to accrete sediments and keep up with sea level rise. Restored tidal flows also enhance salt marsh habitat and water quality (Cahoon et al. 2010). The ability of salt marshes to build upward and migrate landward with their associated shorelines has been a natural response to sea level rise for thousands of years.

A major issue for the conservation, management, and vulnerability assessment of all refuge coastal wetland habitats in the face of climate change and sea level rise is the magnitude and rate of shoreline change in coming years. Coastal geomorphological changes and shoreline condition will be a direct consequence of sea level rise inundation (CCSP 2009). Monitoring coastal shoreline position provides coastal managers with more detailed knowledge of sediment mobilization, transport, deposition, and measurements of morphologic changes and ecosystem response. Shoreline position information has high data value because it can be used to address refuge shoreline management issues (Psuty et al. 2010).

From a scientific perspective, shoreline position represents the morphological response of wave, current, tide, and other physical processes acting on sediment supply (Short 1999). Understanding the dynamics of changes in shoreline position over time, in a systematic manner and through standardized data collection, will provide a scientific basis for informed sediment resource management. The assemblage of reliable and consistent data enables robust statistical analysis, and yields a better understanding of local sediment budget cycles, trends, and storm episode influences (Psuty et al. 2010). Collecting a record of the changes in the shoreline position over time will monitor variations in sediment supply and distribution and can also function as a surrogate for sediment budget. The determination of shoreline position twice a year, in the early spring (fully developed winter beach) and in the early fall (fully developed summer beach), will lead to a time series of seasonal shoreline positions that represent the annual maximum and minimum configurations of the beach. Each annual pair of shoreline position data will document the variation caused by changes in the seasonal wave patterns on the beach sediment supply (Psuty et al. 2010).

Refuge shoreline habitats include areas of wide coastal marshes separated from the Delaware Bay by a continuous, relatively narrow, sandy coastal barrier. This zone starts at Bowers Beach and continues southward to the Great Marsh in Lewes, and is one in which the longshore transport (parallel to the shoreline) of sand and mud sediments is fairly continuous. In this zone, a broad wave fetch that results in wave action and longshore drift systems helps maintain continuous barrier beach habitats between broad coastal marshes and the Delaware Bay. Within a tidal regime and frequent storm setting, sand is normally washed across barrier beach island habitats into marsh areas. However, these barrier beach island segments of Delaware Bay have a relatively limited supply of sand, resulting in narrow and shallow shorelines (sand sediment is rarely deeper than 5 feet and no more than several hundred feet wide), dominated by inlet and overwash processes (Kraft et al. 1976a).

Climate Change and Sea Level Rise Adaptation Strategies and Monitoring
Management to maintain beach habitats requires long-term mitigation and adaptation strategies. Adaptation would allow the beach to migrate inland as the sea rises. Adaptive measures accept the reality of sea level rise and coastline retreat and seek to increase coastal resilience, a concept with ecological, morphological, and socioeconomic components (Carpenter and Folke 2006). Measures to promote resilience include the protection, vegetation, and maintenance of sediment supply to beach habitats, and the provision of buffer zones that allow the landward migration of the coastline. Monitoring is an important component of managing this dynamic system. Strategies include those listed above plus:

- Conduct shoreline surveys according to National Park Service protocols (Northeast Coastal and Barrier Network (NCBN)-Geomorphological Monitoring Protocol) for shoreline position (Natural Resource Report (NPS-NCBN-NRR-2010/185). Protocols include a number of highly detailed standard operating procedures that are intended to ensure scientific consistency and repeatability. Minimally, conduct these surveys in early spring (mid-March to late April) and early fall (mid-September to late October), periods that coincide with the peak expression of seasonal beach variability.

- Coordinate refuge shoreline monitoring efforts with other coastal refuges to integrate the NCBN database to foster Departmentwide sharing of standardized monitoring data. Implement the vital signs program's shoreline position monitoring protocol and shoreline topography monitoring protocol.

Objective 1.2 Maritime Shrub and Maritime Forested Habitats

Over the next 15 years, maintain and protect unique and uncommon maritime shrub and forested habitats which include approximately 60 acres of Atlantic Coast interdune swale, more than 70 acres of maritime red cedar, and more than 180 acres of successional maritime forest communities for migrating passerines and other maritime shrub and forest-dependent species. This approach would allow us to maintain existing shrub and forest habitats or to plant the appropriate native species as invasives are removed or disturbed areas are restored to accelerate the pace of natural native species regeneration.

Manage these habitats especially for short and long distance migrating songbirds, breeding birds, and rare flora and fauna dependent on maritime shrub-forest ecosystems. Conserve insect species (butterflies, skippers, moths, etc.) associated with these habitats include the following state ranked (S-1) species found on the refuge:

- Little wife underwing—*Catocala muliercula*
- Southern broken dash—*Wallengrenia otho*
- Delaware skipper—*Anatrytone logan*
- Little glassywing—*Pompeius verna*
- Graphic moth—*Drasteria graphica*

Rationale

Atlantic Coast interdune swale, mid-atlantic maritime red cedar and successional maritime forested habitats are underrepresented within Delaware's landscape of natural communities and regionally at the mid-Atlantic coastal plain level. These habitat types found on the refuge range from unvegetated pools and interdune swales, to grass or forb-dominated or shrub-dominated communities, to red cedar woodlands and maritime shrub-forested areas.

Prime Hook NWR's maritime red cedar community is recognized as an exemplary natural community of biological diversity in the state (McAvoy et al. 2007). In addition, NatureServe has ranked it as globally rare (G2) in its habitat analysis report of the refuge's NVCS alliance and association descriptions (Prime Hook NWR NatureServe Report 2006).

Widespread population decline in many migratory songbird species is one of the most critical issues in avian conservation. Studies have shown the critical role that barrier beach island shrub and maritime forested communities play for migratory passerines during the fall migration (McCann 1993, Clancy et al. 1997).

The McCann study demonstrated that often these habitats support more than twice as many migratory landbirds as adjacent mainland forested habitats. This is attributed to the fact that birds migrating long distances first reach landfall on barrier beach island habitats. These areas are also the last stopover place where migratory passerines congregate to forage in dense mid-Atlantic shrub and maritime forested habitats that have significant populations of invertebrates and high production of fruits and berries, which provide the energy the birds require before moving on to their wintering grounds.

Radar data collected from migrants departing from stopover coastal habitat sites on Prime Hook NWR and along the Delaware Bay also support the importance of maintaining and managing healthy maritime shrub and forested habitats. High densities of migratory songbirds during fall migration events along the Atlantic Coast and Delmarva Peninsula have been attributed to a higher proportion of hatching year birds and maritime shrub and forested habitats containing a significant abundance of energy rich food resources in the form of fruits, berries, and high densities of insects (Mizrahi 2006, Dawson and Butler 2010).

Strategies

- Maintain or enhance native vegetation communities using prescribed fire where appropriate; consult with the Service's regional fire wildlife biologist to determine, if, when, and where prescribed fire would be appropriate to reduce invasive species, maintain shrub habitats, or maintain or enhance successional maritime forest community health.

- Prevent new invasive species from becoming established by utilizing early detection rapid response techniques that detect newly established invasive species and immediately addresses those populations through the appropriate control measure.

- In an effort to minimize non-target affects on-refuge, the Service will permit the use of adulticides as a management tool once the Section's surveillance program has detected a mosquito-borne human health threat on the refuge or within the flight range of vector mosquitoes, the average of which, according to the Rutgers Center for Vector Biology, is generally considered to be less than 5 miles for the eastern saltmarsh mosquito, Ochlerotatus sollicitans.

Monitoring Elements

Conduct appropriate monitoring and survey programs as funding and staffing permit to measure our success with respect to our objectives. The results may trigger adjustments to management strategies, or reevaluations or refinement of our objectives. Details of planned monitoring will be developed in a subsequent inventory and monitoring plan. Examples of monitoring or surveys that we may implement include:

- Reevaluate existing refuge breeding bird survey points to determine whether they are placed appropriately to monitor birds of conservation concern identified in the Delaware wildlife action plan, BCR 30, and Partners in Flight 44 plans, and establish spring, fall, and breeding landbird survey points in these habitats types, where needed.

- Monitor the little wife underwing moth as an indicator of healthy red cedar woodland and successional maritime forested habitats that contain southern bayberry as a vegetative component.

- Conduct annual habitat condition assessments, survey for invasive species problems, and prioritize treatment areas.

- Evaluate the effectiveness of prescribed burning to reduce invasive species or maintain shrub habitats by conducting post-burn surveys to measure the area, intensity, and success of the burn.

Objective 1.3 North Atlantic Low and High Salt Marsh Habitats

By 2020, enhance the ecological integrity of 2,200 acres of existing salt marsh by 10 percent over baseline condition, as quantified by the regional salt marsh integrity index. Maintaining a mix of North Atlantic high and low salt marsh vegetation composed of less than 5 percent invasive plant cover and pool, panne, and irregularly flooded tidal salt shrub communities consistent with local reference sites will ensure that the quality and natural function of the marsh and tidal hydrology are restored and sustained. This will provide food resources and habitat for nesting species (e.g., seaside sparrow, salt marsh sharp-tailed sparrow, coastal plain swamp sparrow, Henslow's sparrow, sedge wren, black rail, clapper rail, least tern, gull-billed tern, black skimmer, willet, American black duck), migrating and wintering habitat for shorebirds and waterfowl, and passage and rearing habitats for diadromous and prey fish species and marine invertebrates.

- Increase cover of native vegetation to greater than 95 percent by controlling the presence of invasive plant species. Native plant species found high salt marsh communities include *Spartina patens, Distichlis spicata*, and *Juncus gerardii,* with lower densities of *Aster tenuifolius, A. subulatus, Atriplex patula, Solidago sempervirens*, and *Panicum virgatum*. In low marsh communities, native plant species include *Spartina alterniflora,* with lower densities or *Distichlis spicata, Salicornia maritima, Juncus gerardii*, and *Juncus roemerianus*.

- Special emphasis will be given to conserving and protecting small patches of remnant high salt marsh areas on the refuge that are less common than low marsh communities.

- For breeding obligate passerines, maintain extensive stands of salt-meadow hay with scattered shrubs or clumps of black needle rush and salt grass.

- Develop up to 4,000 acres of additional salt marsh within the refuge impounded wetland complex through active wetland restoration efforts; these efforts will be guided by a restoration plan developed with assistance from State and Federal coastal scientists and other subject matter experts (see objective 3.1).

Rationale

Salt marshes in North America are among the most degraded of all habitats (Amezaga et al. 2002). Within the mid-Atlantic region, a substantial number of salt marshes have been lost over the past 200 years. From 1950 to 1970, loss rates were extremely high due to urban and industrial development (Tiner 1985). Protective legislation helped to slow the loss with the passage of the Wetlands Act in 1972, when Delaware was losing nearly 450 acres of salt marsh annually. After protective legislation, losses declined to 20 acres per year (Hadisky and Klemas 1983). Other states in the region experienced similar trends.

Habitat analysis mapping for Delaware shows less than 7 percent of herbaceous wetland habitats remain on the landscape (appendix A) while salt marsh communities are listed as habitats of conservation concern in the DNREC (2005b). Tidal salt marshes are one of the most productive ecosystems and provide significant invertebrate and small fish trophic levels that support many bird communities throughout the year. Patches of low marsh are abundant in the State and refuge landscapes, but high marsh is very uncommon and spatially restricted on the refuge, with less than 85 acres of high marsh compared to 1,756 acres of low marsh (McAvoy et al. 2007).

BCR 30 and Partners in Flight 44 plans listed eight species with high conservation concern scores dependent on salt marsh habitats. Priority species using the low marsh include seaside sparrow and clapper rail, and priority species using the high marsh include salt marsh sharp-tailed sparrow, black rail, prairie warbler, Henslow's sparrow, American black duck, willet, and sedge wren. Species that require high-marsh habitats are the most threatened marsh-nesting species in the region, State, and on the refuge. Within the mid-Atlantic Coastal Plain, all the high marsh species listed breed within extensive stands of salt-meadow hay with scattered shrubs or clumps of black needle rush and salt grass.

Salt marshes provide neighboring communities with flood protection. The presence of salt marsh vegetation in coastal marshes can reduce shoreline erosion by completely dissipating wave energy within 100 feet of the shoreline, which in turn increases the potential for sediment deposition (Morgan et al. 2009, Knutson 1988, Broome et al. 1992).

The regional salt marsh integrity index is a measure of ecological integrity, which includes both physical and biological factors and provides a basis for comparing and monitoring the health of salt marsh units on individual refuges and regionwide.

Mosquito Management in Salt Marshes

The Delaware Mosquito Control Section (hereafter referred to as the Section), under Service permits, has controlled mosquitoes on the refuge since its establishment in 1963. We have been working with our State partners to reduce the quantity of insecticides used on refuge lands and ensure activities are consistent with the Service's policies. Mosquito management is a complicated issue for the refuge. Prime Hook NWR is adjacent to residential beach communities where nuisance issues are amplified. Conflicts arise among nuisance complaints, managing refuge habitats for migratory birds, and maintaining and enhancing biological integrity, diversity, and environmental health within the refuge.

Although the refuge does not regard mosquito control, in and of itself, to be a salt marsh habitat management objective, the control of mosquitoes is a State priority and a reality of management of salt marshes in the State of Delaware. The refuge acknowledges a responsibility to permit management of mosquitoes when it is in the documented interest of public health to do so. There have been three techniques employed to control mosquito populations on the refuge within salt marsh habitats: use of the chemical adulticide, naled, source reduction using the chemical larvicides, Bti and methoprene, and a biological control facilitated by open marsh water management. These mosquito management methods were described in detail in chapter 3, under the discussion of invertebrates. Control of mosquitoes on refuges will be guided by the national Service mosquito management plan, which has not been finalized as of preparation of this CCP. In the interim, we look to the draft policy for guidance.

Integrated Pest Management Approach

The Section currently uses thresholds to determine how, when, and where to conduct mosquito control treatments. These thresholds may require revision under the mosquito management plan to bring them in line with refuge management policies.

Pest management strategies for mosquito control will be implemented by using a tiered risk-assessment decision making process that reduces the use of adulticides.We will not permit the use of adulticides solely for nuisance relief. Use of adulticides will be permitted in instances of an elevated public health threat from mosquito-borne disease . The refuge acknowledges this public responsibility. We are also choosing to employ Bti products over methoprene products, when possible. By favoring the larvicide that would have the least adverse impacts on nontarget invertebrates, we would produce fewer disruptions to food webs critical for migratory birds.

Strategies

- Assist with the development and use of the region's salt marsh integrity index to develop a multi-metric method to score condition of the salt marsh community; use the index as a performance measure to improve annual habitat management planning and restoration actions when scores are low.

- Enhance or restore any degraded wetlands, including salt marsh and adjacent upland habitats that buffer all refuge salt marsh habitats.

- Restore the natural hydrology to tidal marshes whenever feasible and allow natural processes to occur that increase tidal flows to salt marsh habitats.

- Develop an adaptive management framework for *Phragmites* control so treatments are monitored and evaluated for effectiveness. The refuge will be using an integrated approach to *Phragmites* control, which will consider restoration of natural processes, herbicides, prescribed burning, biocontrol, and other tools as they are developed.

- Control additional invasive species if and when they are encountered in the salt marsh

- Use obligate salt marsh passerines, such as the seaside sparrow, as indicators of biological integrity, diversity, and environmental health (BIDEH) for salt marsh habitats.

- Within 1 to 2 years of CCP approval, develop monitoring protocols and an annual biological monitoring and inventory program to document annual salt marsh condition, prescriptive management actions taken, and response to management actions.

- Consider continuing or resuming snow goose hunting to alleviate some snow goose use in salt marsh areas, to reduce salt marsh.

Mosquito Control Strategies

- Modify mosquito integrated pest management strategies to conserve and protect non-target species by restricting the use of adulticides unless they are required during situations of an elevated public health threat.

- Collaborate with State vector control personnel to develop specific action thresholds that would trigger chemical larvicide treatments; begin efficacy reporting of all treatment events to comply with Service end-of-the-year reporting requirements.

- Prepare a refuge mosquito management plan in collaboration with State mosquito control officials, to address human and wildlife health risks from mosquito-borne diseases and use action thresholds that trigger chemical interventions to be incorporated in a refuge decision making response matrix.

- Per mosquito management plan thresholds, permit limited use of larvicides in OMWM systems if appropriate data supports the assertion that the system has failed to function properly and is ineffective for controlling mosquitoes.

- OMWM excavation will be limited to the maintenance of currently existing systems; OMWM projects may not be expanded nor any new projects initiated on refuge lands until marsh elevation data is collected and analyzed. Additional studies that address the effects on obligate salt marsh passerines may be required before any decision will be made to resume construction of new open marsh water management treatments in previously grid ditched marshes.

- Educate refuge users and other public audiences about avian diversity and how it may help buffer human populations from mosquito-borne and other diseases.

Monitoring Elements
As funding and staffing permits, conduct appropriate monitoring and survey programs to measure our success with respect to our objectives. The results may trigger adjustments to management strategies, or reevaluations or refinement of our objectives. Details of planned monitoring will be developed in a subsequent inventory and monitoring plan. Examples of monitoring or surveys that we may implement include:

- Establish ongoing salt marsh monitoring program utilizing the region's salt marsh integrity index.

- Prevent new invasive species from becoming established by utilizing early detection rapid response techniques that detect newly established invasive species, and immediately addresses those populations through the appropriate control measures. This strategy will incorporate a combination of plant identification and inventories, maintaining updates of new invasive species present in the region, and knowing the appropriate management techniques prior to conducting control efforts.

- Develop monitoring protocols and an annual biological monitoring and inventory program to document annual salt marsh condition, prescriptive management action taken, and response to management actions.

- Continue research using OMWM, scoring data collected specific to refuge salt marsh habitat conditions, and incorporate in salt march integrity index assessments.

- Develop habitat monitoring protocols in cooperation with other refuges to quantify impacts (both positive and negative) of snow goose herbivory, increases or decreases of moist-soil invertebrate production, loss of low marsh acreage, and wintering carrying capacity of refuge habitats.

- Evaluate achievement of the objective for obligate salt marsh passerines, conduct bird surveys during the breeding season. Utilize data to document the effectiveness of management activities and adjust management protocols as necessary.

- Monitor elements for mosquito control.

Climate Change and Sea Level Rise Adaptation Rationale
Delaware Bay wide average salt marsh accretion rates have been estimated to range from 3.0 to 5.0 mm/yr (Kraft et al. 1989 in Fletcher et al. 1990). The dominant accretionary processes vary according to geomorphic settings. Peat accumulation is important to all wetlands in the Delaware Bay. Vertical accretion driven by peat accumulation is expected to increase in the future in response to sea level rise (Reed et al. 2008). However, salt marshes may only accrete up to a certain threshold rate set by natural processes. The rate of sea level rise may ultimately exceed and overwhelm the rate of marsh accretion, resulting in stress and potential loss of existing marshes. .

Delaware's Coastal Program is conducting a coastal impoundment accretion rate study. The State has collected baseline data on the sedimentation rates over the last 50 to 100 years in impounded and natural wetlands, by analyzing the presence of radioisotopes (^{210}Pb and ^{137}Cs) in sediment cores. This data can be utilized to evaluate a wetland's ability to achieve optimal habitat benefit under different management strategies and sea level rise scenarios. Correlating long-term wetland sedimentation rates to current wetland elevation will enable a detailed analysis of the potential sedimentation deficits that exist within the impoundments, as compared to the reference wetlands. The elevation and sedimentation gradients between the reference and impounded wetlands can be used to calculate potential future elevation trajectories under different sea level rise and management scenarios.

For this accretion rate study, monitoring sites were chosen within impounded and reference (natural marsh) sites throughout the State based upon a wetland area change analysis using a time-series of available imagery, and basins that have been identified as needing detailed study to aid in their management to optimize future available habitat. Sites studied include marshes along the Delaware River near New Castle, Ted Harvey Wildlife Area, St. Augustine Wildlife Area, and Prime Hook National Wildlife Refuge.

The early results indicate that the refuge's unimpounded salt marsh in Unit I is keeping pace with sea level rise. Based on radiometric sediment core analysis, estimated annual accretion over the past 50 to 100 years ranged from 3.1 mm/year to 6.9/mm/year. This is evidence that the processes discussed in objective 1.1 should be allowed to proceed naturally (Ashton et al. 2007). However, for Unit II and northern Unit III, these preliminary results showed that the marsh accretion rate was only about 1.6-1.7 mm/year, or about half the rate of recent local sea level rise. Since the breach occurred, this Unit has been largely inundated by bay waters and it is likely that it will require an infusion of sediments and/or strategies to accelerate natural accretion to support extensive, viable salt marsh. Thus, an effective monitoring program is necessary to develop an appropriate marsh restoration plan. For further discussion refer to the rationale under objective 1.1.

Climate Change and Sea Level Rise Adaptation Strategies and Monitoring
Strategies include those listed above and under objective 1.1, plus the following:

- Within 1 to 2 years, establish a refugewide marsh elevation and water monitoring program, to include the following components and steps:

  - Establish three monitoring stations within each of two existing salt marsh areas (and an additional six stations in each area of impounded wetlands), with surface elevation tables and marker horizons; read surface elevation table measurements minimally four times per year (seasonally), but ideally once per month, to track seasonal and periodic storm effects on marsh elevation.

  - Establish a real-time U.S. Geological Survey-type tide gauge on Slaughter Canal to begin to monitor localized storm effects on refuge hydrology.

  - Establish geodetic benchmarks in select upland refuge sites and calibrate to newly established surface elevation tables, tide gauges(s), and staff gauges located on water control structures, all to the same geodetic control (such as NAVD 88).

  - Conduct RTK-GPS surveys using regional or national protocols to connect prior survey data points (vegetation data, groundwater wells, bird points, etc.) to the same common geodetic control as used above.

  - After a minimum of 3 years, evaluate surface elevation table data to determine if the sampled areas of the marsh are experiencing shallow subsidence, i.e., is the upper marsh horizon, despite accretionary processes, still losing elevation relative to local sea level rise.

- The stresses imposed by climate change and sea level rise will force a shift in quantity and quality of available waterbird habitat on local and regional scales. To ameliorate the loss, the refuge will employ the protocols and directives of the integrated waterbird management and monitoring project, now under development.
- Permit the natural replenishment of sediments (through overwash) to allow the marsh to keep pace with sea level rise. Where it is determined this will not be sufficient to overcome elevational capital deficits, the use of artificial renourishment or assisted accretion may be appropriate.
- Continue to review new research and all monitoring results, seeking ways to adjust our management or restoration as deemed necessary, e.g., as new research and monitoring data on sea level rise and obligate salt marsh breeding birds come to light, one option to explore may be to fill or restore extant grid ditches and OMWM systems as an adaptation measure in response to climate change.
- Consult with Federal and State coastal scientists and other subject matter experts regarding the most effective way to restore salt marsh within the Unit II, and possibly Unit III, wetland impoundments; restoration options may include adding supplemental sediment, planting desirable species, or other techniques (see objective 3.1).

GOAL 2. Forested Habitats

Manage the biological diversity, integrity, and environmental health of refuge upland and wetland forested cover types to sustain high quality habitats for migratory birds and increase quality habitat for the endangered Delmarva fox squirrel, forest interior breeding and wintering landbirds, reptiles, amphibians, and other forest-dependent wildlife.

Forested Habitats Summary

We envision a composite long-term forest management goal, which combines objectives 2.1, 2.2, and 2.3 and their associated strategies that reflect the desired future conditions of a refuge forest matrix complex. This forest matrix complex incorporates the existing upland and wetland forested acreage, plus projected restored upland forest acreage, and management actions to be conducted on approximately 1,679 acres in the next 15 years. Mechanical silviculture management will generally not occur in hydric soils with the exception of some coastal plain depression swamp areas. A summary of anticipated future forested habitats and management is outlined in Table 4-1.

Table 4-1. Future refuge forest habitats envisioned in next 100 years, and silvicultural management expected over the next 15 years on wetland and upland forest habitats

Forest Habitat Cover-types	Forested Acres with Projected Restored Acres	Silvicultural Management Expected over the Next 15 Years?
Southern red oak/heath	295	Yes
Mesic coastal plain oak	193	Yes
Northern coastal plain basic mesic hardwood	35	Yes
Successional sweetgum	181	Yes
Mid-Atlantic mesic mixed hardwood	20	Yes
Red maple/seaside alder swamp	799	No

Forest Habitat Cover-types	Forested Acres with Projected Restored Acres	Silvicultural Management Expected over the Next 15 Years?
Atlantic white cedar/seaside alder swamp	10	Yes
Coastal plain depression swamp	355	A Portion (75 acres)
Coastal loblolly pine wetland	91	No
Buttonbush coastal plain swamp cottonwood	3	No
Restored mixed-hardwood-oak dominated areas	870	Yes
TOTAL ACRES	2,903	1,679

These desired future forest conditions include approximately 2,900 acres that minimally takes 100 years to develop, will encompass two core areas of restored mature, upland mid-Atlantic coastal plain mixed hardwood forest with a high oak component; one core area will surround red maple-seaside alder and Atlantic white cedar swamp, and the second core area will be restored to upland forest surrounding depressional swamp habitats (Map 4-10).

Restoring additional upland forested habitats is essential to increasing the refuge population size of Delmarva fox squirrels and providing larger forest tracts for breeding, area sensitive forest interior dwelling species. Conserving forested wetland habitats will provide critical supplemental late winter and early spring feeding habitats for fox squirrels and provide important foraging and stopover habitats for migrating landbirds (Mizrahi et al. 2006).

Objective 2.1 Mixed Hardwood Forest Communities

During the next 15 years, conserve and enhance existing forest cover-types to conserve forest interior dwelling birds (e.g., bald eagle, black-and-white warbler, wood thrush, scarlet tanager, whip-poor-will, yellow-throated vireo, and Kentucky warbler) and Delmarva fox squirrel and using silvicultural prescriptions as determined necessary through monitoring to meet the desired conditions criteria.

- Sustain and enhance mast producing trees (e.g., white and red oaks, hickories, walnuts) greater than 12 inch dbh to comprise at least 40 percent of the total canopy cover and with shrub canopy closure of less than 30 percent, providing suitable habitat structure for Delmarva fox squirrel.
- Sustain mature canopy closure 80 percent or greater, with a multi-layered tree species profile and canopy gaps to maximize annual mast production and ensure regeneration of shade-tolerant tree species (e.g., oaks).
- Sustain oak-dominated mixed hardwood patch sizes of greater than 250 acres. Use the presence of long-horned beetle as in indicator species for patch size and environmental health of oak-dominated mature forest stands.

Rationale

Ecosystem function of forested habitats in Delaware has steadily declined in the past four decades. A common consequence of the pattern and intensity of urban and agricultural development in Delaware has been the severe fragmentation of an originally connected forested landscape into an unhealthy and dysfunctional patchwork of isolated habitat patches (Statewide habitat gap analysis map, CCP appendix A). Extensive forest habitat loss and fragmentation provided the impetus for the state to designate upland forested blocks larger than 250 acres as key wildlife habitats in its wildlife action plan. While the Delaware Department of Agriculture's Forest Service owns and manages 9,000 acres, 81 percent of the State's remaining forested cover-type is in private ownership (ELI 1991, DNREC 2005b).

The loss of upland forest habitats has taken a huge toll on migratory songbirds and forest interior breeding birds that require large contiguous blocks of forested habitat. These include black-and-white warbler, whip-poor-will, cerulean warbler, hooded warbler, and American redstart. Also, severe habitat fragmentation and loss had caused the extirpation of the Delmarva fox squirrel from Delaware (ELI 1999). Many of the songbirds that have experienced regional and State declines are bird species that are area sensitive to forest fragmentation and its associated impacts, such as increased nest parasitism by edge species, increased rates of predation, and loss of quality nesting and wintering forested habitats. The Delaware Natural Heritage Program estimated that 41 percent of Delaware's historically common forest-dependent birds have been extirpated or today are extremely rare.

Creating and conserving larger patches of contiguous forested habitats are the best strategies to conserve and manage for area-sensitive vertebrate species, especially breeding and migrating songbirds and the Delmarva fox squirrel. The State plan has targeted many landbird species of greatest conservation need (e.g., summer tanager, black-and-white warbler, yellow-throated vireo, Kentucky warbler, worm-eating warbler, hooded warbler, and veery) as requiring more restored upland habitats and more intensive forest management to provide higher quality forest patches (DNREC 2005b).

The federally endangered Delmarva fox squirrel is a top priority resource. Its short-term viability and conservation recovery on the refuge will depend on actively managing and improving the current available oak-dominated mixed hardwood habitats. Improving and restoring forested habitats will provide potential to expand the current population size for the squirrel's long-term viability on the refuge, while simultaneously providing for and improving the conservation of forest interior dwelling birds.

Our wildlife and habitat analysis described in the CCP identified the Delmarva fox squirrel, forest interior dwelling birds, and other forest-dependent species as high priority management species, and identified forest habitats as a priority refuge habitat to manage for and restore within the next 15-year horizon. Once high priority forest focal species were identified, their life history requirements served as determinants of future forest conditions on the refuge. This habitat analysis determined that sustaining and enhancing a mature mid-Atlantic coastal plain mixed hardwood forest matrix with a high oak component, juxtaposed around a red maple-seaside alder-Atlantic white cedar/coastal plain depression swamp matrix, is the most important ecological contribution the refuge can make to recover the endangered Delmarva fox squirrel and conserve forest interior bird species in the region.

The 15-year scope of our CCP falls short of the decades we expect it will take to create and enhance this forest matrix and future desired forest conditions; we expect that it will take at least 100 years to fully implement some of our forest management goals and objectives. This timeframe is based on our prediction of how long it will take to achieve the desired forest matrix composition and structure of existing stands. Within this 100-year horizon, our long-term objective is to improve refuge forest habitats by developing a structurally diverse forest in terms of size, class, and growth forms (trees, shrubs, vines, and forbs) within a heterogeneous forest canopy. These mature forest stands will have mature trees (greater than 30 cm dbh) and a closed canopy (greater than 80 percent), suitable for the Delmarva fox squirrel (Dueser et al. 1988, Dueser 2000, Morris 2006). They may have patches of shrubs in the understory, which would be suitable for forest interior dwelling species of interest, such as Kentucky warbler (Table 4-1).

Silvicultural management can also be used to reduce the potential impact of gypsy moth and southern pine beetle threats to Delmarva fox squirrel habitat. The gypsy moth and southern pine beetle are the two most significant potential disease threats of the forests at the refuge. Although annual surveys since 1990 for gypsy moth have revealed that insect presence or densities have never reached defoliating levels, oaks are still highly susceptible to gypsy moth infestations. Monotypic stand representing greater than 80 percent of pines offer the highest risk for pine beetle infestation.

Encouraging the development of mixed hardwood stands and reducing monocultures of pines through silviculture management can decrease the likelihood of spot pine beetle infestation originating from monotypic stands. Assessing disease hazards (high, moderate, and low) in specific areas when cruising timber stands will provide improved information to plan prescribed forest management actions to protect Delmarva fox squirrel habitats.

Upland forest management enhancement will also benefit nesting and migrating bald eagles on the refuge. In July 2007, the Service removed the bald eagle from the list of endangered and threatened wildlife. However, other protections remain in place under the Bald and Golden Eagle Protection Act and Migratory Bird Treaty Act. To provide further clarity in the management of bald eagles after delisting, the Service published a regulatory definition of "disturb" as it relates to bald eagle management (50 CFR Part 17), plus there are national bald eagle management guidelines to ensure that eagle populations will continue to be sustained in the future.

The bald eagle due to its rarity and high level of threats in Delaware remains listed as a State endangered species. The refuge currently has two active bald eagle nests. Some birds disperse off-refuge but many birds remain and summer roosts average between 5 to 10 birds and winter refuge roosts may contain 15 to 25 birds. We will follow the State and national management guidelines when establishing nest and landscape buffer zones for bald eagle protection and actively manage and protect current bald eagle nesting and roosting sites on the refuge, which vary in numbers and locations each year.

Strategies

- Manage refuge forest stands to meet the habitat requirements of Delmarva fox squirrels, which are similar enough to also meet habitat requirements of priority forest interior dwelling birds listed as focal forest bird species (Table 4-2).

- During forest inventories, conduct assessment of potential for each stand to harbor gypsy moth and southern pine beetle using a high, moderate, or low disease hazard rating; assessment should be correlated to habitat suitability for Delmarva fox squirrel (good, fair, poor).

- Maintain or enhance forest health through the development of monitoring protocols for insect and disease vectors.

- Treat detected insect or disease infestations using salvage cuts, thinning, and other mechanical techniques, prescribed fire, and insecticides (e.g., *Bacillus thuringiensis* var. *kurstaki* (Btk) or Gypcheck for gypsy moths).

- Participate with other refuges in developing forest integrity index.
- Use prescribed fire where appropriate to maintain and enhance habitat structural requirements for the Delmarva fox squirrel and migratory birds.
- Increase or improve active forest management to enhance habitat quality for targeted songbirds through sound silvicultural practices such as thinning, selective cuts, and other stand improvement techniques in small patches less than 5 acres (2 ha).
- Minimize forest fragmentation; in all stand improvement activities, avoid fragmenting larger forest patches when possible.
- Regeneration cuts should be designed in a pattern that minimizes edge; circular or square cuts have the least amount of edge produced.
- Leave uncut forested buffers along creeks, ditches, streams, and adjacent to wetlands habitats; the wider the buffer, the more benefit it will provide to forest interior birds.
- Utilize triggers outlined in Table 4-2 as thresholds for stand improvement interventions to maintain and enhance wildlife habitat needs for priority focal management species. A time of year restriction. April 1 through July 31 would preclude any forest stand improvement as this is the main breeding season for the birds that utilize the refuge.
- Manage bald eagle nest sites in accordance with State and national bald eagle guidelines (USFWS 2007c), utilizing forest management techniques or prescribed fire and observing recommended time-of-year restrictions and buffer zone guidelines.
- Promote consistent annual mast production by using selection cuts where hard mast trees are greater than 15 inches dbh to develop larger, well-formed crowns and with a species composition target of one-third white oak, two-thirds red oak, and a mixture of hickory and walnut trees (McShea and Healy 2002).
- Do not cut den trees and trees adjacent to den trees during silvicultural treatments. Adjacent trees provide shade the bole of the den tree, keeping it cooler.
- To promote establishment of den sites, leave trees interfering with mast tree crown development standing and kill by girdling or using systemic herbicides (BNWR 1994).
- Explore opportunities to supplement the refuge Delmarva fox squirrel population through translocations.
- Implement field management prescriptions outlined in the habitat management plan (appendix B).

Monitoring Elements
Conduct appropriate monitoring and survey programs as funding and staffing permits to measure our success with respect to our objectives. The results may trigger adjustments to management strategies, or reevaluation or refinement of our objectives. Details of planned monitoring will be developed in a subsequent

inventory and monitoring plan. Examples of monitoring or surveys that we may implement include:

- Prevent new invasive species from becoming established by utilizing early detection rapid response techniques that detect newly established invasive species, and immediately addresses those populations through the appropriate control measure. This strategy will incorporate a combination of plant identification and inventories, maintaining updates of new invasive species present in the region, and knowing the appropriate management techniques prior to conducting control efforts.

- Establish forest inventory schedules on Prime Hook NWR to document stand-specific information of tree species composition, health of crown overstory trees, regeneration in stands, presence or absence of exotic insects at damaging levels, stocking levels, and map invasive plants to guide future refuge forest habitat maintenance, management, and reforestation decisions.

- Improve point-count monitoring surveys for listed forest communities in objective 2.1; include the monitoring of annual habitat condition and characteristics with associated points to assess bird use; monitoring should capture both breeding and migrating forest bird species.

- Monitor changing bald eagle nesting sites and make public use modifications or other habitat management actions necessary to protect sites during critical nesting periods.

- Use the presence of the long-horned beetle as an indicator species for patch size and environmental health of mature forest stands dominated by oaks; this beetle requires healthy, oak-dominated mixed hardwood patch sizes greater than 250 acres.

- Coordinate with the Chesapeake Bay Field Office to implement improved Delmarva fox squirrel monitoring techniques, such as motion-activated cameras, trapping and nest box checks, as recommended.

Table 4-2. Objective 2.1 mixed hardwood forest community maintenance and enhancement prescriptions

Target Forest Conditions	Condition to Trigger Management Action, as feasible
>80% canopy cover in the stand	< 80% canopy cover in the stand
Basal area 70 to 90 ft^2 / acre (16 to 20 m^2/ha)	Basal areas > 100 ft^2/acres (> 28 m^2/ ha)
60% to 80% stocking	> 100% stocking
Vines in overstory on 40%-60% of inventory (cruise) plots	Vines in overstory on < 30% of inventory (cruise) plots
Super-canopy trees on 10% to 20% of inventory (cruise) plots [= 4 to 6 super-canopy trees per acre]	Super-canopy trees < 5% of inventory (cruise) plots
Mid-story canopy cover on 30% to 60% of stand	Mid-story canopy on < 20% of stand
Vines in midstory on 50% to 70% of inventory (cruise) plots	Vines in midstory < 30% plots
Understory canopy cover less 30%	Understory canopy cover > 30% of stand
<30% ground cover occupancy average across inventory (cruise) plots	>30% ground cover occupancy average across inventory (cruise) plots

Target Forest Conditions	Condition to Trigger Management Action, as feasible
Regeneration of hard mast tree species (oaks and hickories) on 30% to 50% inventory (cruise) plots	Regeneration of hard mast tree species (oaks and hickories) on < 20% of inventory (cruise) plots
2 to 4 logs/acres that provide coarse woody debris	< 2 logs/acres providing coarse woody debris
4 to 6 cavity trees (snags) > 4 inches dbh/acres	< 4 cavity trees (snags) > 4 inch dbh/acres
1 to 4 large den trees or unsound cull trees per 10 acres	< 1 large den tree or unsound cull tree per 10 acres

Climate Change and Sea Level Rise Adaptation Rationale

Forest communities are expected to change in the face of climate change, as many tree species shift their ranges northward over time in response to changing conditions. Forest birds, as a group, are generally predicted to adapt well to climate change, with the exception of certain species. The State of the Birds 2010 Report on Climate Change, prepared by the Service in conjunction with numerous partners, addresses climate change impacts to various bird groups and attempts to quantify vulnerability on the basis of the following five factors of sensitivity: migration status, habitat specificity, dispersal ability, niche specificity, and reproductive potential (NABCI 2010). Only 2 percent of forest bird species show high vulnerability to climate change. However, more than half the species with medium or high vulnerability were not previously considered to be species of conservation concern (NABCI 2010). In other words, climate change effects could pose new challenges for species that are not at high risk today.

Expected shifts in eastern forest community distribution could lead to changes in the avian species communities on the refuge in the long term. The U.S. Forest Service provides predictions on these shifts in their climate change atlas which incorporates climate variables and tree species distributions (to quantify habitat availability) to model the current distribution patterns of 147 common bird species in the eastern United States (Matthews et al. 2007). The Forest Service used two climate model scenarios to forecast the shift in forest and bird distributions: the Canadian Climate Center model (CCC) and the Hadley Center for Climate Prediction and Research model (Hadley). The two models span the spectrum of predicted climate change using projected atmospheric carbon dioxide concentrations. Some forest species identified by NABCI to be especially vulnerable to climate change are predicted by the Forest Service atlas to increase in Delaware, perhaps presenting future conservation opportunities, even if they are not currently priority resources of concern (NABCI 2010, Matthews et al. 2007). Examples include chuck-will's-widow and hooded warbler. Species common in the area of the refuge but predicted to incur a clear shift northward and decline in Delaware, such as the house wren, may serve as indicators that predicted change is occurring.

Noss (2001) suggests a number of management guidelines that will promote the resilience of forest ecosystems in the face of climate change. Our forest management strategies for climate change adaptation capture those recommendations that are applicable on a local scale. For example, the refuge seeks to protect its largest patches of forest, which are the areas that are most buffered against change. The refuge will also utilize prescribed fire and thinning to avoid high-intensity fires. Programs that reduce outbreaks of invasive species, damaging insects, and diseases, also enhance forest health and long-term sustainability. The State of the Birds Report recommends that forest management also focuses on processes (such as fire regime and hydrology) rather than strictly on structure and composition, which will increase the resilience of forests to accommodate gradual changes (NABCI 2010). The emphasis is on healthy and diverse forests. Indeed, as Noss (2001) notes, good forest management principles are largely the same in the face of a changing climate as they are during more static conditions.

Carbon sequestration is one mitigation strategy used to offset effects of climate change. The U. S. Forest Service provides widely accepted calculations of carbon stored in various forest types (Smith et al. 2004). Opinions in the literature regarding the effect of active forest management on carbon sequestration capability of forests are not consistent among scientists (Nunery and Keeton 2010, Hennigar et al. 2008). Management of refuge forests will be focused on providing wildlife habitat, and as such would not generally involve intensive or widespread harvest of trees. Practices may include supplemental planting of poorly stocked lands, age (rotation) extension of managed stands, thinning, and fire management and risk reduction. These practices are consistent with refuge objectives to promote healthy native forests, and also support the ability of refuge forests to sequester carbon effectively. These strategies also support the carbon sequestration activities within the Service's proposed climate change objectives, as outlined in the draft strategic plan for responding to accelerating climate change (USFWS 2009b).

Climate Change and Sea Level Rise Adaptation Strategies and Monitoring
In forests, climate change will likely result in shifts in forest composition and structure (Iverson and Prasad 1998) that will greatly change the availability of habitat for many species. Shifts in the dominant vegetation type or even small changes in the understory composition may result in significant changes in animal communities. The goal of adaptation is to reduce the vulnerability of ecosystems to climate change and increase their resilience to climate-induced changes in ecological conditions.

Forest management strategies include those listed above, as well as the following:

- Reduce the impacts of stresses that can exacerbate the effects of climate change, particularly from wildland fire, insects, and diseases
- Step up measures to prevent and control the spread of invasive species
- Prevent or reduce barriers to species migration, such as forest fragmentation
- Improve forest health monitoring for early detection of climate change impacts
- Help forests regenerate after disturbances, e.g., through reforestation
- Support research to better understand forest vulnerability to multiple stressors and to find ways to enhance forest resilience.
- Within 1 year of CCP completion, conduct a complete forest inventory of forest lands and repeat the monitoring every 10 to 15 years
- Consider establishing a continuous forest inventory monitoring system

Objective 2.2 Mixed Hardwood Forest Restoration

In the next 15 years, reduce forested habitat fragmentation and promote habitat connectivity between upland forest patches to improve quality habitat for the Delmarva fox squirrel and conserve focal forest interior dwelling birds. Restore appropriate old field and cropland areas to forest to reflect the historic range of variability for mature upland forest vegetation to sustain the long-term viability of the squirrel. Create approximately 870 additional acres of forested habitats to maintain at least two core habitat patches (approximately 435 acres/patch) with connecting corridors.

Rationale

Population numbers and refuge acreage to improve Delmarva fox squirrel management on the refuge are based on the latest scientific information from population analysis modeling data for the Delmarva fox squirrel. Managing for conditions that benefit this species will simultaneously conserve and protect migratory birds of greatest conservation concern.

Contemporary human activities and land use changes have extirpated Delmarva fox squirrel from Delaware's landscape through the loss of forest, while habitat fragmentation of the refuge's upland habitats has been one of the primary factors in limiting the expansion of its numbers (ELI 1999). Although refuge populations have been stable since the reintroduction of squirrels in 1986 and 1987, this small population of an estimated 20 to 30 squirrels has little probability of being sustained for the long term with current refuge habitat acreage and without supplementing the population.

The most recent population viability analysis data have been incorporated into reforestation objectives. From it, a minimum viable population on the refuge of 130 individuals would be the smallest number of individuals required to maintain a population with a 95 percent probability of persisting for 100 years. This provides a quantitative measure for sustaining Delmarva fox squirrel on the refuge for the long term. Reforesting 700 to 800 acres and creating new habitat, whether by active planting or natural succession, would take 50 to 100 years for areas to mature with the potential of providing habitat for at least 250 individuals.

The loss of upland forests has also taken a huge toll on migratory songbirds and forest interior breeding birds that require large contiguous blocks of forested habitat. These include black-and-white warbler, whip-poor-will, cerulean warbler, hooded warbler, and American redstart. Many of the songbirds that have experienced regional and state declines are those bird species that are sensitive to forest fragmentation. The Delaware Natural Heritage Program estimated that 41 percent of Delaware's historically common forest-dependent birds have been extirpated or are extremely rare. Declines are attributed to increased nest parasitism by edge species, increased rates of predation, and loss of quality nesting and wintering forested habitats (Heckscher 1997).

Forest interior dwelling species require large forest areas to breed successfully and maintain viable populations in the future. This diverse group includes songbirds (tanagers, warblers, and vireos) that breed in North America and winter in Central and South America, as well as residents and short-distance migrants, like woodpeckers, owls, hawks, and eagles. According to Breeding Bird Survey data since 1966 there has been a 60 percent decline in occurrence of individual birds of neotropical migrant species in Maryland and an 83 percent decline in Delaware from 1980 to 2007 (Sauer et al. 2008). Many factors are contributing to these declines, but the loss and fragmentation of forests in breeding grounds in North America, including on the Delmarva Peninsula, are playing a critical role in these declines (Jones et al. 2001).

The conservation of forest interior dwelling species requires the inclusion of their nesting requirements including minimal area and structural characteristics of their habitat. As continental or regional populations of various forest bird species decline, there is more concern over the number of breeding pairs necessary to conserve appropriate gene pools. Increasing available contiguous forest patches helps to provide more breeding areas to retain more species of the forest-breeding avifauna (Chandler et al. 1989). Increasing the size of refuge forest tracts supports more pairs of focal bird species (Blake et al. 1984) and provides greater food resources for migrating and wintering landbirds.

The Delmarva fox squirrel acts as an umbrella species not only by encompassing the structural nesting characteristics of forest interior dwelling species, but also by providing for a wide variety of other forest-dependent species. Although the squirrel does not necessarily require interior forest habitat, it does require more forest cover acreage than the refuge currently contains in order to achieve and maintain a viable local population for the longer term. Expanding forest acreage and baseline habitat to meet Delmarva fox squirrel life history requirements provides a wide variety of ecological forest benefits. These forests provide a more complete ecosystem of plants and animals that sustain greater numbers of target wildlife species, protect and restore seed dispersal and nutrient recycling processes, and buffer refuge wetland and aquatic ecosystems from pollution.

Many of the refuge's upland fields proposed to be reforested in accordance with objectives 2.1 and 2.2 have been part of the refuge's cooperative farming program. In the past, the primary objective of the farming program was to provide food for certain waterfowl species (mallard, American black duck, northern pintail, and Canada goose during the fall, winter, and spring. A secondary objective of the farming program was duck production, in which croplands in grass or clover stages of rotations were designed to provide nesting habitats for ducks. In recent years, it has been apparent from anecdotal observations that duck species seldom or never used cropland field habitats, likely due to wetland and aquatic habitats being readily available on the refuge. Sufficient natural foods are also produced to satisfy the needs of Canada geese in these habitats, especially if measures are taken to reduce snow goose numbers. Waterfowl production is no longer a management objective for Prime Hook NWR. In addition, the elimination of farming on the refuge is consistent with recommendations in the Service's final environmental impact statement on the management of light geese (USFWS 2007a), which encourages refuges to reduce areas planted to agricultural crops that serve as a supplemental food source for overabundant greater snow geese. Reforestation of a portion of these previously farmed acres better serves numerous refuge objectives.

Strategies

- Reduce fragmentation of refuge forested habitats through reforestation projects (planting) to increase forest habitat available to the endangered Delmarva fox squirrel and improve management of area-sensitive wildlife, such as many of the breeding songbirds listed as refuge priority resources of concern in appendix D, table 6.

- Use population viability analysis modeling data to set refuge Delmarva fox squirrel population objectives, refine objectives as new data becomes available and design core habitat patches for reforestation for the long-term viability of Delmarva fox squirrels.

- Design reforestation projects to promote habitat connectivity on the refuge and improve management of area-sensitive wildlife.

- Work with private landowners and partners to establish safe harbor agreements for Delmarva fox squirrel.

- Explore opportunities to supplement the refuge Delmarva fox squirrel population through translocations as suitable forest habitat is restored.

- Install speed bumps in refuge entrance road to reduce Delmarva fox squirrel road mortalities on the refuge.

- Implement field restoration prescriptions outlined in the habitat management plan (appendix B).

Monitoring Elements
Conduct appropriate monitoring and survey programs as funding and staffing permits to measure our success with respect to our objectives. The results may trigger adjustments to management strategies, or reevaluation or refinement of our objectives. Details of planned monitoring will be developed in a subsequent inventory and monitoring plan. Examples of monitoring or surveys that we may implement include:

- Prevent new invasive species from becoming established by utilizing early detection rapid response techniques that detect newly established invasive species, and immediately addresses those populations through the appropriate control measure. This approach will incorporate a combination of plant identification and inventories, maintaining updates of new invasive species present in the region, and knowing the appropriate management techniques prior to conducting control efforts.

- Continue to work with partners to improve population monitoring methodology, habitat assessment techniques, and habitat improvement projects.

- Coordinate with the Chesapeake Bay Field Office to implement improved Delmarva fox squirrel monitoring techniques, such as motion-activated cameras, trapping, and nest box checks, as recommended.

- Assess landbird point count monitoring program and, as necessary, locate new points in areas undergoing reforestation to monitor bird community response.

Climate Change and Sea Level Rise Adaptation Rationale
Further discussion can also be reviewed under objective 2.1.

Corridors provide connectivity and improve habitat viability in the face of conventional challenges such as deforestation, urbanization, fragmentation from roads and powerline rights-of-way, and invasive species. Because dispersal and migration become critical for species of all taxa as vegetation shifts and conditions change in response to climate changes, corridors also offer a key climate change adaption tool. Management of connectivity between protected habitats is an important conservation strategy (Hannah et al. 2002). Reforestation provides an opportunity to increase connectivity of forested habitats. In many areas, forested riparian corridors provide connectivity among conservation units.

Reforestation, rather than relying on local seed sources and natural succession, can proactively incorporate individuals from a wide range of localities, and perhaps should emphasize sources from low elevations or latitudes (Noss 2001). This has the potential to increase genetic diversity in the forest, which may promote genetic adaptation to climate change as local conditions evolve over time. Choosing planting sources from lower elevations or latitudes anticipates the species range shift northward expected by most scientists for eastern tree species (Iverson and Prasad 1998). In addition, this objective promotes the implementation of practices, such as soil preparation, erosion control, and supplemental planting, to ensure conditions that support forest growth following establishment.

Increasing forest and tree cover provides additional benefits for mitigating greenhouse gases through carbon sequestration. Regenerating or establishing healthy, functional forests through afforestation on lands that have not been forested in recent history, including agricultural lands and reforestation on lands with little or no present forest cover contributes to carbon sequestration on the refuge. Forest patches should be of sufficient size to function as a community of trees and related species. Forests planted on land not currently in forest cover will likely accumulate carbon at a rate consistent with accumulation rates of average forest cover in the region (Matthews et al. 2007). Carbon sequestered by afforestation activities can be assumed to occur at the same rate as carbon sequestration in average Delaware forests. These strategies also support the carbon sequestration activities within the Service's proposed climate change objectives, as outlined in the draft strategic plan for responding to accelerating climate change (USFWS 2009b).

Climate Change and Sea Level Rise Adaptation Strategies and Monitoring
Forest restoration strategies include those listed above and in objective 2.1., as well as the following:

- Consider the impacts of climate change in selecting planting stock and choosing planting methods, e.g., emphasize sources from lower elevations or latitudes.

- Target riparian areas for reforestation to provide or increase buffers along streams and promote vital habitat connectivity.

- Keep careful inventory of acres reforested (amount and type) to quantify carbon sequestration contributions of the refuge into the future.

Objective 2.3 Forested Wetland Communities

Protect and manage approximately 1,200 acres of forested wetland cover-types with less than 10 percent invasive species for breeding and migrating birds of greatest conservation need. Improve habitat quality and manage appropriate patch sizes (greater than 250 acres) for breeding Acadian flycatcher, prothonotary warbler, yellow-throated vireo, migrating and wintering landbirds, and other species of conservation concern, such as carpenter frog and hydrangea sphinx.

- Wetland refuge cover-types targeted for conservation and protection include red maple/seaside alder swamp, Atlantic white cedar/seaside alder saturated forest, Coastal Plain depressional swamp, coastal loblolly pine wetland, buttonbush coastal plain pond, and cottonwood swamp.

Rationale
In the BCR 30 and Partners in Flight 44 plans, Swainson's warbler, cerulean warbler, Kentucky warbler, Acadian flycatcher, yellow-throated vireo, and prothonotary warbler are all species associated with forested wetlands and have high conservation concern scores within the mid-Atlantic Coastal Plain Region, as well as in Delaware (DNREC 2005b).

Yellow-throated vireos utilize a diversity of forest types from mixed upland forests to mature deciduous forests they appear to reach their highest densities in forested wetlands. However, it has been suggested that they require a high percentage of landscape in forest cover to breed successfully. They generally do not breed in forest interiors but prefer edges and openings (Rodewald and James 1996). Prothonotary warblers select mature deciduous swamp forests during the breeding season. Habitat characteristics include a relatively low, open canopy with a high density of small stems and a variety of natural cavities

2 to 35-feet high over water. As cavity nesters, cavity availability may serve as a limiting factor to habitat selection and use. Flooded breeding areas usually have higher occupancies due to greater numbers of nest sites and greater prey species densities (Petit and Petit 1996). Acadian flycatchers typically occupy moist deciduous forests along creeks and streams and wetland forested habitats. This species is generally associated with closed canopy forests with an open understory. Nests are also placed near or over water. Acadians have been shown to be area-sensitive, with populations only reaching 44 percent of maximum breeding densities in patches below 168 acres (70 ha) (Whitcomb 1981).

The mid-Atlantic Coastal Plain forested wetlands include a highly diversified gradient of forest types (Cowardin et al. 1979). On the refuge this diversity is typified by some of the rarest communities remaining in the Delaware landscape. These include red maple/seaside alder swamp, unique in Delaware and found nowhere else in the state, Coastal Plain depression swamp, Atlantic white cedar/ seaside alder saturated forested, coastal loblolly pine wetland, swamp cottonwood coastal plain swamp, and buttonbush coastal plain pond (McAvoy et al. 2007). These habitats are dominated by woody species adapted to tolerate saturation of the root zone for varying duration and frequency throughout the growing season. Nationally and locally, forested wetlands have experienced dramatic fragmentation and losses. Much of this loss has been due to the harvest, filling, or draining of forested wetlands for conversion to agriculture or urban development (Cowardin et al. 1979, ELI 1999). As with upland forests, occupation of these habitats by forested wetland-dependent birds is influenced by a number of factors including patch size, vegetation structure, and hydrology.

Several studies and inventories of refuge forested wetland communities were contracted by the Service conducted by the DNHP in 2004 and 2005 (McAvoy 2007). These inventories and studies were part of the refuge's CCP preplanning efforts to assess the current status of its natural resources. Botanical and zoological surveys focused on identifying the presence and absence of rare flora and fauna and assessed the current condition of the refuge's biological diversity. Survey data identified a diverse assemblage of rare flora and fauna in the refuge forest community types listed above, except buttonbush coastal plain pond. A description of rare flora and fauna found within these habitats is located in chapter 3, Affected Environment; tables 3-6–3-7.

Strategies

- Protect large patches (greater than 250 acres) of habitat structural components required by refuge priority resources of concern, which include yellow-throated vireo, prothonotary warbler, and Acadian flycatcher. Management for these species will also provide critical late winter and early spring feeding habitats for the Delmarva fox squirrel, migrating landbirds, and other wetland-forest dependent wildlife.

- Schedule prescribed burns to sustain and enhance Atlantic white cedar communities with adequate precautions to protect extant rare faunal and floral species. Consult with the regional fire wildlife biologist for the best habitat management recommendations.

- Reduce or eliminate factors contributing to site eutrophication of swamp cottonwood coastal plain community. Enhance existing and create new forested buffer zones and reconnect fragmented blocks of all forested wetland cover-types to mitigate eutrophication inputs from off-refuge sources.

- Treat current areas infested with Japanese stiltgrass, *Phragmites*, and other problematic invasive plant species. Monitor all cover-types for invasive encroachment on an annual basis and treat when coverage exceeds 10 percent of the areas.

- For *Phragmites* control, develop an adaptive management framework so that treatments are monitored and evaluated for effectiveness. The refuge will be using an integrated approach to *Phragmites* control, which will consider restoration of natural processes, herbicides, prescribed fire, biocontrol, and other tools as they are developed.

- Restore the natural hydrology of coastal plain depressions swamp communities (Unit III south of Prime Hook Beach Road).

- Consider selective thinning or girdling trees adjacent to sensitive cattail sedge (*Carex typhina*, S3) and slender blue-flag iris *(Iris prismatica*, S2) within the coastal plain depression swamp community.

- Utilize best management practices and other management actions to protect rare plant communities, such as the southern twayblade orchid and swamp cottonwood, as is feasible and consistent with other management objectives.

Monitoring Elements
Conduct appropriate monitoring and survey programs as funding and staffing permit to measure our success with respect to our objectives. The results may trigger adjustments to management strategies, or reevaluation or refinement of our objectives. Details of planned monitoring will be developed in a subsequent inventory and monitoring plan. Examples of monitoring or surveys that we may implement include:

- Prevent new invasive species from becoming established by utilizing early detection rapid response techniques that detect newly established invasive species, and immediately addresses those populations through the appropriate control measure. This strategy will incorporate a combination of plant identification and inventories, maintaining updates of new invasive species present in the region, and knowing the appropriate management techniques prior to conducting control efforts.

- Establish point-count monitoring surveys for each habitat cover-type listed in objective 2.3 to determine nesting landbird use of targeted wetland forest resources of concern.

- Obtain GPS location data from Delaware Natural Heritage Program to document rare flora and fauna locations on refuge GIS database.

- Continue inventories for rare species to better determine their distributions on the refuge through establishing monitoring plots and assess conservation status every 3 to 5 years.

Climate Change and Sea Level Rise Adaptation Rationale
Wetlands with long periods of inundation or surface saturation during the growing season are especially effective at storing carbon in the form of peat, though there are uncertainties associated with carbon storage in wetlands. Riparian wetlands can also capture carbon washed downstream in litter, branches, and sediment. Because they accumulate sediment and bury organic matter, floodplain and tidal wetlands, including forested wetlands, are especially effective as carbon sinks. These lands also reduce nutrient, sediment, and other pollution entering the Delaware Bay and other bodies of water.

Climate Change and Sea Level Rise Adaptation Strategies and Monitoring
Forest wetland management strategies include those listed above and in objectives 2.1 and 2.2.

GOAL 3. **Refuge Impounded Marsh Complex**

Maintain the quality of the wetland habitats within and surrounding the refuge's wetland impoundment complex for migrating shorebirds, breeding rails, wading birds, American black ducks, and migrating and wintering waterfowl consistent with the BIDEH policy. Support other native wetland-dependent species and provide fish passage and nursery habitats for anadromous fish species.

Objective 3.1 Wetland-dependent Breeding, Migrating, and Wintering Birds

Provide up to 4,200 acres of healthy brackish wetlands and salt marsh to meet the needs of a wide variety of wetland-dependent migratory birds, including rails, bitterns, terns, migrating shorebirds, and migrating and wintering waterfowl, by restoring salt marsh and brackish vegetation communities and natural wetland processes in the impounded wetlands in Unit II and Unit III. Successful restoration will include the following elements:

- Restoration of the natural tidal range and salinity with a physical connection to the marine environment for exchange of nutrients, organic matter, and biota
- Restoration of the natural sediment budget to counter wetland subsidence
- Improvement of water quality realized by restored salinity and pH
- Control of invasive plants to less than 5 percent cover, once salt marsh vegetation is established
- Reestablishment of native salt marsh vegetation communities, with a moderate (20 to 25 percent) component of open water and mudflats
- Return of native salt marsh wildlife species, including salt marsh obligate birds
- Improvement of estuarine fish and shellfish habitat

Rationale

The refuge's impounded marshes represent large wetland patches greater than 1,000 acres in area, which are attractive to wetland-dependent breeding and migrating birds and significantly contribute to wetland biological diversity and integrity at both the refuge and State landscape levels. Even as these wetlands undergo changes as a result of storm activity and coastal processes, the refuge remains committed to providing high quality wetland habitat for a diverse assemblage of migratory birds in a manner that is effective and sustainable. The emphasis under this alternative is on active restoration of healthy salt marsh and brackish wetland conditions within wetlands formerly managed as freshwater impoundments. This objective represents the refuge's most significant and tangible shift in habitat management, and is covered here in detail. This shift in habitat management serves as an immediate response to local manifestations of climate change, and is a proactive adaptation in anticipation of likely future changes. However, given the road infrastructure in place, these wetlands will remain at least partially impounded for the foreseeable future, and thus require active management and restoration. Active management of water levels will continue to play a role in influencing habitat conditions, and potentially as a tool for salt marsh restoration. Management strategies in sensitive freshwater wetlands and restoration in inland wetland areas will still be pursued to the extent feasible.

The SLAMM model (Scarborough 2009) and the State's inundation maps (DNREC, unpublished) suggest changes in landcover and losses of tidal wetlands on the refuge in the next 50 to 100 years. Portions of the refuge's marshes or impoundments may have already reached a tipping point. It is important to note that the timeframe of impoundment management has been relatively short on the refuge, in relation to the timeframe of natural coastline processes. Relatively speaking, freshwater impoundment management is not a long-standing management regime on the refuge. It was conceived to meet valid wildlife management objectives but was established in part using existing roads as dike infrastructure that had not been formally engineered for long-term water level management. In developing a memorandum of agreement with DNREC, during the time the impoundment infrastructure was established, it was acknowledged that the lifespan of the facilities would be 20 years, a time span which has now passed. Evidence from numerous sources, as described in chapter 3, clearly indicates that the wetlands on the refuge were historically salt marsh, although there had always been areas of freshwater marsh due to natural freshwater inputs or altered hydrology resulting from human activity.

As information in chapter 3 outlines, portions of the managed impoundments are losing ground to sea level rise and other manifestations of climate change, such as shoreline erosion. While the visible vegetation and wildlife response was favorable during the decades of impoundment management, significant problems were developing beneath the surface. For example, Unit II is accreting new sediment at a pace that is half the documented rate of local sea level rise. It is not reasonable to expect that such a large deficit in elevation-capital can be recovered within Unit II under current freshwater impoundment management strategies. Freshwater marshes dominated by annual vegetation differ from salt marshes in that predominantly annual wetland plant vegetation contributes to high above-ground biomass, whereas the persistent below-ground organic matter of perennial vegetation, such as that found in tidal salt marshes, makes greater contributions to vertical accretion (Cahoon et al. 2009). Impounded freshwater wetlands would be difficult and costly to reestablish, and more importantly are not sustainable in a dynamic coastal setting for the long term.

The reality of these various factors, operating in combination to create significant management challenges, requires a shift in refuge wetland management objectives and strategies. Our refuge goals and objectives strive for successful management of a variety of wetland habitat types, including both salt marsh and freshwater wetlands. But, it is our responsibility to manage for these community types where conditions are appropriate. As our evaluation of the available data illustrates, a shift in management is necessary to ensure healthy wetlands, rather than permit artificially created freshwater wetlands to convert to open water because they are not keeping pace with rising water levels. Although open water environments are not without ecological value, such an outcome would not directly support the wetland objectives outlined in this CCP. It is neither responsible nor sustainable to indefinitely maintain freshwater impoundments along a coastal environment.

It has been determined through analysis of the many complex factors outlined in chapter 3 (influence of climate change on physical environment and refuge management) that continued management of freshwater impoundments for the long term is not appropriate. There is no inexpensive and practical way to freeze the dynamic nature of the impoundment complex at this ecologically and geologically unstable point. Continued freshwater impoundment management would simply not be sustainable. Management action will be necessary to stabilize the health of the degraded system. If no active restoration is undertaken, it is unclear how quickly or effectively the area, in Unit II in particular, would revert to salt marsh vegetation on its own, given the existing elevations and degraded state of the sediments (Williams and Orr 2002). It is also possible that large areas of open water will form instead (Pearsall and Poulter

2005, Williams and Orr 2002, Portnoy and Giblin 1997, DeLuane et al. 1994). In the absence of a healthy marsh community or sufficient wetland elevation within the interior of Unit II, the shoreline along the Bay will remain vulnerable to breaches and overwash during storm events. The most practical and economical management alternative to restabilize the impounded wetlands is carefully executed restoration. Furthermore, an established salt marsh will be able to migrate landward into adjacent refuge uplands, as sea levels rise, in a process that represents the natural adaptation of the coastal ecosystem.

Ultimately, restoration of the refuge impoundments to healthy brackish and salt marsh will encourage the conditions most resilient to sea level rise, while providing valuable habitat for waterfowl, salt marsh obligate passerines and waterbirds, shorebirds, and other wildlife. Furthermore, additional healthy salt marsh in the refuge's wetland complex would provide benefits to neighboring human communities that the freshwater impoundments could not provide, or certainly could not provide in a self-sustaining manner. The presence of salt marsh vegetation in coastal marshes can reduce shoreline erosion by reducing wave energy. Wave heights are reduced by 60% within the first twenty feet of the marsh, which in turn also increases the potential for sediment deposition (Morgan et al. 2009, Broome et al. 1992) Because they are perennials, salt marsh plants develop extensive root systems that improve soil stability through deposition of below-ground biomass; thus, over time salt marshes will accrete vertically to better keep up with sea level rise (Cahoon et al. 2009, Reed et al 2008, Knutson 1988) and serve as a buffer to adjacent uplands. Through greater stability and resilience, a healthy salt marsh will provide neighboring communities with more flood protection than an artificially sustained freshwater wetland or open water. Restoration of salt marsh vegetation within impounded wetlands is a key climate change adaptation approach.

Active restoration is more effective than passive restoration in wetlands with degraded conditions (NOAA 2010). The preferred means of restoration will be the incremental increase in the exchange of tidal floodwaters between the Delaware Bay and at the water control structure in Slaughter Canal. Ideally, tidal restoration will occur gradually over an extended period and will entail concurrent monitoring of environmental response to assess the achievement of project objectives, including assessment of public and stakeholder concerns (Smith et al. 2009). This method is advantageous because the rapid reintroduction of saltwater to a system that has been primarily fresh can cause rapid and extensive death of salt-sensitive plants, which can impose further problems with sediment loss, erosion, and subsidence through peat collapse (Smith et al. 2009, Pearsall and Poulter 2005, Weinstein et al. 2000, Portnoy and Giblin 1997, DeLuane et al. 1994). It is difficult to successfully monitor such a rapid change and, regardless of our monitoring and management efforts, the response will be difficult to accurately predict. A critical factor in the restoration design process is achieving tidal flooding up to the spring high tide elevation in order to restore ecologically sustainable estuarine communities by restoring sufficient tidal exchange to flood and drain the wetland effectively (Williams and Orr 2002).

The refuge must also evaluate and address the elevation of the wetlands to be restored, in relationship to the growth range of desired species (e.g., Spartina alterniflora), because elevation is a critical factor in establishing salt marsh vegetation (Weinstein et al. 2002, McKee et al. 1989, Baca and Kana 1986). The sand-starved system may require decades or more to naturally recoup the elevation already lost in portions of the wetland complex from peat collapse in the manipulated freshwater sediments. In the absence of sufficient elevation, portions of the wetlands will convert to open water (this has already occurred in some areas). Ideally, open water should compose only 20 percent of restored

Delaware Bay salt marsh wetlands (Weinstein et al. 1996). Although open water environments are not without value to wildlife, they can contribute to erosion and inhibit the return of salt marsh vegetation, especially in large sites such as Unit II and Unit III (Williams and Orr 2002).

Salt marsh vegetation will establish more readily if there is sufficient elevation in place, which in turn will facilitate further accretion and salt marsh development (Boumans et al. 2002). This prompts the consideration of assisted accretion through the addition of supplemental sediment by some means (e.g., thin layer deposition of dredge material or modified beach nourishment) or through engineering techniques that reduce wind and wave fetch across expanses of open water and encourage the natural capture and deposition of sediment throughout the wetland complex (Weinstein et al. 2000). In addition, the refuge will limit the control of *Phragmites* to only areas identified in the fire management plan as a Primary WUI Treatment Zone for the purposes of fuels control. Although not a preferred wetland species for habitat value, the presence of *Phragmites* can help to trap sediment, preserve wetland elevation, and reduce peat collapse.

While a carefully monitored, gradual reintroduction of salt water into the impoundment complex is a preferred management option (Smith et al. 2009), the feasibility of such an approach depends on some factors beyond the refuge's immediate control. The shoreline, for example, is extremely vulnerable to overwash, but cannot readily be engineered to prevent breaches, and the refuge may have little control of water levels and salinity within the impounded wetland without substantial intervention. In addition, it can be difficult and costly to find large amounts of supplemental sediment for restoration of elevation, but the refuge will work with partners to seek such opportunities. The restoration plan for the wetland will include an iterative and adaptive approach to manage incremental restoration in response to observed and measured conditions (Teal and Weinstein 2002). Although the conditions at the refuge are somewhat unique, given the management history, there are examples of successful salt marsh restoration projects throughout the eastern U.S., including in the Delaware Bay, which provide valuable guidance (NOAA 2010; Smith et al. 2009; Herring River Technical Committee 2007; Teal and Weinstein 2002; Warren et al. 2002; Weinstein et al. 2000, 1996; ACOE 1996; Roman et al. 1995; Baca and Kana 1986).

For Unit III, the future of management is less certain, although management capabilities are still somewhat intact, and management infrastructure not as compromised. The natural freshwater inputs within Unit III dictate that under any management or restoration scenario, it would likely retain more brackish marsh characteristics and vegetation than Unit II would. However, it may also be at risk for new *Phragmites* invasion. Although the objective for Unit III is also to develop a healthy self-sustaining wetland rather than continue to manage strictly as a freshwater impoundment, the specific fate of Unit III may depend on the actions taken and outcomes realized in Unit II restoration efforts. It is anticipated that this will be a salt marsh dominated-system in the areas dominated by saltwater inputs, and brackish to freshwater in areas with greater freshwater source. Factors such as the pace of Unit II restoration, how natural storms events may affect the wetland complex, modifications of Prime Hook Road by DelDOT, when and whether sediment from outside sources is added, etc. may all affect the pace and choice of restoration actions but not the long-term goal, which is a habitat that is consistent with BIDEH. The refuge will need to adapt future management direction and actions in Unit III, depending on the progress of management and restoration in Unit II, which directly influences Unit III. Coastal refuges in the Northeast Region are currently developing a structured decision tool that can be used to weigh the costs and benefits of maintaining an impoundment and reach a decision about whether to restore or maintain it. Since this model will be science-based, developed through a structured decisionmaking process and have technical expert review, and consistency with other refuges, Prime Hook NWR plans to use the coastal impoundment structured decisionmaking model to evaluate future management direction for the Unit III impoundment. Currently the refuge is collecting the data necessary to populate the decision model in order to further evaluate management options.

While the active restoration of salt marsh within the refuge's impounded wetlands is the underpinning of this objective, the development of a detailed wetland restoration plan is outside the scope of this CCP process. However, there have been a number of formal discussions regarding restoration options and strategies with a diverse group of wetland management and restoration experts, state officials, and the Army Corps of Engineers.

The refuge has been in contact with the Army Corps of Engineers and with DNREC since the summer of 2011 regarding the potential use of dredged sediment to restore wetland elevation in the impoundment complex. Such sediment could come from the Main Channel Deepening Project, maintenance dredging. Because the material is a state resource, DNREC has primary authority over how and where it is used. Marsh restoration at the refuge is only one of several beneficial use possibilities that are being considered.

In May 2011, the refuge convened a group of world-renowned wetland management and restoration experts from outside Delaware for a meeting with refuge staff and a number of DNREC scientists and managers. The invited group of scientists included Dr. Donald Cahoon (U.S. Geological Survey, Patuxent Wildlife Research Center), Dr. Norbert Psuty (Rutgers University), Dr. Charles Roman (National Park Service, Cooperative Ecosystem Studies Unit, University of Rhode Island), and Patricia Rafferty (National Park Service, Jamaica Bay Wildlife Refuge, New York). These scientists represent a wealth of experience in studying, managing, and restoring degraded wetlands throughout the U.S. The group reviewed preliminary monitoring data and toured the refuge's shoreline and wetlands firsthand. They provided feedback and recommendations at the end of the meeting and during follow-up discussions. A similar follow-up workshop was held in April 2012, which included the participation of additional academic experts (e.g., Court Stevenson of the University of Maryland) as well as several community representatives. Participants examined the primary restoration options that the refuge faces, and also proposed restoration scenarios to be examined in more detail through hydrological modeling. A summary of this workshop can be found online *(http://www.dnrec.delaware.gov/coastal/DNERR/Pages/CTP%20Pages/Prime-Hook-Restoration-Workshop.aspx;* accessed August 2012).

Throughout the summer of 2012, the refuge continued discussions regarding restoration options with two engineering firms and with the Partnership for the Delaware Estuary (PDE), to further evaluate and develop restoration options and techniques, including actions that could be taken soon after the CCP is finalized. These partnerships will continue into the implementation phase of marsh restoration. These have included both large-scale wave attenuation strategies and products suitable for the high-energy shoreline interface, and small-scale living shoreline projects suitable for the marsh interior. The resulting suggestions from these various meetings and discussions have been incorporated into the CCP as potential restoration strategies, outlined below.

For example, although an infusion of additional sediment is critical for restoring lost elevation behind the fragile refuge shoreline, the refuge also considers strategies to encourage and accelerate natural accretion of sediment within the wetland complex. The refuge has examined both short and long term solutions, which vary tremendously regarding cost, deployment time, and engineering analysis requirements. Engineered solutions do exist for attenuating waves and encouraging sedimentation in moderate- and high-energy settings, such as various manufactured concrete structures (e.g., Wave Attenuation Devices, Beach Prisms, Reef Balls). These type devices are designed to attenuate wave energy thus reducing erosion and would be more effective than concrete structures not designed for these purposes, such as jersey barriers (designed specifically for traffic control). Relative to rock and rubble structures, these type structures can be designed to provide an effective means to stabilize the shoreline and breach locations. Although wave attenuation may be lower with manufactured structures than with rock and rubble structures, they can allow for passage of fish, crabs, and other species (Douglass et al. in press). One cost estimate obtained suggested at least$1 million for an installation of WADs near the mouth of the breaches that would be sufficient to have the necessary effect (Cardno JFNew Consulting, pers. comm.). The Coastal Engineering Manual (CEM) provides extensive design methodologies for implementing rock and rubble mound structures (USACE 2002). As with manufactured concrete structures, rock and rubble mound structures require hydrodynamic modeling to design properly and can be costly to implement on the scale necessary at the refuge. There are no means to attenuate wave energy through the breaches that would not require careful planning and engineering, to ensure that the water and energy do not simply scour around the structure(s) and impact the refuge potentially forming new breaches and inlets at other locations throughout the shoreline.

Geotubes are another structural technique that have some potential. However, geotubes do not contribute sand to the local sediment system, can affect adjacent shoreline negatively, are prone to failure and vandalism, and are not designed to withstand large-scale storms (McKenna 2001). Geotubes would also likely require the addition of sand to anchor the tubes, a nourished beach in front of the tubes, and may require frequent maintenance as sand is washed away (Gibeaut et. al 2003, McKenna 2001).

Living shoreline techniques using materials such as coconut logs, oyster shell breakwaters, and grass plantings are suitable in low energy settings and can help restore marsh in targeted areas (PDE 2012, PDE 2011). The refuge has been in close contact with the Partnership for the Delaware Estuary (PDE) regarding potential living shoreline projects on the refuge, and has already shared preliminary site information for consideration.

It has been the consensus of these diverse partners that the refuge has a number of potential restoration options, both big and small, which have been included here and evaluated in Chapter 5, but that additional hydrological modeling and analysis is important before the implementation of large-scale restoration efforts. The refuge proposes to continue working with diverse wetland management and restoration experts, state and federal officials, and community representatives as restoration short- and long-term plans are developed. Potential restoration strategies to be considered are derived from the salt marsh restoration scientific literature and consultation with wetland experts and other partners. The public will be given opportunities to learn about restoration plans as they are developed, and provide feedback to the refuge staff and restoration team. Public involvement is recognized as a critical element for successful restoration projects (NOAA 2010). The impacts of the potential restoration strategies outlined below are evaluated within chapter 5, and some or all of the strategies may be implemented in some combination, as determined to be appropriate, feasible, and fundable, during later restoration planning.

Strategies

- Implement water level management and vegetation control strategies, to the extent conditions warrant and permit:

  - If feasible, seek to keep Unit III water levels, in accordance with deed restrictions, at or below a level of 2.8 feet mean sea level between October and March 10th, but if future storm events preclude the ability to manage water levels, then natural levels will prevail.

  - Control invasive species using chemical control, prescribed fire, and other techniques as appropriate so that 95 percent native vegetation is achieved. The exact number of acres treated will depend on funding and management capability.

  - Restore prior converted wetlands and riparian areas on approximately 250 acres.

  - Restore artificially drained and ditched upland areas to improve hydrology around vulnerable communities.

  - Consider planting a green browse crop, such as clover, over managed areas when manipulating the soil to set back succession, in order to provide supplemental food for waterfowl.

- Utilize the Regional impoundment management structured decision making model in order to evaluate and validate management options for refuge impoundments.

- Discontinue all management and construction of dunes on private land.

- In partnership with DNREC Delaware Coastal Programs, and a private contractor, continue development of a model to predict the hydrodynamic response of the wetland complex under a wide variety different potential management and restoration scenarios, such as closed inlets, opened inlets, one inlet opening in response to a storm event, purposeful inlet deepening, Fowler Beach Road removed, Prime Hook Road culverts closed, additional Prime Hook Road openings installed, water control structure at Slaughter Canal/Fowler Beach Road removed, etc. The model will help evaluate what hydrological and vegetation responses may be expected under each scenario.

- Continue consultation with State and Federal coastal scientists, non-profit organizations, engineering firms, academic scientists, other subject matter experts, and community representatives to further explore management options and develop a wetland restoration plan for refuge impoundments.

- Host public forums during restoration planning and implementation to describe the process and techniques under consideration and provide the opportunity for public input.

- Within 1-3 years, implement short-term restoration strategies, even as large-scale and long-term restoration plans are developed. These strategies may include some or all of the following:

  - Continue development of a hydrological model, as described above, to evaluate long-term restoration options.

- Partner with the PDE to plan and implement appropriate application of living shoreline techniques (e.g., coconut logs, Christmas tree fences, oyster shell breakwaters) within the Unit II interior along public roads and neighboring private property to slow wave fetch across large expanses of open water, which may reduce marsh erosion and facilitate the deposition of sediment and establishment of salt marsh vegetation.

- Further evaluate the potential applicability and installation of engineered wave dissipation devices, such as pyramid-shaped or spherical concrete structures designed explicitly for moderate or high-energy settings. Examples include GeoTubes, Wave Attenuation Devices, Beach Prisms, Artificial Reefs.

- Work with DNREC on shoreline stabilization with material from Delaware River Deepening project, maintenance dredging, and other sources within the Delaware Bay.Re-evaluate the easement limiting water level management to a height of 2.8 feet (MSL) with the impoundment, possibly renegotiating or removing the agreement.

■ Within 15 years, implement a comprehensive restoration plan to restore healthy self-sustaining wetlands in refuge impoundments, utilizing methods determined with the assistance of the restoration advisory team and other experts to be most appropriate and effective. Following establishment of healthy salt marsh, strategies outlined under objective 1.3 would become applicable. Specific potential strategies include:

- Explore the potential benefit of constructing temporary dikes or berms to create cells within the impoundments to foster sediment deposition and salt marsh vegetation establishment.

- Work with the Army Corps of Engineers and DNREC to assess the availability of suitable dredge material to assist in restoring lost elevation within Unit II or Unit III necessary for the establishment of *Spartina.*

- Examine the financial and ecological feasibility of reintroducing sand from an outside source into the local sediment transport cycle through a modified beach nourishment project. It must be clear that such a project would not be conducted to create a static beach or dune, but would restore coastal sediment dynamics by replacing lost sand, which would be naturally transported into the back barrier wetlands to improve elevations for vegetation growth.

- If predicted from hydrodynamic modeling analysis to be beneficial for marsh restoration, work with DelDOT on the abandonment and appropriately-timed removal of Fowler Beach Road to provide unimpeded tidal flow between Unit I and Unit II or, minimally, the installation of large openings under the road to increase and improve tidal flow. DelDOT has sole authority over decisions regarding Fowler Beach Road.

- Determine the potential benefit of clearing internal channels within Unit II, such as the old Slaughter Creek channel, with the cookie cutter to improve tidal flow throughout the Unit.

- As areas of suitable growing conditions are achieved in portions of the impoundment complex through the management strategies above, consider supplementing the vegetation through planting of salt marsh plants, such as *Spartina* spp.

- Cease the treatment of *Phragmites* in areas that are susceptible to marsh loss; although not a desired vegetation species, its presence in vulnerable areas will help retain sediment elevation and slow conversion to open water. *Phragmites* would still be treated in areas identified in the fire management plan as a Primary WUI Treatment Zone.

- Work with DelDOT to ensure that improvements to Prime Hook Road will permit optimal management or restoration of Unit III, based on the outcome of modeling analysis. DelDOT has sole authority over decisions to alter Prime Hook Beach Road.

Monitoring Elements

- Resurvey all water-control structure staff gauges to a single geodetic reference and accurately reposition gauges to reflect current mean sea level.

- Within 1 to 2 years, establish a refugewide elevation-capital (marsh surface elevation) monitoring program across the two management units, as outlined in more detail in the climate change adaptation strategies under objective 1.3. In addition to monitoring stations in existing salt marsh, 12 stations will be established in currently impounded areas (6 in Unit II and 6 in Unit III) with surface elevation tables and marker horizons.

- Expand efforts to use real time kinematic (RTK) surveys and underwater sonar technology to monitor elevation throughout the wetland complex, which is less precise than surface elevation table measurements, but can be conducted on a broader geographic scale.

- As deemed necessary, continue to collect water quality samples through grab-sampling and automated sampling; samples are analyzed in partnership with the State through a cooperative agreement.

- Implement the Park Service's vital signs program's shoreline position monitoring protocol and shoreline topography monitoring protocol. Coordinate refuge shoreline monitoring efforts with other coastal refuges to foster Departmentwide sharing of standardized monitoring data.

- Monitor the use of refuge impoundments by waterfowl, shorebirds, passerines, and other waterbirds, in all phases of transition and restoration, in accordance with established protocols such as integrated waterbird management and monitoring; as feasible, coordinate research with academic partners, such as the University of Delaware, and with DNREC.

- Seek opportunities to monitor other species groups such as fish within the wetlands during all phases of transition and restoration, potentially through partnerships with academic institutions, such as Delaware State University, or other organizations.

- Utilize the regional salt marsh integrity index and other suitable monitoring programs as a measure of the success of restoration efforts over the next 15 years.

- Update existing vegetation mapping within the wetland complex to reflect changing vegetation and open water conditions, and repeat as needed and practical; explore the utility of archived satellite imagery for vegetation and open water change analysis.

- Utilize early detection rapid response techniques that detect newly established invasive species and immediately address those populations through the appropriate control measure.

- Develop improved monitoring and inventory program, such as outlined in the integrated waterbird management and monitoring program, to assess annual habitat conditions created through management and restoration in all wetland areas and associated bird use.

- Implement water and soil salinity monitoring to inform decisions about wetland response to management and restoration.

- Obtain location and distribution data of known rare plant and animal populations from the State Natural Heritage Program and store on the refuge GIS database.

- Continue research inventories and studies on the viability and persistence of existing rare plant populations and associated rare faunal species; determine life history requirements for rare plants and animals currently on the refuge to improve future habitat management.

Objective 3.2 Manage Water Quality for Trust Fishery Resources, Migratory Birds, and Resident Wildlife

Over the next 15 years, protect and improve the water quality of 6,000 acres of impounded marsh and waterways and aquatic habitats and delineated buffer zones to provide clean water to safeguard and enhance the quality of breeding and nursery habitats for river herring (alewife, blueback herring), American and hickory shad, striped bass, American eel, and other fishery resources to conserve healthy populations of fish, breeding and migrating birds, and resident wildlife.

Rationale

Many of the refuge's natural resources are water-dependent, and adequate quantities and quality of freshwater are of paramount importance to conserve and manage trust wildlife resources. Protecting healthy aquatic habitats, conserving fish and other aquatic organisms, and managing targeted migratory and breeding birds identified in this CCP will require clean water and good water flow and circulation within the refuge's impounded wetland habitats. Cyclic ditch cleaning is the only way to preserve good water circulation within the impoundments.

In addition to perpetuating healthy migratory bird populations, the Service is committed to restoring and conserving America's fisheries resources (National Fish Habitat Action Plan 2006). Over one-third of the nation's freshwater and anadromous fish species are threatened. It is increasingly urgent to identify and implement actions that will reverse declining trends in fish health and populations before it is too late. Protecting the health of aquatic habitats and restoring fish and other aquatic resources is a very high Service priority.

The Atlantic States Marine Fisheries Commission data and management plans targeting declining species was used to identify and prioritize refuge aquatic and fisheries resources for this CCP. River herring, striped bass, and elvers are top resources of concern for the refuge. The conservation of river herring (alewife and blueback herring), striped bass, and other anadromous fish plus the American eel depend on freshwater habitats that are used by spawning adults and required by fry and early juveniles of these species.

Restoring salt marshes that function naturally requires re-establishing desirable vegetation on the marsh plain, restoring a natural hydroperiod, and maintaining or creating elements of marsh habitat such as tidal creeks, ponds/pannes and vegetated areas. These tidal creeks are part of the intertidal drainage system that allow fish foraging and the exchange of sediments. So the natural function of salt marshes not only is tied to the vegetation on marsh plain but the well developed system of tidal creeks. Weinstein et al. 1997 and 200 outlined the importance restoring the hydrology by maintaining or creating tidal channels. The number of ditches quantified in the strategies below are for freshwater impoundment management. We may need to restore some of these ditches if determined they are no longer needed. The marsh restoration plan may tell us which ones to keep or restore.

Strategies

- Repair, replace, and upgrade water control structures, fish weirs, flapgates, flaplogs, and conventional logs as needed.

- Conserve and improve tidal flows into the salt marshes of Units I and IV by permitting natural coastal processes, such as overwash and inlet formation, to proceed unhindered.

- Continue to provide and improve optimal fish passage capability for anadromous fish in Units II and III.

- Create new or widen existing vegetated riparian buffers greater than 300 feet composed of native vegetation (trees and shrubs), by connecting isolated or disjunctive patches around refuge creeks, waterways, and marshes, through assisted reforestation projects or allowing natural succession to occur.

- Maintain and/or restore water movement and circulation within existing drainage networks of the refuge's former impoundment complex to improve the hydrology of the salt marsh by developing as appropriate tidal drainage systems; drainage networks may include up to 6.2 miles of ditches in Unit II impoundment, up to 7.5 miles in Unit III impoundment, and up to 3,300 linear feet in Unit IV Impoundment. Ditches not needed for marsh restoration may be plugged or allowed to fill in.

- Participate in partnerships with other State and Federal agencies to address interjurisdictional fish and State rare fish issues.

- Participate in spill prevention, control, and countermeasure plans or other environmental emergency action plans as related to protection of Prime Hook's aquatic and terrestrial resources.

- Implement field management and restoration prescriptions outlined in the habitat management plan (appendix B).

Monitoring Elements

Conduct appropriate monitoring and survey programs as funding and staffing permit to measure our success with respect to our objectives. The results may trigger adjustments to management strategies, or reevaluation or refinement of our objectives. Details of planned monitoring will be developed in a subsequent inventory and monitoring plan. Examples of monitoring or surveys that we may implement include:

- Conduct refuge fishery inventories every 5 years to assess fishery health and water quality of aquatic habitats. Document information such as species composition, class size and distribution, abiotic conditions and other information to adjust management prescriptions as needed and recommended by the Service's Fishery Division. Surveyed areas should include Turkle, Fleetwood, Goose, and Flaxhole Ponds and Prime Hook Creek. Analyze data and provide management recommendations (seasonal closures, creel size and species limits or catch and release) to adjust to public use regulations on these closed systems.

- When cleaning ditch systems ensure that at least 75 percent of the ditch depth is free of sediment along ditch courses and the entire length is free of obstructions that impede water flow.

- Conduct water quality monitoring, in cooperation with partners; parameters to measure include salinity, dissolved oxygen, ammonium, nitrate and nitrite, ortho-phosphorus, total dissolved nitrogen, phosphorus, and chlorophyll A/ pheophyton.

GOAL 4. Early Successional Upland Habitats

Maintain, enhance, and restore the native vegetation, biological diversity and ecological integrity of early successional upland habitats to create a mosaic of early successional habitats mixed with transitional forested areas to conserve migratory birds, breeding landbirds, and endangered species and to maximize benefits for other priority resources of concern.

Objective 4.1 Transitional Habitats: Grasslands, Shrublands, and Young Trees

Within the next 15 years, restore and maintain early successional areas to represent the historic range of variability for upland transitional habitats. These habitats will be dominated by native vegetation reflecting several seral stage distributions that mimic historic conditions. Transitional habitats will usually be small in size and imbedded within a habitat matrix of wetland and upland forested habitats. Create a continuum of natural habitats to include a mosaic of grassland, transitional, young and old shrublands, and young forest habitats on 2,000 acres undergoing restoration to native vegetation (included those areas planted in trees or transitioning through natural succession for Delmarva fox squirrel management purposes).

Maintain at least 20 percent of the above acreage in an early successional condition (shrubland or grassland mix) to meet the needs of priority resources of concern. These habitats will support high priority breeding and migrating birds identified in BRC 30, Partners in Flight 44, the State Wildlife Action Plan (2005) and Birds of Conservation Concern (USFWS 2008a) lists and include the following prairie warbler, blue-winged warbler, northern bobwhite, brown thrasher, whip-poor-will, willow flycatcher, eastern towhee, field sparrow, and Henslow's sparrow.

Rationale

By managing native plant succession from early pioneering stages through climax communities through seral stages, we will simultaneously accommodate multiple priority focal species that will be able to use a wide diversity of ecological niches that develop with this habitat management scheme. These lands will be managed in a transitional and ever-changing state.

The reduction in areas and diversity of shrub-land dominated communities has also taken a toll on obligate invertebrates of this habitat type. Tiger beetle conservation status throughout the northeast also exemplifies the rarity of shrublands on the landscape; two are federally listed and 19 are ranked as S1 by several heritage programs throughout the region. Likewise more than two thirds of Lepidoptera listed as S1 and S2 throughout the Northeast are obligates of non-forested early successional communities. The native forbs that grow interspersed in a thicket matrix also support substantial invertebrate richness and abundance (Litvaitis et al. 1999).

Ecological Model for Managing Shrubland Birds
Most early successional communities are temporary and dynamic in nature, constantly changing as more shade-tolerant trees replace sun-loving shrub species. Since old fields and shrubland habitats are relatively short-lived (20 to 25 years), recurring active management must be conducted to maintain desired habitat structure. Shrubland communities are disturbance dependent, but no single prescription effectively manages every successional community. Given the highly ephemeral nature of these successional communities, maintaining specific stages will require strategic periodic disturbance activities to sustain them and constant monitoring to cue the management actions (see Figure 4-1).

Peterjohn (2006) suggests that it is more practical to direct management toward maintaining generalized categories of shrubland seral stages rather than targeting specific plant community composition. To manage shrubland seral stages on the refuge, we will use his ecological model for managing breeding shrubland birds in the mid-Atlantic region. These managed successional stages include transitional shrublands, young shrublands, and older shrublands (Restoring, improving, and maintaining shrubland areas interspersed with grassland and forested areas is conducive to creating a continuum of shifting mosaics of various sized patches and configurations that will benefit a large suite of priority breeding and migrating songbirds. For example, many birds of mature forests heavily use shrubland habitats during the postbreeding period. Dense vegetation and abundant fruit resources found in early successional forest and shrubland habitats have been shown to be very important for survival of mature forest birds during the postbreeding period (Vitz and Rodewald 2007).

Abundant fruit resources produced in shrubland habitats provide an easily captured food source but also attract insects, further enhancing foraging opportunities for both adult and juvenile mature-forest dependent birds during migrational periods. Dense shrub cover also decreases the need to move widely in search of food and reduces energy loss and exposure to predators. Fruits have high sugar content that aids in accumulating fat reserves to facilitate migration (Parrish 2000).

All the priority shrubland species listed in objective 4.1 utilize old fields with different levels of woody intrusion. Prairie warblers, field sparrows, and willow flycatcher prefer relatively young old fields with scattered shrubs and trees with moderate shrub cover. These species do not like later successional stages where shrubs or saplings form dense continuous tangles. By comparison, brown thrasher, eastern towhee, and blue-winged warbler prefer later-stage old fields with moderate to dense shrub cover, and white-eyed vireo and yellow-breasted chat also benefit (see CCP-appendix E, table 6 of focal species life history requirements for early sucessional habitats).

Review of the life history requirements of targeted birds shows that none of the shrubland-dependent species has very specialized habitat requirements, so they can be readily placed into the three distinct shrubland bird guilds—field specialists, ubiquitous species, or multiple habitat species—described by Peterjohn (2006) for shrubland birds in the mid-Atlantic (see Table 4-3).

- Field specialists: restricted to larger (2 to 20 ha/5 to 50 acres) patches of shrubland habitats.

- Ubiquitous species: occurring along linear edge habitats and fields, such as bushy woodland edges, roadsides, hedgerows, and other corridors less than 10 meters (33 ft) wide.

- Multiple habitat species: requiring other habitats in addition to shrublands for breeding.

Figure 4-1. Scheme of management decisions and habitat actions concerning development of secondary successional shrubland habitats on Prime Hook NWR

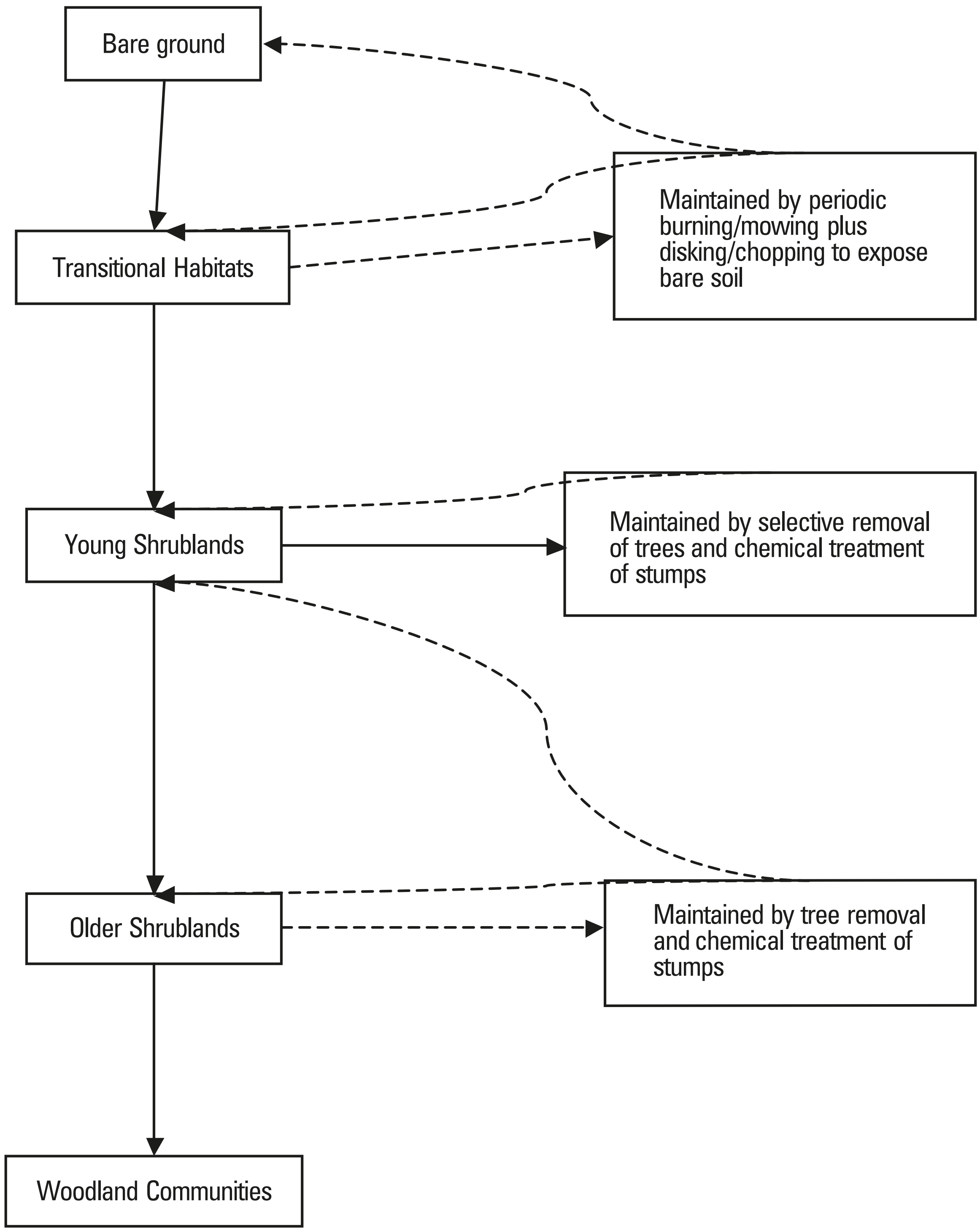


Table 4-3. Shrubland bird ecological requirements

Shrubland Bird Ecological Requirements	
FIELD SPECIALISTS	HABITAT REQUIREMENTS
Field sparrow	Transitional Shrubland
Common yellow throat	Transitional Shrubland
Prairie warbler	Young Shrubland
Willow flycatcher	Young Shrubland
Yellow-breasted chat	Young Shrubland
White-eyed vireo	Young Shrubland
Blue-winged warbler	Young Shrubland
Yellow warbler	Young Shrubland
UBIQUITOUS SPECIES	
Brown thrasher	Young Shrubland
Eastern towhee	Young Shrubland
Blue grosbeak	Young Shrubland
MULTIPLE HABITAT SPECIES	
Northern bobwhite	Transitional Shrubland
Black-billed/Yellow-billed cuckoos	Older Shrubland
Whip-poor-will	Older Shrubland

The Vitz and Rodewald study (2007) results have shown that during the post breeding period, birds (especially red-eyed vireo, worm-eating warbler, ovenbird, hooded warbler, and scarlet tanager) seek out the structurally complex and low vegetation structure (greater than or equal to 4.5 m) that shrub and sapling habitats provide. These habitat factors showed the highest capture rates during migration, demonstrating their importance for seasonal frugivores. It was concluded that early successional stands have legitimate conservation value to mature forest-breeding birds as well as early successional breeding birds, as shrubland habitats promote their survival and improve post breeding season condition for migrants.

Strategies
See strategies listed under objective 4.2.

Objective 4.2 Grassland Bird Habitat Management

Manage for an interspersion of habitat structures for bird species that utilize grasslands during breeding as well as non-breeding seasons by maintaining a mixture of short, medium, and tall native grassland vegetation in areas of the refuge not well-suited to reforestation. This may be accomplished in varying amounts in rotation with shrubland and forest management. This will provide breeding habitats for northern bobwhite, northern harrier, and other obligate grassland nesting birds, and also provide migrating and wintering habitats for Canada geese, shorebird, and songbird species.

Specifically, manage 124 acres (50 hectares) or more of grasslands adjacent to salt marsh habitat to meet the needs of priority species that would be especially attracted to such a landscape context, such as breeding Henslow's sparrows and wintering northern harriers.

- Habitat characteristics include patch sizes of no less than 75 acres (30 ha) in moderately tall grassy vegetation (greater than 30 cm) with a well-developed litter layer, woody species accounting for less than 10 percent habitat coverage, a forb component of about 25 percent, and less than 10 percent of non-native grasses or invasive plant species.

Rationale

Grassland birds are those birds that rely on grassland habitats include various species of waterfowl, raptors, shorebirds, upland gamebirds, and songbirds that require native grasslands for nesting and other habitat functions. We will use habitat generalizations to create a mosaic of grassland habitat conditions to provide quality food and cover resources for a wide spectrum of grassland nesting and wintering birds.

Grassland bird use will vary with the physical habitat structure, disturbance patterns, and other factors (Table 4-4). For each bird species, these grassland habitats can provide protective cover for nesting and brood rearing activities in the spring and summer. They provide a diversity of native plants that produce important food items—mostly insects and other invertebrates that include grasshoppers, crickets, beetles, caterpillars, ants, katydids, dragonflies, cutworms, wasps, flies, spiders, snails, and sow bugs for nesting female birds and young. These habitats provide important raptor prey items like mice, voles, shrews, rabbits, groundhogs, snakes, lizards, songbirds, and other wildlife species, and provide food and cover resources for migrating and wintering Canada geese, northern bobwhite, black-bellied plover, sparrows, and other grassland-dependent bird species.

Table 4-4. Habitat preferences of some birds using grasslands

Species	Preferred Grassland Growth			Avoid Woody Vegetation
	Short	Medium	Tall	
Northern harrier			X	X
Barn owl	X	X	X	X
Short-eared owl		X		X
Northern bobwhite			X	
Willet	X	X		X
Canada goose	X	X		X
Horned lark	X			X
Sedge wren			X	
Black-bellied plover	X	X		X
Bobolink		X		X
Eastern meadowlark		X		
Vesper sparrow	X			
Savannah sparrow	X	X		
Grasshopper sparrow	X			
Dickcissel		X	X	
Henslow's sparrow		X	X	X

Although perpetual grassland maintenance is not a focal component of our habitat management program, we have the opportunity to meet the needs of several species of conservation concern. By focusing some grassland management in areas adjacent to high salt marsh, our efforts can target Henslow's sparrow as a priority species while also serving to umbrella habitat requirements for other grassland species, such as northern bobwhite and various species of waterfowl, raptors, shorebirds, upland gamebirds, and songbirds that need grassland habitats for nesting and other habitat functions. The Henslow's sparrow nests in the highest portion of high marsh zones within the marsh/upland ecotone. This habitat is often linear and characterized by stands of salt meadow hay interspersed with shrubs that grade into patches of switch grass. Availability of switch grass seems to be important to the distribution of these sparrows (Zimmerman 1988 and Smith 1992). Maintaining grassland habitats near high salt marsh areas would also benefit coastal plain swamp sparrow, short-eared owl, eastern meadowlarks, migrating savannah sparrow, vesper sparrow, grasshopper sparrow, willet, sedge wren, horned lark, northern harrier, black-bellied plover, and Canada geese. In addition to birds, species such as migrating and resident butterflies, frosted elfin, American burying beetle, eastern box turtle, milk snake, least shrew, and rare native plant species would benefit.

As with shrubland management, maintenance of grassland communities will require periodic disturbance, resulting in a range of seral stages over time or space. The result of this is a diversity of grassland structure (short, medium, tall) at any one time and in any particular place, each potentially serving the habitat needs of different suites of species.

Many of the refuge's upland fields proposed to be managed in accordance with objectives 4.1 and 4.2 have been part of the refuge's cooperative farming program. In the past, the primary objective of the farming program was to provide food for certain duck species (mallard, American black duck, northern pintail, and wood duck) and Canada geese during the fall, winter, and spring. A secondary objective of the farming program was duck production; croplands in grass or clover stages of rotation were designed to provide nesting habitats for ducks. In recent years, duck species seldom or never used cropland field habitats due to plentiful wetland and aquatic habitats available on refuge marsh habitats. Sufficient natural foods are also produced to satisfy the needs of Canada geese in these habitats, especially if measures are taken to reduce snow goose numbers. Waterfowl production is no longer a management objective for Prime Hook NWR, so promoting early successional grass or clover to provide nesting cover is unnecessary. Finally, the elimination of farming on the refuge is consistent with recommendations in the Service's final environmental impact statement on the management of light geese (USFWS 2007a), which encourages refuges to reduce areas planted to agricultural crops that serve as a supplemental food source for overabundant greater snow geese. Managing a portion of these previously farmed acres as grassland and other transitional habitats better serves numerous refuge objectives.

Strategies for Objectives 4.1 and 4.2

- Implement field management prescriptions outlined in the habitat management plan (appendix B).

- These proactively restored or naturally succeeding areas will occur as a shifting mosaic of patches across the refuge's landscape as we implement decisions to allow open fields to grow to shrub and young forest, maintain early successional grassland patches near salt marsh habitats, or retain field openings adjacent to upland mature forests.

- Increase shrubland and forested buffered areas (greater than 200 m) adjacent to refuge creeks, depressional swamp and emergent wetland habitats, or restore prior converted wetlands for targeted species in both objectives 4.1 and 4.2.

- Use the U.S. Geological Survey publication "Conceptual Ecological Model for Management of Breeding Shrubland birds in the mid-Atlantic Region" (Peterjohn 2006) as a guide to restore and maintain shrubland habitats.

- Develop rotational management action schemes for prescribed fire, mowing, application of herbicides, etc., to create and maintain habitat conditions specified in objectives 4.1 and 4.2; more information on optimal disturbance schedules for shrubland management and other best management practices is currently being reviewed by the regional shrubland management work group.

- Engage the public in outreach and education about the benefits of pollinators, instilling a greater appreciation for invertebrates and their essential links to biological integrity, diversity, and environmental health.

Monitoring Elements for Objectives 4.1 and 4.2
Conduct appropriate monitoring and survey programs as funding and staffing permit to measure our success with respect to our objectives. The results may trigger adjustments to management strategies, or reevaluation or refinement of our objectives. Details of planned monitoring will be developed in a subsequent inventory and monitoring plan. Examples of monitoring or surveys that we may implement include:

- Prevent new invasive species from becoming established by utilizing early detection rapid response techniques that detect newly established invasive species, and immediately addresses those populations through the appropriate control measure. This approach will incorporate a combination of plant identification and inventories, maintaining updates of new invasive species present in the region, and knowing the appropriate management techniques prior to conducting control efforts.

- Develop monitoring protocols for targeted breeding and migratory birds dependent on early successional habitats.

- Conduct annual habitat condition assessments to determine what habitat management actions should be prescribed in annual habitat work plan.

- Develop GIS layers (e.g., RLGIS or similar) needed to document restoration and habitat management actions by field number, along with refuge management actions database to tract shifting mosaics of transitioning habitats.

- Explore the possibility of applying a current arthropod index of biological integrity for shrubland landscapes (Karr et al. 2003) and other shrubland metrics, in consultation with other refuges, as a standardized multi-metric index tool to assess the condition and restoration efforts of early successional upland habitats

Sea Level Rise and Climate Change Strategies and Monitoring
Sea level rise and climate change strategies are the same as those listed above and under objectives 2.1, 2.2, and 2.3.

GOAL 5: Visitor Services

Provide visitors with a place to safely take part in the six priority wildlife-dependent recreational uses established by the Refuge Improvement Act, as well as other public uses as may be allowed without interfering with refuge purposes and objectives for wildlife.

Objective 5.1 Hunting

Provide a high quality hunting program that is administratively efficient and used to maintain healthy habitats through the management of wildlife populations, where appropriate.

Rationale

Additional information regarding the proposed hunting program can be found in the compatibility determination in appendix E, and in the hunting management plan in appendix C.

Summary. To improve the refuge's hunting program, we evaluated hunting use on the refuge, incorporated the opinions of hunters, and developed this plan in collaboration with our State partners in the Delaware Division of Fish and Wildlife. These program changes, which reflect a diversity of hunting preferences and opportunities, strive to meet the guiding principles for a quality refuge hunting program identified in Service policy 605 FW 2. They also support Presidential Executive Order 13443: Facilitation of Hunting Heritage and Wildlife Conservation.

The hunting program has been adjusted to allow for more effective consumptive recreation opportunities along with an increase in opportunities for non-consumptive users to appreciate the refuge while avoiding conflicts with hunters. Our preferred alternative is to expand some aspects of the hunting program to include additional days and acres throughout the hunting seasons established by the state. Deer hunting acreage would increase from 4,020 to 5,221 acres, waterfowl hunting from 1,722 to 3,432 acres (which meets the 40% "inviolate sanctuary" rule), upland game & migratory bird hunting remains at 1,995 acres, and turkey hunting is added, from zero to 3,729 acres. However, we would only issue no more than five turkey hunting permits, and the vast majority of the refuge would remain open to wildlife observation and other non-consumptive uses during the turkey hunting season. Furthermore, we are providing 3,185 acres of sanctuary area (no-disturbance areas) for waterfowl and other wildlife. Given the dominant role of the refuge in the Atlantic Flyway migration corridor, this closed area system was established to provide waterfowl with a network of resting and feeding areas and to disperse waterfowl hunting opportunities on the refuge. Specific descriptions of these sanctuary areas can be found later in this chapter 4 (under Waterfowl Hunting) and chapter 5 of the CCP/EIS, but are roughly Unit II, the lower half of Unit III, and Unit IV (map 4-17).

Areas. Increases in proposed hunting acreages will provide new hunting opportunities from current management; however, many of these proposed "new" hunting areas are currently open to some type of hunting or were previously open either under refuge management or private ownership. For example, Unit I is currently open for deer and upland game hunting and is now proposed to be open for waterfowl hunting—same land, but with a new opportunity. The refuge lands currently closed to hunting and proposed to be open for any type of hunting that are not currently being hunted for any species includes: an area located north of Prime Hook Road commonly referred to as Oak Island (deer only), an area north of Route 16 referred to as the Millman Tract (deer and turkey), an expanded area of the existing Jefferson Lofland Area and Headquarters Area (deer & turkey), an expanded area of the Unit III waterfowl hunt area (waterfowl only), and an area west of Petersfield Ditch in Unit IV. Of these areas, Oak Island was previously hunted under refuge management up until 1995 and the Millman Tract was hunted under private ownership up until the Service purchased it in 2001. The expanded areas of the Jefferson-Lofland Area, Headquarters Area, and nearly all of the proposed Unit III waterfowl hunt area were previously hunted under refuge management. No prior hunting of the area west of Petersfield Ditch is known.

Administration. Other changes to the hunting program would lower administrative burdens to staff resources and improve hunting quality. More specifically, these changes include:

- Eliminating permanent hunting structures.
- Allowing hunters to free roam in most areas that can tolerate pedestrians or navigation without adverse impacts on a first-come, first-served basis following State regulations.
- Adopting one-time seasonal permits for all hunting areas except lottery hunts.
- Enhancing youth and disabled hunting opportunities.
- Establishing seasonal closures to minimize wildlife disturbance and avoid conflicts with other uses.
- Establishing preseason lottery drawings for high demand deer, waterfowl, and turkey hunt areas.
- Eliminating daily standby permit drawings.
- Eliminating permit fees except for lottery hunts.

All persons hunting on the refuge would be required to obtain the necessary State licenses, tags, and stamps. Waterfowl hunters would be required to have a Federal migratory bird hunting and conservation stamp (duck stamp). Each hunter would also be required to have a signed copy of the current Prime Hook NWR hunting regulations leaflet, which would serve as the refuge hunting permit. In addition, hunters participating in the lottery hunts for deer, waterfowl, and turkey would also be required to have a daily permit issued in advance of the hunt date through a contractor. Hunters would not be required to check-in or check-out on the day of any hunt.

For most areas, hunter numbers would not be limited to a specific hunt location. Hunters would have the ability to free roam for deer, waterfowl, upland game, and turkey in designated areas on a first-come, first-served basis. Non-ambulatory disabled hunters would be required to hunt from designated hunt blinds and waterfowl hunters in the waterfowl lottery hunt area (Unit III) within a defined area around a designated blind site. For the Statewide youth hunts, all designated hunt areas would be open for waterfowl, deer, or turkey hunting on a first-come, first-served basis. We don't know the number of hunters who will participate in refuge hunting opportunities; however, we do anticipate a slight increase from current levels.

Lottery. Preseason lottery drawings are proposed for high demand areas, including the lottery deer hunt area (headquarters area), disabled deer and waterfowl hunt areas, lottery waterfowl hunting area (described previously in this section), and lottery turkey area to reduce hunter conflicts, lessen administration, and provide equal opportunity for all hunters. For daily drawings on opening days under current management, it is common to see more than 100 deer hunters show up for 32 available shotgun hunting opportunities and 80 waterfowl hunting parties (with up to 3 people per party) show up for 25 to 27 available hunt blinds. This illustrates how inefficient and frustrating it is for a group of hunters to get up early in the morning when they have less than a one in three chance of getting a hunting spot. As a national wildlife refuge, Prime Hook NWR will provide hunting opportunities through these preseason drawings for local, in-State, and out-of-State hunters. Knowing in advance allows hunters to prepare, plan, and scout, which ultimately improves the quality of their hunting experience.

Preseason lottery drawings would be administered by a contracted company that will feature online and telephone services to collect hunter information and required fees (covered later in this section), and issue permits. These services would provide hunters with the ability to apply, pay for, and receive hunting permits in advance of the hunting dates. All fees must be paid prior to the issuance of a permit. Refuge staff would work with the contractor to provide the highest level of customer support.

For the preseason drawing for the lottery deer hunt area, hunters will be selected for a hunt date based on their date preferences. If selected, a limited number of hunters (no more than 30 hunters) would have access to the hunt area and may choose their hunting location on a first-come, first-served basis on the day of the hunt. For the lottery waterfowl hunt area and disabled deer and waterfowl hunt areas, hunters would be selected for a hunt date and hunting blind site based on their date preferences during the preseason drawing. Hunters could be picked for multiple dates. Only the first two days of each of the state's seasonal splits for waterfowl will be included in the preseason drawing for the disabled waterfowl area and will be first-come, first-serve thereafter. For the lottery waterfowl hunts, the selected hunter may take two additional people on that hunt day. Federal blind sites in addition to eight State blinds will be available each day. Everyone in the lottery drawing has an equal chance of being selected multiple times. The lottery turkey hunt may be administered by the Delaware Division of Fish and Wildlife.

For any vacant hunting opportunities not selected during the preseason lottery drawing, hunters would have the flexibility to go to the contractor's Web site at any time (24 hours a day) during the hunting season, view available hunt dates, and select and pay for these permits at any time. For those individuals who do not have computer access, customer representatives would be available by telephone during business hours on weekdays to assist. Hunters will be allowed to claim only one permit per day to prevent someone from claiming all available vacancies at one time. The licensing contractor would supply refuge staff with a list of permitted applicants. No daily standby lottery drawings would be conducted.

Deer stands and waterfowl blinds. Permanent hunting structures, such as deer hunting stands and duck hunting blinds, would be phased out over a 5-year period in all areas except the disabled hunting areas. We will limit the number of permits in the lottery hunt areas to minimize hunter conflict in areas historically known to attract large hunter numbers. In the case of deer hunting, the phasing out of permanent deer stands would require hunters to find a suitable hunting location within designated hunting areas through effective scouting. Use of portable deer climbing stands is recommended, but not required. In the case of waterfowl hunting, the phasing out of permanent waterfowl hunting blinds in the lottery hunt area will require hunters to provide their own means to camouflage themselves (boat blind, pop-up blind, etc.). Waterfowl hunters would be required to hunt within a defined area around a designated blind site (marker) in the lottery waterfowl hunt area. For any type of hunting, we feel that allowing hunters to scout and have the flexibility to adjust their hunting locations for weather conditions enhances the quality of their hunt. Maintenance mowing will no longer occur to provide trails to facilitate deer hunting. Some conflict among hunters over desired hunting locations is expected and we will continue to encourage proper hunting ethics.

Visitor safety at refuges is a high priority when developing compatible wildlife-dependent recreation programs, such as hunting; however, it is ultimately the responsibility of every hunter to be safe. An accident involving hunter safety results from either a lack of hunting ethics or a violation of hunting regulations. Use of portable deer climbing stands will be recommended but not required. For hunters who may be unable to climb trees using portable deer stands or who may wish to hunt from permanent deer stands or duck blinds, the state-owned Prime Hook Wildlife Area, which adjacent to the refuge, will continue to provide these opportunities. There are many areas on the Delmarva Peninsula, other than Prime Hook NWR, that offer public hunting opportunities in free-roam areas or from designated permanent structures. Additional information about free roam hunting and the use of deer stands and duck blinds on the refuge and on the Delmarva Peninsula can be found in the visitor services section in chapter 3 or the hunting management plan in appendix C.

Disabled. The refuge's proposed action offers opportunities for all disabled individuals. Areas will be reestablished for disabled hunters permanently confined to wheelchairs for movement to ensure that these individuals have opportunities for quality hunting experiences. Hunters confined to wheelchairs have limited mobility and there are no opportunities on the refuge to hunt unless refuge staff provides them with accessible infrastructure such as ground blinds and vehicular access to them. These hunters don't have the option to hunt other areas, as they are limited by the accessibility that the refuge provides them. Since there are no other reasonable accommodation options for non-ambulatory individuals to hunt in other areas of the Refuge, and there are sufficient circumstances affecting their only access provided to them to participate in the Refuge's hunting program, then this a justifiable reason to implement methods that will allow them access to the hunting program. Other disabled, yet ambulatory hunters are provided opportunities to hunt in the free roam areas, are not required in any fixed location, and may choose how far they are capable or willing to travel to hunt. Because these proposed changes do not exclude hunters with other types of disabilities from the Refuge's hunting program, these methods are in compliance with the intent of the Americans with Disabilities Act.

Non-ambulatory hunters have commented about their frustration with the current hunting system. The number of non-ambulatory hunters on the refuge has decreased since 2005, when access was granted to all individuals with any permanent disability (not just non-ambulatory hunters) to hunt in the disabled hunting area along with additional hunting days. Hunter success rates for deer have also decreased from an average of 32% from 2000-2005 to an average of 18% from 2005 to present.

Youth hunting. The Service proposes to enhance youth hunting opportunities by collaborating with State partners and NGO hunting organizations to develop hunter training programs that instruct beginning hunters in the knowledge and skills necessary to become responsible, respected individuals who strive to learn all they can about the species being hunted and to become knowledgeable in firearms safety, hunter ethics and wildlife conservation. The Service will also develop mentored hunting programs for both youth and adults and offer programs developed by NASP, or National Archery in the Schools program, to encourage family participation in archery shooting. Portions of any area open to hunting may be used to facilitate these mentored hunts and these areas will be temporarily closed to the general hunting public during those times.

Season dates, bag limits, and harvest methods for the hunting program at Prime Hook NWR will be consistent with State and Federal hunting frameworks and regulations. However, restrictions to these frameworks are listed below in the strategies and refuge-specific regulations to minimize user conflicts, address natural resource impacts, reduce administrative complexity, and ensure a quality hunting experience. The refuge manager will evaluate and make necessary adaptations to the hunting program to ensure that the refuge is meeting resource management objectives and continuing to offer quality experiences. Therefore, the refuge manager may extend or close hunting opportunities on the refuge within the established hunting seasons of the Delaware Division of Fish and Wildlife. The hunt program would apply to lands now a part of the refuge and lands added to the refuge in the future.

Strategies
In addition to those strategies listed under Actions Common to all Alternatives affecting this program,

- Expand hunting opportunities for deer, waterfowl (including snow geese), upland game, webless migratory birds, and turkey (for details, refer to objectives 5.1a through 5.1d)
  - Support Presidential Executive Order 13443: Facilitation of Hunting Heritage and Wildlife Conservation
  - Adopt all State of Delaware hunting seasons and regulations, except as restricted in refuge-specific regulations
  - Provide additional hunting days and areas over current program
  - Put seasonal closures in effect for some areas to minimize wildlife disturbance and avoid conflicts with other public recreational programs
  - Provide high-quality hunting opportunities for turkey
- Adopt a one-time issued seasonal permit except for lottery hunts
  - Permit must be signed and in possession of hunter
  - Permits are non-transferable
- Remove all permit fees except for lottery hunts
  - Adjust the fee schedule for the lottery deer hunt area, lottery waterfowl hunt area, disabled deer and waterfowl hunt areas, and lottery turkey hunt area
- Increase the application fee for preseason lottery drawing to $5/hunter
- Require a processing fee of $2 to 3 per hunt for vacancies remaining after the preseason lottery drawing
- Adjusted permit fees are as follows:
  - Deer and turkey—$10 per daily permit (per blind for non-ambulatory disabled hunters; application & permit fees for turkey hunting may be waived if the lottery drawing is administered by the State)

- Waterfowl—$15 per daily permit per blind site
- The 50 percent discount on permit fees to interagency senior and access passholders does not apply
- Youth hunters age 15 years and younger must obtain a free seasonal permit. Only hunters aged 16 years and older can apply for or obtain a lottery hunt area permit.

Permit fees. The refuge collects boat ramp launching fees and hunting permit fees under the guidance of the Federal Lands Recreation Enhancement Act, 16 U.S.C. 6803(c), Consolidated Appropriations Act (PL 108-447). This law grants the Secretary authority to collect recreation fee revenues for public recreation. The Recreation Enhancement Act provides for a nationally consistent interagency program, additional on-the-ground improvements to visitor services sites across the nation, a new national pass for use across interagency federal recreational sites and services, and more public involvement in the program. The act replaces the Recreation Fee Demonstration Program and authorizes the Recreation Fee Program for 10 years through 2014. At least 80 percent of the funds raised from user fees on a particular refuge in this region stay at the refuge and are used to enhance visitor services and reduce the backlog of maintenance needs for recreation facilities. Recreation fees may not be used to pay for biological monitoring on Federal recreational lands and waters under the Endangered Species Act of 1973, for listed or candidate species or to pay for employee bonuses. The remaining 20 percent is sent to the region to be distributed to other refuges. In previous years, the refuge has received money from these regional funds for visitor services (appendix I).

This alternative reduces the administrative burden and minimizes the amount of staffing resources needed to conduct the hunt by 54 staff days and $17,890. The benefit to the hunter is a reduction in the cost to hunt. Therefore, the refuge proposes to eliminate permit fees to hunt on the refuge except for the lottery hunts (see chapter 3 for discussion of fees in the current hunting program).

Fees will be required to manage the lottery hunts for deer, waterfowl, and turkey. Application and permit fees for turkey hunting may be waived if the lottery drawing is administered by the State. The Refuge Recreation Act requires that funds be available for the development, operation, and maintenance of the permitted forms of recreation. The proposed permit fee ($10 for deer and turkey, $15 for waterfowl), preseason application fee ($5/hunter), and processing fee for permits acquired after the preseason drawing ($2 to 3 per hunt) are the minimal amounts needed to offset the cost of facilitating the preseason drawings and managing the lottery hunts. Due to the uncertainty in the level of hunter participation with these new program changes, permit fees may need to be adjusted (increased or decreased), and therefore will be evaluated during the first 5 years of the CCP. Preseason lottery drawings will be administered by a contracted company that will collect information and required fees, conduct the drawing, and issue the permits. This may reduce our costs by more than $3,000 and application and processing fees will be paid to the contractors for administering this permitting process. Refuge staff will work with the contractor to provide the highest level of customer support. Signs for posting hunting areas, trails, etc., will have an initial, one-time cost.

- Provide lottery hunts in the lottery waterfowl hunt area, lottery deer hunt area, disabled deer and waterfowl hunt areas, and lottery turkey hunt area. See discussion earlier in this section or objectives 5.1a, 5.1b, or 5.1d for more information.

  - Conduct a preseason drawing to issue permits and collect fees for all available hunting dates. Drawings will be administered by a contracted company that will collect information and required fees, conduct the drawing, and issue the permits. Hunting opportunities for these lottery hunts will be available to hunters through the preseason drawing and throughout the season by going to the contractor's website or calling a customer service representative. For vacant hunting opportunities after the preseason drawing, hunters will be allowed to claim only one permit per day to avoid someone from claiming all available vacancies at one time. Hunters would have the option to forfeit their permit to the contractor if circumstances prevented them from hunting on that day, without compensation, i.e. no refunds, to make their reservation available to other hunters.

  - Permits are non-transferable. No daily standby drawings will be conducted.

  - Permit and application fees apply.

  - Preseason drawings for turkey hunting may be conducted by the Delaware Division of Fish and Wildlife and if so, application and permit fees may be waived.

- Enhance disabled hunting opportunities, particularly for those permanently confined to wheelchairs (see objectives 5.1a and 5.1b for more information).

- Enhance youth hunting opportunities

  - Collaborate with State partners and NGO hunting organizations to develop hunter training programs that instruct beginning hunters in the knowledge and skills necessary to become responsible, respected individuals who strive to learn all they can about the species being hunted and to become knowledgeable in firearms safety, hunter ethics and wildlife conservation.

  - Develop mentored hunting programs for both youth and adults and offer programs developed by NASP, or National Archery in the Schools program, to encourage family participation in archery shooting.

  - Portions of any area open to hunting may be used to facilitate these mentored hunts and these areas will be temporarily closed to the general hunting public during those times.

- Seasonal closures apply to non-consumptive users during the hunting season, which is typically a slower period of use due to weather conditions, and are highlighted below:

  - Deep Branch Road Trail (includes Goose and Flaxhole Ponds; Unit III), Eastern Prime Hook Creek (from Foord's Landing to headquarter ramp) (Unit III), and hiking trail on Fowler Beach Road (southside of Unit II): Closed every day from September 1 through March 15. Additional seasonal closures may apply through the second Saturday in May for hunting during the snow goose conservation order or turkey hunting. If and when the photography blind is available on the southside of Fowler Beach Road, this portion of the trail will be open year round and open every Sunday during the hunting season.

  - Headquarters area (includes Turkle and Fleetwood Ponds) (Unit III): Closed only for a maximum of two days for deer hunts and portions may be closed for turkey hunts.

  - Island Farm Area in Unit IV (includes trail overlooking Vergie's Pond): Closed from the Monday before Thanksgiving through March 15. Additional seasonal closures may apply through the second Saturday in May for hunting during the snow goose conservation order.

  - Hiking trails on Fowler Beach Road (Unit I), Prime Hook Road (Unit III), and Slaughter Beach Road and Slaughter Canal (Unit I): Open only on Sundays from September 1 through the deer and waterfowl hunting seasons, which typically end in February. Additional seasonal closures may apply through the second Saturday in May for hunting during the snow goose conservation order or turkey hunting.

- Add a new full-time law enforcement officer to enforce regulations

- Improve access at boat launching areas

  - Enhance boat ramp access on Fowler Beach Road for access to Slaughter Canal.

  - Work with private landowners to improve access to western end of Prime Hook Creek.

  - Within 5 years of the plan, open a boat ramp for access to Prime Hook Creek at Foord's Landing.

- General regulations for all hunting programs

  - Hunters may not be on the refuge any earlier than two hours before shooting time.

  - Non-toxic shot is required for all hunting except lead slugs are permitted for deer or fox hunting.

  - Individuals assisting non-ambulatory disabled deer hunters are not permitted to hunt; however, up to two individuals may hunt while assisting a non-ambulatory disabled waterfowl hunter. All disabled hunters are required to have an assistant.

  - Designate Slaughter Canal as a slow no wake zone.

  - Digging for any reason is prohibited.

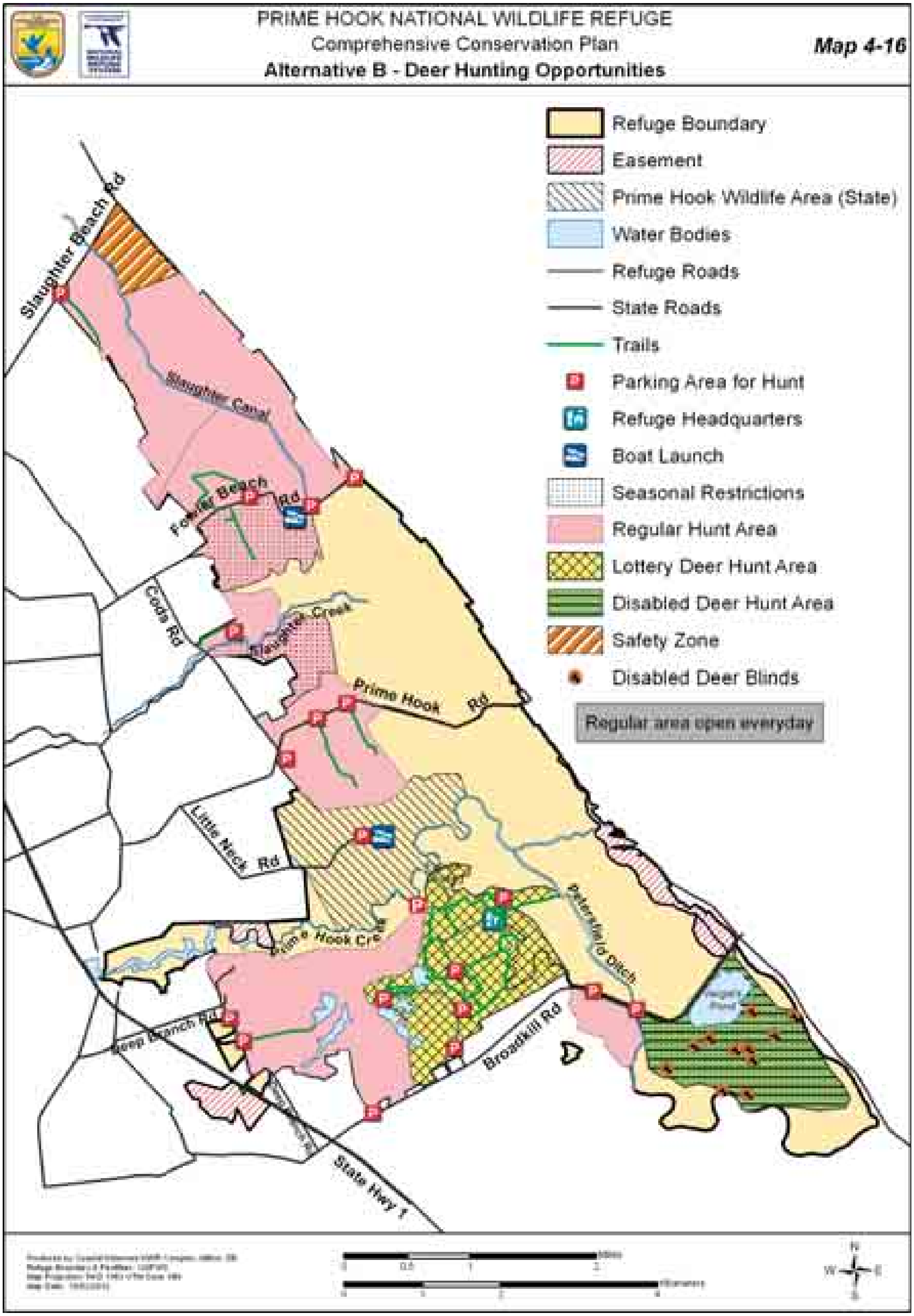
Objective 5.1a White-Tailed Deer Hunting

Provide high-quality hunting opportunities for white-tailed deer.

Rationale

In addition to the information presented under objective 5.1, deer hunting would be increased to include an additional 1,201 acres beyond current management for a total of 5,221 acres. We would open these acres for archery (to include the use of crossbows), muzzleloader, or shotgun (to include the use of handguns) hunting, where appropriate, and would phase out permanent deer stands. Seasonal closures would occur not only to protect wildlife, but also to minimize conflicts between different hunting activities and other non-consumptive recreational uses (e.g., minimize conflict with anglers on Prime Hook Creek and close hunting in late November in designated areas to minimize bald eagle and waterfowl disturbance). The disabled hunting areas in Unit IV under this alternative would limit access to individuals who are permanently confined to a wheelchair for movement. Map 4-16 depicts deer hunting opportunities and infrastructure.

Map 4-16. Deer hunting opportunities under alternative B



Strategies
In addition to objective 5.1 strategies under alternative B:

- Hunting will be on a first-come, first-served basis except for lottery hunts.

- Check in and check out by hunters would not be required for any deer hunt.

- Expand deer hunting opportunities from 4,020 acres to 5,221 acres, an increase of 1,201 acres (Map 4-16).

  - The refuge has adopted State hunting regulations and seasons for the regular deer hunt area with the following restrictions:

    - No access by boat from Slaughter Creek on Cods Road

  - There is no infrastructure to support boat launching.

  - Seasonal closures to deer hunting from the Monday before Thanksgiving through March 15 will occur on the designated area north of Prime Hook Beach Road (Oak Island) and south of Fowler Beach Road to minimize disturbance to waterfowl and nesting bald eagles. The disabled deer hunt area in the Island Farm will be closed following the November shotgun season to minimize wildlife disturbance.

- Phase out permanent deer hunting stands over a 5-year period or when they become unsafe, whichever comes first.

  - Hunters may free roam in hunting areas except in the disabled deer hunt area.

  - Portable stands are permitted.

  - Eliminate maintenance mowing except for disabled hunt areas.

- Hunters will not be required to report their harvest data to the refuge. Refuge staff will collect harvest information from the existing reporting system administered by the State Delaware Division of Fish and Wildlife.

- Enhance hunting opportunities for individuals with disabilities, particularly for those permanently confined to wheelchairs.

  - Reestablish areas for non-ambulatory disabled hunters permanently confined to wheelchairs in a designated area in Unit IV.

  - Provide a limited number of hunting days during the early muzzleloader hunting season, the Statewide non-ambulatory hunt in November, and the early shotgun hunting seasons in the disabled hunt area to minimize deer disturbance and maximize quality hunting experience. A total of 11 ground blinds are currently available and required. Additional sites in this area may be provided.

  - The refuge may evaluate the regular deer hunting area for the potential to incorporate hunting opportunities for non-ambulatory hunters.

- Provide lottery hunts in the lottery deer hunt area and the disabled deer hunt area for a limited number of days during the firearms deer hunting seasons.

- A limited number of permits (no more than 30 for the lottery deer hunt area) will be issued for each hunt day to reduce conflict and maintain quality hunting experiences.

- Hunters may hunt anywhere within the lottery deer hunt area on a first-come, first-served basis. Hunters in the disabled deer hunt area must hunt from one of 11 ground blinds in the area.

  - The areas will be gated to minimize conflict with the general public and times will be designated for ingress and egress to the area.

- The refuge will participate in the Statewide non-ambulatory deer hunt. The lottery deer hunt area will not be open for this hunt.

- General regulations for deer hunting.

  - Enhanced opportunities for scouting will be allowed 2 weeks before the start of archery season and throughout the deer hunting season.

  - Hunters must be out of the hunting areas one and one-half hours after the evening shooting time.

Objective 5.1b Waterfowl Hunting

Provide high-quality hunting opportunities for waterfowl.

Rationale
In addition to the information presented under objective 5.1, waterfowl hunting would be increased to include an additional 1,710 acres from current management for a total of 3,432 acres. Seasonal closures would occur to protect wildlife and minimize conflicts between different hunting activities or other non-consumptive recreational uses (e.g., close hunting in late November in designated areas to minimize bald eagle and waterfowl disturbance). We would phase-out permanent waterfowl hunting blinds. In all hunt areas, hunting is proposed to remain at four days per week and to cease at 3pm to minimize wildlife disturbance and provide quality hunting experiences. The disabled hunting areas in Unit IV under this alternative would limit access to individuals who are permanently confined to a wheelchair for movement.

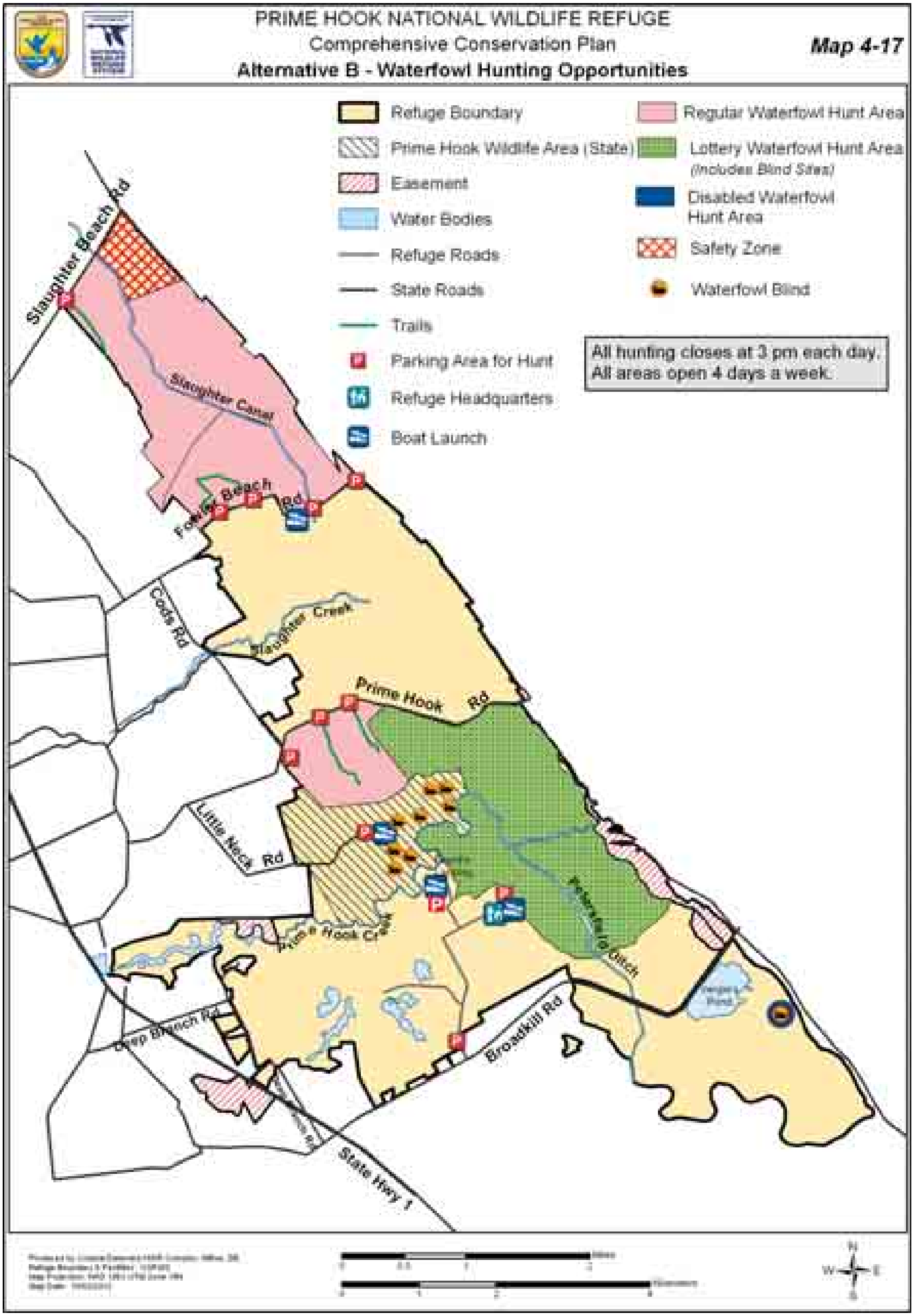
The addition of new free-roam waterfowl hunting areas in salt marsh habitats in Unit I will provide quality opportunities, particularly when refuge impoundments freeze. Sanctuaries totaling 3,185 acres are provided as disturbance free areas for wildlife where no recreational activity is permitted. Map 4-17 depicts waterfowl hunting opportunities and infrastructure. In the lottery waterfowl area, the Service limits the number of hunting parties through the use of designated blind sites. In free roam areas, hunters are limited by the available access for parking and boat launching and by hunters thinning themselves out as a way to minimize conflict with other hunting parties.

Strategies
In addition to objective 5.1 strategies under alternative B,

- Create waterfowl sanctuaries (disturbance free areas) in Unit II (approximately 1,800 acres), Unit III (approximately 390 acres), and Unit IV (approximately 995 acres)

  - The Unit II impoundment area will be closed annually to all public use.

Map 4-17. Waterfowl hunting opportunities under alternative B



- Except for the disabled waterfowl hunt area (approximately 25 acres), most of Unit IV will be closed from the Monday before Thanksgiving through March 15 to all public use.

- Additional seasonal closures may apply through the second Saturday in May for hunting during the snow goose conservation order or for wild turkey.

To support waterfowl conservation efforts, the refuge has designated about 3,185 acres as waterfowl sanctuaries that will be closed to hunting and other recreational use on a seasonal or annual basis. These sanctuaries lie in Unit II (1,800 acres), the southern half of Unit III (390 acres), and most of Unit IV (995 acres) and provide resting and feeding habitat for waterfowl to concentrate rather than dispersing throughout the refuge. These sanctuaries function to provide migrating waterfowl with a more balanced and effective network of feeding and resting areas, to minimize disturbance to feeding and resting waterfowl, and to provide waterfowl hunters with more equitable hunting opportunities throughout the refuge.

- Establish hunter spacing limits

  - Reduce hunter competition and improve hunting quality

- Managed hunts in the lottery waterfowl hunt area will provide opportunities for a limited number of hunters and allow them to choose their hunting location

- Expanded hunting areas will provide greater opportunity for hunters

- Expand hunting opportunities from 1,722 acres to 3,432 acres or 40 percent of the refuge to include new hunting opportunities in Unit I and III. We must follow the guidelines of the 40 percent rule. All areas approved for purchase by the Migratory Bird Conservation Commission prior to 1978 are inviolate sanctuaries and thus subject to the 40% limitation, meaning only 40 percent of the area or areas can be open to migratory bird hunting. In 1978, the Fish and Wildlife Improvement Act amended Section 6 of the Refuge Administration Act of 1966 “to provide the opening of all or any portion of an inviolate sanctuary to the taking of migratory birds if the taking is determined to be beneficial to the species.” In addition, the act amended Section 5 of the Migratory Bird Conservation Act to include the provision that areas could be acquired for other management purposes.

  - The refuge has adopted State hunting regulations and seasons with the following restrictions:

    - Hunting will be on a first-come, first-served basis that includes jump shooting (except for lottery hunts and disabled hunts).

    - In all waterfowl hunting areas, hunting is permitted four days per week until 3pm during the state waterfowl hunting seasons (except everyday during the snow goose conservation order).

    - Check-in and check-out by hunters would not be required for any waterfowl hunt.

- Phase-out permanent waterfowl hunting blinds over a 5-year period or when they become unsafe; whichever comes first.

  - Hunters may free roam in the regular waterfowl hunting areas (except the lottery waterfowl hunt area and disabled waterfowl hunt area).

  - Hunters would be required to hunt from hunting blind site areas in the lottery waterfowl hunt area and disabled waterfowl hunt area.

  - Blind site areas are subject to change due to changing habitat conditions, to improve the quality of hunting, or for safety considerations.

- Hunters will not be required to report their harvest data to the refuge. Harvest information will be collected through the harvest information program system.

- Enhance hunting opportunities for individuals with disabilities, particularly for those permanently confined to wheelchairs.

  - Reestablish areas for nonambulatory disabled hunters permanently confined to wheelchairs in a designated area in Unit IV.

  - One disabled, wheelchair accessible, and camouflaged waterfowl hunting blind is available.

- Provide lottery hunts in the lottery waterfowl hunt area and disabled waterfowl hunt area.

  - Through a preseason lottery drawing, hunters must choose their hunt dates and blind site locations from among the designated blind locations.

  - Only the first two days of each of the state's seasonal hunting splits for waterfowl will be included in the preseason drawing for the disabled waterfowl area and will be first-come, first-serve thereafter.

  - Within 5 years of CCP signing, we will open boat ramp access at Foord's Landing for all public recreational access.

- The refuge will participate in all State of Delaware waterfowl hunting seasons unless otherwise restricted. This includes the duck seasons, early teal season, youth waterfowl hunts, resident Canada goose season, and snow goose season (early and snow goose conservation order).

  - Provide hunting opportunities during the resident Canada goose season and the early teal season in all areas designated as open to waterfowl hunting. In the lottery waterfowl hunt area, all regulations apply as stated in earlier strategies of this objective, except hunting will be on a first-come, first-serve basis and no preseason drawing will occur. In the regular waterfowl area, all regulations apply as stated in earlier strategies of this objective.

  - Institute lethal snow goose control and provide hunting opportunities during the State of Delaware's snow goose conservation order season in all four management units throughout the refuge on a first-come, first-served basis everyday of the season during legal shooting hours.

    - The light goose conservation order is an action implemented under the final environmental impact statement on the management of light geese (USFWS 2007a) to help reduce overabundant greater snow goose populations. Although the refuge has been closed recently to late snow goose hunting, the conservation order presents an opportunity to reopen to snow goose hunting during the late season in coordination with the State Delaware Division of Fish and Wildlife. This will be pursued as an option whenever the conservation order is in effect. All special harvest methods permitted by the conservation order apply.

      * Hunting is not permitted in upland areas.

   * The youth hunts will occur in all designated hunting areas on a first-come, first-served basis.

   * In the lottery hunt area and disabled waterfowl hunt area, snow geese may only be taken when already open for duck hunting or during the snow goose conservation order.

- General information for waterfowl hunting

   * Enhanced opportunities for scouting will be allowed on Sundays immediately prior to each of the duck season splits.

   * Hunters must be out of the hunting areas by 4:00 pm.

Objective 5.1c Upland Game and Webless Migratory Bird Hunting

Provide high-quality hunting opportunities for upland game (rabbit, quail, pheasant, and red fox) and webless migratory birds (mourning dove, snipe, and woodcock).

Rationale
In addition to the information presented under objective 5.1, upland game and webless migratory bird hunting will remain the same at 1,995 acres. However, the dove hunting acres will be decreased by 110 acres. The hunting of red fox will assist State management efforts in reducing the incidence of mange outbreaks to maintain a healthy population and reduce the predatory impact of this species on migrating and breeding birds, particularly State and federally endangered or threatened species. Map 4-18 depicts upland game and webless migratory bird hunting opportunities and infrastructure.

Strategies
In addition to objective 5.1 strategies under alternative B:

- Continue upland game and webless migratory bird hunting opportunities on 1,995 acres (110 of the total acres would not be open to dove hunting). See objective 5.1b for explanation of 40 percent migratory bird hunting rule.

   * The refuge has adopted State hunting regulations and seasons for the upland game hunting area with the following restrictions:

      * Provide new hunting opportunities for red fox.

         ◆ Hunting of red fox is permitted only when concurrently hunting deer and is only permitted in areas open to deer hunting.

         ◆ Chase hunting is prohibited.

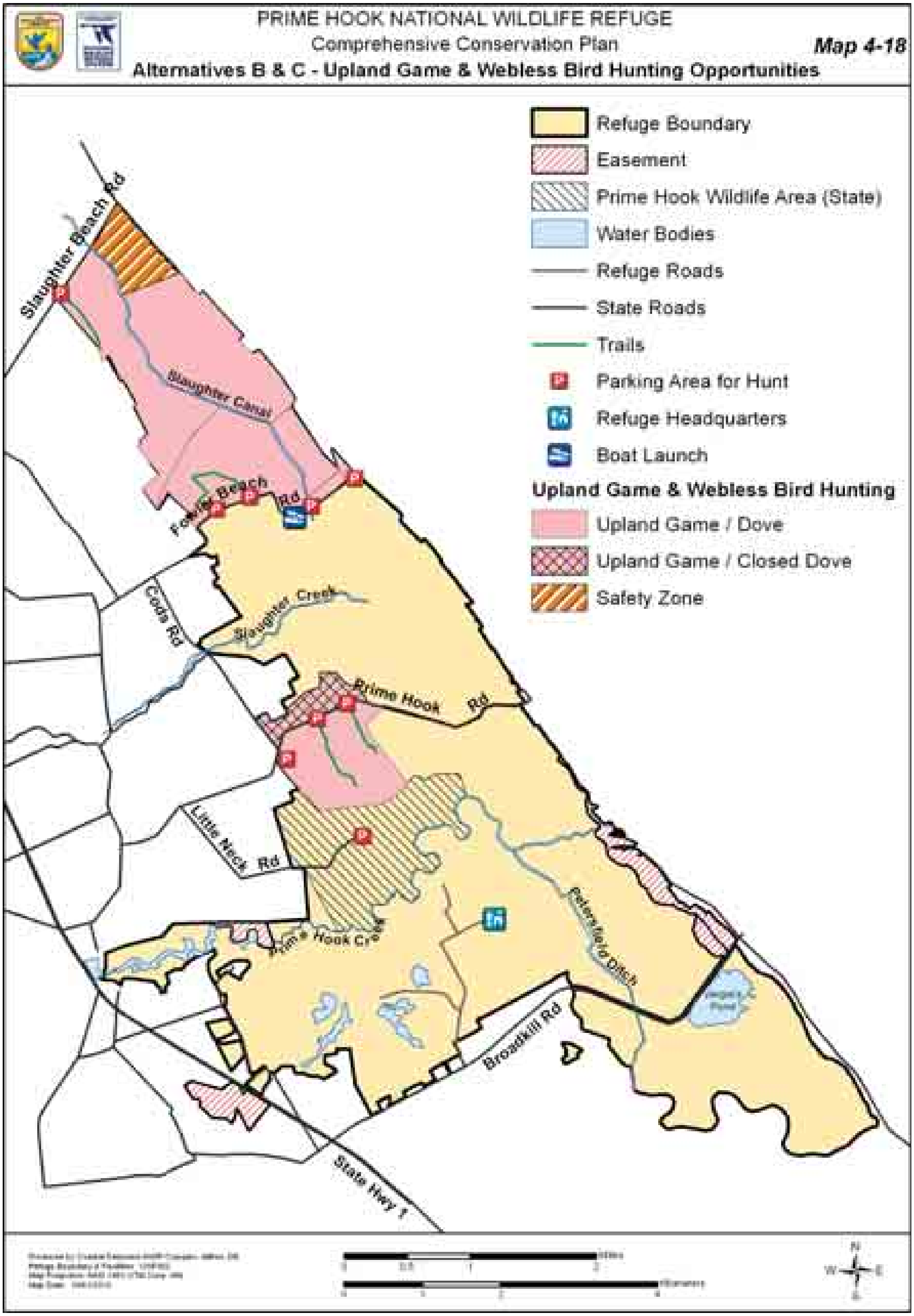
         ◆ Rimfire or centerfire rifles are prohibited.

      * Dove hunting is open in the upland game hunting area except the designated area north of Prime Hook Beach Road.

      * Hunters will not be required to report their harvest data to the refuge.

      * Hunting will be on a first-come, first-served basis. Check-in and check-out by hunters would not be required for any upland game and webless migratory bird hunt.

Map 4-18. Upland game and webless migratory bird hunting opportunities under alternative B



- ◆ Hunters must be out of the hunting areas one-half hour after legal shooting hours.

Objective 5.1d Wild Turkey Hunting

Provide high-quality hunting opportunities for turkey.

Rationale
Wild turkey is a resident game species that is managed by DNREC's Division of Fish and Wildlife. Prime Hook NWR falls within Zone 9 of DNREC's Wild Turkey Management Regions. Zone 9, which includes the state-owned Prime Hook Wildlife Area that is adjacent to the refuge, is currently open during the spring turkey hunting season. To ensure a sustainable harvest of the state's turkey population, DNREC biologists track their health, distribution and reproductive success. Current efforts include a volunteer-based survey used to generate an index of annual turkey productivity and recruitment, monitoring turkey harvest and hunter efforts, tracking turkeys with radio transmitters to evaluate their reproductive ecology, habitat use, and survival, and evaluating the genetic diversity of turkeys.

We would provide new opportunities for hunting wild turkey on 3,729 acres for a limited number of hunters. We recognize turkey hunting as a traditional outdoor pastime. When managed responsibly, it can instill a unique appreciation of wildlife, their behavior, and their habitat needs. Turkey hunting was initiated on the refuge in 1993. After two seasons of hunting and only one harvested turkey, the opportunity was discontinued. In recent years, hunter and staff observations indicate that a huntable population of turkeys may exist on the refuge, particularly in the headquarters area and in areas near Deep Branch Road. Limited opportunities exist on public lands to hunt turkey and the refuge may contribute to providing additional opportunities. Seasonal closures and time and space zoning among user groups may change on an annual basis to adapt to changing State of Delaware hunting seasons, federal or state regulations, user conflicts, or impacts to natural resources. Map 4-19 depicts turkey hunting opportunities and infrastructure.

Strategies
In addition to objective 5.1 strategies under alternative B,

- ■ Collaborate with the Delaware Division of Fish and Wildlife to evaluate the status of the wild turkey population on the refuge. Hunting will be permitted if State and refuge personnel determine that the turkey population in the area is sufficient to support hunting on the refuge.

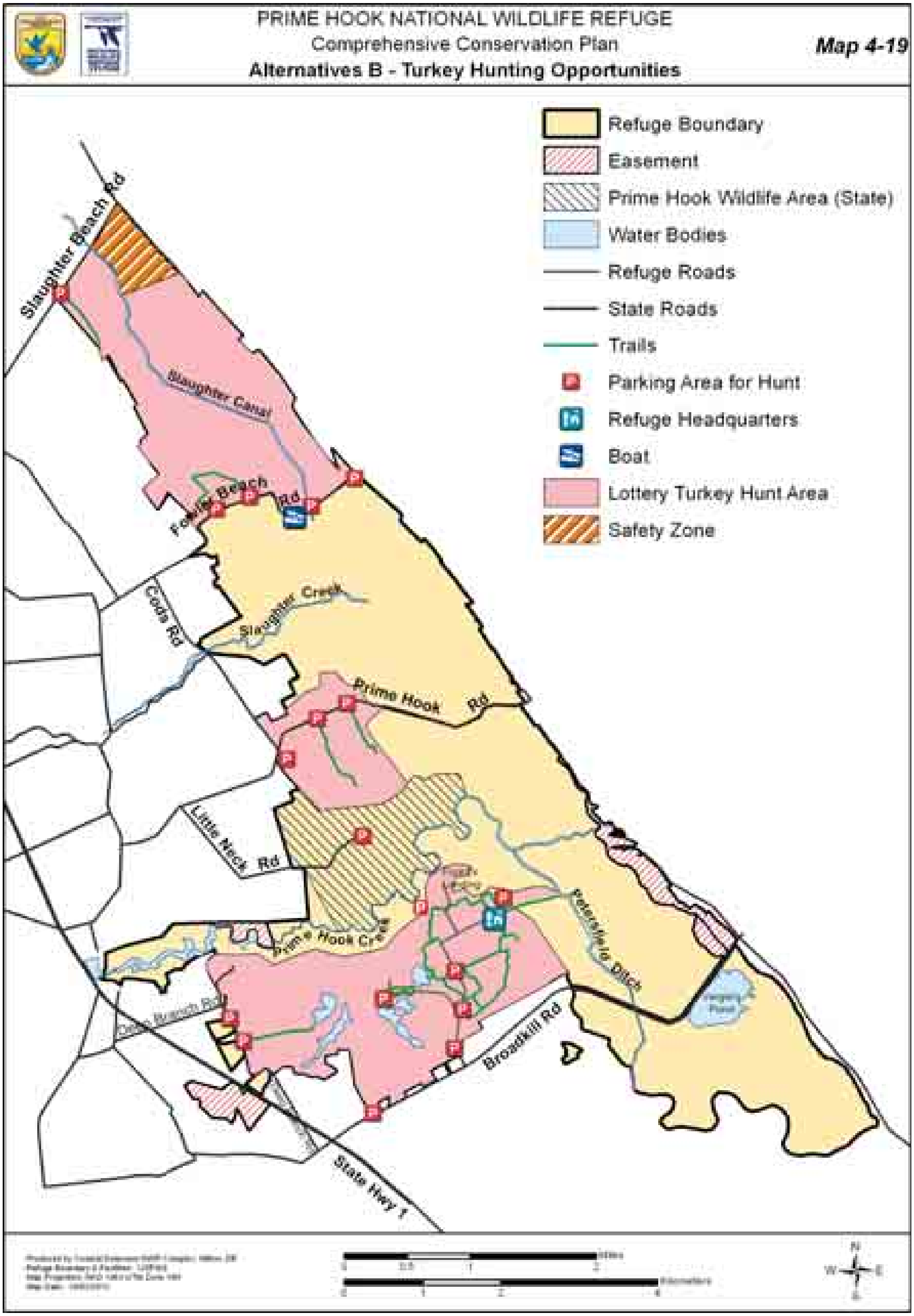
  - ✷ Consult with the Delaware Division of Fish and Wildlife on an annual basis to determine the status of the turkey population and whether to allow turkey hunting on the refuge.

- ■ Hunting of turkey will be permitted to a limited number of hunters (no more than five) in the designated lottery turkey hunt area in accordance with State hunting regulations and seasons.

  - ✷ Provide lottery hunts in the lottery turkey hunt area, which may be administered by the Delaware Division of Fish and Wildlife and if so, application and permit fees may be waived.

  - ✷ Conduct a preseason lottery drawing. No daily standby drawings will be conducted.

Map 4-19. Turkey hunting opportunities under alternative B



- During hunts, all public access will be closed in designated hunt areas during legal hunting hours.
- Participate in the statewide youth/non-ambulatory disabled turkey hunt.
- The number of permitted hunters may be adjusted (increased or decreased) based on changes in turkey population data.
- Enhanced opportunities for scouting will be allowed during designated dates and times.

Objective 5.2 Wildlife Observation and Photography

Provide high-quality wildlife observation and photography opportunities.

Rationale

To improve the refuge's wildlife observation and photography program, we evaluated wildlife observation and photography on the refuge, incorporated the opinions of birders, nature photographers, hikers, etc., and developed this plan in collaboration with our State partners in the Delaware Division of Fish and Wildlife. These program changes, which reflect a diversity of preferences and opportunities for wildlife observation and photography, strive to meet the guiding principles for a quality refuge wildlife observation and photography program identified in Service policy 605 FW 4 and 5. They also support the Refuge System Improvement Act of 1997, which identifies wildlife observation and photography as priority wildlife-dependent recreational opportunities that should be offered on refuges when deemed to be compatible.

Maintaining quality infrastructure and providing new facilities would enhance visitor opportunities to view the relationships among resource management, wildlife, habitat, and people. Opportunities for wildlife observation and photography have been expanded to include seven new trails totaling 3.7 miles throughout the refuge in all four management units on existing maintained trails or interior refuge roads, bringing the total number of trails to 14 and 9.9 miles. Other expanded opportunities include the developing interpretive material highlighting wildlife viewing and photography areas along adjacent State roads, improvements to roadside viewing areas along Prime Hook Beach Road and Broadkill Beach Road, constructing a photography blind along a restored wetland area, and enhancing opportunities for disabled individuals.

We propose limited seasonal closures in areas of the refuge that provide opportunities for wildlife observation and photography. One closure that is different from alternative A is the closure of the eastern portion of Prime Hook Creek from September 1 through March 15. We will continue to allow year-round access to the western 4 miles of Prime Hook Creek for visitors engaged in uses such as wildlife observation, wildlife photography, and fishing Additional seasonal closures may apply until the second Saturday in May for hunting during the snow goose conservation order or turkey hunting.

At first glance, these seasonal closures give the appearance that opportunities for wildlife observation and photography are being significantly reduced or totally eliminated for over eight months during the proposed expanded hunting activities. To the contrary, the majority of the refuge would remain open to wildlife observation and other non-consumptive uses and provide more opportunities and open areas than under current management. The Headquarters area remains available 363 days a year for non-consumptive uses, but portions may be closed for turkey hunting. All other areas except for the Deep Branch Trail, Fowler Beach Road trail (southside), and Prime Hook Creek are open on every Sunday during the hunting seasons. The Deep Branch

Trail, the Fowler Beach Road trail (southside), and Prime Hook Creek are open with seasonal closures of every day from September 1 through March 15 and if necessary during the snow goose conservation order or turkey hunting seasons. If and when the photography blind is available on the southside of Fowler Beach Road, this portion of the trail will be open year round and open every Sunday during the hunting season. The majority of the hunting will occur during the main hunting season, which typically runs for five months from September through January, with additional hunting opportunities for rabbit through the end of February. The actual season length, including starting and ending dates, will vary annually, and the actual number of huntable days will vary annually as well. For example, the Federal framework only permits a maximum of 60 days hunted during the waterfowl season, but because of additional restrictions imposed by the refuge (e.g., only allowing waterfowl hunting 4 days a week rather than 6 days a week), the regular duck season on the refuge will actually be approximately 40 days, and only to 3 p.m. on those days. Hunting during the snow goose conservation order, which will occur for 2 ½ months from late January through mid-April, will take place mostly in the wetland areas, leaving the upland areas open to other uses. This hunt is not anticipated to bring large numbers of hunters, but is beneficial to the species and other wildlife due to overpopulation. With five or fewer turkey hunting permits issued in April and May, a vast majority of the refuge would still remain open to wildlife observation and other non-consumptive uses.

During public involvement for the CCP, some questioned why hunters are often allowed to go into some areas that the non-consumptive public is not allowed. The time of year, the numbers of people, and the opportunities afforded at other areas, and how these relate to habitat and wildlife, all go into our consideration. Since the number of hunters is significantly smaller than the number of people who observe wildlife at the refuge, the amount of people on the area is easier to plan, control and monitor. The relatively smaller number of hunters also do not have the same trampling effects on vegetation, especially from September through January, than the unregulated general public could create. As far as clearing new areas for wildlife viewing, we feel as though removing habitat for the sole purpose of increasing wildlife viewing opportunities conflicts with the Service mission and refuge's purposes because the reduction of habitat may decrease the biological diversity and the integrity of the area. Removing habitat fragments the landscape and may reduce the potential viewing of many species that are area-dependent or have specific habitat requirements. We also feel that the refuge has sufficient parking areas, hardtop roads, foot trails, and observation towers available for physical and visual access to wildlife. Refuge staff will continue to evaluate the wildlife observation and photography program on an annual basis and modify it, as warranted, given new biological or visitor data. This plan reflects a balanced and measured increase in facilities and opportunities for wildlife observation and photography, while continuing to meet fish and wildlife protection and management responsibilities. Map 4-15 depicts wildlife observation and photography opportunities and infrastructure.

Strategies

In addition to those strategies listed under Actions Common to all Alternatives affecting this program,

- Expand or enhance wildlife observation and photography opportunities by creating seven new trails totaling 3.7 miles using existing and already maintained trail and road networks. The total number of refuge trails becomes 14 with 9.9 miles.

- Except as noted below, access to all areas is provided everyday throughout the year from one-half hour before sunrise to one-half hour after sunset. Seasonal restrictions in areas where hunting occurs will allow access on every Sunday from September 1 through the deer and waterfowl hunting seasons, which typically end in February. Additional seasonal closures may apply through the second Saturday in May for hunting during the snow goose conservation order or turkey hunting. Due to the low number of permitted turkey hunters afield and that snow goose hunters will be hunting in wetland areas, a vast majority of the refuge would still remain open to wildlife observation and other non-consumptive uses.

  - Unit I—Slaughter Beach Road (Slaughter Woods) Trail (NEW)

    - Create a one to two space parking lot and use the existing interior road as the trail. The location of the existing parking lot will not be used for this trail because it creates safety issues by requiring visitors to walk along the roadside.

    - Opportunities available year round but only open every Sunday during the hunting season

  - Unit I—Slaughter Canal (existing, but previously promoted for only fishing)

    - Opportunities available year round but only open every Sunday during the hunting season

  - Unit I—Willow Oak Trail (NEW)

    - Located north of Fowler Beach Road, access will be provided using the existing trail network

    - Opportunities available year round but only open every Sunday during the hunting season

  - Units I & II—Fowler Beach (existing)

    - Open year round with seasonal closures of designated beach dunes and overwash areas from March 1 through September 1 (for more information, refer to “Actions Common to All Alternatives”).

    - Adaptive management is necessary if Fowler Beach Road, from Slaughter Canal to its terminus at the Delaware Bay, is abandoned by DELDOT and donated to the Service. If, upon DelDOTs removal of the existing layer of asphalt overlying unconsolidated fill, the walking trail will serve its purpose of public use until marsh vegetation and hydrologic function reclaim the trail and the formally bisected habitat (Units I & II) function as one unit. When conditions are deemed unsafe, access will not be permitted to Fowler Beach for public use opportunities such as wildlife observation, wildlife photography, and fishing.

  - Unit II—Fowlers South Trail (NEW)

    - Use existing interior road to provide access

    - Provide parking area at existing gate on north side of Fowler Road

    - Explore the possibility of providing access to seasonal wetland (if developed) with a wheelchair-accessible photography blind

    - Open with a seasonal closure of every day from September 1 through March 15 and if necessary during the during the snow goose conservation order or turkey hunting seasons.
        - If and when the photography blind is available, the portion of this trail from the trailhead to the photography blind will be open year round and open every Sunday during the hunting season.
- Unit III—Prime Hook South Trails (NEW)
    - Use existing parking lots and interior roads to provide access
    - Increase nesting boxes for tree swallows and bluebirds through volunteer support where the public may observe wildlife activity
    - Opportunities available year round but only open every Sunday during the hunting season
- Unit III—Deep Branch Road (Goose Pond) Trails (NEW)
    - Using the existing hunting parking areas and interior road to provide access
    - Open with a seasonal closure of every day from September 1 through March 15 and if necessary during the snow goose conservation order or turkey hunting seasons.
- Unit III—Refuge headquarters area (existing with NEW trail)
    - Improve the trail base for the dike portion of the Blue Goose Trail
    - Create the Broadkill Dike Trail (NEW)
        - Open a portion of the existing interior road near the deer check station building to provide additional parking and wildlife observation opportunity.
    - Open 363 days a year (closed for two deer hunts) and portions may be closed for turkey hunts.
- Unit III—Prime Hook Creek (includes mainstem of creek & Headquarters Canal; existing)
    - Open with a seasonal closure of Eastern Prime Hook Creek (from Foord’s Landing to headquarters ramp): Closed every day from September 1 through March 15. Additional seasonal closures may apply through the second Saturday in May for hunting during the snow goose conservation order.
- Unit IV—South of Broadkill Beach Road (NEW; existing but not currently open)
    - Reevaluate the trail and observation platform overlooking Vergie’s Pond
        - Option 1: Keep the existing trail and create a parking lot at the existing trail head.

      - ✧ Option 2: Abandon and remove the existing walkway. Reroute the trail to the east and construct a smaller, less intrusive boardwalk and trail to the firebreak and existing tower and a three to five space parking lot on the existing high ground.

    - ◆ Open with a seasonal closure from the Monday before Thanksgiving through March 15 and if necessary during the during the snow goose conservation order hunting season.

  - ✻ All Units—Interpretive auto tour route

    - ◆ Create an interpretive brochure outlining the wildlife viewing areas, trails, pull-offs, etc., that can be accessed from public roads and highways

    - ◆ Investigate the potential to use advanced technology (radio, compact disc, cell phones, or downloadable programming) to provide visitors with interpretive material about the refuge related to wildlife observation and photography.

    - ◆ Open year round

- ✺ Improve access at boat launching areas.

  - ✻ Upgrade boat ramp access on Fowler Beach Road for access to Slaughter Canal

    - ◆ Designate Slaughter Canal a no wake zone.

  - ✻ Work with private landowners to improve access to western end of Prime Hook Creek

  - ✻ Within 5 years of the plan, open a boat ramp at Foord's Landing for access to Prime Hook Creek

    - ◆ Provide visitor opportunities to canoe or fish for 3 miles in a loop, eliminating the need for two vehicles due to close proximity of the launch area at the refuge office.

- ✺ Eliminate boat launching fees at all refuge boat ramps.

  - ✻ Maintenance to boat ramps and parking areas will be funded through deferred maintenance projects

- ✺ Add a new full-time law enforcement officer to enforce regulations.

- ✺ Within 5 years of the CCP approval, develop a visitor services plan for the refuge.

Objective 5.3 Recreational Fresh and Saltwater Fishing and Crabbing

Provide high-quality fishing and crabbing opportunities.

Rationale

To improve the refuge's recreational fishing and crabbing program, we evaluated fishing on the refuge, incorporated the opinions of anglers and crabbers, and developed this plan in collaboration with our State partners in the Delaware Division of Fish and Wildlife. These program changes, which reflect a diversity of fishing preferences and opportunities, strive to meet the guiding principles for a quality refuge fishing program identified in Service policy 605 FW 3. They also support the Refuge System Improvement Act of 1997, which identifies fishing as one of the priority wildlife-dependent recreational opportunities that should be offered on refuges when deemed to be compatible.

Increasing fishing opportunities on the refuge would serve the demand for more fishing opportunities in Sussex County. Improved habitat quality resulting from proposed habitat restorations on the refuge would likely result in improving water quality and increasing some fish populations. This could positively affect the fishing experience and fishing success.

Bank and boat fishing opportunities have been expanded, where possible, to include additional areas for fresh and saltwater fishing. Some of the program changes include allowing saltwater fishing at Fowler Beach during nighttime hours, eliminating boat launching fees at all refuge boat ramps, opening Goose and Flaxhole Ponds as primitive fishing area (boat only access, manual propulsion only, boats must be ported in), and implementing seasonal closures to protect wildlife and reduce user conflicts.

A fishery assessment conducted at Prime Hook NWR in 1994 (USFWS 1994) recommended that consideration be given to opening Flaxhole Pond due to the healthy and desirable sport fishery in the pond at that time. Access to these ponds was noted in the refuge's 1986 fishing plan as an obstacle to providing this use for visitors. However, the refuge has since acquired land that would provide that access.

To minimize fishing mortality and increase the quality of fishing, we propose to adopt catch-and-release regulations, including the mandatory use of barbless hooks, for Turkle Pond, Fleetwood Pond, Goose Pond, Flaxhole Pond, and Prime Hook Creek west of Foord's Landing.

We have proposed seasonal closures in new and existing areas that would provide opportunities for fishing; these are discussed in detail in the strategies below. One closure that is different from alternative A is the closure of the eastern portion of Prime Hook Creek from September 1 through March 15. Additional seasonal closures may apply until the second Saturday in May for hunting during the snow goose conservation order or turkey hunting.

The refuge proposes to allow fishing and crabbing at the pulloffs along Prime Hook Road due to increased visitor demand in this area and existing pulloffs already provide safe parking areas for wildlife observers and photographers. Access is restricted to only the pulloff area to provide safety for visitors and to avoid traffic issues. The refuge will consider fishing and crabbing along Broadkill Road and Fowler Beach Road in the future if there is a demand and if visitor safety and adequate parking can be guaranteed. Adequate parking and visitor safety along State-maintained roads has historically been an issue. Crabbing decreased significantly from 3,644 visits in 1976 to 880 visits in 1977 due to new regulations making state highway bridges into refuge waterways off limits in an effort to increase pedestrian safety along these roads.

The refuge will continue to partner with local bass fishing clubs to promote fishing to youngsters, provide opportunities for disabled anglers, conduct fishery assessment surveys in refuge waters, and make management recommendations.

The implementation of the refuge fishing program is consistent with State regulations and additional refuge regulations stipulated in 50 CFR. We will continue to evaluate the program on an annual basis and modify it, as warranted, given new biological or visitor data. This plan further develops an appreciation for fish and wildlife and expands public fishing opportunities. Map 4-15 depicts recreational fishing and crabbing opportunities and infrastructure.

Strategies
In addition to those strategies listed under Actions Common to all Alternatives affecting this program,

- Open Slaughter Canal between Fowler Beach Road and Slaughter Beach Road year round and only on Sundays from September 1 through the deer and waterfowl hunting seasons, which typically end in February. Additional seasonal closures may apply through the second Saturday in May for hunting during the snow goose conservation order or turkey hunting.

- Close Prime Hook Creek (mainstem of the creek and Headquarters Canal) to anglers during the following:

  - Eastern Prime Hook Creek (from Foord's Landing to headquarters ramp): Closed every day from September 1 through March 15. Additional seasonal closures may apply through the second Saturday in May for hunting during the snow goose conservation order or turkey hunting.

- Expand fresh and saltwater fishing and crabbing opportunities to include the following areas:

  - Open Fowler Beach (shore only) to night fishing by permit only

  - Open Goose and Flaxhole Pond

    - Designate this new area as a primitive fishing area.

    - Provide access by boat only; manual propulsion only; float tubes allowed.

    - Anglers must use the existing parking area and walk and carry in boat.

    - Closed every day from September 1 through March 15 to avoid conflicts with deer hunting and minimize disturbance to waterfowl. Additional seasonal closures may apply through the second Saturday in May for hunting during the snow goose conservation order or turkey hunting.

    - Area will remain closed until fishery and contamination surveys are completed and management recommendations are made (see objective 3.2 of habitat management objectives).

  - Open Prime Hook Beach Road to fishing and crabbing

    - Parking only allowed on existing pulloffs and access is restricted to the pulloff area to provide safety for visitors and to avoid traffic issues.

    - The refuge will consider fishing and crabbing along Broadkill Road and Fowler Beach Road in the future if there is a demand and if visitor safety and adequate parking can be guaranteed.

  - Adopt catch-and-release regulations, including the mandatory use of barbless hooks, for Turkle Pond, Fleetwood Pond, Goose Pond, Flaxhole Pond, and Prime Hook Creek west of Foord's Landing.

    - Regulations, such as catch-and-release and the use of barbless hooks, may be modified if fishery surveys and analysis indicate that other management options are needed to sustain healthy fish populations such as creel or size limits.

- Conduct refuge fishery inventories every 5 years to assess fishery health and water quality of aquatic habitats; documented information should consist of species composition, class size and distribution, abiotic conditions and other information to adjust management prescriptions as needed and recommended by the Service's Fishery Division. Surveyed areas should include Turkle, Fleetwood, Goose, and Flaxhole Ponds, and Prime Hook Creek. Analyze data and provide management recommendations (seasonal closures, creel size and species limits, etc.).

- Eliminate boat launching fees at all refuge boat ramps.

  - Maintenance to boat ramps and parking areas will be funded through deferred maintenance projects.

- Do not allow recreational gill-netting, commercial fishing, food fishing with equipment other than hook and line on the refuge, or crabbing using pots or trot lines.

  - The use of gill netting by commercial or recreational fishermen has occurred in the tidal waterways of Slaughter Canal for over 30 years by a small number of fishermen. These activities, whether commercial or recreational, are not consistent with goals and objectives in any refuge management plan, conflict with rod and reel recreational fishermen and wildlife observers using canoes or kayaks, and has the potential to harm non-targeted fisheries through incidental by-catch. Fishing for bait fish is permitted for recreational uses only, subject to regulations stated in Title 7 (Conservation) of the Delaware State Code.

  - Crabbing will only be permitted using hand lines, collapsible traps, crab nets, or hoop crab nets. Collapsible traps must be fished from the shore only and the owner must be present. Other types of crabbing equipment are prohibited. The use of crab pots could conflict with 16USC668dd, 50CFR 27.93, abandonment of property, on a national wildlife refuge, if left unattended, and the use of trot lines would cause conflicts with other recreational activities, particularly on Slaughter Canal.

- Increase or enhance disabled fishing opportunities, particularly for those permanently confined to wheelchairs, at the wheelchair-accessible fishing pier on Fleetwood Pond.

- Improve access at boat launching areas.

  - Enhance boat ramp access on Fowler Beach Road for access to Slaughter Canal.

  - Work with private landowners to improve access to the western end of Prime Hook Creek.

  - Within 5 years of the plan, open a boat ramp at Foord's Landing for access to Prime Hook Creek.

  - Designate Slaughter Canal as a no wake zone.

- Within five years of the CCP approval, develop an updated fishing plan for the refuge.
- General regulations for recreational fishing and crabbing
  - No refuge-specific permits are required, except for night fishing at Fowler Beach.
  - Catch and release regulations apply, including mandatory use of barbless hooks, for Turkle Pond, Fleetwood Pond, Goose Pond, Flaxhole Pond, and Prime Hook Creek.
  - Boats must be ported in by foot from the parking areas to Goose and Flaxhole Ponds.
  - Boat motor restrictions:
- Manual propulsion only on Goose and Flaxhole Ponds
  - Crabbing will be conducted using only hand lines, collapsible traps, crab nets, or hoop crab nets. Collapsible traps must be fished from the shore only and the owner must be present. All other types of crabbing equipment are prohibited.

Objective 5.4 Environmental Education and Interpretation

Provide high-quality environmental education and interpretation opportunities.

Rationale

To improve environmental education and interpretation on the refuge, we evaluated these programs, incorporated the opinions of visitors and community residents, and developed this plan in collaboration with our State partners in the Delaware Division of Fish and Wildlife. These program changes, which reflect a diversity of preferences and opportunities for environmental education and interpretation, strive to meet the guiding principles for a quality refuge environmental and interpretive program identified in Service policy 605 FW 6 and 7.

Expanded and enhanced opportunities in environmental education and interpretation will be accomplished through developing and implementing more interpretive guided walks (fishing, birding, nature), interpretive auto tour and hiking routes using advanced technology (radio, compact disc, cell phones, or downloadable programming), and a new public use map and regulations tear sheet, in addition to the revitalizing of the waterfowl festival in October, and continuing existing programs. The refuge also proposes to expand the visitor contact station/refuge office building. This expansion will provide offices for staff, volunteers, and the Friends Group, feature a larger auditorium, and provide storage for biological and public use programs.

This objective reflects an increase in interpretation and environmental education capability and programs. It also reflects the basic needs for a refuge to provide the necessary facilities to inform and educate visitors and help them make the most of their refuge visit. Since environmental education is curriculum-based and labor-intensive, initial efforts will be limited with existing staff, but will increase if and when staff are added.

Refuge staff will continue to evaluate the environmental education and interpretation programs on an annual basis and modify them, as warranted, given new biological or visitor data. This plan reflects a balanced and measured increase in facilities and opportunities for environmental education and interpretation, while continuing to meet fish and wildlife protection and management responsibilities. Map 4-15 depicts facilities and infrastructure used to support environmental education and interpretation.

Strategies
In addition to those strategies listed under Actions Common to all Alternatives affecting this program,

- Enhance and continue to partner with local educational institutions, refuge volunteers, Friends of Prime Hook, and other partners to plan, develop, and implement environmental education programs that focus on refuge key resources and messages for local schools, scout troops, and other organized education-oriented groups. This network would act as supporters of the refuge, advocates for environmental education, and a liaison to the community.

  - Develop a partnership with a local school district or non-governmental organization to provide funding (full- or part-time) for an onsite education specialist to coordinate the development and implementation of curriculum based environmental education programs.

  - Evaluate the potential for adult educational partnerships through universities or programs such as Elder Hostel.

- Conduct environmental education and interpretive programs in newly opened areas outlined in objective 5.2.

- Offer curriculum-based programs developed by NASP, or National Archery in the Schools program, to encourage family participation in archery shooting.

- Develop detailed environmental education and interpretive programs for the refuge that tiers to the visitor services plan.

- Increase and enhance interpretive materials and programs explaining the historic, cultural, and natural resources of the refuge to gain public awareness and understanding of their value.

  - Develop interpretive auto tour and hiking routes using advanced technology (radio, compact disc, cell phone, or downloadable programming).

  - Provide interpretive facilities and materials for newly opened areas outlined in objective 5.2.

  - Increase interpretive programs by providing more regularly guided field trips for nature, birding, fishing, photography, etc.

  - Implement a volunteer master naturalist program.

  - Develop new interpretive panels and maps for information kiosks near the refuge office and along State roads.

  - Revitalize the waterfowl festival, or similar event, celebrating National Wildlife Refuge Week in October only if additional staff is available.

  - Explore other partnerships to develop programs for various age groups.

- Expand the existing visitor contact station/refuge office building to provide offices for staff, volunteers, and the Friends Group, feature a larger auditorium, and provide storage for biological and public use materials.

Sea Level Rise and Climate Change Strategies:

- In conjunction with conservation partners, develop useful and accessible information resources to help Americans fully appreciate the significant implications of sea level rise and climate change on refuge species and their habitats, and to engage these constituencies in seeking solutions.

- Incorporate climate change and sea level rise information and messages into interpretive sign panels, brochures, Web sites, and environmental education programs.

- Hire a temporary staffing position to assist in these outreach efforts.

Objective 5.5 Other Recreational Use

Provide opportunities for the public to use and enjoy the refuge for traditional and appropriate non-wildlife-dependent recreation that is compatible with the purposes for which the refuge was established and the mission of the Refuge System.

Rationale
Much of the basis for other recreational use is described under Actions Common to All Alternatives. Non-priority recreational uses that the refuge manager proposes as compatible on this refuge, with stipulations, are detailed in appendix E.

Strategies
In addition to those strategies listed under Actions Common to all Alternatives affecting this program,

- Allow commercial photography.

  - Guidance in 43 CFR Part 5 will be followed for fees related to commercial filming and still photography.

- Prohibit commercial fishing, commercial trapping of muskrat, raccoon, etc., turtle trapping, picnicking, 5K road race, beekeeping, waterfowl retrieval permits, dog walking, roller blading, competitions or organized group events, and non-competitive organized events.

GOAL 6. Outreach and Community Partnerships

Collaborate with the local community and partners to complement habitat and visitor service programs on the refuge and the surrounding landscape.

Objective 6.1 Community Outreach

Increase community outreach by conducting up to 15 outreach programs or events* each year, and initiate up to 10 news articles to increase community understanding and appreciation of the refuge's significance to natural resource conservation and its contribution to the Refuge System, and to garner additional support for refuge programs.

Rationale
Much of the basis for community outreach is described under Actions Commons to All Alternatives. Opportunities for community outreach would be enhanced from alternative A.

*Note: These events will be both onsite and offsite, and are the same (not additive) as those discussed under alternative B, objective 5.4.

Strategies
In addition to those strategies listed under Actions Common to all Alternatives affecting this program,

- Increase outreach in conjunction with interpretive programs under alternative B, objective 5.4 by offering additional and more diversified activities, special events, or programs.
- Create and improve outreach materials and continue to issue news releases on significant accomplishments, advertise special events, and announce major management initiatives.
  - Update refuge fact sheets.
  - Create media press kit to promote events scheduled on the refuge.
  - Enhance Web page with virtual tours of the refuge and a wildlife webcam.
- Participate in those community service, professional association, and Chamber of Commerce events throughout the Delaware Bay ecosystem that would provide the greatest benefit to achieving goals and objectives and furthering the mission of the Refuge System.
  - Coordinate with the Delaware Division of Fish and Wildlife and other partners to develop outreach materials better explaining the refuge's habitat management and visitor services programs.
- Conduct public meetings, as needed, to facilitate communications and raise awareness and understanding of, and seek support for, refuge management programs.

Climate Change and Sea Level Rise Adaptation Rationale
A survey to gauge the opinions of Delawareans on climate change and sea level rise was conducted in 2010 by the Delaware Department of Natural Resources and Environmental Control (DNREC) and received responses from more than 1,500 Delawareans. The respondents were asked questions to gauge their knowledge, concerns, attitudes, perceptions, and opinions about the issues involving climate change and sea level rise. When asked to rank lists of general and environmental issues, respondents ranked climate change and sea level rise last on both lists (DNREC 2010). The survey indicated that Delawareans were aware of climate change and sea level rise and, while ranking those issues very low, they were concerned with other issues related to climate change and sea level rise, such as water pollution, air quality, and loss of forest habitat (DNREC 2010). The results of the survey illustrate that there is more work to be done to increase awareness of climate change and sea level rise. The refuge will work to better inform the public about climate change and sea level rise and relay how the Service and the refuge plan to address these issues.

The Service proposes as a goal in its draft appendix: 5-Year Action Plan for Implementing the Climate Change Strategic Plan (USFWS 2009b), that "We will engage Service employees, our public and private partners, our key constituencies and stakeholders, and everyday citizens in a new era of collaborative conservation to seek solutions to the impacts of climate change and other 21st century stressors to fish, wildlife, and habitats." Proposed actions include providing Service employees with climate change information, education and training; sharing climate change information, education, and training opportunities with external audiences; and forging alliances and creating forums on climate change to exchange information and knowledge and to influence policy internationally. Our strategies, as outlined in this document support this goal.

Sea Level Rise and Climate Change Strategies
In conjunction with conservation partners, develop useful and accessible information resources to help Americans fully appreciate the significant implications of sea level rise and climate change for refuge species and their habitats, and engage these constituencies in seeking solutions. These strategies are supported by the Service's strategic plan for responding to accelerating climate change objective 6.2.

- Incorporate these messages into interpretive sign panels, brochures, Web sites, and environmental education programs.

- Hire a temporary staffing position to assist in these efforts.

Objective 6.2 Private Landowner Assistance

Work with regional and State partners to develop a common, consistent message.

- Within 5 years of CCP approval, establish a greater role assisting landowners who seek to maintain and improve wildlife habitat on private lands within and adjacent to the refuge boundary.

Rationale
Much of the basis for private landowner assistance is described under Actions Common to All Alternatives. Additional staffing will expand refuge assistance to private landowners. There are funding sources specifically targeted for improving wildlife habitat on private lands that could be competitively directed to the refuge to implement on-the-ground projects.

Strategies
In addition to those strategies listed under Actions Common to all Alternatives affecting this program,

- Expand our technical assistance capability to assist private landowners on invasive species identification and control, wetland protection, and habitat restoration and management.

Climate Change and Sea Level Rise Adaptation Rationale
Adaption to climate change and sea level rise requires the refuge to consider lands and waters outside the refuge boundaries. There are several partnership incentive programs that could be used to create collaborative conservation partnerships such as Partners for Fish and Wildlife, safe harbor agreements, habitat conservation plans, Natural Resource Conservation Service incentive programs, etc. These strategies are supported by the Service's strategic plan objective 2.3.

One example of a potential partnership is restoring the natural hydrology to lands that may or currently are impacted by sea level rise. In many cases ditches, some of which were dug more than 50 years ago to drain farmland and control mosquitoes, now serve to transport brackish water inland, a problem that could become increasingly prevalent as sea level rises. Saltwater intrusion into agricultural soils and peat collapse are major consequences of this process. Plugging ditches in selected places to reduce saltwater flow inland could be effective for local stakeholders. Another option is to install new water control structures, such as tide gates, in selected locations (Poulter et al. 2008). This technique is currently being used elsewhere on the Delmarva Peninsula. Plugging ditches would also help restore natural drainage patterns to the marshes.

Sea Level Rise and Climate Change Strategies

- Work with partners to identify how key ecological processes are likely to be affected by climate change

- Determine how management actions might help maintain or restore key ecological processes using the various incentive programs offered Federal and State agencies and other conservation organizations.

Objective 6.3 Regional and Community Partnerships

Within the next 15 years, enhance our existing partnerships, and seek additional, collaborative relationships with Federal, State, and local government agencies and regional and community economic development and conservation organizations to fulfill mutual natural resource conservation mandates and help us meet our wildlife, habitat, and visitor services objectives.

Rationale
Much of the basis for regional and community partnerships is described under Actions Common to All Alternatives.

Strategies
In addition to those strategies listed under Actions Common to all Alternatives affecting this program,

- Enhance our existing collaborative relationships, and seek additional ones, to increase the likelihood of meeting natural resource mandates and objectives.

- Participate in regional and local community economic development and conservation partnerships and initiatives.

- Facilitate demonstration areas on the refuge and on other conservation lands that showcase applied management to benefit natural resources.

- Enhance the volunteer program to better assist with accomplishing refuge projects

  - Develop a refuge volunteer plan and handbook that covers volunteer program coordination, training, job descriptions, volunteer policy, recruitment policy, monitoring, evaluation, dispute, and termination policies.

  - Explore the possibility of constructing a bunk house or other similar type housing for interns and volunteers to support the refuge's biological and public use programs.

  - Expand the resident workcamper volunteer program.

Climate Change and Sea Level Rise Adaptation Rationale
The rationale is the same as stated above under objective 6.1.

Sea Level Rise and Climate Change Strategies

- Work with Federal, State, and conservation organizations on land acquisition priorities.

- Enhance existing and develop new partnerships to conduct research related to fish and wildlife adaptation to climate change and sea level rise on the refuge, in neighboring watersheds, and elsewhere in the State of Delaware.

- Within 1 year, establish a cooperative agreement with the Delaware Coastal Program on research and monitoring needs for the refuge.

Alternative C. Historic Habitat Management

This alternative emphasizes a return to habitat management programs that were conducted on the refuge through most of the refuge's existence, but which were stopped in recent years for a variety of reasons. These historic habitat management programs include the use of cooperative farming in upland refuge fields, and management of freshwater wetland impoundments, both conducted for the benefit of migratory birds. In 2006, a lawsuit against the refuge charged that farming was being conducted on the refuge without having been properly evaluated through NEPA and a compatibility determination. In 2009, the refuge was ordered to cease farming until the practice could be properly and transparently evaluated during the CCP process. Thus farming has not been a part of recent refuge management, but is evaluated as a component of this alternative.

Similarly, management of freshwater impoundments was conducted on the refuge from the early 1980's, until 2009. Breaches along the refuge shoreline introduced full tidal flow of salt water into the impounded refuge wetlands, converting the freshwater wetlands into brackish/salt marsh and large expanses of open water and prohibiting freshwater impoundment management as conducted previously. As described in chapter 3, the freshwater impoundments at the refuge were successful at providing quality foraging and roosting habitat for migrating and wintering waterfowl. However, as outlined in that same chapter, significant obstacles must be overcome in order for these impoundments to be managed into the future as they have in recent decades. Significant environmental, physical, and structural changes and management actions would need to be addressed to return to freshwater impoundment management on the refuge, and those strategies are outlined within this alternative.

When the Service installed its water management structures in 1988, it utilized the existing east-west roads through the marshes to the barrier island to form the barriers to open water movement. On several occasions the State redistributed sand on the barrier island without bringing in any supplement sand, and on one occasion, brought in a small amount of sand. These approaches were successful in maintaining the integrity of the barrier, even as it continued to erode from the bayside, see Chapter 1. As indicated at the beginning of this Chapter, under Actions Considered by Eliminated from Detailed Analysis, the approach of redistributing the sand on the barrier, is infeasible because there is not enough sand to effectively maintain an intact barrier and prevent salt water from entering the impoundments. As soon as salt water enters the impoundments in sufficient quantity, salt intolerant vegetation dies. Therefore, to be robust enough to last through most anticipated storms, a major beach engineering approach will be required.

Under this alternative, public use programs would be modified somewhat from current management, but not as extensively as in Alternative B. Compared to alternative A (current management), for visitor services programs and refuge uses, alternative C would expand opportunities for hunting and have a greater emphasis on public outreach and education. Fishing, wildlife observation, and wildlife photography would be similar to alternative A (Map 4-25). Compared to alternative B, proposals for hunting in alternative C would decrease the amount of hunting opportunities.

Under alternative C, we would further enhance local community outreach and partnerships, continue to support a Friends Group, and continue to provide valuable volunteer experiences. We would also promote research and the development of applied management practices through local universities to sustain and enhance natural composition, patterns and processes within their range on the Delmarva Peninsula.

Staffing levels would be similar to alternative A (current management).

To reduce repetition, much of the objectives and rationale explained in earlier sections (actions common to all alternatives, alternative A, and alternative B) are relevant to alternative C, but are not included here.

GOAL 1. Barrier Beach Island and Coastal Salt Marsh Habitats

Manage, enhance, and protect the dynamic barrier beach island ecosystem for migratory birds, breeding shorebirds, and other marine fauna and flora. Perpetuate and restore the biological integrity, diversity, natural sustainability, and environmental health of North Atlantic high and low salt marsh habitats.

The objective of traditional beach nourishment is to protect the shoreline from storm damage or to stop erosion.

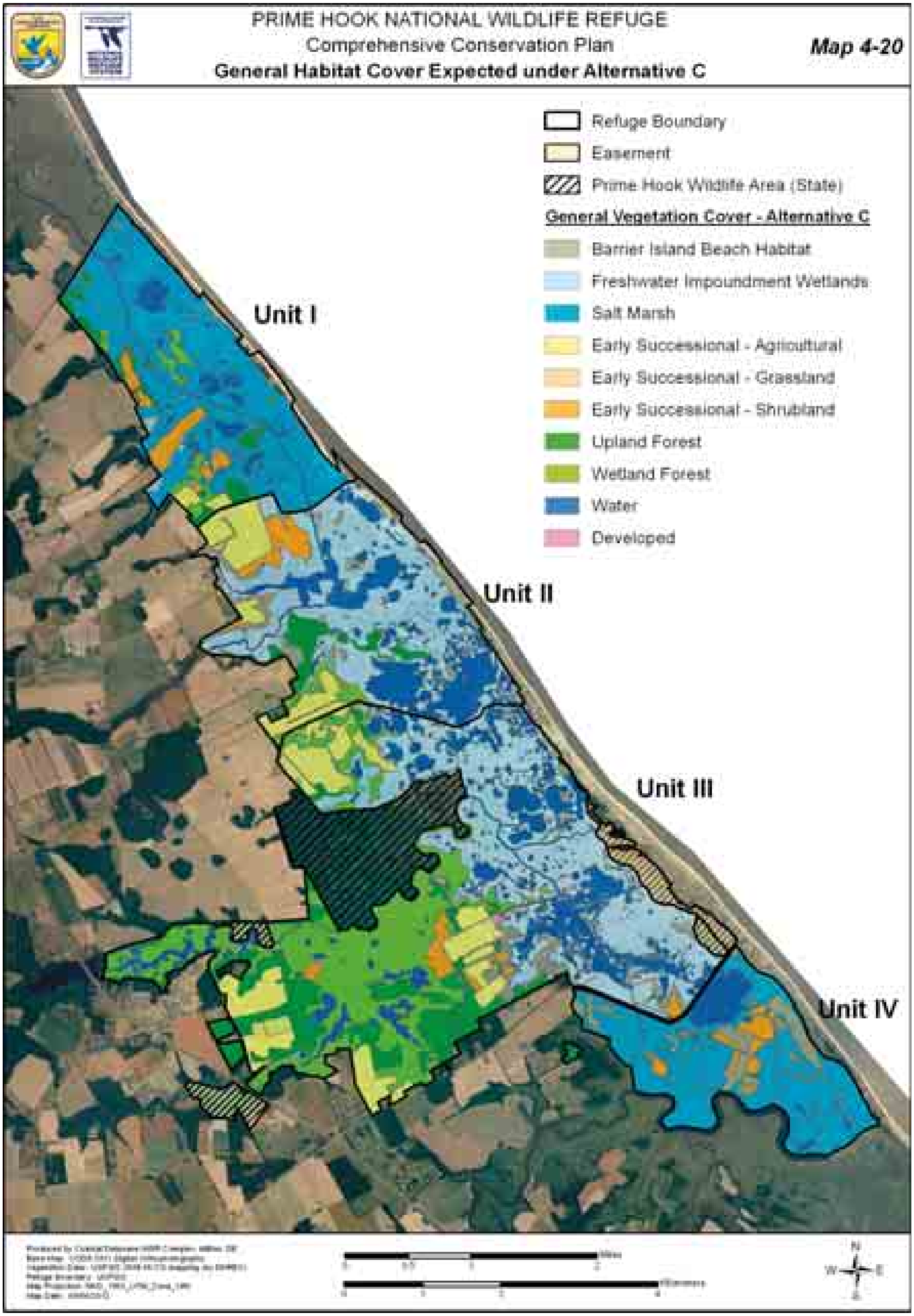
The USACE sediment replenishment projects are those which are designed to add sand to beaches.

Beach replenishment actions designed to maintain prior beach profiles are commonly conducted by the U.S. Army Corps of Engineers (USACE). The (USACE) describes beach nourishment, also referred to as beach replenishment, as a process by which sediment (usually sand) lost through longshore drift or erosion is replaced from sources outside of the system and is deposited on an eroding beach. Nourishment is typically a repetitive process, since nourished beaches tend to erode faster than natural beaches, due to the sediment deficit of the area, the lack of established beach grass and vegetation to hold the sand in place, and the fact that most beach nourishment projects are placed too far seaward due to existing construction on the beach. DNREC does not conduct this sort of beach nourishment on state owned natural beaches. (DNREC 2004) Since the barrier beach along the eastern boundary of the refuge is not backed by houses, it is not imperative for it to be replaced in the exact same alignment as the current beach, but even if it were to be placed somewhat inland of its current alignment, given the erosional forces and sea level rise, any such project will still require substantial quantities of sand both to form the new barrier and to regularly replace the material that is lost to erosion.

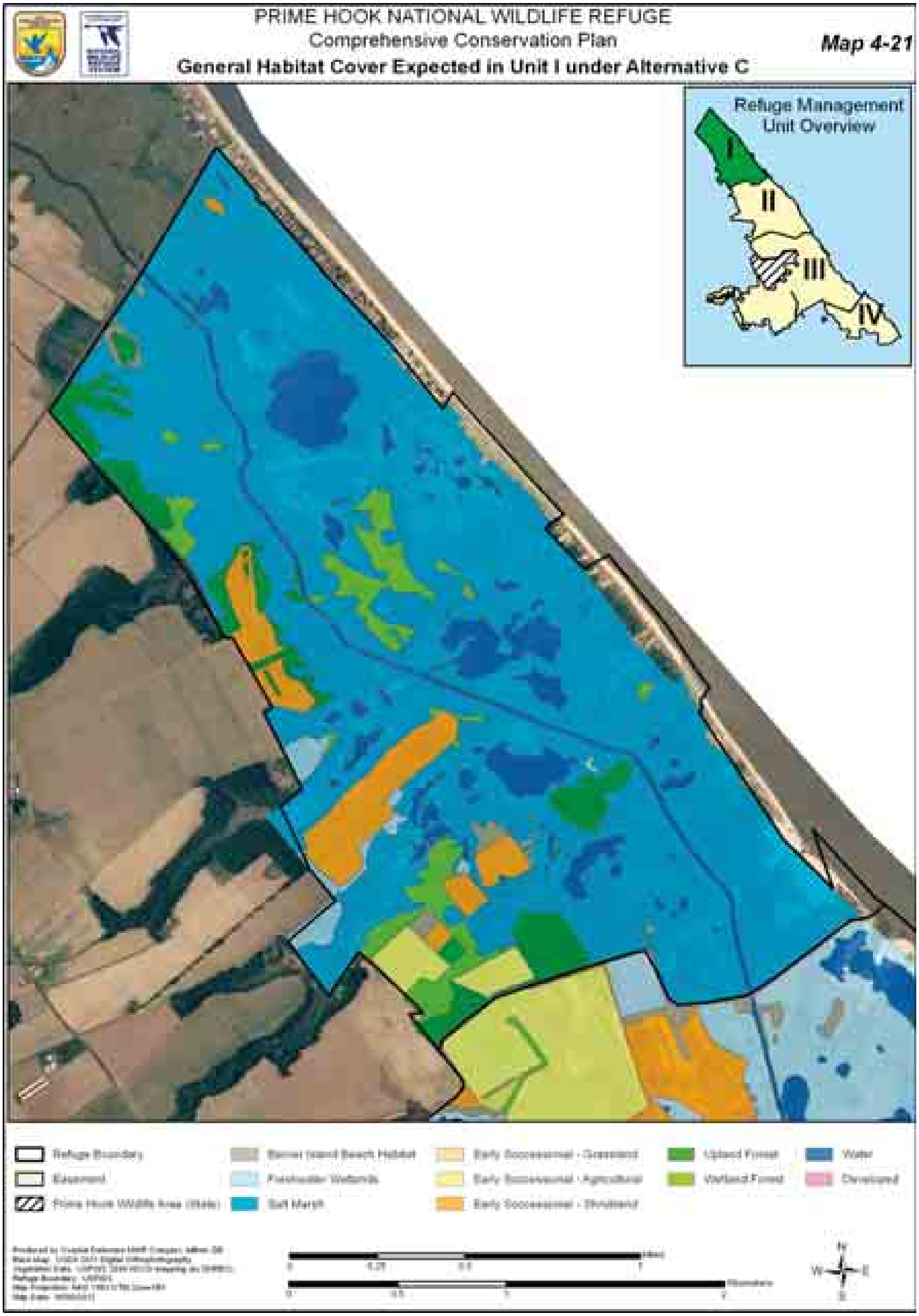
Like icebergs, a barrier beach contains a relatively small amount of its structure above water. The subsurface extent of the barrier island extends substantially off-shore and the gradual slope of off-shore sediments both serve to ‘feed’ the visible beach face and to dissipate wave energies, thus protecting the beach and dune from erosion. Typically, the amount of submerged sand (in an offshore bar) eroded is much greater than the amount of visibly missing sand onshore (sandy beach face). Nourishing a beach that has little submerged sand requires addressing the reason that the submerged sand is missing. Replacing only the visible sand is insufficient without replacing the sand off shore that supports any accretion process to maintain the dune and beach naturally. If insufficient sand is placed on the upper beach without extending the supplemental sand over a substantial amount of the subtidal area, the beach is unstable and the visible sand quickly erodes (Psuty 2004). Thus, in any planning phase of a beach nourishment project, it is important to develop an accurate understanding of the local sediment budget. Knowledge about the sediment budget and natural sediment movement provides a framework for understanding the complex coastal processes that take place in the vicinity of the project area. (NOAA 2011).

The refuge’s sandy beach habitat is representative of a microtidal, wave-dominated, barrier formed along the Delaware Bay’s sandy coastline with a tidal

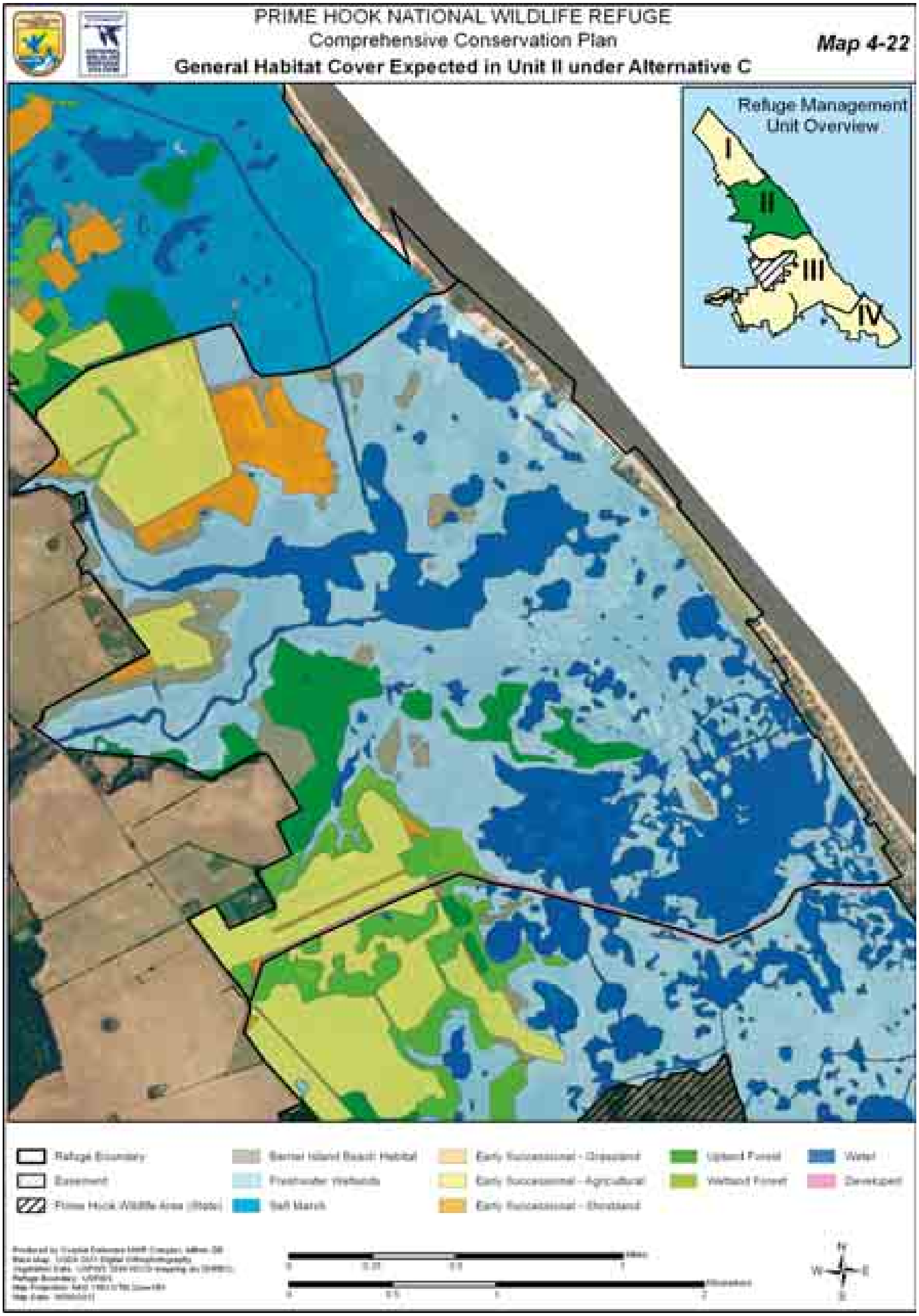
Map 4-20. Overview of general habitat cover under alternative C



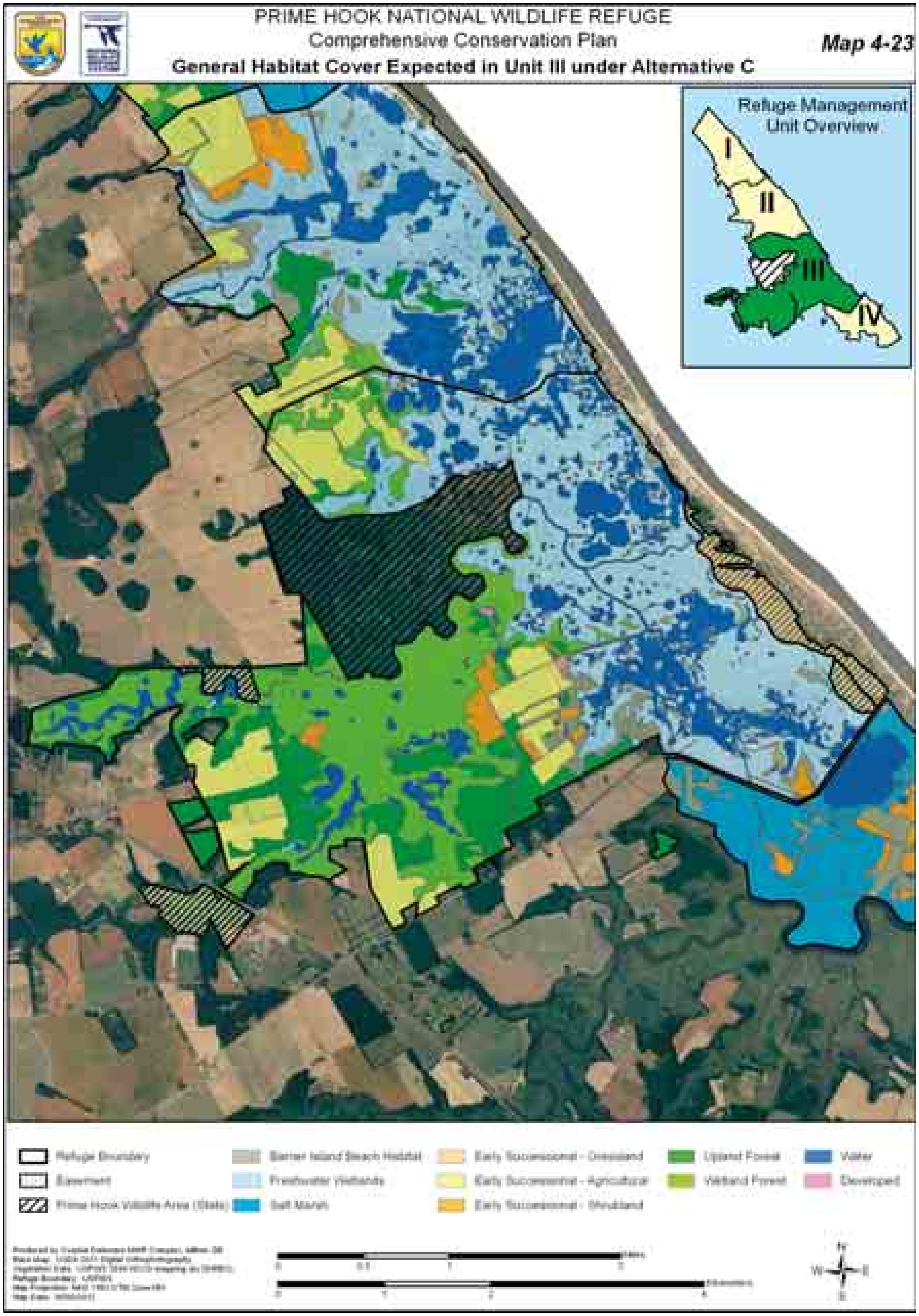
Map 4-21. General habitat cover in Unit I under alternative C



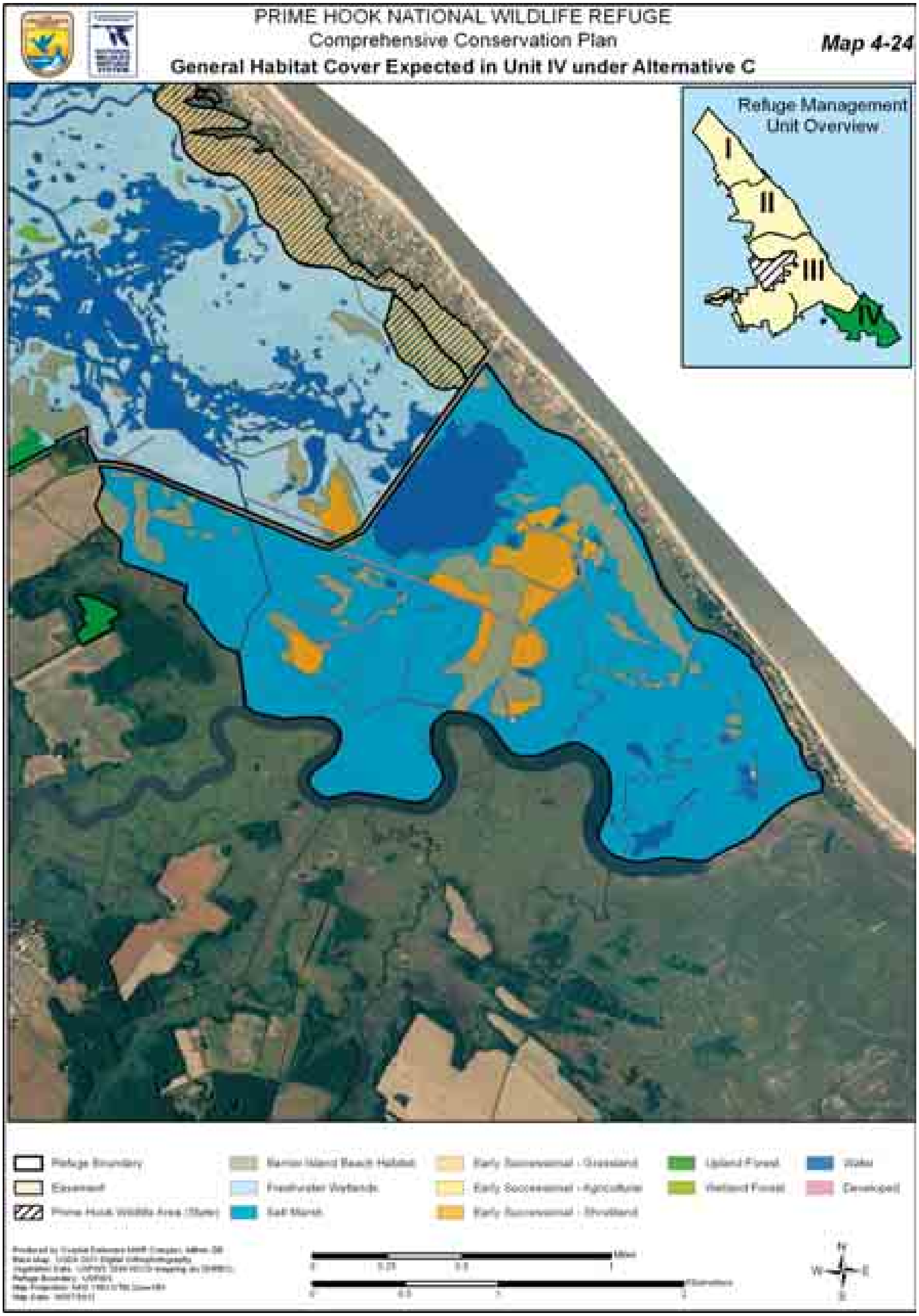
Map 4-22. General habitat cover in Unit II under alternative C



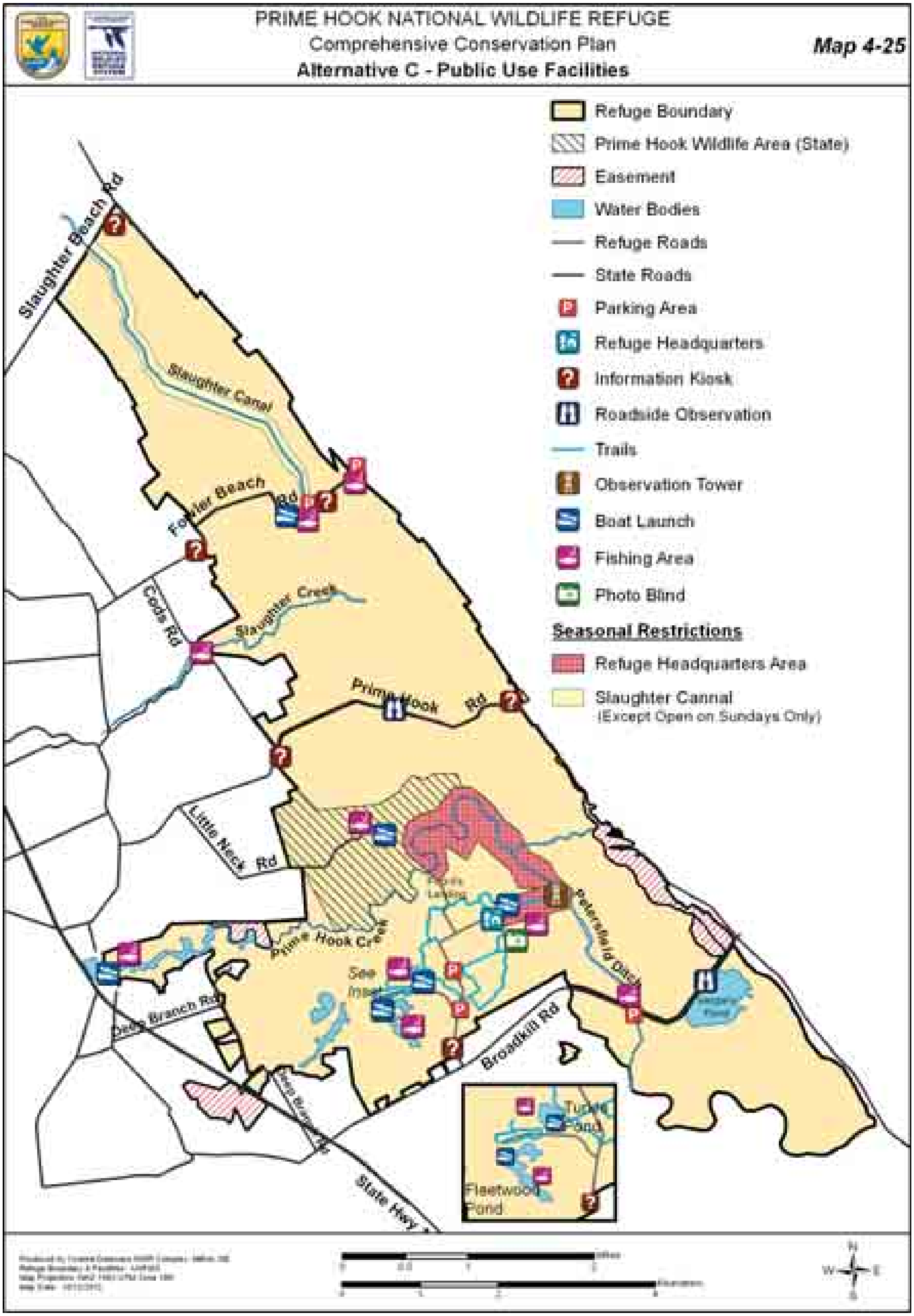
Map 4-23. General habitat cover in Unit III under alternative C



Map 4-24. General habitat cover in Unit IV under alternative C



Map 4-25. Public use opportunities under alternative C



range of less than 6 feet (Komar 1998). Leatherman (1988) further distinguishes between two types of classifications based on sediment supply conditions. Trangressive indicates sand deficiency and propensity for shoreline migration landward. Regressive denotes accretion, often evidenced by multiple dune ridges or crests. The refuge's barrier is best described as a microtidal transgressive barrier system, which is the less stable and more vulnerable to storm-induced changes than a wider beach. This type of barrier is long and narrow with a few inlets and is characterized by low-lying topography and numerous washovers, indicating deficient sand supply and relatively rapid shoreline retreat (Leatherman 1988). Beach nourishment to stabilize dunes on such a barrier by using repetitive beach nourishment projects, can interfere with the long-term viability and is very costly. Beach nourishment does not halt the physical forces that are constantly acting on a microtidal transgressive system. To maintain its environmental health and to sustain the barrier and salt marsh system in the face of sea level rise, the barrier needs to migrate.

The shorelines of barrier island morphology are extremely changeable. The dynamism of the natural coastal processes characteristic of barrier island habitats means that beaches will constantly erode and accrete, dunes and shorelines will shift positions, overwash fans will be periodically active, and inlets will open, migrate and close (McLachlan and Brown 2006, Psuty 2004, Kraft et al 1975). Inlets are also the primary means by which sand is transported landward across a migrating barrier island system. They open and close in response to changing conditions and will migrate up and down along a barrier shoreline, provided they do not encounter an obstacle such as a road or jetty. Inlets that periodically form along microtidal coasts tend to close unless there is substantial outflow of water from inland sources (Leatherman 1988).

Beach nourishment has been used for dune stabilization mostly to protect recreational beaches and developed barrier island strands, but costs tens of millions of dollars annually. For example, shortly after Northeast winter storms of 1992-1993 opened a breach east of Fire Island National Seashore (Westhampton Dunes Section), just down drift of a group of groins installed decades before to stem erosion in the Hamptons. The inlet was reclosed using beach nourishment of 1.5 million cubic yards of sand at a cost of $6.2 million by the USACE and has to be renourished about every four years. We do not have precise cost projections for the construction and long-term replenishment costs to maintain a barrier island across the eastern side of the refuge with sufficient integrity to withstand a major (100 year) storm, but it could easily be millions of dollars.

Heavy equipment, dredge pipes, and other activities necessary to construct this action, as well as the regular replenishment actions, will affect beach and dune habitats and the species nesting, feeding, or resting there. While some activities can be timed outside of the active shorebird nesting season, there will still be repetitive disturbance to these habitats and to vegetation, invertebrate communities, and other species which do not migrate.

The use of sand nourishment to repair the breaches south of Fowler Beach Road has been suggested by many members of the public. It has been suggested that the refuge should re-establish the barrier to reduce erosion or flood risk to nearby developed properties. The Service empathizes with the plight of landowners on the very low-lying barrier island and continues to explore alternatives for access to the barrier under high water conditions, but it cannot be responsible for private decisions to construct in flood prone and vulnerable locations. This alternative is not under consideration as a means of flood damage protection for adjacent development.

Others have suggested that reconstruction of the barrier island will reduce salt water intrusion into local farmland. As explained above, both land subsidence and sea level rise are occurring in this area and subsidence occurs through compaction of the soil, ground water drainage and ground water withdrawal. Service-owned former uplands have already been affected by salt water intrusion, and the Service does not withdraw ground water and has halted agricultural activities on much of the refuge. Refuge lands, as well as private farmlands surrounding the refuge, share the common future of increased saturation by salt water. As the refuge lands become increasingly saturated, they will transition to more moist and salt-tolerant vegetation; private lands are likely to be less able to support traditional agricultural crops. Salt marsh haying or, if sufficient fresh water supplies are available, perhaps freshwater impoundments or cranberries may be feasible on these more saturated uplands.

Alternative C is being evaluated in recognition that the refuge once supported thousands of acres of fresh water marsh and moist soil habitat, which was a very valuable for certain migratory birds. Under all of the Alternatives, the refuge will continue to have beach and marsh habitats which are important to other species of migratory birds, but it is likely to have reduced numbers of mallards and/or pintails under Alternatives A or B.

Given the environmental impacts arising from beach nourishment, there would need to be additional NEPA and other environmental reviews, based upon more specific engineering designs, which have not been developed at present. In addition to other significant environmental impacts, the two strongest factors tempering the likelihood of implementation of this alternative are the high costs, which are clearly outside of any budget likely to be appropriated to the Service, and the fundamental problem of project integrity. Recognizing how quickly freshwater vegetation dies if rapid salt water intrusion occurs, if a dune and beach system is designed to be sufficiently robust to withstand any likely coastal storm, it will have to be quite large, and it may deflect wave forces to adjacent areas. If it is designed at a lower level of structural integrity, then given the increasing likelihood of sea level rise, increased storminess or increased intensity of storms with climate change, its ability to meet the purpose of the project would be compromised. Of the three alternatives, Alternative C is therefore least likely to be able to meet the project's purpose of sustainability and adaptability in the face of climate change and sea level rise or be economically realistic.

Objective 1.1 Overwash, Sandy Beach and Dune Grassland Habitats

Allow natural processes to affect the evolution and functioning of coastal landforms and habitats (including sandy beach, overwash tidal flats, dune and grasslands, and mudflats) along approximately 1.5 miles of shoreline only in Unit I, as they naturally evolve in order to conserve spawning horseshoe crabs, American oystercatcher, and other State and federally listed beach nesting bird species, and provide feeding and staging habitats for sanderlings, whimbrel, and other migratory shorebirds

Rationale

BCR 30 has the densest human population of any region in the country. The highest priority bird species listed for immediate conservation action are those that have sustained the greatest loss of beach, sand, overwash, and dune grassland habitats in this region and State. Development of roads and homes along and in these habitats has been and continues to be the primary factor for imperiling listed bird species along the Delaware Bayshore and BCR 30 Atlantic coastal areas.

Barrier beach island habitats are storm-maintained ecosystems, and are the preferred habitats of many migrating and breeding shorebird species identified as of greatest conservation need by both State and regional conservation plans. The protection and conservation of these birds entails allowing the dynamic nature of these habitats to perpetuate, as they are critical for many rare species like American oystercatchers, least and common terns, piping plovers, black skimmers, beach dune tiger beetles, and seabeach amaranth that are all dependent on habitats maintained by coastal storms. Under this alternative, naturally functioning barrier beach habitats are limited to the shoreline of Unit I, whereas such habitats within Unit II are subject to manipulation in order to support the management of freshwater impoundments.

Strategies

- Permit the natural processes of inlet formation, sand migration, and overwash development only in Unit I

- Monitor resources of concern and conduct baseline inventories and surveys as funding and staffing allows

- Conduct seasonal beach closures if and when Federal or State endangered shorebird species attempt to nest on refuge overwash habitat

Objective 1.2 Maritime Shrub and Forested Habitats

Continue passive management of approximately 320 acres of successional maritime salt shrub and successional maritime forest and maritime red cedar woodland habitats.

Rationale
Same as Alternative A

Strategies
Same as Alternative A

Objective 1.3 North Atlantic Low and High Salt Marsh Habitats

Conserve approximately 2,200 acres of existing refuge salt marsh resources, located in Units I and IV, for the benefit of salt marsh-dependent species, to include a mix of high and low *Spartina* salt marsh, pool panne, and irregularly flooded eastern tidal salt shrub habitats.

Rationale
Same as under alternative B, objective 1.3

Strategies

- Restore the natural hydrology to existing tidal marshes in Unit I and Unit IV whenever feasible and allow natural processes to occur that increase tidal flows to salt marsh habitats.

- Develop an adaptive management framework for *Phragmites* control so treatments are monitored and evaluated for effectiveness. The refuge will be using an integrated approach to *Phragmites* control, which will consider restoration of natural processes, herbicides, prescribed burning, biocontrol, and other tools as they are developed.

- Control additional invasive species if and when they are encountered in the salt marsh

- Use obligate salt marsh passerines, such as the seaside sparrow, as indicators of biological integrity, diversity, and environmental health (BIDEH) for salt marsh habitats.

- Within 1 to 2 years of CCP approval, develop monitoring protocols and an annual biological monitoring and inventory program to document annual salt marsh condition, prescriptive management actions taken, and response to management actions.

- Consider continuing or resuming snow goose hunting to alleviate some snow goose use in salt marsh areas, to reduce salt marsh.

Mosquito Control Strategies
- Same as alternative B

GOAL 2. Forested Habitats

Manage the biological diversity, integrity, and environmental health of refuge upland and wetland forested cover-types to sustain high quality habitats for migratory birds and increase quality habitat for the endangered Delmarva fox squirrel, breeding and wintering landbirds, reptiles, amphibians, and other resident wildlife.

Objective 2.1 Mixed Hardwood Forest Communities

Continue enhancing and protecting more than 750 acres of existing oak forest and mixed hardwood cover-types using prescribed fire and mechanical treatments of understory in appropriate stands to improve habitat conditions to benefit migratory birds.

Rationale
Extensive upland forest loss and fragmentation provided the impetus for the State to designate upland forested blocks greater than 250 acres in size as key wildlife habitats. Exotic species are another great conservation concern. Of the 115 tree species found in Delaware, only 60 are native species. The loss of native upland forested habitats has taken a large toll on migratory song birds and forest interior dwelling breeding birds that all require large contiguous blocks of forested habitats. These include black-and-white warbler, whip-poor-will, cerulean warbler, hooded warbler, and American redstart. Severe forest loss and habitat fragmentation were also responsible for the extirpation of the Delmarva fox squirrel from Delaware (ELI 1999).

The reintroduction of Delmarva fox squirrels to Sussex County in the mid-1980s included two locations, one of which was the refuge. The purpose of these reintroductions was to restore the squirrel to its historic range. To provide more optimal habitat for the fox squirrel before and after its introduction, increased forest management treatments (low intensity understory prescribed fire and hydro-axe removal of dense understory thickets in mixed hardwood stands) were recommended by recovery team members as good management practices to benefit the squirrel. These conservations actions were performed several times in various timber stands from 1987 to 1995.

The first bald eagle nest was established on the refuge in 1991 on Second Hill. A single bird was produced and banded by State biologists and fledged that summer. The same pair has produced two young and built an additional nest on First Hill in Unit II. The nest on Second Hill was blown away in a storm but the pair produced eggs in 2007 and 2008 in a First Hill nest.

In 2006, a second bald eagle pair established a breeding territory on Horse Island in Unit III adjacent to Turkle Pond and has produced a pair of birds each breeding season up to and including 2008. Refuge breeding territories have proven successful due to plentiful food supplies, minimal human disturbance, and adequate habitat features. New juveniles recruited each year have increased the numbers of summer roosts on the refuge. Roost sites typically offer isolation and good food resources nearby. Bald eagles remain designated as a State endangered species, despite Federal delisting in 2008.

Strategies
- Use prescribed fire where appropriate to maintain or restore habitat for Delmarva fox squirrel.
- Monitor migratory bird use in forested habitats.
- Perform early detection/rapid response of invasive species and treat accordingly using integrated pest managements strategies.
- Improve forested habitat conditions to benefit fox squirrels.
- Follow the bald eagle management guidelines.
- Support Service and State efforts to monitor local populations.

Objective 2.2 Wetland Forested Habitats

Continue passive management of approximately 1,200 acres of existing forested wetland cover-types on the refuge.

Rationale
The mid-Atlantic Coastal Plain forested wetlands include a highly diversified gradient of forest types. These habitats are dominated by woody species that are adapted to tolerate saturation of the root zone for varying duration and frequency during the growing season. Nationally and on a State level, forested wetlands have experienced dramatic fragmentation and losses. Much of this loss has been due to clear cutting, filling, or draining of forested wetlands for conversion to agriculture or urban development (Cowardin et al. 1979, ELI 1999) leading to sharp declines in prothonotary warbler, Acadian flycatcher, yellow-throated warbler, and other migratory birds dependent on forested wetlands (PIF 44 and BCR 30 plans).

Strategies
- Monitor bird use.
- Map vegetation communities.
- Monitor and treat for invasive plant species.

GOAL 3. Refuge Impounded Marsh Complex

Maintain, create, and enhance the quality of managed wetland habitats within and surrounding the refuge's impoundment complex for migrating shorebirds, breeding rails, wading birds, American black ducks, and migrating and wintering waterfowl. Support obligate amphibians and other native wetland-dependent species, provide fish passage and nursery habitats for anadromous fish species, and protect and conserve rare native flora and fauna dependent on refuge-managed hydrology.

Objective 3.1 Refuge Impoundment Management

Create a mosaic of habitat structural diversity across 4,200 acres of freshwater and brackish impounded areas for spring and fall migrating shorebirds, fall and spring migrating waterfowl, and wintering waterfowl.

Acreage and location of specific habitat types will vary from one impoundment to another from year to year, depending on weather, hydrology, wetland processes, native vegetation and invasive plant management, snow goose herbivory patterns, and plant successional changes. Seasonal objectives will include the following habitat condition targets and acreage:

- ***Spring migrating waterfowl (March 1 to May 1):*** *Provide 4,000 acres of shallowly flooded (2 to 14-inch depth surface water) mixed annual and perennial vegetation remnants from the previous growing season. Shallow water depths will also make invertebrate food resources available. An interspersion of 2,000 acres of vegetated areas with 2,000 acres of open water will mimic hemi-marsh conditions to serve as both feeding and resting waterfowl areas.*

- ***Spring shorebirds (mid-April to first week in June):*** *Create 1,200 acres of foraging habitat, consisting of low water depths (1 to 4 inches) to mudflat habitat with sparse to no vegetation (less than 15 percent coverage) during peak spring shorebird migration (entire month of May). Throughout the remainder of the year use moist-soil management techniques to encourage the annual production of invertebrates for shorebird foraging with densities of at least 4 grams per square meter.*

- ***Summer wading and secretive marsh birds (June to August):*** *Provide 800 acres of high quality feeding and breeding habitat for waders and secretive marsh birds. Habitat structure will consist of open, shallow water (5 to 15 inches) with patches of emergent wetland plants (rushes and cattails) that support fish, aquatic invertebrates, and amphibians interspersed with drier marsh areas required by rails during summer for brood foraging.*

- ***Fall shorebirds (July 1 to September 30):*** *Provide 500 acres of various impounded wetland habitats consisting of shallow water depths to mudflat(1 to 6 inches)with little to no vegetation (less than 15 percent coverage) to supplement barrier beach island and salt marsh habitats, as supplemental feeding and roosting areas for fall migrants.*

- ***Migrating, staging, and wintering waterfowl (November 15 to March 1)****: Annually create 2,000 acres of hemi-marsh wetland conditions consisting of a 1:1 ratio of emergent plants to open water within three refuge impoundments.*

- ***Fall migrating waterfowl (September 1 to December 30):*** *Make available 4,200 acres of feeding and resting habitats by conducting slow re-flooding regimes within moist-soil areas to provide natural foods dominated by wild millet, panic grasses, sprangletop, nutsedge, and smartweeds with various water depths ranging from 4 to 12 inches. Patch sizes within the impoundments will range from 50 to 500 acres with at least 50 percent of surface areas exposed to generate moist-soil plants in the summer and flooded to optimum forage depths for dabbling ducks in the fall.*

- ***Wintering waterfowl (December to end of February):*** *Provide 4,200 acres of feeding and resting habitats within the refuge's impoundment complex. These areas will consist of predominately annual emergent moist-soil vegetation with patches of perennials and open water areas, created from gradual asynchronous drawdown and reflood schedules among all three impoundments. Final full-pool water levels will generally not exceed 18 inches of foraging water depths.*

Rationale

The refuge will manage three impoundments (ranging from freshwater in Units II and III, to brackish in Unit IV) for the primary purpose of providing high-quality feeding and resting habitats for migrating waterfowl, shorebirds, and other wetland-dependent species. Prime Hook's impounded marsh complex can provide important wetland habitats and natural food resources for waterfowl in the State. During the last decade of impoundment management the refuge hosted at least 50 percent of the State's migrating and wintering waterfowl aerially surveyed, more than 65 percent of the State's wintering pintails, 50 percent green-winged teal, and 40 percent of wintering black ducks, with peaks of more than 75,000 dabbling ducks seasonally using these marshes. These same habitats are also very important for breeding and migrating shorebirds, secretive marshbirds, waterbirds, and other wetland-dependent wildlife (see chapter 3, Affected Environment, for more detailed information on waterfowl and shorebird use of refuge wetland habitats under impoundment management as proposed in alternative C).

Hemi-marsh and native vegetation management provide broad cover and optimal food resources, resulting in the best habitat management outcomes for migrating, staging and wintering waterfowl. Impounded marshes managed to create shallow water levels, native emergent patches, and a hemi-marsh condition provide habitat conditions for waterfowl use throughout the fall migrating and wintering periods to sustain the annual life cycle requirements of waterfowl (Bookhout et al. 1989). The emergent plant component is a 50:50 mix of emergent stands and open water and consists of a wide diversity of native vegetation. Stands will be of two types: perennial stands composed of cattail, hibiscus, wild rice, marshmallow, water dock, etc. and stands of annual moist-soil plants, such as wild millet, panic grasses, sedges, sprangletop, smartweeds, spikerushes, and beggarsticks. Managing native vegetation in the form of moist-soil crops has more benefits for waterfowl than managing agricultural crops.

The refuge's freshwater impounded marshes located within Unit III have supported several areas of exemplary native plant communities found nowhere else in the state (McAvoy et al. 2007). The most significant community found on the refuge is the NVCS association twig rush peat mat. Six different locations occurred along the red maple-seaside alder swamp matrix, within the Unit III impoundment, connected to Prime Hook Creek. These sites may represent an intermediate stage in the succession from open water to peatland and forested wetland, but they are floristically diverse and support many state rare plants (see table 3-9).

Although managed impoundments may deviate from the historic natural conditions in a wetland area, they constitute a management option that is consistent with the BIDEH policy. The BIDEH policy states that "individual refuges may at times compromise elements of biological integrity, diversity, and environmental health at the refuge scale in support of those components at larger landscape scales." Effectively managed impoundments can contribute to diversity on the local scale, and can contribute to landscape-scale conservation of species, which concentrate in the impoundments during migration and winter. Water level manipulation in impoundments is intended to mimic natural hydrological regimes in a controlled and enhanced manner to maximize plant production.

As described in chapter 3, the freshwater impoundments at the refuge were remarkably successful at providing quality foraging and roosting habitat for migrating and wintering waterfowl. However, as outlined in that same chapter, significant obstacles must be overcome in order for these impoundments to be re-established as freshwater wetlands and managed into the future as they were in recent decades. Significant environmental, physical, structural, monetary, and regulatory hurdles would need to be addressed to maintain freshwater impoundments on the refuge. Accomplishing of the infrastructure improvement strategies listed below would be essential to create the prescribed freshwater impoundment management regime with any level of effectiveness, and even then may not be achievable for the full duration of the 15-year planning horizon.

Strategies

- As funds can be secured, replace or upgrade water control structures to compensate for the subsidence (or initial construction error) that has reduced water management effectiveness.
- Work with DelDOT to correct the issue of low elevation roads, which increasingly hampers the ability to manage water levels effectively.
- Utilize an off-site sand supply to reestablish the dunes along Unit II to protect the freshwater integrity of the Unit II and Unit III impoundments.
- To the extent feasible with existing infrastructure (unless or until replaced), use a combination of slow and rapid drawdowns to increase the production of invertebrates and wetland plant foods for shorebirds and waterfowl.
- Practice asynchronous drawdown and reflooding schedules between impoundments to maximize seed yields of annual moist-soil plants in areas where appropriate conditions persist, and annually develop structural diversity and mudflat habitats for shorebirds and waterfowl.
- Water levels are raised slowly in the fall (not to exceed 2.8 msl) to provide a continuous supply of food resources throughout the migration period.
- Control invasive and noxious plant and animal species.

Objective 3.2 Manage Water Quality for Trust Fishery Resources, Migratory Birds, and Resident Wildlife

Manage impounded wetlands for interjurisdictional fish species and improve water quality to perpetuate fish and migratory bird resources.

Rationale

Because of their wide geographic distribution and migratory patterns, many fish populations are dependent on freshwater, coastal, and marine areas that are managed by multiple states. The Service's Northeast Region Fisheries Program has identified the need to work with partners to restore and manage interjurisdictional fish species along the Atlantic Ocean. The Atlantic State Marine Fisheries Commission manages 22 species of Atlantic coastal fish; several of these species depend on refuge habitats, especially populations of freshwater, coastal, and anadromous fish.

For example, shad and river herring are anadromous fish that spend the majority of their adult lives at sea, only returning to freshwater areas in the spring to spawn. Historically, shad and river herring supported the largest fishery populations in the Atlantic Coast, but due to habitat degradation and impediments of passage to freshwater resources, shad and river herring populations are severely depleted. Other species of management concern include American eel, striped bass, and horseshoe crabs. Maintaining fish passage for spawning and nursery habitats and improving water quality are key management actions to address declines of anadromous fish populations and ensure healthy ecosystems to perpetuate interjurisdictional fish species. Through these actions, the refuge can contribute potential habitat to meet the needs of interjurisdictional fish species that occur throughout the Delaware Bay.

Strategies

- Conduct fisheries inventories and water quality assessments to evaluate resource conservation needs and receive direction from fisheries biologists regarding management recommendations to protect and enhance refuge fish and other aquatic species.

- Install and maintain fish weir passages in Unit II and III water control structures to allow unimpeded passage of river herring and other anadromous trust species.

- Improve or restore water quality by restoring water circulation within refuge impoundments by ditch cleaning and maintaining approximately 7.5 miles of ditch-network in Unit III and 3,300 linear feet in Unit IV.

GOAL 4. Early Successional Upland Habitats

Maintain, enhance and restore the native vegetation, biological diversity, and ecological integrity of early successional upland habitats to create a mosaic of native grassland or herbaceous scrub/shrub habitats mixed with transitional forested areas to conserve migratory birds, breeding landbirds, and endangered species, and to maximize benefits for other priority resources of concern.

Objective 4.1 Transitional Habitats: Grasslands, Shrublands, and Young Trees

Conduct a cooperative farming program on a maximum of 600 acres to provide green browse for ducks (primarily mallard, black duck, pintail, and wood duck) and Canada geese during the fall and winter.

Rationale

Farming was historically accomplished on the refuge under an annual cooperative farming agreement under which cooperators harvested 100 percent corn or soybeans. Instead of cash payments for land rental, cooperators provided the refuge in-kind services that included planting of cover crops (barley, wheat, ryegrass, buckwheat or clover) to benefit wildlife.

As stated in the 1970 Cropland Management Plan, the primary objective of the refuge's cooperative farming program was to provide supplemental foods for waterfowl in upland habitats and for Canada geese during the fall, winter, and spring. Upland farmed habitats were also to supply forage areas to benefit the endangered greater snow goose population. A secondary objective of the farming program was to promote duck production with croplands in grass and clover stages of rotation designed to provide nesting habitats for duck species. Farming, as a management activity, is consistent with the Refuge System's BIDEH policy only if it is determined to be necessary to meet refuge purposes. Furthermore, the BIDEH policy dictates that refuges may not use genetically modified organisms (GMO), such as crop seeds, in habitat management without the approval of the regional chief of refuges.

From the early 1970s to 1987 cropland acreage on the refuge increased annually. Peak farmed acreage reached about 1,000 acres by the late 1980s with a gradual reduction to about 600 acres by 2002. The reduction is attributed to access, saltwater intrusion, and inclusion of several fields in a grassland bird research project.

In 2006, a lawsuit against the refuge charged that farming was being conducted on the refuge without having been properly evaluated through NEPA and a compatibility determination. In 2009, the refuge was ordered to cease farming until the practice could be properly and transparently evaluated during the CCP process. As a historic management practice, farming is evaluated within this CCP as part of this alternative.

Strategies

- Use cooperative farming programs, including the utilization, as approved, of GMO crops (glyphosate-tolerant corn and soybeans), to provide cover crops for migrating and wintering waterfowl from November 1 to March 1. This also includes non-harvested cover crops, such as winter wheat and clover.

Objective 4.2 Grassland Bird Habitat Management

Continue to restore old field areas that have been abandoned from cropland program using passive management, i.e., allow areas to revert to natural succession, controlling noxious weeds as needed or actively reforesting old field areas with approved planned restoration projects to benefit Delmarva fox squirrel and migratory landbird species.

Rationale

Some fields will be opportunistically removed from farming, even as the farming program is implemented. The restoration of some old fields to natural vegetation via natural succession, maintaining native grassland areas, or conducting assisted reforestation in other areas to increase potential habitat for Delmarva fox squirrel will improve long-term endangered species management on the refuge and benefit other priority breeding landbird and migratory bird species that are declining in the state and region. These have been identified as priority resources of concern for the refuge and listed as target focal species in the beginning of this chapter.

Strategies

- As cropland areas are abandoned by cooperators or used for research purposes, opportunistically convert them to natural vegetation to benefit endangered species and other migratory bird species of concern that are not waterfowl species.

GOAL 5.

Visitor Services

Provide visitors with a place to safely take part in the six priority wildlife-dependent recreational uses established by the Refuge Improvement Act, as well as such other public uses as may be allowed without interfering with refuge purposes and objectives for wildlife.

Objective 5.1 Hunting

Provide a high-quality hunting program that is administratively efficient and is used to maintain healthy habitats through the management of wildlife populations, where appropriate.

Rationale

Hunting on the refuge would be expanded from alternative A (current management) but not to the degree proposed under alternative B. With staffing levels similar to alternative A, staff time made available by the more efficient hunting program will be shifted toward focusing on public outreach and education. Hunting days and areas will be increased from alternative A, but turkey hunting will be closed. Upland game and webless migratory bird hunting would be the same as under alternative A. The cost of the hunting program would be $1,300 less than the annual hunting program proposed under alternative B.

Strategies

The strategies would be the same as alternative B except for the following modifications or exceptions,

- Do not open the refuge to turkey hunting.

- Do not open a boat ramp at Foords Landing for access to Prime Hook Creek.

- Seasonal closures apply to non-consumptive users during the hunting season, which is typically a slower period of use due to weather conditions, and are highlighted below:

  - Eastern Prime Hook Creek (from Foord's Landing to headquarters ramp) (Unit III): Closed every day from September 1 through March 15.

  - Headquarters area (includes Turkle and Fleetwood Ponds) (Unit III): Closed only for one day for a deer hunt.

  - Slaughter Canal: Open year-round, only open on Sundays from September 1 through the end of the deer and waterfowl hunting seasons.

Objective 5.1a White-Tailed Deer Hunting

Provide high-quality hunting opportunities for white-tailed deer.

Rationale
Deer hunting on the refuge would be expanded from alternative A (current management) but not to the degree as proposed in alternative B. More emphasis will be placed on public outreach and education. When compared to alternative B, deer hunting would consist of a reduction in hunting days from every day during the State hunting season to three days per week in the regular hunt area and a reduction from a two-day to a one-day hunt in the Lottery Deer Hunt Area.

Map 4-26 depicts deer hunting opportunities and infrastructure under alternative C.

Strategies
The strategies would be the same as objective 5.1 and alternative B except for the following modifications or exceptions:

- Expand deer hunting opportunities to include 5,221 acres (an increase of 1,201 acres from current management).

  - Hunting would be open only three days per week throughout the State hunting season in the regular deer hunt area.

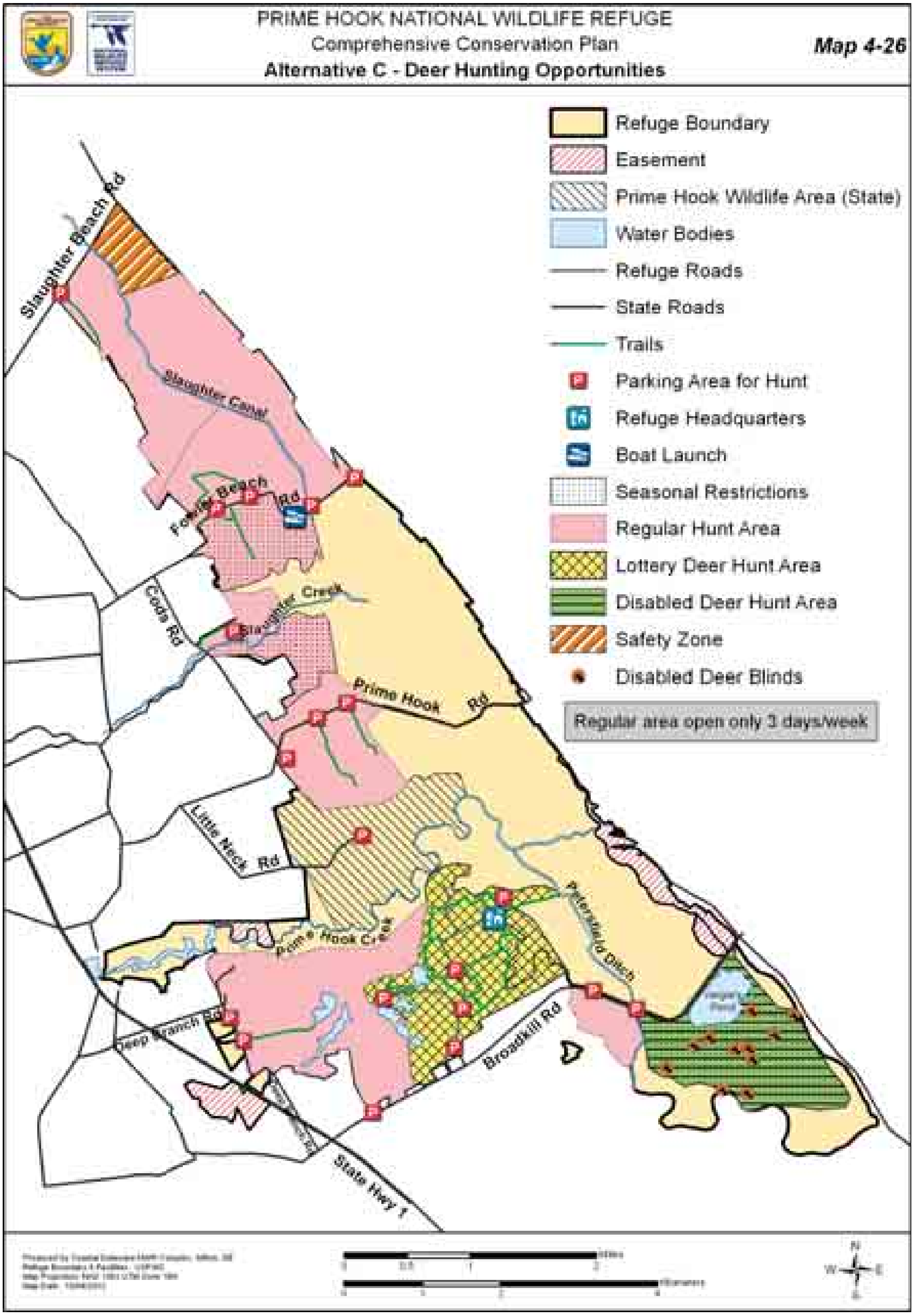
  - The number of deer hunts in the headquarters area (lottery deer hunt area) is reduced from two to one hunt.

Objective 5.1b Waterfowl Hunting

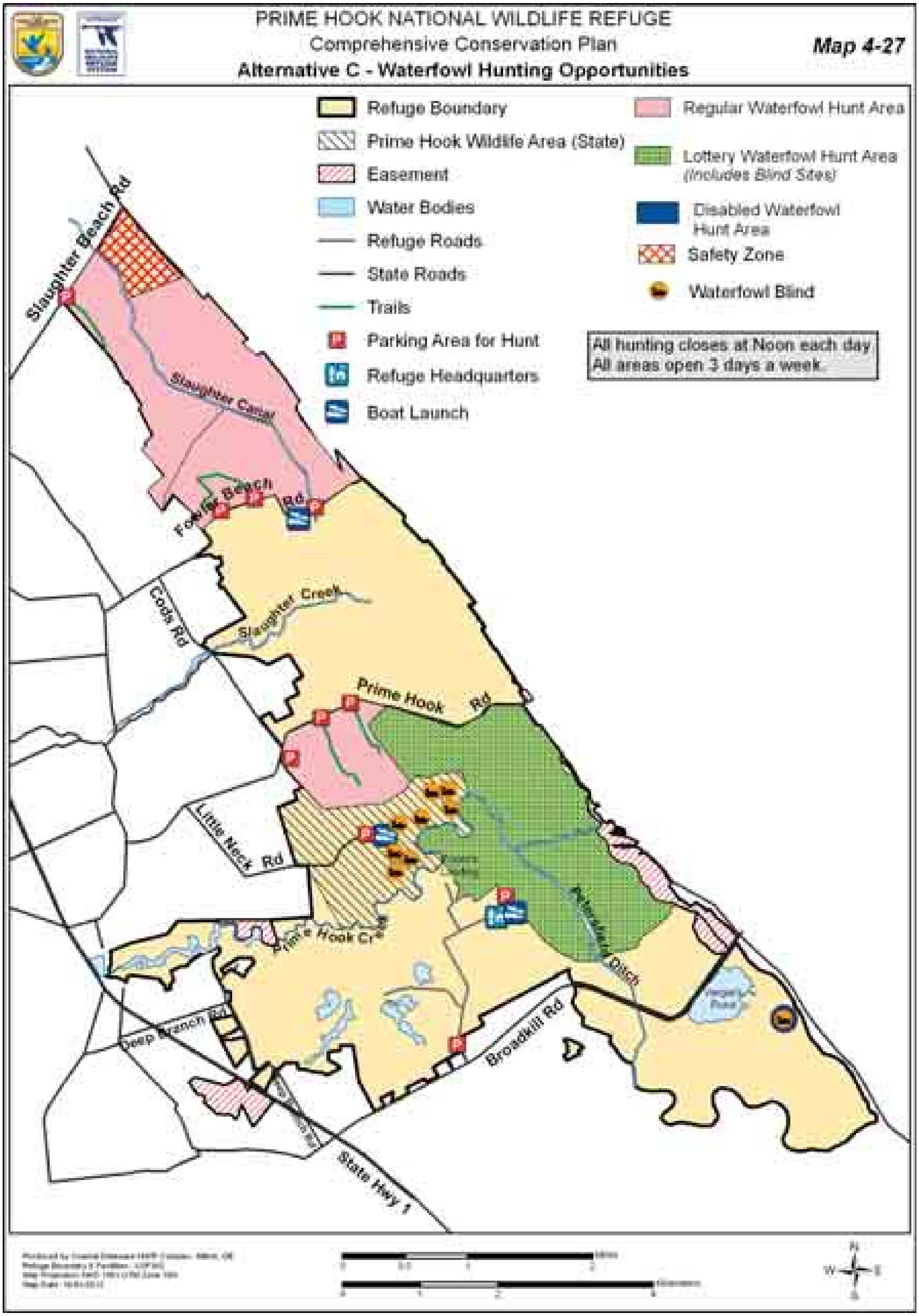
Provide high-quality hunting opportunities for waterfowl.

Rationale
Waterfowl hunting on the refuge would be expanded from alternative A (current management) but not to the degree proposed in alternative B. More emphasis will be placed on public outreach and education. When compared to alternative B, waterfowl hunting would consist of a reduction in hunting days from four to three days a week in all waterfowl hunt areas during the State hunting season, hunting will cease at noon instead of 3pm, and the closure of hunting for early teal, resident Canada geese, and the snow goose conservation order. Map 4-27 depicts waterfowl hunting opportunities and infrastructure under alternative C.

Map 4-26. Deer hunting opportunities under alternative C



Map 4-27. Waterfowl hunting opportunities under alternative C



Strategies
The strategies would be the same as objective 5.1 and alternative B except for the following modifications or exceptions,

- Expand hunting opportunities to include an additional 1,710 acres from current management.
    - Hunting would be only open three days a week until noon during the State hunting season in all hunting areas (both lottery and regular areas).
    - Close hunting for early teal, resident Canada goose, and the snow goose conservation order.

Objective 5.1c Upland Game and Webless Migratory Bird Hunting

Provide high-quality hunting opportunities for upland game (rabbit, quail, pheasant, and red fox) and webless migratory birds (mourning dove, snipe, and woodcock).

Rationale
Same as under alternative B, objective 5.1c.

Strategies
Same as under alternative B, objective 5.1c.

Objective 5.2 Wildlife Observation and Photography

Provide high-quality wildlife observation and photography opportunities.

Rationale
Opportunities for wildlife observation and photography on the refuge would be the same as alternative A but would also include the closure of the trail and observation platform overlooking Vergie's Pond and the boat ramp at Foord's Landing on Prime Hook Creek. Trail mileage would total 6.0 miles over six trails. More emphasis will be placed on public outreach and education. Map 4-25 depicts wildlife observation and photography opportunities and infrastructure under alternative C.

Strategies
The strategies would be the same as alternative A except for the following,

- Eastern Prime Hook Creek (from Foord's Landing to headquarters ramp) (Unit III) will be closed every day from September 1 through March 15.
- Slaughter Canal open only on Sundays from September 1 through the deer and waterfowl hunting seasons.
- Abandon the project to open the boat ramp at Foord's Landing to access Prime Hook Creek.
- Abandon and close the trail and observation platform overlooking Vergie's Pond on the south side of Broadkill Beach Road
- Interpretive auto tour route

  - Create an interpretive brochure outlining the wildlife viewing areas, trails, pull-offs, etc., that can be accessed from public roads and highways.

    - Investigate the potential to use advanced technology (radio, compact disc, cell phone, or downloadable programming) to provide visitors with interpretive material about the refuge related to wildlife observation and photography.

  - Area will be open year-round.

- Within 5 years of the CCP approval, develop a visitor services plan for the refuge.

Objective 5.3 Fresh and Saltwater Fishing and Crabbing

Provide high-quality fishing and crabbing opportunities.

Rationale
Opportunities for recreational fishing and crabbing on the refuge would be the same as alternative A and also include adopting catch-and-release regulations for Turkle Pond, Fleetwood Pond, and Prime Hook Creek, requiring the use of barbless hooks in catch-and-release fishing areas, and not allowing recreational gill netting, commercial fishing, food fishing with equipment other than hook and line, and crabbing using pots or trot lines. More emphasis will be placed on public outreach and education. Map 4-25 depicts recreational fishing and crabbing opportunities and infrastructure under alternative C.

Strategies
The strategies would be the same as alternative A except for the following:

- The eastern portion of Prime Hook Creek (Unit III) is closed from Foord's Landing to the headquarters boat ramp from September 1 through March 15.

- Adopt catch and release regulations, including the mandatory use of barbless hooks, for Turkle Pond, Fleetwood Pond, and Prime Hook Creek.

  - Regulations, such as catch-and-relese and the use of barbless hooks, may be modified if fishery surveys and analysis indicate that other management options are needed to sustain healthy fish populations such as creel or size limits.

- Do not allow recreational gill netting, commercial fishing, food fishing with equipment other than hook and line, crabbing using pots or trots lines (hand lines, crab nets, hoop crab nets, and collapsible traps if attended to at all times are permitted).

- General regulations for recreational fishing and crabbing

  - Catch-and-release regulations apply, including mandatory use of barbless hooks for Turkle Pond, Fleetwood Pond, and Prime Hook Creek.

  - Crabbing will be conducted using only hand lines, collapsible traps, crab nets, or hoop crab nets.. Collapsible traps must be fished from the shore only and the owner must be present. All other types of crabbing equipment are prohibited.

Objective 5.4 Environmental Education and Interpretation

Provide high-quality environmental education and interpretation opportunities.

Rationale
Opportunities for environmental education and interpretation on the refuge would be greatly enhanced from alternative A and alternative B with more staff time being devoted to these programs. In addition to alternative B, alternative C would develop more programs directed toward youth and career development, provide more interpretive programs and displays, and implement a volunteer master naturalist program. Map 4-25 depicts facilities and infrastructure used to support environmental education and interpretation opportunities under alternative C.

Strategies:
The strategies would be the same as alternative B and also include the following:

- Develop education programs targeting teens and young adults focusing on practical applications such as how to make environmentally conscious decisions.
- Develop a program designed for those interested in education as a career and give participants an opportunity to be involved in planning and implementing youth environmental education programs.
- Develop three to five presentations that focus on different themes associated with refuge goals and objectives, such as habitat, wildlife, and visitor services.
- Develop an educational presentation that plays continually in the visitor contact station informing the public on topics such as the history of the refuge, types of habitat present, upcoming events and activities, and volunteer opportunities.
- Develop a new display(s) in the visitor contact station promoting backyard habitat and the importance of native species.

Objective 5.5 Other Recreational Use

Provide opportunities for the public to use and enjoy the refuge for traditional and appropriate non-wildlife-dependent recreation that is compatible with the purposes for which the refuge was established and the mission of the Refuge System.

Rationale
Same as under alternative B, objective 5.5.

Strategies
Same as under alternative B, objective 5.5.

GOAL 6. Outreach and Community Partnerships

Collaborate with the local community and partners to complement habitat and visitor service programs on the refuge and the surrounding landscape.

Objective 6.1 Community Outreach

Continue to provide community outreach by conducting programs or events each year, and initiate news articles to increase community understanding and appreciation of the refuge's significance to natural resource conservation and its contribution to the Refuge System, and to garner additional support for refuge programs.

Rationale
Opportunities for community outreach would be greatly enhanced from alternative A and alternative B with more staff time being devoted to this effort.

Strategies
The strategies would be the same as alternative B and also include the following:

- Develop a comprehensive outreach strategy
- Allow visitors to register for upcoming activities and events online
- Utilize new technology such as Twitter
- Conduct an evaluation of the effectiveness of current outreach techniques and identify at least two specific audiences for outreach goals that have been unexplored

Objective 6.2 Private Landowner Assistance

Within 5 years of CCP approval, establish a greater role assisting landowners who seek to maintain and improve wildlife habitat on private lands within and adjacent to the refuge boundary.

Rationale
Same as under alternative A, objective 6.2 except for climate change and sea level information in alternative B.

Strategies
Same as under alternative A, objective 6.2 except for climate change and sea level information in alternative B.

Objective 6.3 Regional and Community Partnerships

Within the next 15 years, enhance our existing partnerships, and seek additional, collaborative relationships with Federal, State, and local government agencies and regional and community economic development and conservation organizations to fulfill mutual natural resource conservation mandates and help us meet our wildlife, habitat, and visitor services objectives.

Rationale
Same as under alternative B, objective 6.3.

Strategies
Same as under alternative B, objective 6.3.

Table 4-5. Summary comparison of management actions and issues by alternative

Actions Common to All the Alternatives describes many important actions, which are not discussed in the table below. Table 4.5 highlights those actions that distinguish the alternatives, how they relate to our goals, and how they address the significant issues identified in chapter 1. Please refer to the glossary to interpret any acronyms.

	Alternative A **Current Management**	**Alternative B** **Focal Species and Proactive Habitat Management (Service-preferred Alternative)**	**Alternative C** **Return to Historic Habitat Management, with Modified Public Use**
Delaware Bay Shoreline Overwash	Allow the natural processes of inlet formation, sand migration, overwash development and vegetative succession to proceed unimpeded along the Unit I and Unit II Delaware Bay shoreline in all refuge units..	Same as Alternative A, with the exception that shoreline modifications may be conducted if deemed necessary to accomplish comprehensive salt marsh restoration.	Allow the natural processes of inlet formation, sand migration, overwash development and vegetative succession to proceed unimpeded only along the Unit I Delaware Bay shoreline.
	Make no efforts to maintain the dunes along the Unit II—Delaware Bayshore. We will allow physical forces to shape shoreline transgression, and permit overwash and inlet formations to prevail.	Recognizing that storm damage to the dune line and impoundment infrastructure has become cost prohibitive to repair, the impoundment will be proactively restored to tidal brackish/salt marsh.	Maintain and enhance, as needed the dunes along the Unit II-Delaware Bayshore, utilizing off-site sand material to protect freshwater impoundments.
Beach Nesting Birds	Monitor bird nesting activity on refuge beaches. Conduct seasonal beach closures if and when shorebird and colonial waterbird species attempt to nest on refuge overwash habitats.	Monitor bird nesting activity on refuge beaches. Conduct seasonal beach closures annually to actively encourage nesting by shorebird and colonial waterbird species on beach and overwash habitats.	Same as alternative B
	No action	In coordination with the Chesapeake Bay Field Office, develop a refuge-specific piping-plover contingency management plan should piping plovers establish nesting sites on refuge over-wash areas.	Same as alternative B
Management of *Spartina* High and Low Salt Marsh Habitats	Units I and IV are currently not actively managed.	We will manage, and/or restore the natural/historical hydrology of 2,200 acres of existing salt marsh cover types in Units I and IV to include a mix of North Atlantic high and low *Spartina* salt marsh, pool, panne, and irregularly flooded eastern tidal salt shrub habitats.	Same as alternative A; Unit I and Unit IV salt marshes will not be actively managed.
	Passive development of additional salt marsh within Unit II, and ultimately Unit III, will be permitted.	Active salt marsh restoration, e.g., improving wetland elevation and increasing historical flow and hydrology, will be pursued within impounded refuge wetlands to facilitate the healthy succession, resulting in additional brackish/salt marsh.	As managed freshwater impoundments, Unit II and Unit III contain little/no salt marsh.

	Alternative A Current Management	Alternative B Focal Species and Proactive Habitat Management (Service-preferred Alternative)	Alternative C Return to Historic Habitat Management, with Modified Public Use
Impoundment Management	Impounded refuge wetlands will be permitted to passively convert to salt marsh, mudflats, and/or open water.	Impounded refuge wetlands will be proactively restored to tidal brackish/salt marsh.	Establish an intensive moist soil management regime in Units II and III. This will require substantial repair and investment of wetland management infrastructure (e.g., dike roads, dunes, water control structures).
	Make no efforts to maintain the dunes along the Unit II—Delaware Bay shore, instead allow nature to take its course so shorelines can migrate inland.	Active restoration, e.g. improving wetland elevation and increasing historical flow and hydrology, will be pursued within refuge impounded wetlands to ameliorate damage and facilitate the healthy succession to a brackish/salt marsh.	Maintain and enhance, as needed the dunes along the Unit II-Delaware Bay shore in an effort to maintain the freshwater integrity of impoundment II and III.
	Natural conversion to salt marsh, mud flats, and open water within refuge impounded wetlands will be permitted..	Active restoration, e.g., improving wetland elevation and increasing historical flow and hydrology, will be pursued within refuge impounded wetlands. This may include the eventual removal of Fowler Beach Rd., to permit full tidal flow and drainage between Unit I and Unit II.	The refuge will shunt brackish/saline water from periodic overwash of State roads during storm events, and daily tidal flow through State-owned/managed culverts back to Unit I, via refuge-owned/managed water control structure, as much as is feasible.
	Movement of brackish/saline water over the Fowler Rd and under the road through culverts is not managed in any manner by the refuge	Same as alternative A. We will also work actively with State partners (DNREC, DelDOT) on flooding issues affecting state roads that cross the refuge. We will continue to work with them on any other road improvements that will alleviate flooding and ensure refuge resources are not significantly impacted.	The refuge will shunt brackish/saline water from periodic overwash of State roads during storm events, and daily tidal flow through State-owned/managed culverts back to Unit I, via refuge-owned/managed water control structure, as much as is feasible.
	Allow natural filling of ditches with sediment and detritus, and ultimately succeed to historical emergent salt marsh community to occur unimpeded.	Clean refuge ditches using a cookie cutter/rotary ditcher on a 5-year rotational basis.	Periodically clean refuge ditches using a cookie cutter/rotary ditcher.
Predator Management	Currently, no action	Develop a predator management plan designed to reduce predation on trust resources, particularly beach nesting birds. Predators will be managed through non-lethal and lethal means, including administrative trapping and shooting if losses endanger population viability. State licensed trappers or refuge staff would conduct predator management.	Same as alternative A; No active predator management

	Alternative A Current Management	Alternative B Focal Species and Proactive Habitat Management (Service-preferred Alternative)	Alternative C Return to Historic Habitat Management, with Modified Public Use
Pest/Nuisance Animal Control	In cooperation with the USDA, continue reducing depredations by resident Canada geese on priority refuge habitats. Methods may include, but are not limited to, egg addling, lethal control, and roundups of molting birds for donation to charity soup kitchens and the needy.	Same as alternative A	Same as alternative A
	Same as alternative B.	In order to meet management objectives, pest animals will be controlled on the refuge to maintain acceptable population sizes. This includes but not limited to resident Canada geese, mute swans, beaver, muskrat, nutria, red fox, raccoon, gulls, and crows. Should the location and or number of nuisance and pest animals become an issue for proper management of critical habitats or infrastructure, the refuge will undertake prudent, cost-effective control measures. Individual animals or local populations will be managed through non-lethal and lethal means, including, but not limited to, exclosures, administrative trapping and shooting. State-licensed trappers or refuge staff would conduct pest or nuisance animal management.	Same as alternative B;
Snow Goose Habitat and Population Management	Currently, no action	Within the limits of established regulations, and policies, the refuge will support a unified and coordinated approach generated by the Service and States (and Canadian Wildlife Service) to address the issue of snow goose overpopulation in the flyway. These actions may include, but are not limited to, managed increase of hunter harvest (conservation order), and alteration of refuge upland and impoundment management regimes.	Same as alternative A; No active snow goose management.
Invasive Plant Control	Invasive plant management is an integral component of refuge habitat management. Various control methods are available including, but not limited to, prescribed fire, herbicides, tilling, mechanical removal, and biological control.	Same as alternative A	Same as alternative A
Mosquito Control	Currently, we allow the use of Naled adulticides.	Restrict use of adulticides except under an elevated public health threat or as directed by the Secretary.	Same as alternative B
	Currently, we allow use of larvicides methoprene and Bti.	Only methoprene formations with short-term residuals (5 to 10 days) will be used for mosquito larval control when environmental conditions or lifestage are likely to limit the efficacy of Bti products.	Same as alternative B
	Allow State of Delaware Mosquito Control Section to maintain and manage existing open marsh water management systems when the need is clearly documented.	Same as alternative A	Same as alternative A
Cooperative Farming Program	Allow passive succession to shrublands or forest to occur in upland fields.	Manage upland fields to restore native habitats, especially forest, and benefit priority migratory landbirds.	Use cooperative farming programs to provide about 600 acres of supplemental food crops for migrating and wintering waterfowl.

	Alternative A Current Management	Alternative B Focal Species and Proactive Habitat Management (Service-preferred Alternative)	Alternative C Return to Historic Habitat Management, with Modified Public Use
Habitat Management Using Prescribed Fire	Maintain and/or enhance native vegetation communities using prescribed fire where appropriate.	Prescribed fire will be used more often and more proactively to manage early successional habitats, achieve desired forest conditions, and control invasive species.	Conduct prescribed burning as appropriate to maintain habitat for the listed Delmarva fox squirrel and to control priority invasive species such as Phragmites.
Management of Wildfires	Currently, prescribed fires are being used to reduce fuel hazards.	Same as alternative A	There would be no proactive management to reduce fuel hazards. Prescribed fires would not be used to reduce fuel hazards except in WUI communities.
	Respond appropriately to any unplanned ignitions. No natural ignitions or human caused wildfires will be allowed to burn uncontrolled.	Same as alternative A	Same as alternative A
Early Successional Habitat Management	Open field areas will be allowed to naturally move through various stages of succession without conducting proactive habitat management actions, such as mowing, disking, or using prescribed fire to maintain habitats in early successional seral stages.	Allow all agricultural land to revert to early successional grass, forb and shrub-scrub plant communities. Maintain early seral stages via mowing, disking, and prescribed fire, in select fields.	Allow some marginal agricultural land to revert to early successional grass, forb and shrub-scrub plant communities. Maintain early seral stages via mowing, disking, and prescribed fire in those select fields.
Delmarva Fox Squirrel Habitat/Forest Management	No proactive management. We allow extant forest and non-forested tracts to mature and develop via the process of natural vegetative succession.	Proactively manage extant forest and restore/reforest select non-forested tracts to increase DFS population viability and benefit forest interior dwelling birds by: 1. promoting stands dominated by early seral stages at the refuge periphery; 2. improving stands dominated of later seral stages in the refuge interior and along water courses; 3. promoting increased compositional and structural heterogeneity in managed stands, including large-diameter coarse woody debris and snags; 4. using management techniques that emulate natural ecological disturbances (e.g., single tree mortality for multi-aged stands, stand (cohort) replacement in even-aged stands); and 5. using commercial and non-commercial forestry mechanical treatments, when and where appropriate.	Conduct limited management of extant forest and restoration/reforesting of select non-forested tracts to increase DFS population viability and benefit forest interior dwelling birds.
General Hunting Information	Continue permit-based hunt program.	Same as alternative A	Same as alternative A
	Continue to provide 115 permanent hunting structures for deer and waterfowl hunting.	Phase out permanent hunting structures over 5 years or when they become unsafe.	Same as alternative B
	Continue to maintain infrastructure, such as parking and access roads, to facilitate this opportunity.	Same as alternative A	Same as alternative A

	Alternative A Current Management	Alternative B Focal Species and Proactive Habitat Management (Service-preferred Alternative)	Alternative C Return to Historic Habitat Management, with Modified Public Use
General Hunting Information (cont.)	Continue to provide seasonal closures and time and space restrictions for hunters to eliminate user conflicts and minimize wildlife disturbance.	Same as alternative A	Same as alternative A
	Continue to provide four portable toilets.	Eliminate four portable toilets.	Same as alternative B
	No action	Expand hunting opportunities to include additional days and acres (see specific programs below).	Same as alternative B but reduce the number of hunting days and areas for deer and waterfowl hunting.
	No action	Provide a more administratively efficient hunting program (alternative B reduces cost of hunting program by 54 staff days and $17,890).	Provide a more administratively efficient hunting program (alternative C reduces cost of hunting program by 59.75 staff days and $19,205).
	Maintain daily standby permit drawings onsite for waterfowl and firearms deer hunts.	Eliminate daily standby permit drawings. Allow hunters throughout the season to claim vacant opportunities in lottery hunt areas through a contracted reservation service by phone or online. Blinds reserved but not claimed the morning of the hunt will remain vacant for the day.	Same as alternative B
	Require permit fees for all daily hunts.	Eliminate permit fees except for lottery hunt areas for deer, waterfowl, and turkey (no 50 percent discount; hunters under age 16 would still hunt free). Turkey application and permit fees are waived if lottery is conducted by the State.	Same as alternative B
	Preseason drawings will continue for firearms deer hunting.	Conduct preseason drawings for high demand deer and waterfowl hunting areas through a contractor's reservation system by phone or online. Drawings for turkey hunting may be conducted by the State.	Same as alternative B
	Require hunters to hunt at fixed blind sites maintained by Service personnel for waterfowl and most firearms deer hunts.	Phase out permanent hunting structures except non-ambulatory blinds. Allow hunters to free roam in all hunt areas on a first-come, first-served basis, and select their own hunting sites (except lottery waterfowl hunt area and disabled hunt areas). Hunters provide blinds or portable tree stands as desired.	Same as alternative B
	Maintain existing hunting opportunities for disabled hunters.	Enhance hunting opportunities for non-ambulatory disabled hunters.	Same as alternative B
	No boat ramp provided at Foord's Landing on Prime Hook Creek.	Within 5 years of the plan, open a boat ramp at Foord's Landing for access to Prime Hook Creek.	Same as alternative A
	Hunters would be required to report harvest data to the refuge.	Hunters would not be required to report harvest data to the refuge.	Same as alternative B
	Continue to encourage youth participation in hunting programs.	Collaborate with State partners and NGO hunting organizations to develop hunter training programs such as mentored hunting programs for both youth and adults.	Same as alternative B

	Alternative A Current Management	Alternative B Focal Species and Proactive Habitat Management (Service-preferred Alternative)	Alternative C Return to Historic Habitat Management, with Modified Public Use
Deer Hunting	Continue to provide deer hunting on 4,020 acres using archery, shotgun, and muzzleloader during State seasons.	Open 1,201 additional acres for deer hunting for a total of 5,221 acres using archery (to include the use of crossbows), shotgun (to include the use of handguns), and muzzleloader during State seasons.	Same as alternative B
	Continue to facilitate a preseason lottery drawing and daily standby lottery drawings to issue hunt permits.	Conduct preseason lottery drawings for a limited number of hunters for headquarters lottery hunt area and disabled deer hunt area. Opportunities in these areas not claimed in the preseason drawing will be available throughout the season either online or by contracted phone-in reservation system.	Same as alternative B
	Continue to maintain 78 permanent elevated deer hunting stands and 11 wheelchair-accessible ground blinds for disabled hunters.	Phase out the use of permanent elevated deer hunting stands. Hunters will be allowed to roam freely within the designated areas.	Same as alternative B
	Continue to require hunters to hunt from permanent deer hunting stands except for archery hunting or for party zone areas.	Use of permanent deer hunting stands will no longer be required. Hunter-owned portable stands are permitted.	Same as alternative B
	Continue to close refuge headquarters area to all visitors during scheduled hunts.	Same as alternative A	Close refuge headquarters area for 1 day to all visitors during scheduled hunts.
	Continue to participate in the statewide youth deer hunt.	Same as alternative A	Same as alternative A
	Currently no regular/non-lottery deer hunting areas available.	In regular/non-lottery deer hunting areas, hunting permitted everyday during State seasons.	In regular/non-lottery deer hunting areas, reduce hunting from everyday during the State season to 3 days per week.
	Prime Hook Creek will remain closed to deer hunting.	Same as alternative A	Same as alternative A
	Continue special areas open to deer hunters with permanent disabilities and provide accessible facilities for wheelchairs. A permanent disability is defined as a permanent physical, mental, or sensory impairment that substantially limits one or more major life activities, such as caring for oneself, performing manual tasks, walking, seeing, hearing, speaking, breathing, learning, and working.	Reestablish hunting areas only for non-ambulatory disabled hunters permanently confined to wheelchairs to provide them with the necessary facilities (wheelchair accessible blinds) to have a hunting opportunity that is as effective as other disabled hunters.	Same as alternative B
	Continue to provide deer hunting for disabled hunters during the firearms and muzzleloader seasons on the Island Farm area during selected days, throughout the entire State deer hunting season.	Provide deer hunting, specifically for non-ambulatory hunters, during the firearms and muzzleloader seasons on the Island Farm area and during State deer hunting seasons in October and November only.	Same as alternative B
	Prime Hook Beach remains closed to disabled deer hunting.	Same as alternative A	Same as alternative A
	Check-in and check-out is required for all hunts.	Check-in and check-out is not required.	Same as alternative B
	Continue a headquarters lottery deer hunt.	Same as alternative A	Reduce the headquarters lottery deer hunt to 1 day.

	Alternative A **Current Management**	**Alternative B** **Focal Species and Proactive Habitat Management (Service-preferred Alternative)**	**Alternative C** **Return to Historic Habitat Management, with Modified Public Use**
Waterfowl Hunting	Continue to provide waterfowl hunting on 1,722 acres.	Open 1,710 additional acres for waterfowl hunting, for a total of 3,432 acres, equivalent to 40 percent of the refuge (the maximum allowed).	Same as alternative B.
	Hunting will be permitted (4 days/wk) on Monday, Wednesday, Friday, and Saturday during the State waterfowl season in the waterfowl hunt area.	Hunting will be permitted 4 days per week during the State waterfowl season in all waterfowl hunt areas, including the disabled waterfowl hunt area.	Hunting will be permitted 3 days per week during the State waterfowl season in all waterfowl hunt areas, including the disabled waterfowl hunt area.
	Salt marsh areas in Unit 1 remain closed to waterfowl hunting.	Open non-lottery/first come first served waterfowl hunting in salt marsh areas in Unit I.	Same as alternative B.
	Salt marsh areas in Unit 4 remain closed to waterfowl hunting.	Same as alternative A	Same as alternative A
	Prime Hook Creek remains closed to waterfowl hunting.	Same as alternative A	Same as alternative A
	Currently, late season snow goose, resident Canada goose, and early teal hunting are closed.	Establish hunting opportunities for late season snow geese, resident Canada geese, and early teal.	Same as alternative A
	Currently, there are no regular/non-lottery waterfowl hunt areas.	Hunting will be permitted in regular/non-lottery waterfowl hunting areas.	Same as alternative B
	All hunting closes at 3:00 pm.	Same as alternative A	All hunting closes at noon.
	Currently, there is no preseason lottery drawing.	Institute a preseason lottery drawing. Preseason lottery hunt opportunities not claimed in preseason drawing will be available throughout the season either online or by telephone. Blind sites not reserved on the online reservation system will go vacant. Blind sites reserved but not claimed the morning of the hunt will remain vacant for the day.	Same as alternative B
	Continue to facilitate daily standby lottery drawings to issue hunt permits on the current lottery hunt area.	Eliminate daily standby drawings. Conduct preseason lottery drawings for the lottery waterfowl hunt area and disabled waterfowl hunt area. For the disabled hunt area, only the first two days of each seasonal split will be included in the lottery and then first-come, first-serve thereafter on the day of the hunt. Vacancies are available by the contractor either online or by telephone.	Same as alternative B
	Continue to require hunters to hunt from grassed and maintained permanent blinds on the lottery hunt area, including 17 Federal, 8 State, and 1 wheelchair-accessible blind for disabled hunters only	Phase out permanent blind structures over a 5-year period in the current lottery hunt area. Instead, establish blind sites.	Same as alternative B.
	Continue managing Unit II as a waterfowl sanctuary.	Same as alternative A	Same as alternative A
	No additional waterfowl sanctuaries.	Manage additional waterfowl sanctuaries in portions of Unit III and Unit IV.	Same as alternative B

	Alternative A **Current Management**	**Alternative B** **Focal Species and Proactive Habitat Management (Service-preferred Alternative)**	**Alternative C** **Return to Historic Habitat Management, with Modified Public Use**
Waterfowl Hunting (cont.)	Continue special areas open to waterfowl hunters with permanent disabilities and provide accessible facilities for wheelchairs.. A permanent disability is defined as a permanent physical, mental, or sensory impairment that substantially limits one or more major life activities, such as caring for oneself, performing manual tasks, walking, seeing, hearing, speaking, breathing, learning, and working.	Reestablish hunting areas only for non-ambulatory hunters permanently confined to wheelchairs to provide them with the necessary facilities (wheelchair accessible blind) to have a hunting opportunity that is as effective as other disabled hunters..	Same as alternative B
	Continue to provide hunting for disabled hunters in the Island Farm Area during selected days throughout the entire waterfowl hunting season.	Provide waterfowl hunting opportunities, specifically for non-ambulatory disabled hunters, by permitting hunting in the disabled waterfowl hunt area in the Island Farm four days per week throughout the waterfowl hunting seasons.	Same as alternative B
	Check-in and check-out is required for all hunts.	Check-in and check-out is not required.	Same as alternative B
	Establish a memorandum of agreement with the Delaware Division of Fish and Wildlife to manage waterfowl hunting program in the Prime Hook Wildlife Area.	Same as alternative A	Same as alternative A
	Continue to provide youth opportunities by participating in the statewide youth waterfowl hunt and young waterfowler program.	Same as alternative A	Same as alternative A
Upland Game and Webless Migratory Bird Hunting	Continue to provide upland game and webless migratory bird hunting on 1,995 acres.	Same as alternative A, except areas open to dove hunting decrease by 110 acres.	Same as alternative B
	Do not allow red fox hunting.	Provide new hunting opportunities for red fox only when concurrently hunting deer and only in areas open to deer hunting. Chase hunting is prohibited. Rimfire or centerfire rifles are prohibited.	Same as alternative B
	Continue self-service check-in and check-out permitting system.	Check-in and check-out is not required.	Same as alternative B
	Continue to require non-toxic shot.	Same as alternative A	Same as alternative A
	Continue to prohibit the hunting of squirrels.	Same as alternative A	Same as alternative A
Turkey Hunting	Turkey hunting will remain closed.	Provide a quality wild turkey hunt program in partnership with the Delaware Division of Fish and Wildlife after determining if a huntable population is present. Open 3,729 acres for turkey hunting.	Same as alternative A
	Turkey hunting will remain closed.	Work with Delaware Division of Fish and Wildlife to annually evaluate the program and turkey populations, and to conduct outreach and enforcement.	Same as alternative A
	Turkey hunting will remain closed.	Conduct a preseason lottery drawing for a limited number of hunters (no more than five) for the turkey lottery hunt area, which may be administered by the State.	Same as alternative A
	Turkey hunting will remain closed.	Check-in and check-out is not required.	Same as alternative A
	Turkey hunting will remain closed.	Require non-toxic shot.	Same as alternative A

	Alternative A Current Management	Alternative B Focal Species and Proactive Habitat Management (Service-preferred Alternative)	Alternative C Return to Historic Habitat Management, with Modified Public Use
Wildlife Observation and Photography	Continue to maintain six miles of hiking trails, seven miles of canoe trail, Slaughter Canal, and roadside pull-offs along Broadkill Beach Road and Prime Hook Beach Road to facilitate these activities.	Same as alternative A	Same as alternative A
	Allow visitors to use the existing trails and observation platform overlooking Vergie's Pond on the south side of Broadkill Beach Road.	Option #1: Keep the existing trail and create a parking lot at the existing trail head Option #2: Abandon and remove the existing walkway. Reroute the trail to the east and construct a smaller, less intrusive boardwalk and trail to the firebreak and existing tower and a three to five space parking lot on the existing high ground.	Eliminate this opportunity and close the existing trail and observation platform overlooking Vergie's Pond on the south side of Broadkill Beach Road.
	Continue to maintain existing benches, fishing pier, observation platforms on Dike Trail, photography blind near refuge office, boardwalks and walkways, parking areas, kiosks, roads, and boat launching ramps.	Same as alternative A	Same as alternative A
	Continue to provide general information on opportunities via refuge Web site, general refuge brochure, maps, and kiosk maps.	Same as alternative A	Same as alternative A
	Continue to partner with Friends of Prime Hook, volunteers, Milton Chamber of Commerce and other partners to host special events, conduct field trips, conduct bird nestbox surveys, and assist with maintenance of trails, observation platforms, photography blinds, and benches.	Same as alternative A	Same as alternative A
	Continue to close headquarters area to general public access for scheduled deer hunts.	Same as alternative A	Same as alternative A
	Continue to close the easternmost 3 miles of Prime Hook Creek from October 1 through March 15.	Close the easternmost 3 miles of Prime Hook Creek every day from September 1 through March 15.	Same as alternative B

	Alternative A Current Management	Alternative B Focal Species and Proactive Habitat Management (Service-preferred Alternative)	Alternative C Return to Historic Habitat Management, with Modified Public Use
Wildlife Observation and Photography (cont.)	Continue to require a $1 daily boat launch fee at refuge boat ramps.	Eliminate boat launch fee.	Same as alternative A
	Establish a memorandum of agreement with Delaware Division of Fish and Wildlife to manage public use along Prime Hook Creek adjacent to the Prime Hook Wildlife Area.	Same as alternative A	Same as alternative A
	No action	Expand program by creating seven new trails totaling 3.7 miles for wildlife observation and photography by using existing trails and interior roads. These include opening the following new areas: North of Fowler Beach Road, South of Slaughter Beach Road, South of Fowler Beach Road (includes new wheelchair-accessible photo blind), Deep Branch Road Trail, South of Prime Hook Road, and expand and improve Blue Goose Trail.	Same as alternative A
	Provide area-specific seasonal closures to reduce user conflicts and minimize wildlife disturbance.	Provide area-specific seasonal closures to reduce user conflicts and minimize wildlife disturbance. Most new areas (currently closed) would be open year round with seasonal closures allowing access only on Sundays during designated hunting seasons.	Same as alternative A
	No action	Develop an interpretive auto tour route using advanced technology, such as radio, downloadable programming, etc., to provide visitors with interpretive information while traveling along the refuge's roadways.	Same as alternative B
	No action	Provide new opportunities for guided field trips featuring nature, birding, fishing, etc.	Same as alternative A
	No action	Designate Slaughter Canal as a no wake zone.	Same as alternative B
	No boat ramp provided at Foord's Landing on Prime Hook Creek.	Within 5 years of the plan, open a boat ramp at Foord's Landing for access to Prime Hook Creek.	Same as alternative A
Recreational Fishing and Crabbing	Continue to provide fishing and/or crabbing opportunities at Turkle Pond, Fleetwood Pond, Prime Hook Creek, Petersfield Ditch, Slaughter Canal, Fowler Beach, and Slaughter Creek in conformance with State seasons and bag limits.	Same as alternative A. In addition, expand fishing opportunities to include night fishing at Fowler Beach, portage-in fishing at Goose and Flaxhole Ponds, and fishing/crabbing on the pulloffs on Prime Hook Beach Road.	Same as alternative A
	No action	Adopt catch-and-release regulations for Turkle Pond, Fleetwood Pond, Goose Pond, Flaxhole Pond, and Prime Hook Creek west of Foord's Landing.	Adopt catch-and-release regulations for Turkle Pond, Fleetwood Pond, and Prime Hook Creek west of Foord's Landing.
	No action	Require the use of barbless hooks in catch-and-release fishing areas.	Same as alternative B
	Continue to close the easternmost 3 miles of Prime Hook Creek from October 1 through March 15.	Close the easternmost 3 miles of Prime Hook Creek every day from September 1 through March 15.	Same as alternative B

	Alternative A Current Management	Alternative B Focal Species and Proactive Habitat Management (Service-preferred Alternative)	Alternative C Return to Historic Habitat Management, with Modified Public Use
Recreational Fishing and Crabbing (cont.)	Continue to require a 30 horsepower motor restriction on Prime Hook Creek and Slaughter Canal and electric motor/ manual propulsion in Turkle and Fleetwood Ponds.	Same as alternative A and require manual propulsion only in Goose and Flaxhole Ponds.	Same as alternative A
	No action	Designate Slaughter Canal as a no wake zone.	Same as alternative B
	Continue partnership with Delaware Division of Fish and Wildlife and Brumbley Family Park to provide boat ramp access to Prime Hook Creek.	Same as alternative A	Same as alternative A
	Continue to require a $1 daily boat launch fee at refuge boat ramps.	Eliminate boat launching fees.	Same as alternative A
	Continue to provide disabled fishing opportunities at the wheelchair-accessible fishing pier on Fleetwood Pond.	Same as alternative A	Same as alternative A
	Continue to partner with the Lower Sussex Bassmasters to host the annual youth fishing event in Milton in June.	Same as alternative A	Same as alternative A
	Continue to maintain boat ramps, roads, parking areas, and accessible fishing pier on Fleetwood Pond.	Same as alternative A	Same as alternative A
	Establish a memorandum of agreement with Delaware Division of Fish and Wildlife to manage public use along Prime Hook Creek adjacent to the Prime Hook Wildlife Area.	Same as alternative A	Same as alternative A
	Follow State fishing regulations.	Same as alternative A with the following exceptions: • no recreational gill netting • no commercial fishing • no food fishing with equipment other than hook and line • no crabbing using pots or trot lines (hand lines, crab nets, hoop crab nets, and collapsible traps if attended to at all times are permitted)	Same as alternative B
	Continue to survey fish populations in refuge waterways.	Survey fish populations every 5 years in refuge waterways and provide appropriate management recommendations (more restricted creel or size limits, seasonal closures, etc.).	Same as alternative A
	Provide area-specific seasonal closures to reduce user conflicts and minimize wildlife disturbance.	Provide area-specific seasonal closures to reduce user conflicts and minimize wildlife disturbance, which includes new and existing fishing areas.	Same as alternative B
	No boat ramp provided at Foord's Landing on Prime Hook Creek.	Within 5 years of the plan, open a boat ramp at Foord's Landing for access to Prime Hook Creek.	Same as alternative A

	Alternative A Current Management	Alternative B Focal Species and Proactive Habitat Management (Service-preferred Alternative)	Alternative C Return to Historic Habitat Management, with Modified Public Use
Environmental Education	Continue to respond to requests for onsite field trips and offsite environmental education programs when staffing and funding allow.	Same as alternative A	Same as alternative A
	Continue to plan, develop, and implement quality educational programs on the refuge that meet or exceed State-mandated curriculum standards.	Same as alternative A	Same as alternative A
	Continue to work with Friends Group, volunteers, and other partners to implement programs.	Same as alternative A	Same as alternative A
	No action	Expand the visitor contact station/refuge office to support environmental education and visitor services programs.	Same as alternative B
	Continue partnerships and formalize relationships with environmental education agencies and academic institutions to develop a network of educators willing to develop curriculum-based lessons focused on refuge resources.	Expand partnerships and formalize relationships with environmental education agencies and academic institutions to develop a network of educators willing to develop curriculum-based lessons focused on refuge resources.	Same as alternative B
	No action	Develop a partnership with a local school district or NGO to provide funding (full- or part-time) for an onsite education specialist to coordinate the development and implementation of curriculum based environmental education programs. Evaluate potential for adult educational partnerships through universities or programs such as Elder Hostel.	Same as alternative B
	No action	In conjunction with conservation partners, develop useful and accessible information resources to help Americans fully appreciate the significant implications of sea level rise and climate change on refuge species and habitats, and to engage these constituencies in seeking solutions.	Same as alternative B
	No action	Incorporate sea level rise and climate change information and messages into environmental education programs.	Same as alternative B
	No action	Hire a temporary staffing position to assist with outreach efforts for sea level rise and climate change.	Same as alternative B
	No action	No action	Develop education programs targeting teens and young adults focusing on practical applications, such as how to make environmentally conscious decisions.
	No action	No action	Develop a program designed for those interested in education as a career and give participants an opportunity to be involved in planning and implementing youth environmental education programs.

	Alternative A **Current Management**	**Alternative B** **Focal Species and Proactive Habitat Management (Service-preferred Alternative)**	**Alternative C** **Return to Historic Habitat Management, with Modified Public Use**
Interpretation	Continue to respond to requests for onsite and offsite interpretative programs when staffing and funding allows.	Same as alternative A	Same as alternative A
	Continue to partner with Friends of Prime Hook, volunteers, Milton Chamber of Commerce, and other partners to host special events, conduct interpretive programs, develop signage, etc.	Same as alternative A	Same as alternative A
	Continue to conduct offsite interpretive opportunities annually for civic groups, conservation organizations, and community events.	Same as alternative A	Same as alternative A
	Continue to provide interpretive displays, movies, and various mounted species of animals found on the refuge at the visitor contact station and auditorium.	Same as alternative A	Same as alternative A
	Continue to provide self-guided information along hiking and canoe trails.	Same as alternative A	Same as alternative A
	Maintain refuge Web site.	Same as alternative A	Same as alternative A
	No action	Increase interpretive programs by providing more regularly guided field trips for nature, birding, fishing, photography, etc.	Same as alternative B
	No action	Develop new interpretive panels and maps for the information kiosks located throughout the refuge.	Same as alternative B
	No action	Develop new and improved brochures for the refuge's general brochure, hunting regulations, and a tear sheet with public use regulations.	Same as alternative B
	No action	Revitalize the waterfowl festival celebrating National Wildlife Refuge Week in October only if additional staff is available.	Same as alternative A
	Conduct routine condition review of interpretive signs and information kiosks and complete maintenance and sign replacement as needed.	Same as alternative A	Same as alternative A
	No action	Develop an interpretive auto tour route using advanced technology, such as radio, downloadable programming, etc., to provide visitors with interpretive information while traveling along the refuge's roadway.	Same as alternative B
	No action	Explore other partnerships to develop programs for various age groups.	Same as alternative B
	No action	No action	Develop three to five power point programs that focus on different themes associated with refuge goals and objectives such as habitat, wildlife, and visitor services.

	Alternative A Current Management	Alternative B Focal Species and Proactive Habitat Management (Service-preferred Alternative)	Alternative C Return to Historic Habitat Management, with Modified Public Use
Interpretation (cont.)	No action	No action	Develop an educational power point that plays continuously in the visitor contact station informing the public on topics such as the history of the refuge, types of habitat present, upcoming events and activities, and volunteer opportunities.
	No action	No action	Develop a new display(s) in the visitor contact station promoting backyard habitat and the importance of native species.
	No action	Implement a volunteer master naturalist program.	Same as alternative B
	No action	In conjunction with conservation partners, develop useful and accessible information resources to help Americans fully appreciate the significant implications of sea level rise and climate change on refuge species and habitats, and to engage these constituencies in seeking solutions.	Same as alternative B
	No action	Incorporate sea level rise and climate change information and messages into interpretive sign panels, brochures, and websites.	Same as alternative B
	No action	Hire a temporary staffing position to assist with outreach efforts for sea level rise and climate change.	Same as alternative B
Other Recreational Use	Allow non-priority compatible uses: research, public leases of the FAA VORTAC tower, canoeing, walking, hiking, jogging, and specialized uses such as commercially guided tours for wildlife observation and continuing education.	Same as alternative A	Same as alternative A
	Allow non-priority compatible uses: commercial fishing; commercial trapping of muskrat, raccoon, etc.; turtle trapping; picnicking; 5K road race; beekeeping; waterfowl retrieval permits; dog walking; roller blading; competitions or organized group events; and non-competitive organized events.	Prohibit the activities in alternative A	Prohibit the activities in alternative A
	No action	Allow non-priority compatible uses: commercial photography and commercial forest management.	Same as alternative B
	Prohibit the following inappropriate or non-compatible activities: recycling trash using State-sponsored recycle containers located on the refuge, ice skating, camping, horseback riding, geocaching/metal detecting, off-road and mountain biking, off-road vehicles including ATVs, commercial dog walking, operation of model boats and airplanes, swimming and sunbathing, waterskiing, personal watercraft, air thrust boats, soliciting of funds (50CFR 27.97 for private operations and per 50CFR 27.86 for begging), and other activities identified in 50CFR part 27.	Same as alternative A	Same as alternative A
	Adhere to commercial wildlife observation guide program stipulations found in appendix E.	Same as alternative A	Same as alternative A

	Alternative A Current Management	Alternative B Focal Species and Proactive Habitat Management (Service-preferred Alternative)	Alternative C Return to Historic Habitat Management, with Modified Public Use
Community Outreach	Continue to conduct outreach in conjunction with interpretive programs under goal 5.	Increase outreach in conjunction with interpretive programs.	Same as alternative B
	Continue to issue news releases on significant accomplishments, to promote special events, and to announce major initiatives.	Same as alternative A	Same as alternative A
	Continue to maintain refuge Web site and also post information on refuge kiosks.	Same as alternative A	Same as alternative A
	Continue to coordinate, co-host, and/or partner with local Chambers of Commerce and Friends Group to conduct annual community events.	Same as alternative A	Same as alternative A
	No action	Create new and improve existing outreach materials (Web site, media and press kits, fact sheets, virtual tours of the refuge, and Webcam for wildlife).	Same as alternative B
	No action	Increase numbers and types of outreach activities, special events, or programs, and consider additional venues.	Same as alternative B
	No action	Coordinate with Delaware Division of Fish and Wildlife and other partners to develop outreach materials better explaining the refuge's water level management, other habitat management programs, and visitor services programs.	Same as alternative B
	No action	Conduct meetings as needed with the general public to facilitate communications, raise awareness and understanding of, and seek support for, refuge management programs.	Same as alternative B
	No action	Incorporate sea level rise and climate change information and messages into interpretive sign panels, brochures, Web sites, and environmental education programs.	Same as alternative B
	No action	Hire a temporary staffing position to assist with outreach efforts for sea level rise and climate change.	Same as alternative B
	No action	Work with regional and State partners to develop a common, consistent message for sea level rise and climate change.	Same as alternative B
	No action	No action	Develop a comprehensive outreach strategy.
	No action	No action	Allow visitors to register for upcoming activities and events online.
	No action	No action	Utilize new technology such as Twitter.
	No action	No action	Conduct an evaluation of the effectiveness of current outreach techniques and identify at least two specific audiences for outreach goals that have thus been unexplored.

	Alternative A Current Management	Alternative B Focal Species and Proactive Habitat Management (Service-preferred Alternative)	Alternative C Return to Historic Habitat Management, with Modified Public Use
Private Landowner Assistance	Continue to assist private landowners and other cooperators in controlling *Phragmites* on their lands.	Same as alternative A	Same as alternative A
	Assistance includes on-the-ground support, as well as seeking grants and other funding sources.	Same as alternative A	Same as alternative A
	No action	Expand technical assistance capability to assist landowners on invasive species identification and control, wetlands protection, and habitat restoration and management.	Same as alternative A
	No action	Work with partners to identify how key ecological processes are likely to be affected by climate change.	Same as alternative B
	No action	Determine how management actions might help to maintain or restore key ecological processes using the various incentive programs offered by Federal and State agencies and other conservation organizations.	Same as alternative B
Regional and Community Partnerships	Continue to maintain the collaborative relationship with Federal, State, and local governmental agencies to meet natural resource mandates and objectives.	Enhance our existing collaborative relationships, and seek additional ones, to increase the likelihood of meeting natural resource mandates and objectives.	Same as alternative B
	Continue to work with the Friends of Prime Hook to promote an appreciation of natural and cultural resource conservation and stewardship and to assist in funding and implementing refuge projects through the approved memorandum of agreement.	Same as alternative A	Same as alternative A
	Continue to administer a program that actively engages volunteers in the biological, maintenance, and visitor services program areas each year in carrying out the mission of the Service and Refuge System.	Same as alternative A	Same as alternative A
	Continue to conduct wildlife and habitat research studies through partnerships with local universities.	Same as alternative A	Same as alternative A
	No action	Participate in regional and local community economic development and conservation partnerships and initiatives.	Same as alternative B
	Update the existing memorandum of agreement with the Friends Group.	Same as alternative A	Same as alternative A
	No action	Develop a refuge volunteer plan and handbook that covers volunteer program coordination, training, job descriptions, volunteer policy, recruitment policy, monitoring, evaluation, dispute, and termination policies.	Same as alternative B
	Continue the resident camper volunteer program on the refuge.	Expand the resident camper volunteer program on the refuge.	Same as alternative B
	No action	Explore the possibility of permanent housing for refuge interns.	Same as alternative B

	Alternative A Current Management	Alternative B Focal Species and Proactive Habitat Management (Service-preferred Alternative)	Alternative C Return to Historic Habitat Management, with Modified Public Use
Regional and Community Partnerships	No action	Facilitate demonstration areas on-refuge and on other conservation ownerships that showcase applied management to benefit natural resources.	Same as alternative A
	No action	Work with Federal, State, and conservation organizations on land acquisition priorities.	Same as alternative B
	No action	Enhance existing and develop new partnerships to conduct research related to fish and wildlife adaptation to climate change and sea level rise on the refuge, neighboring watersheds, and elsewhere in the State of Delaware.	Same as alternative B
	Continue implementing tasks outlined in a 5-year cooperative agreement with the Delaware Coastal Program on research and monitoring needs for the refuge.	Same as alternative A	Same as alternative A

Table 4-6. Summary comparison of hunting and wildlife observation opportunities by alternative

This table shows what areas of the refuge are open for hunting and wildlife observation by month. It is color-coded to show the differences among the alternatives in hunting and wildlife observation opportunities. Where overlaps in hunting and wildlife observation occur, the table also describes how conflicts between user groups are minimized. For example, some areas are only open to wildlife observation on Sundays and in other areas only hunted portions are closed to wildlife observation.

CCP – Prime Hook NWR

KEY

H = Hunting Open **W = Wildlife Observation/Photography Open**

Alternative A Only **All Alternatives** **Alternative A & B Only**

Alternative B Only **Alternative B & C Only**

Unit Name	Area	Month											
		Jan[1]	Feb[1]	Mar[1]	Apr[1]	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Unit I	Slaughter Canal Area	H, W*	H, W*	H, W	H[2], W	H[2], W	W	W	W	H, W*	H, W*	H, W*	H, W*
	Slaughter Canal	H, W*	H, W*	H, W	H, W	W	W	W	W	H, W*	H, W*	H, W*	H, W*
	Fowler North Area	H, W*	H, W*	H, W	H[2], W	H[2], W	W	W	W	H, W*	H, W*	H, W*	H, W*
	Fowler Beach	W	W	W[B]	W[B]	W[B]	W[B]	W[B]	W[B]	W	W	W	W
	Roadside Viewing on Slaughter Beach Road & Fowler Beach Road	W	W	W	W	W	W	W	W	W	W	W	W
	Viewing at Water Control Structure at Slaughter Canal	W	W	W	W	W	W	W	W	W	W	W	W

*Open only on Sundays

[1] Wetland areas only open to hunting during the snow goose conservation order from Jan/Feb through mid-April and will involve temporary closures of portions of the hunt area to other users

[2] Turkey hunting for five hunters is available in portions of the 3,700 acre turkey hunt area; only hunted portions will be closed to other visitors

B Indicates a seasonal closure of designated beach dunes and overwash areas – access to the intertidal zone is permitted

KEY
H = Hunting Open **W = Wildlife Observation/Photography Open**
Alternative A Only **All Alternatives** **Alternative A & B Only**
Alternative B Only **Alternative B & C Only**

Unit Name	Area	Month											
		Jan[1]	Feb[1]	Mar[1]	Apr[1]	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Unit II	Fowler Beach	W	W	W[B]	W[B]	W[B]	W[B]	W[B]	W[B]	W	W	W	W
	Fowler South Area	H[S1], W**	H[S1], W**	H[S1], W	H, W	W	W	W	W	H, W**	H, W**	H[S1], W**	H, W**
	Cods Road Area	H	H	H	H	CLOSED	CLOSED	CLOSED	CLOSED	H	H	H	H
	Oak Island	H[S1]	H[S1]	H[S1]	H	CLOSED	CLOSED	CLOSED	CLOSED	H	H	H	CLOSED
	Prime Hook North Area	H	H	H	H[2]	H[2]	CLOSED	CLOSED	CLOSED	H	H	H	H
	Roadside Viewing on Prime Hook Beach Road & Cods Road	W	W	W	W	W	W	W	W	W	W	W	W
	Unit II Marsh (Sanctuary)	CLOSED[S]	CLOSED[S]	CLOSED[S]	CLOSED[S]	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED

*Open only on Sundays
**Upon completion of photography blind, this portion of trail will be open year round and only on Sundays during the hunting season
[1] Wetland areas only open to hunting during the snow goose conservation order from Jan/Feb through mid-April and will involve temporary closures of portions of the hunt area to other users
[2] Turkey hunting for five hunters is available in portions of the 3,700 acre turkey hunt area; only hunted portions will be closed to other visitors
[S] Indicates a sanctuary area unless open for hunting during the snow goose conservation order
[S1] Indicates a sanctuary area from the end of November through March 15 unless open for snow goose conservation order
[B] Indicates a seasonal closure of designated beach dunes and overwash areas – access to the intertidal zone is permitted

KEY
H = Hunting Open W = Wildlife Observation/Photography Open
Alternative A Only
Alternative B Only
All Alternatives
Alternative B & C Only
Alternative A & B Only

Unit Name	Area	Month											
		Jan[1]	Feb[1]	Mar[1]	Apr[1]	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Unit III	Prime Hook South Area	H, W*	H, W*	H, W	H[2], W	H[2], W	W	W	W	H, W*	H, W*	H, W*	H, W*
	Prime Hook Creek – East of Foord's Landing	H[S2]	H[S2]	H	H,W	W	W	W	W	H, W	H	H	H
	Prime Hook Creek – West of Foord's Landing	W	W	W	W	W	W	W	W	W	W	W	W
	Unit III Marsh (North & Mid Sections)	H	H[S2]	H[S2], W	H[S2],W	W	W	W	W	H, W	H	H	H
	Unit III Marsh (Southern Section = Sanctuary)	CLOSED[S]	CLOSED[S]	CLOSED[S]	CLOSED[S]	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED
	Headquarters Area	H, W[D]	W	W	H[2], W	H[2], W	W	W	W	W	W	H, W[D]	W
	Jefferson Lofland Area (Deep Branch Road Trail)	H, W***	H, W***	W***	H[2], W	H[2], W	W	W	W	H, W***	H, W***	H, W***	H, W***
	Millman Area	H	H	H[2]	H[2]	CLOSED	CLOSED	CLOSED	CLOSED	H	H	H	H
	Viewing at Water Control Structure at Petersfield Ditch	W	W	W	W	W	W	W	W	W	W	W	W
	Roadside Viewing on Prime Hook Beach Road & Broadkill Beach Road	W	W	W	W	W	W	W	W	W	W	W	W

*Open only on Sundays
***Seasonal closures to non-consumptive users from September 1 to March 15 to reduce cumulative disturbance to waterfowl in and adjacent to Goose & Flaxhole Ponds
[1] Wetland areas only open to hunting during the snow goose conservation order from Jan/Feb through mid-April and will involve temporary closures of portions of the hunt area to other users
[2] Turkey hunting for five hunters is available in portions of the 3,700 acre turkey hunt area; only hunted portions will be closed to other visitors
[S] Indicates a sanctuary area unless open for hunting during the snow goose conservation order
[S2] Indicates a sanctuary area from the end of the hunting season through March 15 unless open for snow goose conservation order
W[D] Indicates that the HQ area is only closed to non-consumptive users for a deer hunt for one day during the indicated month

KEY
H = Hunting Open **W = Wildlife Observation/Photography Open**
Alternative A Only **All Alternatives** **Alternative A & B Only**
Alternative B Only **Alternative B & C Only**

Unit Name	Area	Month											
		Jan[1]	Feb[1]	Mar[1]	Apr[1]	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Unit IV	Graves Area	H	H	H	H	CLOSED	CLOSED	CLOSED	CLOSED	H	H	H	H
	Trail on Vergie's Pond	H[S1], W[S1]	H[S1], W[S1]	H[S1], W[S1]	H, W	W	W	W	W	W	W	W[S1]	W[S1]
	Island Farm Area	H[S1]	H[S1]	H[S1]	H	CLOSED	CLOSED	CLOSED	CLOSED	H	H	H	H[S1]
	Southern Section of Unit IV (Sanctuary)	CLOSED[S]	CLOSED[S]	CLOSED[S]	CLOSED[S]	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED
	Roadside Viewing on Broadkill Beach Road	W	W	W	W	W	W	W	W	W	W	W	W

[1] Wetland areas only open to hunting during the snow goose conservation order from Jan/Feb through mid-April and will involve temporary closures of portions of the hunt area to other users

[S1] Indicates a sanctuary area from the end of November through March 15 unless open for hunting during the snow goose conservation order (in the Island Farm Area, applies to all but the designated area for disabled waterfowl hunting)

Chapter 5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Eastern towhee

Environmental Consequences

- Introduction
- Impacts of Refuge Management on the Socioeconomic Environment
- Impacts on Cultural and Historical Resources
- Impacts on Air Quality
- Impacts on Soils
- Impacts on Hydrology and Water Quality
- Impacts on Vegetation
- Impacts on Federal and State Endangered Species
- Impacts on Waterfowl
- Impacts on Shorebirds
- Impacts on Landbirds
- Impacts on Secretive Marsh and Waterbirds
- Impacts on Mammals
- Impacts to Reptiles and Amphibians
- Impacts on Fisheries
- Impacts to Invertebrates
- Impacts on Public Use and Access
- Cumulative Impacts
- Relationship Between Short-Term Uses of the Human Environment and the Enhancement of Long-Term Productivity
- Unavoidable Adverse Effects
- Potential Irreversible and Irretrievable Commitments of Resources
- Environmental Justice

Introduction

This chapter describes the environmental consequences we predict from implementing management alternatives presented in chapter 4. Where detailed information is available, we present a more analytic comparison between alternatives and their anticipated consequences. These consequences are described as impacts or effects. In absence of detailed information, we make comparisons based on our professional judgment and strategies of the three alternatives: current management/passive management or no action (alternative A); expanded public use incorporated with proactive habitat restoration management in the Service-preferred alternative (alternative B); and an attempt to return to earlier conditions and management approaches including some intensive engineering actions and continued human manipulation of refuge lands (alternative C).

We focus our discussion on the impacts associated with the goals and significant issues identified in Chapter 1, Purpose of, and Need for, Action. The direct, indirect, short-term, long-term, and cumulative influences of both beneficial and adverse effects likely to occur over the 15-year life span of this CCP are discussed. Beyond the 15-year planning horizon, we consider a more speculative description of environmental consequences with particular emphasis on climate change predictions and associated sea level rise impacts based on current models. We will also consider the relationship between short-term uses of the human environment and the enhancement of long-term productivity, potential irreversible and irretrievable commitments of resources, and environmental justice. At the end of this chapter, a matrix summarizes the effects predicted for each alternative and allows for a side-by-side comparison.

Regulations adopted by the Council for Environmental Quality and the Service on implementing NEPA require that we assess the importance of the effects of all alternatives based on their context and intensity.

The context of our impact analysis ranged from small scale to large, from the invertebrate community on the Refuge to the Atlantic flyway population for a migratory bird. For example, we considered direct and indirect impacts of insecticides on chironomid larvae and the consequences of this reduction in insect number on migratory birds; the direct impacts to soils of kiosk construction on the refuge; or the direct contribution to biodiversity through the protection of rare flora or fauna by the refuge to the populations of species at the State, regional, and global levels. Table 5-1 illustrates the range in scale, from a square meter to nearly 25 million acres, of the context of various Service actions.

Table 5-1. Impact Contexts for Service Actions Under CCP at Prime Hook NWR

Invertebrate/vegetation sampling size (m^2)	0.000247 acres (square meter)
Kiosk Footprint	0.001 to 0.5 acres
Pintail Potholes	0.1 to 200 acres
Refuge Management Units	1,111 to 3,823 acres
Prime Hook Impoundments	4,200 acres
Prime Hook NWR Refuge Lands	10,144 acres
Coastal Delaware NWR Complex Lands	26,110 acres
Delaware Bay	500,480 acres
Sussex County	600,320 acres
State of Delaware	1.6 million acres
Delmarva Peninsula	6.9 million acres
PIF Mid-Atlantic Coastal Plain Area 44 (Partners in Flight)	13.5 million acres
New England/Mid-Atlantic Coast Bird Conservation Region (BCR 30)	24.4 million acres

Although the area of the refuge only covers a small percentage of these larger geographical regions, it represents a hotspot of biodiversity across the regional landscape. Our proposed conservation objectives and strategies for focal species and habitat management actions are consistent with Delaware's comprehensive wildlife management plan and contribute to achieving state bird population objectives for bird species of greatest conservation need (Rosenberg 2004) and conserving tier 1 and tier 2 wildlife species in Delaware (DNREC 2005).

Significance also encompasses the magnitude of change or of an impact. It is not a value judgment, as some impacts can be beneficial for one species and adverse for another, or have a positive impact on visitor use but a negative impact on migratory birds. The following table defines this aspect of significance by giving more detailed information about the magnitude or level of intensity for each of the impacts topics which will be discussed in more detail in this chapter.

Table 5-2. Impact Significance Criteria Threshold Definitions

Impact Topic	Significance Criteria
Socioeconomic	Effects to socioeconomic elements would be considered significant if: • Management actions would result in readily apparent changes to economic conditions. While there may be some apparent changes in social or economic conditions in nearby communities, if such effects are localized, they are considered not to be significant. Significant social or economic effects encompass measurable changes in social or economic conditions at the regional level.
Cultural and Historical Resources	Effects to cultural and historic resources would be considered significant if: • Management actions would have a substantial, noticeable, and permanent effect on a site or group of sites. The action would severely change one or more characteristics that qualify the site(s) for inclusion in the National Register, diminishing the integrity of the site(s) to such an extent that it would no longer be eligible for listing in the National Register. For purposes of section 106, the determination of effect would be an adverse effect.
Air Quality	Effects to air quality would be considered significant if: • Implementation of a proposed refuge action would result in: emissions equal to or in excess of the standards set in local implementation plans for the Clean Air Act; large areas of soil becoming routinely exposed and subject to wind erosion; or sensitive receptors being exposed to substantial pollutant concentrations, including air toxics such as diesel particulates. Significant indirect effects to air quality would occur if a proposed refuge action results in frequent heavy congestion on adjacent roadways. Significant cumulative effects would occur if the "de minimis" (minimum) thresholds developed by the EPA for proposed Federal actions in a nonattainment area are exceeded.
Soils	Effects to soils would be considered significant if: • management actions would result in the permanent loss or alteration of geologic features or soils in relatively large areas, such as 1,000 acres, or there would be a strong likelihood for erosion or mass movement of large quantities of soil, sediment, or rock as a result of the action. Mitigation measures to offset adverse effects would be necessary, extensive, and their success could not be guaranteed. • management actions would preserve or restore geologic features, geologic processes, or soil resources in relatively large areas, such as 1,000 acres.

Impact Topic	Significance Criteria
Water Quality and Hydrology	Effects to water quality and hydrology would be considered significant if: • actions would result in substantial increased flooding on- or off-site, accelerating flooding or further deviation from historical hydrological patterns above reasonably anticipated levels due to climate change or sea level rise, or a substantial reduction in the local groundwater table. • actions would violate any water quality standards or waste discharge requirements, substantially increase sedimentation, introduce persistent contaminants (nonpoint source pollution) into the watershed, or otherwise substantially degrade water quality. Water quality impacts could include increased loads of sediment, debris, chemical, or toxic substances, or pathogenic organisms. The impact could be easily visible to visitors. • restoration projects and best management practices would measurably improve water quality in most tributaries in the refuge, and overall effect would be clearly detectable.
Vegetation	Effects to vegetation would be considered significant if: • an action would result in a substantial change in the amount or quality of available habitat for a wildlife species. (For wintering waterfowl, other migratory birds, or native resident wildlife, a substantial reduction in habitat resulting in a significant adverse impact would be defined as a reduction of 30 percent or more of the available acreage or 50 percent of the quality of habitat for these species within the refuge; a significant beneficial impact would be defined as a 30 percent or greater increase in the quantity or 50 percent increase in the quality of habitat for wintering waterfowl, other migratory birds, or native resident wildlife). • a substantial portion of native habitat would be removed or otherwise modified as to accommodate a proposed action. The impacts would be substantial and highly noticeable and could result in widespread change. This could include changes in the abundance, distribution, or composition of a local vegetation community or regional plant population to the extent that it would be likely to be replaced by a different vegetation community. Significant ecological processes would be altered, and changes would be expected. • a refuge action causes mortality of greater than 30% of a regional or state population of a species. • management actions would restore or preserve vegetation or unfragmented forest blocks throughout much of the refuge. • management actions to remove invasive vegetation are not considered significant even if the result substantially decreases the abundance of the invasive species, if the result is the restoration or increase in quantity or distribution of native vegetation.
Threatened and Endangered Species	Effects to threatened and endangered species would be considered significant if an action would result in a substantial adverse effect; either directly or through habitat modifications, on any Federal threatened, endangered, candidate, or special concern wildlife or fish species. Also included would be species listed threatened or endangered by DNREC. Management actions could result in a noticeable change to a population or individuals of a listed or protected species or designated critical habitat. The change would be substantial and highly noticeable and would most likely result in a likely to adversely affect opinion from the U.S. Fish and Wildlife Service. Management actions would measurably increase a population or numbers of individuals of a listed or protected species or enhance designated critical habitat.

Impact Topic	Significance Criteria
Terrestrial Wildlife Waterfowl, Shorebirds, Secretive Marsh and Waterbirds, Mammals, Reptiles and Amphibians, and Invertebrates	Effects to species would be considered significant if: • an action would result in a substantial change in the amount or quality of available habitat for a wildlife species. (For wintering waterfowl, other migratory birds, or native resident wildlife, a substantial reduction in habitat resulting in a significant adverse impact would be defined as a reduction of 30 percent or more of the available acreage or 50 percent of the quality of habitat for these species within the refuge; a significant beneficial impact would be defined as a 30 percent or greater increase in the quantity or 50 percent increase in the quality of habitat for wintering waterfowl, other migratory birds, or native resident wildlife). • a substantial portion of native habitat would be removed or otherwise modified to accommodate a proposed action. • a refuge action causes mortality of greater than 30% of a regional or state population of a species. • management actions would restore or preserve aquatic wildlife populations in large portions (1,000 acres) of the refuge. This could include changes in the abundance, distribution, or composition of local terrestrial wildlife populations.
Fisheries	Effects to fisheries would be considered significant if: • an action would substantially change the availability of habitat for fish. • an action would result in an obvious detectable effect to aquatic wildlife populations at the regional level. Extensive mitigation would be needed to offset any adverse effects, and their success would not be guaranteed. • an action would restore, improve, or preserve aquatic wildlife populations in large portions (i.e., 1,000 acres) of the refuge. This could include changes in the abundance, distribution, or composition of local aquatic wildlife populations.
Public Use and Access	Effects to public use and access would be considered significant if: • a proposed action resulted in substantial displacement of a wildlife-dependent public use (>25% of existing activities or opportunities moved to a different area or terminated at the refuge); • substantial reduction in the quality of the wildlife-dependent experience (crowding increasing by more than 50% or substantial anticipated losses of wildlife or habitat supporting the experience). • proposed actions resulted in substantial increase in opportunity for or quality of a wildlife-dependent public use (>25% increase over existing opportunity or quality of experience). • management actions would result in impacts that would be readily apparent and would likely be perceived as highly positive by visitors because they would obviously enhance the visitor experience by making access to most refuge resources and experiences very easy.

Some impacts are not considered major or significant, and are described as either negligible, minor, or moderate. The magnitude of such changes is defined as follows:

- Negligible—Management actions would result in impacts that would not be detectable or if detected, would have effects that would be considered slight, localized, and short-term.

- Minor—Management actions would result in a detectable change [i], but the change would be slight and have only a local effect on the community, the resource, or ecological processes. The change would be discountable, insignificant, and of little consequence and short-term in nature.

- Moderate—Management actions would result in a clearly detectable change. This could include changes to a local biotic population or habitat sufficient to cause [a] change in [the] abundance, distribution, or composition, but not changes that would affect the viability of regional populations or habitats. Changes to local ecological processes would be of a limited extent.

- Major—As described in more detail in Table 5-2, management actions would result in a clearly detectable change. The impacts would be substantial and highly noticeable and could result in widespread change. This could include changes in the abundance, distribution, or composition of a local or regional populations or habitats to the extent that it would not likely recover or continue in its previous condition or size. Significant ecological processes would be altered, and changes throughout the ecosystem would be expected.

In addition to the magnitude of impact (negligible, minor, moderate, or major) the impacts of the management action on some of the environmental attributes are also, at times, described as beneficial or adverse. Generally, an impact will be described as 'beneficial' if it results in a condition that improves the biological health, population size of native or naturally occurring species, or the robustness or sustainability of that characteristic. However, many times value judgments cannot be given for ecological change. A change in habitat that is beneficial for certain species of waterfowl may be adverse for others with different habitat preferences. Factors which reduce the population of a predator may be adverse for the predator and positive for the prey. Therefore, sometimes our impact assessments do not describe impacts as either positive or negative, or describe them specifically in term of what the impact applies to. The duration of identified effects and their consequences varies, from those occurring only once for a brief period in the 15-year period of this plan—for example, the effects of construction for expanding existing facilities—to those occurring more frequently during the year, like multiple salt water intrusion events into freshwater impoundments due to sea level rise with increased frequency and severity of coastal storms. The environmental consequences analysis provided in this chapter will also furnish the level of detail necessary to assess the compatibility of all proposed uses.

We based our evaluation of the frequency and intensity of the effects of the alternatives on these factors:

- Expected degree or percent of change in the resource from current conditions

- Frequency and duration of the effect

- Sensitivity of the resource to a particular effect or its natural resiliency to recover from such an effect

- Potential for implementing effective preventive or mitigating measures to lessen the effect

A matrix table at the end of this chapter (table 5-15) summarizes the different approaches to delivering refuge wildlife and habitat conservation actions and providing public access and recreational uses, ranging from the current management/passive management or no action (alternative A), to expanded public use incorporated with proactive habitat restoration management in the Service-preferred alternative (alternative B), and an attempt to return to earlier conditions and management approaches including some intensive engineering actions and continued human manipulation of refuge lands (alternative C). All three alternatives take an integrated approach that seeks to conserve wildlife and their associated habitats balanced with providing quality and diversified recreational and educational opportunities for visitors.

The environmental baseline: It is important to understand that while this EIS was under development, there were major habitat changes within the Refuge. As explained in Chapter 3, the formerly freshwater impoundments in Units II and III (particularly in Unit II) have undergone significant change, due to breaches in the barrier island allowing for the free exchange of salt water in the formerly maintained freshwater marshes. The rapid inundation of salt water killed substantial amounts of freshwater vegetation and has increased the salinity of brackish waters but, to date, has not brought in sufficient sediment to overcome the sediment deficit incurred over the decades of freshwater management. The refuge continues to assess the biological, chemical, and geological impacts of these changes, specifically exploring whether the underlying peat layers, which were not increasing during the decades of freshwater management, have recently experienced increased subsidence or other biochemical changes. Therefore, while the environmental baseline for these habitats is difficult to fully assess, for this analysis we assume that the baseline is the condition of the refuge as of mid-2012. Thus, alternative A assumes little or few future proactive efforts and assumes that future habitats will evolve on the template of past natural events and earlier human manipulations of the marshes. Alternative B assumes that the service will undertake future proactive measures, geared to restoration of a more natural system than existed in 1988, or even decades before, with the goal of limiting its actions to ones which will result in more naturally sustainable future conditions, i.e. “fix it, and then let it be.” Alternative C assumes a return to former management conditions and recognizes that extensive engineering actions to construct a robust barrier island capable of sustaining freshwater marshes in light of sea level rise and climate change will require construction of a substantial sand barrier with perpetual renourishment actions. Similarly, for upland management, since the refuge has not been engaged in active farming for 6 years, Alternative A assumes that incremental vegetation changes will result in the gradual development of bushes, thickets, and ultimately woodlands, which the Service will not actively manage other than to remove invasives. Alternative B will bring these areas into a forested condition more rapidly by planting certain desired trees and other species. Alternative C anticipates a return to active farming.

This chapter does not separately evaluate the consequences of certain types of conservation actions described in chapter 4. These actions often have impacts too trivial to matter, and would be categorically excluded if independently proposed, which would exclude them from further analysis or review. Such categorically excluded actions include but are not limited to:

- Conducting environmental education and interpretation programs (unless major construction is involved, or significant increase in visitation is expected)
- Conducting research, inventorying biological resources, or otherwise collecting habitat data or other natural resource information
- Operating and maintaining infrastructure and facilities (unless major renovation or improvements are involved)
- Recurring, routine habitat management actions and improvements
- Constructing small projects (e.g., fences, berms, interpretive kiosks) or developing access for routine management
- Planting and restoring native vegetation
- Changing minor amounts or types of public use
- Issuing new or revised management or public use plans when only minor changes are planned
- Enforcing Federal laws or policies

Impacts of Refuge Management on the Socioeconomic Environment

Chapter 3, Description of the Affected Environment, describes in more detail the regional socioeconomic setting of Prime Hook NWR. It also highlights community attitudes and opinions about the refuge as reported by the U.S. Geological Survey-Fort Collins Science Center (Sexton et al. 2007). A regional economic impact analysis was also conducted by the Fort Collins Science Center to estimate how current management and proposed management activities affect the local economy. The refuge management activities of economic concern in the analysis are:

- Refuge purchases of goods and services within the local community
- Refuge personnel salary spending
- Revenues generated from the Refuge Revenue Sharing Program
- Spending in the local community by refuge visitors
- Other management activities, e.g., cooperative farming program

The complete report of the regional economic impact of alternatives A, B, and C can be found in appendix I. The report also includes a cost analysis of administering refuge hunting programs.

We also considered the general socioeconomic consequences of managing habitat and wildlife to maintain, enhance, or restore elements of biological integrity, diversity, and environmental health on ecosystem services and how they affect humans. We also evaluated socioeconomic impacts in terms of the degree in which the proposed alternatives might affect the local economy, social structures, or quality of life of the local communities in and around the refuge and in Sussex County.

Managing for biological integrity, diversity, and environmental health on refuge lands will likely have impacts and consequences on the socioeconomic environment. However, it is difficult to accurately quantify a local monetary value on socioeconomic consequences of ecosystem services accrued when we maintain and enhance the biological integrity and diversity of refuge habitats.

Ecosystem services are the benefits to humans from a multitude of resources and processes that are supplied by nature. Services include climate regulation, waste treatment, water supply, carbon sequestration, protecting areas against storm and flood damage, nutrient cycling, habitat provision, and others that all contribute toward human comfort, security, and well-being. Saltwater wetlands, freshwater wetlands, forests, and ponds all provide different levels of environmental services.

The notion of ecosystems providing important services is not new. However, assigning ecological, socio-cultural, and economic values to ecosystem services is causing us to think differently about conservation. For example, quantifying ecosystem services as "natural capital" creates innovative financial incentives for conservation. Striking a balance between ecology and economy promises to provide practical ways to link the environment and people, and lead us toward more sustainable solutions.

Several recent reports have focused on the ecosystem services and the economic value of those services. Table 5.3 highlights some of these recent studies.

Table 5-3. Ecosystem Services

Ecosystem	Southwick Associates (2011) NWR lands (Value/acre/year)	Weber (2007) Cecil County, Maryland (Value/acre/year)	Kauffman (2011) Delaware River Basin (Value/acre/year)
Upland Forest	$1,674	$12,033	$1,978
Wetlands (nonspecific)	$10,608		
Riparian Forest		$52,765	
Freshwater Wetland		$43,685	$13,621
Salt marsh		$28,146	$7,235
Open Water			$1,946

	Southwick Associates (2011) NWR lands (Value/acre/year)	Weber (2007) Cecil County, Maryland (Value/acre/year)
Carbon Sequestration		$31 Upland Forest $65 Tidal Marsh
Clean Air		$191 Upland Forest
Soil and Peat Formation		$1,351 Tidal Marsh $17 Upland Forest
Flood Protection/ Stormwater Mgmt	$2,800/acre/year	$1,430 Tidal Marsh $679 Upland Forest
Water Supply/ Hydrologic Regulation	$2,344/acre/year	$8,630 Upland Forest
Clean Water	$2,577/acre/year	$11,000 Tidal Marsh $1,000 Upland Forest
Erosion/Sediment Control		$12,700 Tidal Marsh
Pest Control		$50 Upland Forest
Pollination		$75 Upland Forest

In 2011, the National Fish and Wildlife Foundation released a report by Southwick Associates (2011) titled "The Economics Associated with Outdoor Recreation, Natural Resource Conservation, and Historic Preservation in the United States." The reported value for ecosystem services was $10,608 per acre per year for wetlands and $1,014 per acre per year for forests. Weber (2007) also reported the value of ecosystem services in Cecil County, Maryland to include the following values per acre per year: $12,033 for upland forest, $43,685 to $52,765 for freshwater wetlands (non-riparian wetlands and riparian forest), and $28,146 for tidal marsh. Weber (2007) further broke these figures down based on the type of ecosystem services (e.g. carbon sequestration of upland forest valued at $31 per acre per year), which are discussed below. Kauffman (2011) discussed ecosystem services values in the Delaware River Basin and reported the following values per acre per year: $13,621 for freshwater wetlands, $7,235 for salt marsh, $1,978 for upland forest, and $1,946 for open water.

Similarly, Industrial Economics, Incorporated in 2011 prepared a report for the Division of Water Resources in the Delaware Department of Natural Resources and Environmental Control titled, "Economic Valuation of Wetland Ecosystem

Services in Delaware." Industrial Economics (2011) reported a 1.2 percent decline in wetlands across the State of Delaware (3,132 acres) over a 15 year time frame (2007 to 2022), with an estimated annualized loss of approximately $2.4 million in the value of ecosystem services. This included ecosystem services such as carbon storage ($1.59 million annualized cost), water purification ($770,000 annualized cost), inland flood control, coastal storm protection, and wildlife protection.

Based on these previous studies, the value of Prime Hook's ecosystem services (not including outdoor recreation) can be estimated. Since the Refuge is approximately 80 percent wetlands and 20 percent uplands (2,026 acres), the value of Prime Hook's wetlands, if healthy, can range from $58 million to $86 million per year. The value of Prime Hook's uplands, if healthy, can range from $2 million to $24 million per year. Combining wetland and upland habitats, the total value of Prime Hook's ecosystem services can range from $60 million to $110 million per year. However, current refuge marshes are not healthy due to the impacts of ongoing saltwater intrusion from the Delaware Bay; therefore, the current value of ecosystem services is lower than previously estimated.

For purposes of the report, pest control focused on native herbivores, decomposition focused on dung burial of animal wastes, and nutrient recycling and wildlife nutrition focused on maintenance of wildlife species from insect food resources. This was a very conservative estimate, as other insect services like suppression of weeds and exotic herbivorous species, facilitation of dead plant and animal decomposition, and improvement of soils were not included. But the authors (Losey and Vaughan) felt that estimating even a minimum value for services that native insects provide to the socioeconomic environment would elevate priorities for insect conservation. Managing a large block of native habitats (10,000 acres of refuge forest, wild grassland, and other early successional habitats) will allow 40,000 acres of agricultural lands surrounding the refuge to benefit from wild insect-mediated pollination and other services.

Insect pollinators can have impacts on the socioeconomic environment but are seldom considered in economic analyses. We have considered strategies and conservation actions that incorporate insect conservation in our alternatives to locally stem pollinator population declines and reviewed the impacts and environmental consequences of doing so. Implications of habitat and mosquito integrated pest management practices on insect pollinators and impacts to humans and wildlife will also be discussed in respective alternative sections in the invertebrate section of this chapter.

Impacts of Refuge Management on Socioeconomic Environment that Would Not Vary by Alternative

We expect the three proposed alternatives to have minimal adverse impacts on the economy of the towns or county in which the refuge lies. We would expect none of the alternatives to significantly alter the demographic of economic characteristics of the local community. All refuge actions we propose would neither disproportionately affect any communities nor damage or undermine any businesses or community organizations. No adverse impacts are foreseen to be associated with changes in the community character or demographic composition by proposed alternatives.

Impacts of Refuge Management on the Socioeconomic Environment in Alternative A

Under alternative A, refuge management activities directly related to refuge operations will generate an estimated $2.7 million in local output, 25 jobs and $742 thousand in labor income in the local economy. Including direct, indirect, and induced effects, all Refuge activities would generate total economic impacts of $3.9 million in local output, 33 jobs and $1.1 million in labor income (appendix I).

Values of ecosystem services in alternative A will be lower than those reported in the other two alternatives. Passive management will let "mother nature run its course" and may likely result in the conversion of more than 5,000 acres of wetlands to open water, including both existing tidal salt marsh and impounded marshes. The loss of ecosystem services could exceed 50 percent as reported in other alternatives. Natural wetland recovery is not impossible, but could take decades or hundreds of years and will be dependent on sea level rise. With more open water, the wetland complex may only partially meet the potential for flood control, storm surge protection, erosion, and habitat value for fish and wildlife.

From 1963 to present, extensive mosquito control has occurred on the refuge to "…effect nuisance relief, to protect public health, and to avoid adverse impacts to local economies from severe mosquito infestations…" by the State of Delaware Mosquito Control Section (Section). To significantly reduce the heavy reliance on insecticides from 1989 to 2002, the Section employed its preferred method to control mosquitoes: a source reduction technique of open marsh water management (OMWM). Total acres sprayed before OMWM averaged several thousands of acres per year (e.g., 8,010 acres were sprayed on refuge in 1985). Gradually, sprayed acres fell to 1,500 acres by 1994. Following OMWM construction, average annual acres sprayed was reduced to 400. Thus, public health was protected while reducing insecticide use.

The adverse impact to agriculture if the marsh is not restored is the increase of saltwater intrusion, erosion of the coast, and increased damages from storms. As salinity levels increase with continued marsh loss, the risk of storm damage to agricultural resources may increase. Many crops have very low tolerance to salinity, and as salinities increase, field productivity and quality decreases. As the coastal landscape erodes and tidal surges force higher salinity waters inland, many areas would have to counteract this effect by installing tide gates or levees. The loss of agricultural productivity associated with saltwater intrusion and an increased risk of storm damage may have an adverse economic impact to adjacent landowners.

Most of the wildlife-dependent recreational activities that occur on the refuge include hunting, fishing, wildlife observation, and general enjoyment of the marsh environment. Recreational resources would be adversely affected with the loss of wetlands and habitat diversity. Wildlife abundance is directly related to the amount of wetland present. As land loss through erosion or subsidence continues the wildlife abundance in the project area would decrease. The abundance of migratory birds and other animals directly dependent on the wetlands would also decrease as they move to more suitable habitat.

Lower quality fishery spawning, nursery, and foraging habitat may translate to a decline in sport fishing success on the refuge. Hunting opportunities would decline with the declines in game species. Wildlife observation opportunities may decline with declining migratory bird usage. In general, loss of emergent wetlands to shallow, unvegetated open water would result in decreased fishery production and therefore have adverse impacts on recreational fishing. Conversion of emergent marsh to large unvegetated open water would result in a diminished capacity of the area to support fish and wildlife populations (USACOE 2010).

Marsh wetlands reduce storm surges from tropical systems. An increase in storm surge impacts from a loss of emergent marsh can directly affect land loss, which may result in the loss of parking areas, roads, observation towers, piers, and other recreational infrastructure (USACOE 2010). The continued loss of these coastal barrier systems would result in the reduction and eventual loss of the natural protective storm buffering of these barrier systems, including the adjacent marshes.

We conclude that while social or economic impacts would be greater under alternative A than the other alternatives, these adverse effects would not be realized at a regional level for Sussex County or the state of Delaware, either directly, indirectly, or cumulatively. Therefore, there will be no significant impact on the socioeconomic environment under alternative A.

Impacts of Refuge Management on the Socioeconomic Environment in Alternative B

Under alternative B, refuge management activities directly related to refuge operations will generate an estimated $3.3 million in local output, 30 jobs and $892.9 thousand in labor income in the local economy. Including direct, indirect, and induced effects, refuge activities will generate total economic impacts of $4.7 million in local output, 41 jobs and $1.29 million in labor income. In 2007, total labor income was estimated at $2.996 billion and total employment was estimated at 87,113 jobs for Sussex County (IMPLAN 2007 data). Total economic impacts associated with refuge operations under alternative B represent less than one percent of total income (0.04%) and total employment (0.05%) in the overall Sussex County economy. Total economic effects of refuge operations play a larger role in the Prime Hook communities near the refuge such as Milton and Lewes where most of the refuge public use related economic activity occurs. (This information is summarized from the more detailed analysis presented in appendix I).

Alternative B proposes to restore over 4,000 acres of impounded marshes to tidal salt marsh and to reforest nearly 900 acres, which will enhance the value of ecosystem services through better storm surge and flood protection, carbon sequestration, fish and wildlife habitat, and better air and water quality. Ecosystem services values will be slightly greater than those estimated in alternative A.

Habitat management objectives and strategies for refuge wetland and upland habitats in this alternative maximize biological diversity and enhance and restore biological integrity and environmental health. These management actions enhance insect conservation. For example, the elimination of several hundred acres of non-native crop cultivation and subsequent restorations of this acreage to native plant communities increase insect densities and biodiversity, which in turn support greater avian diversity and abundance.

Alternative B management and conservation actions that increase avian diversity and abundance can potentially increase the capacity for human disease prevention. Managing wildlife habitats to maintain or enhance biological integrity, diversity, and environmental health (BIDEH) may lead to the reduction in risk of mosquito-borne disease transmission to humans. Functional wetlands and other natural habitats can decrease mosquito vector populations and mosquito-borne disease. Providing a greater diversity of habitat types with increased biological integrity and environmental health enhances populations of natural mosquito predators such as birds, frogs, insects, and other invertebrates that live in wetlands and feed on mosquito larvae and adults.

Recent infectious disease models illustrate a suite of mechanisms that can result in lower incidence of disease in areas of higher disease host diversity (defined as the dilution effect). These models are particularly applicable to human zoonoses, i.e., infectious disease of wildlife or domestic animals that enter human populations (Keesing et al. 2006, Krasnov et al 2007, Ostfeld and Kessing 2000). Examples of zoonoses include avian influenza, anthrax, Lyme disease, and West Nile virus.

Research conducted in the eastern U.S. during the West Nile virus epidemic in 2002, found fewer incidences of West Nile virus in humans in areas with a diverse array of bird species (Swaddle and Calos 2008). This link between higher bird diversity and reduced human West Nile virus infection is attributed to the fact that crows, jays, thrushes, and sparrows are competent (amplifying) hosts of the West Nile virus, making them able to contract the disease and pass it on through a vector more efficiently. When bird diversity is low, the competent host species tend to represent a higher proportion of the bird population, increasing the likelihood that a mosquito will encounter an infected bird and transmit the virus during its next bite. A diverse suite of bird species, including a large number of incompetent hosts in the population, tends to reduce the transmission rate to other birds, or mammals, including humans. Similar studies have shown how increased mammalian diversity decreased Lyme disease risk to humans (LoGiudice et al. 2003).

A more recent study by Johnson et al. (2012), addressed avian diversity and mosquito populations associated with urban wetlands and urban residential environments where most human West Nile infections actually occur. Findings indicate that residential areas contained significantly higher proportions of WNV-competent mosquito species and WNV -competent avian host species when compared to nearby urban wetlands. WNV infection rates within the mosquito population were also found to be higher in urban residential areas than adjacent urban wetlands; large urban wetlands had lower mosquito infection rates and larger avian diversity than small urban wetlands. These findings may indicate that increasing BIDEH in large rural habitat patches like PHNWR will have little effect on infection rates where disease incidence is already low.

It should be understood, however, that increased BIDEH will not necessarily equate with reduced nuisance mosquito complaints. The ability of natural predation pressure to reduce certain species of mosquitoes substantially, if environmental conditions are appropriate, is perhaps limited. Likewise, the ability of chemical mosquito treatment alone to substantially reduce the threat of periodic pulses of mosquitoes is limited. Mosquitoes have evolved successfully to overcome mass mortality, regardless of the source. Neither BIDEH nor mosquito management is a panacea upon which the public can depend to eliminate the nuisance of mosquitoes if one is near marshes and wetlands.

The human threshold for mosquito tolerance is largely cultural in origin, and varies considerably across the landscape, largely upon one's frame of reference. Humans raised in a relatively urban or suburban landscape have generally little experience with persistent mosquito annoyance. Individuals born into or having lived a substantial period of time in mosquito country are more likely to take the natural pulses in mosquito (or no-see-um, deer fly, blackfly) numbers in stride. Regardless of where one resides, actual mosquito-borne disease outbreaks are spotty and rare.

It should be noted that it has been the policy of other refuges on the Delmarva Peninsula not to allow mosquito control except during public health emergencies. Blackwater (approximately 25,000 acres), Martin (4,528 acres), Eastern Neck (2,285 acres), Chincoteague (approximately 14,000 acres), Wallops Island (373 acres), Eastern Shore of Virginia (1,393 acres), and Fisherman's Island (1,850 acres) NWRs, totaling over 49,400 acres, of which some smaller proportion is actually mosquito breeding habitat, do not allow either larval or adult mosquito control. Assateague National Seashore, (8,200 acres), managed by the National Park Service, does not permit mosquito control. Additionally, the State of Maryland limits mosquito control in some of its State parks and sensitive natural areas (Jim McCann, personal communication). The refuge does not expect an increased incidence of mosquito-borne disease in the human population.

The sociological aspects of forest habitat management programs are complex, and vary widely across geographic boundaries. In many cases, members of the public see and hear only the negative aspects of forest management and associate forest management programs on refuges, especially the cutting of trees, with wildlife destruction and commercialization of the resource rather than with the objectives of wildlife habitat improvement, improved forest health, and other benefits to the environment. These concerns and issues would be addressed in environmental education and interpretation programs about the refuge's forest management program. Furthermore, forest management activities proposed in alternative B would likely require the contracted services of private timber companies or equipment companies in the region.

Wetlands in many locations play an important role in flood protection. Nowhere is this function more important than along the coast. Preserving and restoring coastal marshes can help reduce storm damage because coastal wetlands serve as storm surge protectors when storms come ashore. Wetlands can prove a significant and potentially sustainable buffer for wind wave action and storm surges generated by storms. A 1-acre wetland can typically store about 3-acre feet of water, or 1 million gallons. Trees and other wetland vegetation help slow the speed of floodwaters. This action, combined with water storage, can actually lower flood heights *(http://www.epa.gov*; accessed February 2012). Wetlands that occur along the shorelines help protect the shoreline soils from the erosive forces of waves and currents. The wetland plants act as a buffer zone, dissipating the water's energy and providing stability by binding the soils with their extensive root systems. Morgan, et al. (2009) noted more than a 60 percent reduction in non-storm wave heights within seven meters into a vegetated salt marsh compared to 33 percent within a marsh area with no vegetation. Similarly, Knutson et al. (1982) found wave heights reduced by57% 5 m into a *S. alterniflora* marsh, and 65% at 10 m. Leonard and Luther (1995) found a 65% reduction in the turbulent energy of water coming onto the marsh after it had traveled just 3 m in from the marsh edge. Wetlands that occur along the shorelines help protect the shoreline soils from the erosive forces of waves and currents. The wetland plants act as a buffer zone, dissipating the water's energy and providing stability by binding the soils with their extensive root systems.

Wetlands protect water quality by trapping sediments and retaining excess nutrients and other pollutants such as heavy metals. These functions are especially important when a wetland is connected to groundwater or surface water sources that are used by humans for drinking, swimming, fishing, or other activities. These same functions are also critical for the fish and other wildlife inhabiting the waters.

Sediments, which are particles of soil, settle into the gravel of streambeds and disrupt or prevent fish from spawning, and smothering fish eggs. Other pollutants—notably heavy metals—are often attached to sediments and present the potential for further water contamination. Wetlands remove these pollutants by trapping the sediments and holding them. The slow velocity of water in wetlands allows the sediments to settle to the bottom where wetland plants hold the accumulated sediments in place.

Failure to restore and maintain coastal wetlands may result in significant increases in damages from storm surges that are currently reduced by coastal wetlands. Local long-term minor to moderate beneficial impacts to the socioeconomic environment would be realized from the deposition of dredged spoil into the marsh or open water areas of the refuge. Restoration of these marshes to historic salt marsh conditions would once again provide natural storm buffering, limit storm surge heights, and provide protection for the interior wetlands and uplands (USACOE 2010). Emergent or submergent vegetation may become established, complementing the existing fish and wildlife-dependent recreation. Recreation fishing may increase due to increased fisheries habitat on the refuge.

Other local direct short-term adverse impacts would result to recreational resources during construction or placement of spoil onto the former impoundments to restore these areas as viable salt marshes. During and immediately after construction, there would be a decrease in the quality of habitat, and wildlife and fisheries species associated with recreational opportunities would be displaced; however, the area would reestablish emergent wetland vegetation. These adverse impacts would be temporary and localized. Adverse impacts would be offset by the restoration of the salt marsh that could contribute to restoring base organisms used for recreational activities such as fishing, birding, and hunting (USACOE 2010). Restoring wetlands and reducing the land loss rates may protect nearby recreational infrastructure such as parking areas, roads, piers, and observation towers. Recreation activities dependent upon wetland habitat may be maintained or possibly increased (USACOE 2010).

We conclude that while there may be some apparent changes in social or economic conditions in nearby communities as described above, these localized effects would not be realized at a regional level for Sussex County or the state of Delaware, either directly, indirectly, or cumulatively. Therefore, there will be no significant impact on the socioeconomic environment under alternative B.

Impacts of Refuge Management on the Socioeconomic Environment in Alternative C

Alternative C is dependent upon the capability of maintaining the freshwater impoundments from saltwater intrusion. Currently, the refuge is losing water management control at the water control structures, the marsh is not accreting at a level to keep up with sea level rise, and extensive beach replenishment is required in the midst of increased storm frequency and intensity. If the 4,000 acres of impounded marsh revert to open water, and if additional impacts to upland buffer habitats from salt water intrusion or future storm events are not considered, then the value of Prime Hook's ecosystem services for wetlands could decrease by as much as 50 percent.

Under alternative C, refuge management activities directly related to all refuge operations generate an estimated $2.9 million in local output, 26 jobs and $768.4 thousand in labor income in the local economy. Including direct, indirect, and induced effects, all Refuge activities would generate total economic impacts of $4.03 million in local output, 34 jobs and $1.1 million in labor income. Total economic impacts associated with refuge operations under alternative C represent less than one percent of total income (0.04%) and total employment (0.04%) in the overall Sussex County economy (appendix I). Similar to alternative B, total economic effects of refuge operations play a larger role in the Prime Hook communities near the refuge such as Milton and Lewes where most of the refuge public use related economic activity occurs.

In order to achieve water management control over the impoundments which will not likely result in another breach, construction and maintenance of a barrier island adequate to withstand a 100-year storm may be required. The design, costs, specifics, and impacts of a detailed plan for construction of a dike sufficient to withstand a 100-year storm would entail subsequent NEPA analysis, as well as engineering and economic evaluations. While the costs of such an endeavor would be substantial, the magnitude of change for the regional economy is far less, as refuge visitation and public recreational opportunities benefits have not changed substantially despite the dramatic habitat changes. In terms of local viewpoints, some members of the adjacent Prime Hook community have expressed concerns about increased flooding of their bayside properties since the breaches have occurred. Tidal levels are being monitored to examine this, and alternative C would also address this concern to a degree. However, actions within the alternative would not alter the inherent risks associated with construction on a very low-lying barrier from high or intense storms directly impacting the community from Delaware Bay side.

Similar to alternative B, we conclude that while there may be some apparent changes in social or economic conditions in the nearby communities as described above, these effects would not be realized at the Sussex County or state of Delaware regional level, either directly, indirectly, or cumulatively. Therefore, there will be no significant impact on the socioeconomic environment under alternative C.

Impacts on Cultural and Historical Resources

Chapter 3, Description of the Affected Environment, describes in more detail the refuge's 14 prehistoric sites and 31 historic sites, which were identified in archaeological, historical, and geomorphological surveys conducted in 1982, 1984, and 2004 (USFWS 1982, USFWS 1983, Tetra Tech FW, Inc. 2004).

Impacts on Cultural and Historical Resources That Would Not Vary by Alternative

We expect all of the alternatives to have local long-term minor beneficial impacts and local negligible adverse impacts on cultural and historical resources on the refuge. Refuge lands are protected from development or destructive land uses that may result in substantial impacts on cultural and historic resources. Regardless of which alternative we select, we would protect known cultural and historic resources.

For compliance with section 106 of the National Historic Preservation Act, the refuge staff will, during the early planning stages of proposed new actions, provide the regional historic preservation officer with a description and location of all projects, activities, routine maintenance, and operations that affect ground and structures, details on requests for compatible uses, and the range of alternatives considered. That office will analyze those undertakings for their potential to affect historic and prehistoric sites, and consult with the State historic preservation officer and other parties as appropriate. We will notify the State and local government officials to identify concerns about the impacts of those undertakings.

Refuge lands are vulnerable to looting, despite our best efforts at outreach, education, and law enforcement; however impacts are expected to be negligible based on our observations of past visitor impacts from public uses. Upland areas adjacent to wetland areas have been identified for high potential for cultural resources. In addition, refuge visitors may inadvertently or even intentionally damage or disturb known or undiscovered cultural artifacts or historic properties. We would continue our vigilance in looking for this problem, use law enforcement where necessary, and continue our outreach and education efforts.

For each of these alternatives, we have concluded that the impacts will not be significant.

Impacts on Cultural and Historic Resources in Alternative A

Impacts on cultural and historical resources under Alternative A ("No Action") serve as a baseline for comparing and contrasting alternatives B and C to the refuge's existing management activities.

Refuge activities under alternative A have the potential to impact cultural resources either by direct disturbance during the construction of facilities related to public use or administration and operations, or indirectly by exposing artifacts during actions such as limited prescribed burning. The passive habitat management approach in alternative A would result in less manipulation of refuge habitats, particularly in managing for early successional habitats, conducting reforestation projects, and prescribed burning. Although the presence of cultural resources, including historic properties, cannot stop a federal undertaking, the undertakings are subject to section 106 of the National Historic Preservation Act and, at times, other laws. As projects are underway, we would remain watchful for potential sites or artifacts, and take all necessary precautions should we locate them.

Conclusion for Management Actions in Alternative A
Management action in alternative A would result in local long-term minor beneficial impacts and local negligible adverse impacts on cultural and historic resources. Subject to section 106 of the National Historic Preservation Act and other relevant policies and laws, there would be no impairment of refuge cultural and historic resources.

Impacts on Cultural and Historic Resources in Alternative B

The benefits for cultural and historic resources would increase under alternative B due to a proposed increase in interpretation and environmental education capability and programs that would foster a greater public appreciation of their value.

Adverse impacts to cultural and historic resources under alternative B may increase as more acreage is actively managed through reforestation or wetland restoration. Negligible impacts are expected and are avoided by following section 106 of the National Historic Preservation Act as described under alternative A.

Conclusion for Management Actions in Alternative B
Management action in alternative B would result in local long-term minor beneficial impacts and local negligible to minor adverse impacts on cultural and historic resources. Subject to section 106 of the National Historic Preservation Act and other relevant policies and laws, there would be no impairment of refuge cultural and historic resources.

Impacts on Cultural and Historic Resources in Alternative C

The benefits to cultural and historic resources would be enhanced from both alternatives A and B because more staff will be devoted to environmental education and interpretive programs to foster a greater public appreciation of their value. Refuge management activities under alternative C have the potential to impact cultural resources by indirectly by exposing artifacts during actions such as cooperative farming, managing for early successional habitats, conducting reforestation projects, and prescribed burning. Although the presence of cultural resources, including historic properties, cannot stop a federal undertaking, the undertakings are subject to section 106 of the National Historic Preservation Act and, at times, other laws. As projects are underway, we would remain watchful for potential sites or artifacts, and take all necessary precautions should we locate them.

Conclusion for Management Actions in Alternative C
Management action in alternative C would result in local long-term minor beneficial impacts and local negligible adverse impacts on cultural and historic resources. Subject to section 106 of the National Historic Preservation Act and other relevant policies and laws, there would be no impairment of refuge cultural and historic resources.

Impacts on Air Quality

Chapter 3, Affected Environment, discusses the status of air quality in the landscape around the refuge. We evaluated the management actions each alternative proposes for their impacts on air quality.

Impacts on Air Quality That Would Not Vary by Alternative

There are no major stationary or mobile sources of air pollution present on the refuge, nor would any be created under any of the alternatives. We expect refuge land management to help reduce any future direct and cumulative impacts by maintaining natural vegetative cover on the 10,000 plus acres where suitable, requiring that all upgrades to existing facilities or all new facilities be energy efficient, and limiting public uses to those that are appropriate, compatible, and wildlife-oriented activities. Collectively, these management actions would help reduce the potential for additional synthetic sources of emissions in the surrounding landscape.

Localized increases in emissions from visitor vehicles or boat motors would be negligible compared to current off-refuge contributions to pollutant levels and likely increases in air emissions in the Sussex County airshed from land development over the next 15 years. Impacts are mitigated by prohibiting gasoline motors on Turkle and Fleetwood Ponds. We will continue to encourage the non-motorized use of trails, particularly the Canoe Trail, for wildlife observation and other compatible recreation. Any adverse air quality effects from refuge activities would be more than offset by the benefits of maintaining the refuge in natural vegetation.

The two management actions that may most affect air quality the most are prescribed fires and planting or perpetuating trees. Although both of these will occur no matter which alternative is selected, the degree to which we practice them, and their impacts, will vary. The major pollutants from prescribed burning are particulates (small particles of ash, partly consumed fuel, and liquid droplets) and gases (carbon monoxide, carbon dioxide, hydrocarbons, and small quantities of nitrogen oxides). Those will increase or decrease based on the alternative we select.

Low intensity prescribed burning would release inconsequential amounts of gases (USDA 1989). Particulates can reduce visibility or cause negative effects on the health of people with respiratory illnesses. Appropriate smoke management can minimize or nearly eliminate both negative effects. The consideration of the wind speed, direction, and mixing heights is all-important in managing smoke. In planning our prescribed burns, we consider all those factors and other environmental and geographical factors. Based on our experience, we expect prescribed burning to produce no major, long-term adverse impacts.

Tree planting or letting old fields grow naturally into forest cover will improve air quality. Trees store carbon and release oxygen. Because air quality in the region is generally good, we do not expect our management to result in measurably improved air quality, but it may contribute to improved local, ambient conditions. However, we recognize that Sussex County is an EPA non-attainment area for air quality with State burning bans in place during summer months.

The area of the refuge has a history of wildfire, which was mostly caused by humans. We would seek to minimize the possibility of serious fires and their associated health and safety concerns. We would assess the hazards associated with the wildland urban interface along the refuge boundaries with privately owned land to ensure that our management practices are not creating excessive fuel loading that would lead to severe fires.

In summary, our management activities would not significantly adversely affect regional air quality; none of the alternatives would violate EPA standards, and all three would comply with the Clean Air Act.

Impacts on Air Quality in Alternative A

Air quality is generally good in Sussex County, with certain periods of non-attainment of State air quality standards during the late summer and early fall. Eliminating smoke impacts resulting from any refuge prescribed fire during non-attainment periods will ensure that no negative impacts to public health and safety will be a consequence of the refuge using prescribed burning during these times.

Air quality would benefit from the filtering effects of the 10,144 acres of the refuge. The sequestering effects of presently owned forested acres would produce a negligible reduction in atmospheric carbon.

We expect very short-term, negligible localized adverse impacts on air quality from the emissions of motor vehicles used by staff and refuge visitors, from refuge equipment, and from prescribed burning. However, no foreseeable long term or cumulative impacts on local or regional air quality will result from any proposed refuge activities, nor will these activities contribute to any substantial increase in regional ozone levels, particulate matter, or other negative air quality parameters.

Conclusion for Management Actions in Alternative A

Management actions in alternative A would result in negligible short-term and long-term cumulative impacts on air quality. With the use of best management practices, there would be no impairment of refuge's air quality. However, changes in wetland vegetation caused by failing impoundment infrastructure and more frequent and severe annual coast storms may have uncertain impacts on local and regional air quality.

Impacts on Air Quality in Alternative B

This alternative increases wetland vegetation on the refuge through restoration of freshwater wetlands to salt marsh and increases forests by planting or allowing lands to regenerate naturally, which may result in local long-term minor beneficial impacts on air quality. Forests contribute positively to air quality in two ways: by precluding development and sequestering carbon. Under this alternative, we would convert at least 450 additional forested acres from managed croplands. We would manage our forests with longer rotation ages, which would result in increased carbon sequestration. The predominance of more mature stands would improve forest health, diversity, and resilience to disturbance. Impacts on the physical environment (water, soil, geology and hydrology, and air quality) would be negligible as long as forestry best management practices are employed. A list of all possible best management practices, developed by Delaware Forest Service, is provided in the habitat management plan. Carbon sequestration will also be increased by restoring about 3,000 acres of salt marsh.

Given our emphasis on maintaining about 200 acres of early successional habitat, annual prescribed burning may increase, resulting in local, temporary increases of particulate matter and various combustion gases. By adhering to the established standards of smoke management, we can minimize the potentially negative effect of particulates.

Under alternative B, construction of the expanded facilities would cause negligible local impacts on air quality. Short-term, localized effects from construction vehicles and equipment exhausts would occur. Operations of these facilities would result in emissions from heating and cooling systems, and visitor and employee travel would add sources of air pollution; however, these are partially offset by energy-efficient heating and cooling systems and our replacement of our fleet with more energy efficient models.

Public use of the refuge is expected to increase under this alternative, resulting in additional emissions from visitor vehicles and boats (e.g., in hunting waterfowl). Impacts are mitigated by prohibiting gasoline motors on the proposed fishing areas of Goose and Flaxhole Ponds. Impacts to air quality are expected to be negligible.

Conclusion for Management Actions in Alternative B

Management actions in alternative B would result in negligible to local long-term minor beneficial impacts and local negligible adverse impacts on air quality. Alternative B would contribute an imperceptible beneficial impact and an imperceptible adverse impact to the total cumulative long-term impact to air quality. With the use of best management practices, there would be no impairment of refuge's air quality.

Impacts on Air Quality in Alternative C

Same as alternative B..

<u>**Conclusion for Management Actions in Alternative C**</u>
Same as alternative B.

Impacts on Soils

Soils play key roles in regulating elements and nutrient cycles, and serve as a fundamental basis of the physical environment of all habitats on the refuge. Soil biotic communities consume wastes and the remains of dead organisms and recycle their constituent materials that are incorporated into the soil into forms usable by plants. (Daily et al. 1997). Natural geologic processes within coastal marine environments also perform fundamental roles in sediment supply and sedimentation rates of marsh soils. The linkage between marsh elevation, sea level rise, and sedimentation rates represents important aspects of the morphodynamics of marsh soils and the impacts on wetland soil elevation changes (Komar 1988).

We evaluated the alternatives and various proposed actions and activities with respect to their potential impacts on refuge soils. We considered the impact of the following actions:

- Restoring and enhancing native plant communities
- Conducting prescribed fires, mowing, and brush-hogging
- Manipulating water levels in impounded marshes
- Controlling invasive plant species with herbicides
- Reducing mosquito pesticide use to conserve and protect insects
- Mosquito control
- Restoring salt marsh in impounded wetlands

Impacts on Soils That Would Not Vary by Alternative

The refuge has used herbicides in the past and will into the future to meet management objectives under all alternatives, for pre- (site preparation) and post-restoration to control vegetation. The mobility of an herbicide is a function of how strongly it is adsorbed to soil particles and organic matter. Whenever possible, we choose herbicides that strongly adsorbed to soil particles, relatively insoluble in water, and not environmentally persistent, which would therefore be less likely to move across the soil surface into surface waters or leach through the soil profile and contaminate groundwater. Cost will not be the primary factor in selecting an herbicide for use on refuge land and waters; the most efficacious herbicide available with the least risk to soils will be chosen for use on the refuge.

All pesticide usage would comply with the applicable federal (FIFRA) and state regulations pertaining to pesticide use, safety, storage, disposal and reporting. Before pesticides can be used to eradicate, control or contain pests on refuge lands and waters, pesticide use proposals (PUPs) would be prepared and approved in accordance with 7 RM 14. In addition, best management practices will minimize or eliminate possible effects associated with pesticide drift or surface runoff that may impact refuge soils.

Impacts on Soils in Alternative A

Impacts on soils under Alternative A (“No Action”) serve as a baseline for comparing and contrasting Alternatives B and C to the refuge’s existing management activities.

Managing and Protecting Habitat
Recent and ongoing afforestation of 200 acres and continuing to allow an additional 100 acres to revert to native vegetation restores the ecological services that improve soil fertility and sustain soil health. Over time, soil structure and associated microbial communities in these areas will reestablish themselves. The refuge has conducted a limited prescribed burning program over the years. The appropriate prescribed burning of wetlands and uplands habitats can improve soil conditions by releasing vital nutrients back into the soil.

Ongoing natural succession on several hundred acres of refuge upland fields to native vegetation will continue to reduce soil erosion and increase natural levels of soil fertility. As refuge soils are rehabilitated naturally, early pioneering species like sweetgums are very important for nitrogen cycling and serving as hosts for mycorrhizae that are needed by later succession plant species. These beneficial fungi pump essential elements to conifer and hardwood tree zones from below, and help restore microbial activity and channels in the soil for native soil biota.

Regular tidal flow would continue to enter Unit II through the newly formed inlets. Tidal flow would try to reestablish, reverting impounded marshes to a brackish and ultimately a saline wetland or open water environment. Marsh accretion rates are spatially and temporally variable, and dependent to a large degree on storm-dominated sediment dynamics and overwash processes to supply sediment to coastal marsh and barrier beach systems (Aubrey and Speer 1985, Leatherman and Zaremba 1986, Roman et al. 1997). Preliminary data from radiometric coring conducted by DNREC's Coastal Program indicates that Unit II marshes have not been keeping up with current sea level rise rates over the last 50 years (Scarborough and Wilson, *unpublished data*). In the end, restored tidal flow may improve the current low rate of sediment accretion, as the effects of storm sedimentation could aid in the vertical accretion of these marshes. However, in the absence of proactive restoration of the sediment and elevation, there may be a very slow or limited return of vertical, unless precluded by sea level rise altogether.

There remains a recognized lack of understanding regarding the interactions among changes in wetland elevation, sea level, and wetland flooding patterns, and changes in other sediment accretion drivers, such as nutrient supply, sulfate respiration, and soil organic matter accumulation (CCSP 2009). Human-altered drainage patterns, as exist in the refuge impoundments, appear to be limiting the vertical accretion of sediment. In such cases, rapid saltwater intrusion into the unit can cause subsidence through collapse of organic soils and conversion to open water (DeLuane et al. 1994, Pearsall and Poulter 2005). Too rapid a conversion of the former marsh system may cause, or has already caused, unanticipated or unfortunate biochemical results, which has led marsh restoration experts to advise that tidal restoration programs be conducted gradually (Portnoy and Giblin 1997).

Even with greater sediment availability and tidal exchange, under some circumstances sediment building process may not overcome the combination of sediment loss and relative sea level rise (Boumans, et al. 2002). Where sedimentation rates are low, on a shallowly subsided site breached 100 years ago, insufficient sediment had accumulated for vegetation to become established (NECIA 2007). Pethick (2002) found a negative sediment budget for restored sites during the period of no vegetation. Erosion was reduced once the vegetation established. Williams, et al (2002) indicated that the time required for a 1.5 m subsided site to reach colonization by vegetation ranges from 10 to more than 30 years.

Washover and inlet formation can potentially contribute to the sediment budget of the refuge's sandy beach and marsh environments in the long term. Washover is a major process in the retreat mechanism of coastal barrier beaches in response to sea level rise (Dillon 1970, Kraft et al. 1973, Kraft et al. 1976b).

Public Use

At current levels of public use and under current regulations, the refuge expects negligible impacts to refuge soils. Hiking trails, boat launch sites, wildlife observation areas, parking areas, and other high-use areas would continue to be well maintained to keep soil impacts to a minimum. We will note any erosion problems during routine monitoring and correct them as soon as possible. Potential adverse impacts on soils can also result from compaction by visitors using trails and other areas. These trails are for pedestrian use and preclude the use of mountain bikes or ATVs. Hiking or walking can alter habitats by trampling vegetation, compacting soils, and increasing the potential of erosion. In moderate cases of soil compaction, plant cover and biomass is decreased. In highly compacted soils, plant species abundance and diversity is reduced in the long-term, as only the most resistant species survive (Liddle 1975). To minimize impacts on bank erosion, no wake zones and a maximum motor restriction of 30 horsepower on Prime Hook Creek and Slaughter Canal will be posted.

Conclusions for Management Actions in Alternative A

Management actions under alternative A would have local long-term minor impacts and local short-term and long-term significant impacts, in terms of the sediment within the impounded wetlands. Although there is the potential that the affected wetlands may receive sufficient sediments through the breaches to naturally restore sediment elevation eventually, this is unlikely over the 15-year timeframe of this plan. Impacts during that timeframe would be significant. Service policy 6 RM 4.1 states that the long-term productivity of the soil will not be jeopardized to meet wildlife objectives. In addition, the BIDEH policy (601 FW 3) states, “We favor management that restores or mimics natural ecosystem process or functions to achieve refuge purposes.” Management actions under alternative C should result in no impairment of the refuge’s BIDEH; however, there may be some impairment to BIDEH with the loss of salt marsh to open water. Alternative A management actions in upland areas related to public use would have negligible local impacts on upland soils.

Impacts on Soils in Alternative B

Proposed management actions in alternative B that would affect soils include five primary changes: elimination of intensive agricultural practices, an increase in acreage of native plant communities, restoration of impounded wetlands, allowing natural processes to proceed on barrier island habitats, and increased public use.

Managing and Protecting Habitat

The proposed habitat management changes in alternative B will use more natural means to meet habitat and wildlife objectives through the maintenance of natural ecosystems when the more intensive and artificial method of cropland management is discontinued and through restoration actions to return the former freshwater impoundments to salt or brackish water systems. On the basis of acreage alone, the cumulative impacts of these actions will be substantial. Nearly all of the actions will result in positive impacts on natural soil processes, as described in detail below. We anticipate minor or negligible and short-term negative impacts as fields are burned, additional sediment is placed in the impoundments, or heavy equipment is used for afforestation.

Eliminating farming will have beneficial impacts on refuge soil resources by restoring native soil biota. Enhancing complex multi-trophic interactions in soils is critical to rehabilitating lands impoverished by intensive agricultural practices. However, restoration is a slow process and may take a century or more for native soil communities to rebound (Hendrix and Bohlen 2002). Restoring native plant communities is an essential rehabilitative action to restoring and enhancing native soil biota. Whether soils are restored or naturally revert, increases in underground soil organisms reestablish vital processes of decay and nutrient cycling restore natural soil fertility and soil structure (Lal 2003).

The rehabilitation of the refuge's soils through the restoration of native plant communities will significantly increase carbon sequestration and increase soil carbon stocks for utilization by plant resources. The amount of carbon sequestration in soils is often measured as carbon stock equilibrium of soil to vegetation. Generally, carbon stocks in soils are about four times greater than carbon stocks in vegetation (Lal et al. 2004).

Conducting low intensity and infrequent prescribed burns (2 to 5 year intervals) on the refuge in early successional habitats, and understory burns to improve Delmarva fox squirrel forested habitats can also improve soils by maintaining native vegetation and regularly returning quick pulse of nutrients to soils across the refuge landscape on a rotational basis.

Improved forest management practices on current refuge acreage and increasing forest-cover of prior converted agricultural lands using proactive reforestation techniques would also increase the coverage of native forested vegetation that conserves and protects soils for the long term. Restoration of native forests and improving existing stands will also increase and enhance microbial and invertebrate biomass in the forest soils, which in turn stimulates microbial activity and naturally restores and conserves soil fertility and reduces soil erosion. Impacts of forestry management practices on soil are possible because of the involvement of heavy equipment and possible clearing of vegetation, but are expected to be negligible as long as forestry best management practices are employed. A list of all possible best management practices, developed by Delaware Forest Service, is provided in the habitat management plan (appendix B). Because nearly all refuge lands are flat, with less than 2 percent slope, they would be more resistant to erosion, siltation, and runoff.

Cumulatively, the impacts of the Service's proposed actions under alternative B will have moderate impacts to upland soils and, as described above, these impacts will all or nearly all be positive.

Salt marsh restoration proposed within alternative B will improve the quantity and quality of soil and sediment within the impoundments. The sustainability of the refuges' restored tidal marshes will depend upon the balance between relative sea level rise and re-establishing and enhancing sediment supply to reverse the adverse impact of restricted tidal flow. Restored tidal range leads to higher sediment transport and deposition onto the wetland surface, as sediment-carrying flood tides flood over creek banks and onto the marsh platform. Restored sedimentation will allow the wetland surface to rise through accretion. Washover and inlet formation, permitted to occur unimpeded under alternative B, can contribute to the sediment budget of the refuge's sandy beach and marsh environments in the long term. Washover is a major process in the retreat mechanism of coastal barrier beaches in response to sea level rise (Dillon 1970, Kraft et al. 1976b).

The salt marsh restoration and rehabilitation of former freshwater impounded marsh areas (4,000 acres) in Units II and III and the reestablishment and enhancement of natural geologic processes would have moderate site-specific beneficial impacts on refuge wetland soils and increase the resiliency of refuge marshes to predicted future rates of sea level rise by increasing and enhancing refuge sediment budgets.

As described in chapter 4, the alternative B objective 3.1 rationale explains that successful restoration will require the restoration and enhancement of refuge sediment budgets and the restoration or possible increase of the tidal range of refuge wetlands. Current refuge coastal marsh conditions can be categorized as micro-tidal, subsiding, and sediment-starved. The restoration of the impounded wetlands to salt marsh will reduce the wave velocity, resulting in increased sediment deposition on the marsh surface and decreased sediment erosion. Weinstein (2002) constructed berms to divide an experimental site to prevent continuous flow and wave build up to promote sediment settling. Similar sacrificial levees or berms or islets may provide a protective environment during which time a marsh can become established. As the levee or berm degrades, the restored marsh will reconnect to adjacent areas. However, even in a sand deficient barrier island setting, well-established, vegetated dunes cannot prevent the natural transgression of the shoreline in front of it and will eventually be eroded as the shoreline continues to narrow (Mendelssohn 1990).

Sand will likely be placed on the beach as a cinoibebt of salt marsh restoration. Sand placed on the refuge's beaches must be similar in character to the sand naturally occurring on the beach. When using sand from off-site sources, it is important to consider the appropriate grain size for each specific project. Characterizations of sand from the project area can be achieved by conducting an analysis to determine the grain size of sand needed and avoid sand particles that are too small that tend to be transported in suspension when overwashed with water (Wanless 2009). Herrera et al. (2010) reported the similarity between sand densities, grain size, or color may have reduced negative effects of adding sand.

Improper sand sources (incorrect sediment grain size) could have adverse impacts on piping plover or horseshoe crab habitats of the refuge. The Shoreline and Waterways Management Section has successfully conducted beach nourishment projects hauling sand from off-site sources to project sites that have been found to successfully create suitable habitat for horseshoe crabs and piping plovers (DNREC 2004). Refuge staff would work with DNREC and the U.S. Army Corps of Engineers to ensure proper sand size is obtained for any sand placed on the refuge. DNREC and the U.S. Corps of Engineers have analyzed the sediment of the main channel of the Delaware River. The results can be found at *http://www.dnrec.delaware.gov/Info/Pages/US_Army_Corps_of_Engineers_2010_Dredging_Application.aspx* and at *http://www.nap.usace.army.mil/cenap-pl/drmcdp/pr.html.*

The rapid introduction of saltwater into the refuge's freshwater impoundments has resulted in and may be continuing peat and marsh collapse. Peat or marsh collapse occurs because the geochemical character of the sediments has been altered. Seasonally flooded freshwater peat is low in porewater sulfides. Rapid reintroduction of sulfate-containing seawater can lead to rapid decomposition of the fresh marsh peat through sulfate reduction. Rapid decomposition of the marsh peat, i.e. the collapse of the peat, can lead to subsidence, or sinking, as below-ground root material and turgor (rigidity of plant tissue) is lost. This will hinder the establishment of salt marsh vegetation, which cannot be established if the sediment is constantly flooded, and thus is far more likely to lead to open water.

The discharge of dredged or fill material for restoration on the refuge may, in varying degrees, change the complex physical, chemical, and biological characteristics of the substrate. Discharges that alter substrate elevation or contours can result in changes in water circulation, depth, current pattern, water fluctuation, and water temperature. Erosion, slumping, or lateral displacement of the surrounding bottom of such deposits can adversely affect areas of substrate outside the perimeters of the disposal site by changing or destroying habitat. The bulk and composition of the discharged material and the location, method, and timing of discharges may all influence the degree of impact on the substrate (40 CFR 230). The effects can be minimized by using containment levees or berms, maintaining and containing the discharged material properly to prevent point and nonpoint sources of pollution, and timing the discharge to minimize impact, for instance, during periods of unusually high water flows, wind, wave, and tidal actions. In addition, distributing the dredged material widely in a thin layer at the disposal site maintains natural substrate contours and elevation.

The discharge of dredged or fill material on the refuge may result in greatly elevated levels of suspended particulates in the water column for varying lengths of time. The new levels may temporarily reduce the primary productivity of the area. The biological and the chemical content of the suspended material may react with the dissolved oxygen in the water, which can result in oxygen depletion. The extent and persistence of these adverse impacts caused by discharges depend upon the relative increase in suspended particulates above the amount occurring naturally, the duration of the higher levels, current patterns, water level, fluctuations present when discharges occur, volume, rate, and duration of the discharge, particulate deposition, and the seasonal timing of the discharge (USACOE 2010). These actions are minimized by selecting sites or managing discharges to confine and minimize the release of suspended particulates and decrease turbidity levels.

The refuge may have adverse impacts from excessive elevations using dredge material. Overfilling (excessive elevation) should be avoided so as not to impede channel formation and encourage undesirable vegetation. This can be minimized by setting limitations on the amount of material to be discharged or volume receiving water.

The potential use of engineered wave attenuation techniques, such as pyramid-shaped or spherical concrete structures designed explicitly for such purposes in high-energy settings, or the use of rock pile structures, may actually decrease the rate of natural sedimentation and accretion within portions of the wetland complex, particularly in the absence of supplemental dredge material for restoration and nourishment. These techniques might further hinder the natural recovery of wetland elevation and vegetation, which may otherwise take decades. Without proper design these type structures could impact the natural movement of sediments along the shoreline (littoral drift) and negatively affect the adjacent shoreline. The shoreline along the Delaware Bay has limited natural sediment supply and arguably any small alteration along the shoreline could have lasting impacts to the adjacent beaches and neighboring wetland communities (Tabar, 2010). Therefore, any such alternation would need to be supplemented with proper nourishment. Geotubes are another structural technique that have some potential. However, geotubes do not contribute sand to the local sediment system, can affect adjacent shoreline negatively, are prone to failure and vandalism,

Living shoreline techniques utilize natural materials such as coconut fiber logs, oyster shells, and marsh grass plantings to establish buffers in areas subject to erosion, while still maintaining natural processes associated with shoreline mobility and sediment exchange (PDE 2012). They have the potential to reduce erosion in low to moderate energy portions of the wetland complex and promote the recovery of desirable salt marsh vegetation (PDE 2012, PDE 2011). Such techniques alone are not appropriate for high-energy settings without the addition of structural components such as breakwaters into “hybrid” living shoreline systems (PDE 2012, Priest 2006, Duhring 2006, Burke et al. 2005, Broome et al. 1992). Hybrid systems have been found to convey many of the expected ecological benefits, with a demonstrated ability to encourage sediment accretion (Currin et al. 2010).

The conversion of some prior wetlands, which were enrolled in the past cooperative farming program, to moist soil management would result in fewer impacts on the physical environment than past management practices. Removing these lands from cropland management would avoid existing problems with soil compaction and annual disturbance of native vegetation. “The restoration of disturbed wetlands would have its greatest potential in areas of marginal agricultural lands” (Frederickson et al. 1988).

Adverse impacts from establishing moist-soil vegetation and management in fields on the refuge would be short-lived and mitigated by proper timing and use of best management practices for construction. Virtually all problems with siltation, erosion, and degraded water quality would be eliminated by proper use of silt fences, grassy waterways, and proper and timely revegetation of exposed soils. Specific provisions in sediment and erosion plans and permits administered by Delaware’s Department of Natural Resources and Environmental Control and the U.S. Army Corps of Engineers would regulate any construction.

Public Use

Under alternative B, an increase of public use opportunities such as deer and waterfowl hunting, fishing, wildlife observation and photography, interpretation, and environmental education, will cause additional impacts to soils. These impacts are expected to have negligible to minor and adverse impacts (short-term, long-term, or cumulative) to soils.

We predict negligible-to-minor short-term impacts from the construction of expanded facilities for environmental education and visitor services programs. Maintenance or improvement of facilities (parking areas, roads, trails, and boat ramps) will cause negligible-to- minor short-term impacts to localized soils and waters. Negligible, short-term disturbance to soils will occur during the construction of new parking areas on Fowler Beach Road, Slaughter Beach Road, and on Broadkill Beach Road to facilitate hunting and wildlife observation and photography activities. Negligible, short-term disturbance will also occur on proposed trails on existing interior roads and maintained access routes north and south of Fowler Beach Road, south of Broadkill Beach Road, south of Prime Hook Beach Road, on proposed extensions of the Blue Goose Trail, and on Deep Branch Road. Minimal disturbance is expected for the proposed trail and wheelchair-accessible photography blind on the south side of Fowler Beach Road and for the construction of a new section of boardwalk that may be needed for the trail on the southside of Broadkill Beach Road, which may be rerouted and the existing boardwalk removed. The construction of new walking trails will influence vegetation, causing some soil compaction, which ultimately reduces vegetation composition and structure. For both new construction and maintenance of facilities, we will employ silt fencing and other best management practices during construction of any facilities in proximity of wetlands to avoid runoff of sediments. As these new parking areas and trails are used, the cumulative effects of these new visitor facilities will be long-term (although readily reversible if refuge missions change.) Nonetheless, even cumulatively, the impacts to soils of these proposed actions is minor.

Several rare peat bog communities have been located near Goose Pond and Flaxhole Pond; these areas are open to deer hunting. Sensitive hydric soils that support these rare plant communities are easily destroyed by trampling. Visitation to these sites will be kept to a minimum in order to prevent damage to hydric soils and trampling of sensitive rare plants. At Goose Pond and Flaxhole Pond, there is enough parking for only 6 vehicles at each location; therefore, we anticipate less than 10 hunters.

Soil compaction will increase in the immediate areas surrounding blind site stakes for waterfowl hunting in the Unit III waterfowl lottery area. Soil compaction will also occur along heavily traveled hunt areas in the regular waterfowl hunt areas, regular deer hunt areas, and in the lottery deer hunt area and on heavily used shoreline areas for boat access in Goose and Flaxhole Ponds. To minimize impacts on bank erosion, no wake zones and a maximum motor restriction of 30 horsepower on Prime Hook Creek and Slaughter Canal will be posted.

Conclusions for Management Actions in Alternative B

Management actions under alternative B will have local long-term significant beneficial impacts and local short-term minor adverse impacts to soils, associated with salt marsh and upland forest restoration. To accomodate increased visitor use, impacts to soils are anticipated to be negative and minor and short-term, long-term, and cumulative. Service policy 6 RM 4.1 states that the long-term productivity of the soil will not be jeopardized to meet wildlife objectives. In addition, actions under alternative B support the BIDEH policy (601 FW 3) which states, "We favor management that restores or mimics natural ecosystem process or functions to achieve refuge purposes. We will restore lost or severely degraded elements of integrity, diversity, and environmental health at the refuge scale and other appropriate landscape scales where it is feasible and supports achievement of refuge purpose(s) and System mission." Visitor uses accommodate priority uses, and help to reduce impacts over random unplanned impacts, such as those which arise when parking occurs along berms instead of in designated parking lots. Management actions under alternative B should result in no impairment of the refuge's BIDEH.

Impacts to Soils in Alternative C

Managing and Protecting Habitat

Soil erosion, soil compaction, and reduction of soil bacteria can occur with conventional farming tillage practice. However, the refuge's cooperative farming program incorporates cover crops and other best management practices that encourage conservation tillage to reduce soil erosion. When conservation tillage is used, it can reduce soil disturbance and increase crop residue, which decreases soil erosion. Cooperative farming under alternative A utilizes, as approved, glyphosate-tolerant corn and soybeans, which increase the chance that conservation tillage can be implemented successfully (Towery and Werblow 2010).

Approximately 400 acres of cover crops, such as winter wheat that grow in late fall and provide soil cover during the winter, would be planted on the refuge annually. Cover crops on the refuge will greatly reduce winter wind and water erosion (Dabney 2001; Hartwig 2002). By reducing soil erosion, cover crops often reduce both the rate and quantity of water that drains off the field, which would normally pose environmental risks to waterways and ecosystems downstream (Dabney et al. 2001). Cover crop biomass acts as a physical barrier between rainfall and the soil surface, allowing raindrops to steadily trickle down through the soil profile. Cover crop root growth results in the formation of soil pores, which in addition to enhancing soil macrofauna habitat provides pathways for water to filter through the soil profile rather than draining off the field as surface flow. With increased water infiltration, the potential for soil water storage and recharging of aquifers can be improved (Joyce et al. 2002).

In addition, one of the primary uses of cover crops is to increase soil fertility. These types of cover crops are referred to as green manure. They are used to manage a range of soil macronutrients and micronutrients. Often, green manure crops are grown for a specific period, and then plowed under before reaching full maturity in order to improve soil fertility and quality. In the spring of each year, the cooperative farmers would till cover crops under which would improve soil fertility and quality. In addition, cover crops sequester atmospheric carbon, which is converted to organic matter and improves soil quality.

Under alternative C, alterations to the refuge's marshes, such as presence of tidal restrictions (roads), dune stabilization, creation of drainage ditches, and the creation of freshwater impoundments will have a profound impact on sedimentation rates in the impounded wetland complex. Such alterations and management regimes cut off sediment supply and have resulted in the loss of sediment accretion, contributing to the sinking of the impounded marsh platform in Units II and III. Radiometric isotope analysis of sediment core data from Unit I (tidal salt marsh) and Units II and III (impounded freshwater marsh) demonstrated that historic sedimentation rates in Units II and III fall far below local sea level rise rates of 3.20 mm/yr (Lewes Tide Gauge data), and representing the lowest such rates measured in the state (DNREC, *unpublished data*). Meanwhile, the relatively intact Unit I tidal salt marsh areas are keeping pace with local sea level rise rates. These soil impacts will be increased under alternative C, because the longer a site is diked, the greater the difference in surface elevations between diked and natural marshes (Weinstein et al. 2002).

Public Use
Under alternative C, impacts to soils would be similar to alternative A, except slightly higher during the hunting season due to increased deer and waterfowl hunting opportunities from current management.

Conclusions for Management Actions in Alternative C
Upland management actions would have short-term minor benefits with the use of cover crops and other conservation tillage practices on soils. Service policy 6 RM 4.1 states that the long-term productivity of the soil will not be jeopardized to meet wildlife objectives. In addition, the BIDEH policy (601 FW 3) states, "We favor management that restores or mimics natural ecosystem process or functions to achieve refuge purposes…We will restore lost or severely degraded elements of integrity, diversity, and environmental health at the refuge scale and other appropriate landscape scales where it is feasible and supports achievement of refuge purpose(s) and System mission." Although these policies recognize farming and impoundment management as appropriate management tools, we must consider the sustainability and contribution to biological integrity, diversity and environmental health. Both farming and impoundment management will have short- and long-term minor-to-moderate adverse impacts on soils, which may adversely affect the biological integrity, diversity, and environmental health of the refuge.

Impacts on Hydrology and Water Quality

None of our proposed refuge management activities in any alternative should adversely affect local or regional hydrology and water quality. None would violate Federal or State standards for contributing pollutants to water sources, and all three alternatives would comply with the Clean Water Act.

Impacts on Hydrology and Water Quality That Would Not Vary by Alternative

Managing and Protecting Habitat
For all three alternatives climate change and sea level rise will have direct impacts on the hydrology and water quality of refuge habitats with considerable uncertainty as to exactly when and how quickly potential changes to hydrology will occur. Even as the local sea level rises at the current rate, there will be continued management implications and impacts on refuge hydrology, water quality, and marsh and water management, which must be considered under all alternatives. The refuge is working to develop a hydrodynamic model which will utilize local data to more accurately model local hydrological behavior, and enable us to predict the outcome under various management scenarios.

Recent refuge water quality condition of aquatic environments have been evaluated in 2011 and compared to criteria based on EPA National Coastal Condition Assessment Guidelines for the Northeast coast. These guidelines are based on indicators of anthropogenic enrichment. Measured water quality parameters included nitrogen, phosphorus, silica and chlorophyll a concentrations. These parameters are all directly related to phytoplankton biomass and on algal loading in the water column. EPA water quality standardized concentrations for these parameters categorize good, fair and poor water quality conditions. High nutrient concentration levels imply that excessive nitrogen, phosphorus and organic inputs from human activities lead to eutrophication.

The refuge's location along the Delaware Bay is at the receiving end of the Broadkill watershed for any run-off that results from rain or storm events. Known point-sources for nitrogen and phosphorus loading occur at the headwaters of Slaughter Creek that enters Unit II and then is dispersed into Units III and IV following the current hydrological flow of water through the refuge ecosystem. Non-point sources come from land uses adjacent to the refuge that includes agricultural and septic-system run-offs into the refuge during heavy rain and storms. Specific monitoring data shows that heavy nutrient loading into the refuge results in poor water quality conditions long after rain and storm events occur where chlorophyll a, nitrogen and phosphorus concentrations have exceeded 100-fold the over "poor water quality" concentration levels set by the EPA.

These data indicate that for much of the year refuge aquatic systems are highly eutrophic. There is little the refuge can do to mitigate heavy nutrient loadings from run-off from upstream actions within the Broadkill watershed. Under all three alternatives the refuge will work to expand public awareness and knowledge about how and when heavy nutrient loading processes occur and impacts on refuge wetland vegetation and aquatic environments.

Herbicides use for pre- (site preparation) and post-restoration to control non-native vegetation will be conducted using appropriate equipment and best management practices to reduce or eliminate potential exposure of non-target habitats and species associated with drift, surface runoff, and leaching to groundwater. The most efficacious herbicide available with the least potential risk to groundwater and surface water quality would be chosen for use on the refuge.

Public Use

Recreational uses on the refuge, especially those in wetlands and open water, may affect water quality negatively by increasing erosion, stirring up bottom sediments, or introducing pollutants into waterways. We do not expect emissions from vehicles or boat motors to substantially affect the water quality of the region. Most hunters are now using air-cooled mud-motors instead of water-cooled two-cycle outboard motors. Localized increases in emissions from boat motors would be negligible compared to current off-refuge contributions of boaters to pollutant levels in the nearby Broadkill River and the Delaware Bay. Impacts are minimized by prohibiting gasoline motors on Turkle and Fleetwood Ponds. Anglers in boats with paddles or electric motors could disturb the bottoms of ponds. No wake zones and maximum horsepower restrictions of 30 horsepower on Prime Hook Creek and Slaughter Canal will help to minimize bank erosion. We do not expect the other water-related recreational uses to have significant adverse impacts on hydrology or water quality.

Non-toxic shot is required for all hunting except lead slugs are permitted for deer and fox hunting. Fishing may impact water quality and create bank erosion, for example if vegetation is trampled and erosion occurs along Petersfield Ditch and Slaughter Canal banks. Negative impacts to water quality can result from human waste and litter associated with public use activities. Under all alternatives, we will be monitoring the condition of the banks of ditches and canals within the refuge and posting signs, closing areas, or using fencing to direct fishing activities towards the less steep slopes as needed. Public outreach and education on littering and proper waste disposal will lessen potential negative water quality impacts.

Environmental education activities that involve the sampling of wetlands and ponds could cause temporary, localized, minor impacts on water quality as the students disturb the bottom of the pond or walk on the marsh to gather specimens.

Impacts on Hydrology and Water Quality in Alternative A

Impacts on hydrology and water quality under alternative A ("No Action") serve as a baseline for comparing and contrasting alternatives B and C to the refuge's existing management activities.

Managing and Protecting Habitat

Continued management emphasis of maintaining wetland and riparian buffers, treating invasive plants especially *Phragmites* and improving and restoring water flows and circulation in impounded systems by periodically cleaning existing ditches all result in beneficial impacts to water quality of freshwater ecosystems on the refuge. There are some risks to water quality from prescribed fire and herbicide use in conjunction with invasive plant control.

There will be direct impacts on hydrology and water quality as upland field acres continue to revert to natural succession characteristic of the Delmarva coastal plain ecosystem, without proactive management actions to sustain early successional seral stages (grassland and shrublands) or conduct farming.

In salt marsh habitats, the return of tidal flow to Units I will have several beneficial impacts on the natural hydrology and water quality of existing salt marshes by allowing nature to take its course. However, Units II and III would completely revert to open water and tidal mudflat habitats, interspersed with salt marsh vegetation. It would be very likely that little emergent wetland plant production would be able to occur in these areas because of significant marsh platform elevational deficiencies.

This alternative will make no effort to control saltwater intrusion into Unit III, which has had poor sediment accretion, as described in Chapter 3 and demonstrated from refuge wetland studies. Resulting increased frequency and duration of saltwater incursion into Unit III will increase the salinity of the water in Unit III, and this rapid change could result in a conversion of emergent wetland areas in Unit III to largely permanent open water.

The low wetland surface elevation and reduced historic accretion in the impounded wetland complex leave the wetlands vulnerable to substantial changes under a scenario of natural return to tidal hydrology, without mitigation through active marsh restoration. Williams et al. (2002) found that deeply subsided areas in high wave energy conditions had not vegetated after 17 to 20 years, remaining open water and/or mud flat. Stevenson et al. (1986) stated that changes in marsh acreage to open water could in turn lead to reconfiguration of prevailing currents, which influence sediment transport patterns. Orr et al. (2003) states although salt marshes can adjust their levels in response to sea level rise, they may not be able to keep up beyond a threshold rate. If that rate is surpassed, intertidal marshes may convert to open water, a process that could dramatically affect the rest of the system.

Public Use

The impacts of public use on hydrology and water quality for alternative A are discussed in Impacts on Hydrology and Water Quality That Would Not Vary by Alternative.

Conclusions for Management Actions in Alternative A

Most of the impacts on water quality and hydrology associated with managing and protecting uplands are negligible, local, and short term, provided best management practices are followed. The use of best management practices for herbicide use, prescribed fire and other upland habitat management actions described in alternative A would not impair water quality or the environmental health of aquatic environments.

Continuing to allow nature to take its course will create greater hydrological instability and flooding to occur on refuge impounded marsh areas that have substantial marsh accretion deficiencies. Alternative A management actions will exacerbate inadequate marsh accretion and lead to more rapid flooding that stresses plants and eventually causes open water to replace emergent marsh in degraded impounded area areas. Thus management actions under alternative A would continue have local short-term and long-term moderate impacts to water quality and hydrology.

Impacts on Hydrology and Water Quality in Alternative B

Managing and Protecting Habitat

Direct and indirect impacts on hydrology and water quality result from habitat restoration to native vegetative communities and converting agricultural ecosystems to natural ecosystems, as planned in alternative B. Compared to Alternative A, we would extend and enhance forested upland buffers parallel to all refuge waterways and protect wetland habitats with greater than 100-foot forested buffer zones through proactive reforestation actions in zone areas. Buffer zone creation would help mitigate heavy nutrient loading from run-off into refuge aquatic environments.

Impacts from forest management on hydrology would be minimal as long as forestry best management practices are employed. A list of all possible best management practices, developed by Delaware Forest Service, is provided in the habitat management plan included in this CCP (Appendix B). Because nearly all refuge lands are flat, with less than 2 percent slope, they would be more resistant to erosion, siltation, and runoff that could otherwise impact refuge hydrology.

Proposed salt marsh restoration in Unit II will ultimately permit natural tidal flows and natural hydrologic patterns that create mini-inlets. Proper hydrology must be attainable and channels to drain the marsh are essential for successful restoration (Teal et al. 2002). Despite salt marsh restoration efforts, the wetlands in Unit II and Unit III will still be impounded due to the roads that stretch across them, which will require some consideration with regard to management and restoration strategies. Water management strategies used for brackish (mesohaline 5 to 18 ppt) and saline (polyhaline 18 to 30 ppt) wetlands, with limited rainfall inputs, emphasize an active drawdown and reflooding scheduling regimes to maximum water circulation within impounded wetlands, which is required to control salinity management and maintain soil aeration. Periodic ditch cleaning of an extensive network of refuge marsh ditches and tidal channels, where appropriate for natural marsh functioning, will maintain and enhance water circulation, improve water quality, and avoid stagnant water conditions.

As described in Chapter 4, prior to any wetland restoration actions proposed in alternative B, the refuge will conduct hydrology and water quality modeling and analysis several specific restoration scenarios. Salt marsh restoration actions proposed in alternative B would have numerous impacts to water quality and hydrology on the refuge.

Adherence to requirements in the Clean Water Act ensures that the use of dredged material for salt marsh restoration will ensure that we do not have adverse impacts on water quality and hydrology in the impounded wetlands. As mandated by section 404 (b)(1) of the Clean Water Act, the use of dredged material would require that the reintroduction of sediments into a project area “will not have an unacceptable adverse impact either individually or in combination with known and/or probable impacts of other activities affecting the ecosystems of concern.” The section 404 (b)(1) guidelines (40 CFR 230) are the criteria for evaluating the proposed discharges for dredged or fill material into waters of the United States. Any project must demonstrate through the completion of a section 404 (b)(1) evaluation that may proposed discharge of dredged material is in compliance with the guidelines. A project using dredge spoil must satisfy four requirements as follows:

(1) Section 230.10(a)—address impacts associated with loss of aquatic site functions and values at the disposal site and requires that the discharge represent the least environmental damaging practicable alternative.

(2) Section 230.10(b)—requires that the discharge not violate state water quality standards.

(3) Section 230.10(c)—requires that the discharge not significantly degrade the aquatic ecosystem.

(4) Section 230.10(d)—requires all practicable means be used to minimize adverse environmental impacts.

Section 230.61 mandates the any proposed dredged material project use an effects-based testing protocol to determine the impacts of the discharges of dredged or fill material into the waters of the U.S. The protocols can be found in Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S.–Testing Manual (USEPA/USSACE 1998). This constitutes an approach that depends on the preponderance of evidence acquired through physical, chemical, and biological assessments required by sections 230.60 and 230.61 of the guidelines.

For example, the dredge material that will be retrieved from reach E of the Delaware River Main Channel Deepening project is one potential source for dredged material for salt marsh restoration on the refuge. These sediments have been found to contain negligible and environmentally acceptable levels of contaminants that could impair water quality at the restoration site (ACOE 1997). Dredged material from any other potential source would be similarly analyzed before use in restoration. In addition, as the restoration project develops, an application for a water quality certificate would be made in accordance to the Clean Water Act.

The discharge of dredged or fill material for restoration may change chemistry and the physical characteristics of the water at a restoration site within the impoundment, through the introduction of chemical constituents in suspended or dissolved form. The introduction of nutrients or organic material to the water column because of the discharge can lead to a high biological oxygen demand, which in turn can lead to reduced dissolved oxygen. Turbidity associated with the disposal of dredged material would increase locally; however, this would be temporary. With the increase in sediments may come increased trace metals associated with bed sediments and agrichemicals in the water may increase (USACOE 2010).

In addition, dredged material used in refuge wetland restoration may modify current patterns and water circulation by obstructing flow, changing the direction or velocity of water flow, changing the direction or velocity of circulation, or otherwise changing the dimensions of the wetland water body. As a result, changes could occur in refuge shoreline and substrate erosion and deposition rates, the deposition of suspended particulates throughout the impoundment complex, the rate and extent of mixing dissolved and suspended components of the wetland water body, and water stratifications. Consequently, this material can alter the normal water level fluctuations pattern of the impounded wetland restoration site, resulting in prolonged periods of inundation, exaggerated extremes of high and low water or a static non-fluctuating water level. Such water level modifications may change salinity patterns, alter erosion or sedimentation rates aggravate water temperature extremes, and upset the nutrient and dissolved oxygen balance of the aquatic ecosystem. Obstructions that divert or restrict flow of salt water may change existing salinity gradients. The dredged or fill material can cause changes in water circulation that may permanently flood or dewater refuge wetlands or mudflats, or disrupt periodic inundation, resulting in an increase in the rate of erosion or accretion. These actions will be minimized by selecting specific restoration sites or managing discharges to confine and minimize the release of suspended particulates decreasing turbidity levels. The effects will be further minimized by using containment levees or berms as needed, maintaining and containing the discharged material properly to prevent point and nonpoint sources of pollution, and timing the discharge to minimize impact, for instance, during periods of unusual high water flows, wind, wave, and tidal actions. In addition, distributing the dredged material widely in a thin layer at the disposal site will maintain natural substrate contours (40 CFR 230). These undesired impacts will be minimized through careful restoration planning and implementation.

During marsh restoration in the impounded wetland complex, tidal channels will be incorporated into the restoration design to minimize erosional losses and maximize deposition on the marsh surface. The ebb flow needs to be low as to not carry sediments off the marsh (Teal et al. 1998). Construction of channels will assist restoration success by enhancing tidal flooding, increased sedimentation rates, improved drainage, enhanced plant colonization rates, and species diversity and distribution range (Wolters et al. 2005). Hypersalinity can be a common problem in restoration sites (Burdick et al. 1997). Restoration of proper hydrologic regimes in the impoundment complex will promote rapid recovery of salt marsh functions that, in turn, will minimize any adverse impacts.

Restoration of salt marsh will also impact hydrology through reduction of wave heights. Morgan et al. (2009) found marshes reduced the height of waves coming onto the marsh surface by 63 percent only 7 meters into the marsh; where no marsh was present, wave heights were reduced by only 33 percent. Wamsley et al. (2011) found barrier islands, even if degraded, reduce wave heights and can reduce wave energy in wetland areas, protecting them from erosion. Restoration resulted in further decreases in storm surges and waves. Levees or berms constructed for the restoration of salt marsh in the impounded wetland complex will provide a sheltered environment to protect the developing site from externally generated waves (NECIA 2007). Designing water control structures, culverts, tidal channels, and diversions that will pass both low and high water levels and maintain circulation are important for the long-term sustainability of the hydrology of the restored marsh. The removal of a portion of Fowler Beach Road or increases in culvert size may improve tidal flushing and the overall hydrology of the area.

The potential use of engineered wave attenuation techniques, such as pyramid-shaped or spherical concrete structures designed explicitly for such purposes in moderate- and high-energy settings, or the use of rock pile structures, may alter hydrology inside the impounded wetland complex. Such devices are widely used to attenuate wave energy successfully for erosion control and wetland restoration applications, which could assist in the restoration of desired hydrological conditions within the impoundment. T heir exact impact on hydrology and wave energy is not well-understood (Douglass et al. in press). Without careful planning and selection of the appropriate engineered solution, hydrology could be adversely impacted as wave energy may scour around any installed structures and create new overwashes or inlets.

The low wetland surface elevation and reduced historic accretion in the impounded wetland complex pose a challenge for restoration of tidal hydrology. Williams et al. (2002) found that deeply subsided areas in high wave energy conditions had not vegetated after 17 to 20 years, remaining open water and/or mud flat. Stevenson et al. (1986) stated that changes in marsh acreage to open water could lead to reconfiguration of prevailing currents, which influence sediment transport patterns. Orr et al. (2003) states that although salt marshes can adjust their levels in response to sea level rise, they may not be able to keep up beyond a threshold rate. If that rate is surpassed, intertidal marshes may convert to open water, a process that could dramatically affect hydrology of the entire impounded wetland system. Marsh restoration utilizing added sediment to restore wetland elevation is the most effective way to restore local tidal hydrology, although the use of wave attenuation devices and living shoreline strategies may encourage natural accretion and ultimately benefit restoration of tidal hydrology, though not as quickly or perhaps as completely.

Restoration of prior converted wetlands used for intensive agriculture will restore and improve altered hydrology in these areas and improve water quality. Ceasing farming activities in wet areas will also improve the water quality and hydrology of surrounding wetlands.

The use of a cookie cutter or rotary ditcher to maintain numerous existing ditches in refuge impoundments will increase water circulation, provide drainage flow for water level management capabilities, and avoid stagnant water conditions. Ditches periodically become clogged with silt and decaying vegetation exacerbated by extensive snow goose herbivory sustained during the fall and winter months. The use of a cookie cutter or rotary ditcher to maintain numerous existing ditches in refuge impoundments will maintain water circulation and water quality and provide drainage flow for water level management capabilities. However, the operation of the machine leaves large amounts of dead and decaying vegetation in its wake resulting in an immediate increase in the biological oxygen demand in the system, which may last several months. The magnitude of the biological oxygen demand increase depends upon the rate of decay that is dictated by water temperatures. The aerating action of the cutter blades may offset this impact somewhat, but the increased oxygen supply in the water is a short-lived benefit. Since the operation of the cookie cutter includes sediment redistribution, dead vegetation contained in the suspension of bottom materials will further aggravate the available oxygen demand. Turbidity around the machine will be extremely high during operation but should return to normal shortly after completion of the work. Monitoring around the operation will assure that the turbidity does not significantly increase beyond the work area.

The impacts of the cookie cutter/rotary ditcher operations can be partially mitigated by consideration of anticipated biological oxygen demand, dissolved oxygen, water temperature, and water levels. The oxidation and decay of cut vegetation and disturbed bottom material from maintained sites is expected to require three months to a year to return to normal, depending on temperature and available oxygen. Associated with this will be mats of decaying matter. In order to reduce these impacts, a seasonally conducted and routine channel rehabilitation process will be used. Ditches requiring both vegetation removal and sediment redistribution will be worked only during cooler water temperature periods (less than 60 °F) between February 1 and March 15 to limit the impact on biological oxygen demand. Depressed water temperatures during a drawdown will prolong the decay process and should allow vegetative mats to flow out of the system. A monitoring effort will also be implemented in conjunction with the cookie cutter to determine the magnitude of the impact on the ditches and impoundments. Refuge staff will ensure that at least 75 percent of the ditch depth is free of sediment along ditch courses, and the entire length is free of obstructions that impede water flow.

Extensive ditching for drainage and mosquito control has altered the natural hydrological cycles on refuge salt marshes. Several refuge Open Marsh Water Management (OWMW) studies have shown that OMWM ditching can have negative impacts on salt marsh areas when water tables drop below six inches from the marsh surface. Lowered water tables, excessively dry out the marsh surface and allows undesirable vegetation to take over salt marsh cordgrass stands. High ditch densities excavated for OMWM purposes have negative impacts on salt marsh hydrology and should be avoided (Meredith et al. 1983; Meredith et al. 1985; James-Pirri et al. 2004; James-Pirri 2012).

Public Use

Potential impacts on hydrology and water quality from increased recreational use would slightly increase over those described for alternative A due to expansions in public use activities. Impacts are expected to be negligible.

Expanded hunting opportunities for deer and waterfowl will cause negligible, yet increased, impacts on the water quality in refuge hunting areas.

Anglers using Goose and Flaxhole Ponds are restricted to boats only and are not permitted to fish from shore, thereby minimizing vegetation trampling and soil erosion along the banks. Boat motor restrictions in these water bodies will prevent unwanted pollution and sediment suspension.

Conclusions for Management Actions in Alternative B

Alternative B management actions that propose proactive re-forestation, the creation and expansion of vegetated buffer zones around aquatic environments, and restoration of farmed fields to native vegetative communities will generally improve water quality.

Salt marsh and natural hydrological restoration actions proposed in alternative B will repair hydrological and coastal geomorphological functioning to Units II and III by restoring severely degraded wetland integrity and health within impounded areas, consistent with our BIDEH policy.

Impacts on Hydrology and Water Quality in Alternative C

Managing and Protecting Habitat
Exclusion of salt water intrusion into freshwater impoundments, and maintenance of water flows and circulation in impounded systems by periodically cleaning existing ditches, will maintain the freshwater quality of freshwater ecosystems on the refuge. There are some risks to water quality from prescribed fire and herbicide use in conjunction with invasive plant and upland habitat management programs, including farming. Agricultural practices also greatly affect hydrologic patterns. Clearing the early successional environments generally decreases interception of rainfall that would occur with natural plant cover year round and reduces soil infiltration, resulting in increased overland flows.

Cooperative farming practices under alternative A involve the use, as approved, of glyphosate-tolerant soybean and corn, which are sprayed with glyphosate herbicides to control pest plants. Glyphosate herbicides are associated with less surface run-off than are other common herbicides (Shipitalo et al. 2008). Drainage ditches for farming that currently exist in refuge wet areas directs water flows more quickly downstream, increasing size and frequency of run-off and accelerating water delivery to wetlands and waterways.

Intensive ongoing farming of marginal soils on the refuge can impact the hydrology of freshwater ecosystems and moist-soil management of impoundments, because maintain lower water levels may be necessary to maximize crop yields for farmers during summer months, which in turn lowers water tables in the marsh in order to keep upland areas drier.

In the absence of artificial dune restoration in Unit I, natural dynamic hydrologic patterns of highly dynamic coastal environments, like barrier beach island ecosystems, are not be impeded. This action will renew tidal flows in Unit I salt marshes, and restoration of natural hydrologic patterns that create mini-inlets, expanding overwash habitats. This increased circulation of salt water into Unit I will continue to have implications for Units II and III. Even if Unit II is managed as a freshwater impoundment, periodic saltwater intrusion into Unit II will be likely, which will increase the salinity of water in both Units II and III freshwater impoundments. Overall, the hydrology of refuge salt marshes will continue to be affected by the long-term effects on hydrology of coastal structures present, e.g., roads, levees, etc. (Burdick et al. 1997).

The impacts of the use of a rotary ditch under alternative B are the same as those discussed under alternative B.

As described in Chapter 3, radionuclide studies of refuge marsh accretion rates conducted in 2010 and 2011 indicate that for the past 50 years refuge salt marshes are keeping up with the local sea level rise rate of 3.20 $\pm$ 0.28 mm/yr as measured at the Lewes tide gauge. However, refuge impounded marsh areas are found to have significant elevational deficiencies in relation to local sea level rise that can cause the total conversion of impounded marsh areas to open water, drastically altering hydrology. The rapid intrusion of salt water through several breaches formed in Unit II in 2009, coupled with upgrading of culvert pipes connecting Unit II to Unit III, has already significantly altered the hydrology of these units, with the rapid reintroduction of salt water. Immediate and cumulative impacts on hydrology of rapid introductions of saline waters into these areas have been rapid emergent marsh loss, prolonged flooding and impaired hydrological function and drainage capability, subsidence of the marsh platform, and the large-scale conversion of emergent marsh to open water. These impacts will continue until all infrastructure associated with impoundment water management is repaired. Even with repairs and upgrades to impoundment infrastructure, these data suggest that impoundment management described under Alternative C, which cuts off sediment transport into impounded marsh areas, will have a substantial impact on the hydrology of the impounded wetland complex into the future.

Public Use

Proposed expansions in hunting opportunities are expected to cause more impacts to water quality in alternative C than those outlined in alternative A, but less than alternative B. Impacts for other recreation will be similar to alternative A. Impacts are expected to be negligible.

Conclusions for Management Actions in Alternative C

Management actions under alternative C would have local short-term minor beneficial impacts and local short-term and long-term moderate-to-major adverse impacts to water quality and hydrology. Most of the adverse impacts on water quality and hydrology associated with managing and protecting uplands are negligible, local, and short term, provided best management practices are followed. The use of best management practices for herbicide use, prescribed fire and other upland habitat management actions described in alternative C would not impair water quality or the environmental health of aquatic environments.

The manipulation associated with creating managed freshwater wetlands represents a major impact on local hydrology. Furthermore, climate change and accelerated sea level rise have already and will continue to have minor-to-moderate adverse impacts on our ability to manage salinity and water levels in our wetlands and control salinity intrusion into our upland habitats. Even once necessary infrastructure repairs and upgrades are made, impoundment management will be challenging and will contribute to marsh elevational deficiencies within the impounded marsh complex, further altering hydrology.

Increasing salinity intrusion across the entire refuge wetland complex will have substantial consequences that would require extensive and costly measures to repair failing impoundment infrastructure in order to offset adverse impacts. However, such costly mitigation measures would not assure success given current and future conditions associated with climate change and sea level rise.

Impacts on Vegetation

The types of activities proposed in the three alternatives that would affect vegetation and other biological resources include water level and salinity management in impoundments, prescribed burning, brush-hogging and mowing, disking, treating invasive or unwanted vegetation with herbicides; controlling erosion; thinning and other forest management practices; afforestation and restoring prior converted wetlands; constructing new trails; constructing new buildings or public use facilities such as piers, docks, trails, photo blinds, observation towers; increasing or offering new opportunities for public use such as opening new tracts to visitors or offering new areas for hunting waterfowl; ceasing dune stabilization to allow natural succession and dynamic coastal processes to proceed unimpeded along undeveloped barrier island areas of the refuge; or initiating proactive salt marsh restoration projects.

Impacts on vegetation of the refuge habitats will also be significantly influenced by climate change and sea level rise as increased weather extremes and more severe coastal storms will introduce greater frequency and duration of salt water intrusions in freshwater wetland and upland habitats.

Impacts on Vegetation That Would Not Vary by Alternative

Managing and Protecting Habitat

Across all alternatives, we would engage in prioritized invasive species control at the early-detection, rapid-response stage, which will result in the protection of up to 100 percent of the native cover from targeted threats. Working closely with adjacent private landowners to control invasive plants like *Phragmites* and encourage the propagation of native vegetation will assist in lowering risks of catastrophic fire. Regardless of alternative, it is hoped that, over the long term, the invasive species coverage and associated resources required to control them will decline, as native communities are restored, become established, and represent the dominant vegetation cover-type.

Restoration and proper maintenance of refuge vegetation communities associated with achieving wildlife and habitat objectives will contribute to long-term prevention, eradication, or control of pests. Herbicides used for pre- (site preparation) and post-restoration to control non-native vegetation will increase desirable plant communities by the manipulation of species composition, plant density, and growth rate. Thus, the control of invasive pests and eventual restoration of the native plant community will have moderate local impact to the native vegetation communities throughout the refuge. During ditch maintenance using the rotary ditcher, vegetative loss is expected to be negligible. There is also a potential for the spread of *Phragmites* through the relocation of rhizomes downstream of the project site; however, this potential remains negligible if the *Phragmites* in the project site area has been treated with an herbicide prior to any work activity. Staff will also monitor the soil deposition areas for an increased occurrence of *Phragmites*.

Additional habitat management activities proposed under all alternative that will have a local impact on vegetation include establishing and enhancing vegetated buffers along riparian and wetland borders, and establishing connecting corridors between isolated forested patches either through proactive plantings or natural succession. Buffer zones created either through proactive reforestation or allowing natural succession to occur will enhance areas that serve as native seed dispersal corridors by establishing connective networks and reducing fragmentation across the refuge landscape, which will expand natural native plant seed colonization of new areas. This, in turn, has the local impact of enhancing biological integrity and restoring environmental health (Lars et al. 2009).

Regardless of the alternative, the refuge will continue to conserve, manage, and maintain healthy and diverse forest habitats as funding and resources permit, although the means of achieving this may vary by alternative.

Canada goose herbivory during the growing season is a relatively new impact upon wetlands. In 2002, a research study conducted at neighboring refuges, Bombay Hook and Chincoteague NWRs, suggested that higher levels of use by geese may cause a long-term change in wetland community structure (Laskowski et al. 2002). Biomass of several species of vegetation was significantly adversely impacted by feeding resident Canada geese at both refuges. Resident geese directly damage agricultural resources by eating grain crops and trampling spring seedlings. Heavy grazing by geese can result in reduced yields and in some instances a total loss of the grain crop (Allen et al. 1985, Flegler et al. 1987). While migratory Canada goose are an indigenous North American species, the behavior, genetics, and behavior of the non-migratory flocks have been influenced by human actions; the Service recently issued a national EIS addressing Canada goose control. Lethal and nonlethal Canada goose control activities outlined under all strategies common to all alternatives would be expected to significantly decrease the number of injurious resident Canada geese in specific areas, thus reducing local impacts on vegetation. The long-term viability of migrant Canada goose populations would not be affected, however. Similarly, because mute swans are highly invasive of wetland habitats, and can consume large quantities of submerged aquatic vegetation, control of mute swans on the refuge will have a local beneficial impact on wetland vegetation communities.

Various light goose (snow goose) populations in North America have reached such high levels that they are damaging habitats on their Arctic and subarctic breeding areas (Abraham and Jefferies 1997, Alisauskas 1998, Jano et al. 1998, Didiuk et al. 2001) as well as in some migration and wintering areas (Giroux and Bedard 1987, Giroux et al. 1998, Widjeskog 1977, Smith and Odum 1981, Young 1985). The increasing numbers of light-geese are viewed as a continental problem, but with real local adverse impacts on vegetation. Grubbing for rhizomes, especially in salt marshes, results in areas denuded of vegetation, typically referred to as eat-outs. Vegetation density at these eat-outs may return to previous normal levels after several years, if left alone. However, where eat-outs occur within salt marsh habitats, snow geese often return each winter to the same areas to feed. Such impacts have been observed at the refuge. It is also speculated that during the time snow geese are feeding in a salt marsh, much of the soil and sediment may be loosened and placed into suspension. In fact, recently analyzed water quality samples from the refuge impoundments have found extremely high sediment concentration in the water during times of extensive snow goose browsing on the refuge. This material may then be washed away during high or flood tide periods. After several years of successive erosive eat-outs at the same location, the lower ground elevation may further prevent the return of vegetation, causing a more long-term impact to vegetation community on the site. Reducing snow goose numbers on the refuge will reduce adverse minor-to-moderate impacts of snow goose herbivory on salt marsh habitats.

Deer overabundance can affect native vegetation and natural ecosystems and has been well-studied (Tilghman 1989, Nudds 1980, Hunter 1990; Behrend et al. 1970). White-tailed deer selectively forage on vegetation (Strole and Anderson 1992), and thus can have substantial impacts on certain herbaceous and woody species and on overall plant community structure (Waller and Alverson 1997). Over-browsing by deer can decrease tree reproduction, understory vegetation cover, plant density, and plant diversity (Warren 1991). High densities of deer have also been recognized as vectors for spreading invasive species like Japanese stiltgrass. Historically (pre-European contact and during the colonial times) there was more extensive forest/fewer open fields and more human and natural predation, therefore deer numbers were in greater balance than at present. Thus, control of the white-tailed deer population on the refuge will have a moderate beneficial impact on the vegetation communities.

Public Use

Under all alternatives, repeated visitation to any particular locale at the refuge would continue to cause minor site-specific damage to vegetation. However, overall impacts to vegetation are expected to be negligible because visitors are expected to remain on existing trail routes and interior access roads. Repeated use of an aquatic area by boats equipped with go-devils can damage to emergent and submergent vegetation beds. Portions of or whole plants can be torn, sometimes by roots, and boat wakes contribute to erosion. Accidental introduction of invasive plants, pathogens, or exotic invertebrates attached to boats or trailers, or on shoes or clothing, is another source of direct minor impacts on vegetation. Maintenance activities may involve the occasional trimming or felling of trees to maintain or improve infrastructure such as roads or trails. In places where unmarked paths are created by hunters and anglers, little used pathways will retain their dominant vegetation species, but on medium-use pathways some plant species will be replaced and heavily-used paths will often contain invasive species (Liddle and Scorgie 1980). Such unmarked paths have been observed on the refuge in areas where anglers access the water along its edge, but overall this impact is negligible.

Impacts to vegetation communities resulting from hunter access are expected to be negligible, as most species will have already undergone senescence or become dormant. Salt marsh habitats were found to be the most resistant to human trampling when compared to other habitats such as a natural dune, a man-made dune, and man-made coastal grasslands (Anderson 1995). This study analyzed the vegetation of five paths (one in each of the habitats) created and sustained by human trampling and reported that trampling of vegetation (estimated to be 1,815-3,630 passages per year) can be considered as very light. Even though it created paths and reduced vegetation cover and species diversity, the paths still retained a persistent vegetation (Anderson 1995). Additional impacts to vegetation are minimized by not permitting hunters to cut vegetation for shooting lanes or for use as camouflage. Impacts to vegetation are further minimized because hunting from a stand that has been attached with nails, wire, screws, or permanently attached to a tree in any other way is prohibited.

As a result of research activities, the removal of vegetation core samples can cause increased negligible site-specific impacts on vegetation communities, and sampling activities can cause site-specific trampling of vegetation.

Impacts to Vegetation in Alternative A

Impacts on vegetation under Alternative A (“No Action”) serve as a baseline for comparing and contrasting Alternatives B and C to the refuge’s existing management activities.

Managing and Protecting Habitat*s*

Salinity increases and intrusion into impounded marsh areas will have significant impacts on historic freshwater perennial and annual plant communities. Allowing passive conversion to salt marsh and open water in refuge coastal wetland habitats as proposed in alternative A or proactive salt marsh restoration as proposed in alternative B will both result in drastic changes in emergent wetland vegetation communities as freshwater plants are replaced by halophytic marsh plants. As relatively few plant species are halophytes (less than 2 percent of all plant species) the transition from freshwater to brackish and salt water salinity regimes across the refuge’s wetlands will also result in a decrease of wetland plant diversity. On the brackish end of salinity ranges, vegetation such as salt marsh bulrush in low marsh areas and saltmeadow cordgrass in high marsh areas may increase temporarily during growing seasons with abundant rainfall and accompanying lower salinities. Species such as dwarf spikerush, widgeongrass, and sea purslane may predominate in higher salinity marshes (Williams et al 2002, Whitman 1987). Letting brackish or saline water impoundments dry out will encourage saltmeadow cordgrass to become established, while more stable water level regimes will allow cattails to establish if salinities stay low. Algal mats, primarily Cladophora, will cover more saline open water areas, especially if a strong flow of water is not maintained (Daiber 1986). These changes and potential impacts will be similar under either alternatives A or B, and may differ only in degree and specific distribution, depending on rainfall, salinity, and hydrologic conditions.

During spring and summer of 2010, an outbreak of an algal species (Genus Cladophora) occurred in the impounded wetland complex; this form of algae is common in both freshwater and marine water systems. Although it is not clear exactly why the bloom occurred, it is believed to have been a combination of several factors, including warm weather conditions, excess nutrient levels from dying freshwater vegetation, run-off from high waters flushing nutrients from adjacent farmlands and septic systems, and the vulnerability of a stressed system in transition. Negative impacts of the bloom were aesthetic, not ecological. A bloom could recur if freshwater vegetation is killed by saltwater influxes and salt marsh vegetation is not sufficiently established.

Reforestation in portions of Unit III will continue to create early successional communities, which are rare and declining in the state and along the East Coast. Native herbaceous and grass species will reappear in Unit IV, in fields currently being maintained as grasslands, ultimately to a level where they become self-sustaining population sources. The direct impacts of habitat management associated with alternative A would be the recurring temporary removal of vegetation through brush-hogging, mowing, burning, or applying herbicides. Some non-target species like milkweeds, goldenrods, and other native wildflower plants would experience short-term direct impacts, but would recover as vegetation grows quickly during the growing season. Broad-spectrum herbicides, such as glyphosate products, when applied aerially or on the ground, also kill non-target desirable plant species. We reserve these methods for areas that are infested with high densities of invasive plants, making selective application impossible. In other areas, localized spot spraying or physical removal of invasive plants may be required to protect rare plants. Other direct impacts to vegetation result from prescribed fire, including the return of nutrients to soils by combustion of dead plant biomass, reduction of litter, and creation of openings where grasses and fire-adapted herbaceous vegetation can become established.

Under Alternative A, tidal flows established from inlets formed in fall 2009 would continue to introduce new sediments to Unit II that could aid in the natural return of the unit to salt marsh. The higher saline conditions would result in halophytic vegetation re-colonizing back-barrier wetlands and washover habitats. However, relying on a passive reversion of 1,500 acres in Unit II into salt marsh, without any alteration of road and water management infrastructure, will increase salt water intrusion from Unit II into Unit III. Saltwater intrusion in Unit III is likely to have long-term adverse impacts on the globally rare seaside alder *(Alnus maritima*, S1, G1), Atlantic white-cedar, and other hardwood swamp communities adjacent to the upper reaches of Prime Hook Creek. Depending on rate and frequency of salt water incursions into Unit III, most of the forested wetlands (1,300 acres) would become highly stressed and not likely recover and elements of freshwater wetland plant diversity would be lost.

In the absence of any proactive marsh restoration efforts, it is likely that additional portions of the Unit II and Unit III impoundments will convert to open water due to subsidence, peat collapse, and low accretion rates, resulting in open water where there had previously been dense stands of freshwater wetland vegetation (Smith et al. 2009, Pearsall and Poulter 2005, Weinstein et al. 2000, Portnoy and Giblin 1997, DeLuane et al. 1994). While salt marsh may be re-established in the former fresh water impoundments, there is a strong likelihood that much of the former freshwater marshes would convert to open water unless sufficient sediment erodes from the surrounding uplands or is washes into the interior from the bay. Conversion to open water would be a major and adverse impact, as this habitat supports less vegetation than either freshwater or salt water marshes. Larger expanses of open water would also make existing salt marsh stands more susceptible to the adverse impact of erosion (Weinstein et al. 2000) and hinder the establishment of new stands of salt marsh vegetation (Williams and Orr 2002, Weinstein et al. 1996).

If forests are permitted to return to open fields solely through natural regeneration, invasive species and other factors are likely to result in less desirable forest conditions. This would have an overall minor-to-moderate impact on the health and composition of upland forest vegetation communities.

Public Use

The impacts on vegetation under this alternative would be the same as those discussed in the section Impacts on Vegetation That Would Not Vary by Alternative.

<u>Conclusion for Management Actions in Alternative A</u>

Management actions under alternative A would have long-term minor-to-moderate impacts as well as opposing short-term and long-term moderate-to-major impacts. No impairment of the refuge’s BIDEH is expected. However, if large areas convert to open water, diversity, and the refuge's integrity may be impaired at the local level.

Under Alternative A, permitting natural succession in upland fields would restore and conserve native vegetation and create contiguous forest blocks by connecting currently fragmented forested parcels throughout much of the refuge with long-term beneficial impacts on natural upland vegetation communities, primarily forests. However, the absence of active reforestation efforts would result in more forest area in an undesirable condition. Given the dynamic nature of the coastal system encompassing the refuge, there will be continued passive conversion of wetland vegetation communities from artificially managed freshwater vegetation to a mix of natural salt marsh, open water, and mudflats. However, if no actions are taken to encourage salt marsh development through restoration, larger portions of the refuge may convert to open water than would otherwise, which could further hinder wetland vegetation development. Thus, adverse impacts to vegetation are greater under alternative A than under alternative B.

With non-consumptive users staying on designated trails and provided facilities, and hunters confined to elevated deer stands and provided waterfowl blinds, impacts to vegetation from public use in alternative A are expected to be negligible.

Impacts to Vegetation in Alternative B

Managing and Protecting Habitat

This alternative would focus on increasing the acreage of upland forested habitats from the current level of 775 acres to approximately 1,645 acres. We would increase the numbers of transitional habitats (grasslands, shrublands, and young trees) by restoring and maintaining a greater number of acres of early successional areas that were previously farmed. Such restoration will promote habitat connectivity and reduce habitat fragmentation. These improvements to the vegetation communities on the refuge will also protect and restore key ecological processes, such as pollination, seed dispersal of native plants, and nutrient cycling.

Selective forestry techniques involving partial removal of trees (not clear-cutting), usually in uneven-aged stands of hardwoods, will promote the growth of desired shade-tolerant or intermediate tolerant tree species. The remaining desirable trees will be able to better receive sufficient light, moisture, and nutrients to grow to optimal size. Selection system harvesting would allow a timber stand to retain its forest appearance in the years immediately following harvest. Active forest management will result in the temporary removal of vegetation, but such impacts are of short-term duration, as vegetation grows quickly during the growing season. Potential minor adverse impacts of selective cutting on forest vegetation would be slower long-term growth, allowing undesirable species to predominate in the stand, holding back valuable sun-loving species, and being an easily and frequently abused method. Establishment of weedy or undesirable vegetation would also be a possible adverse impact in regenerating managed forest stands, whether natural or planted, and would require control through mechanical or chemical means.

Relying on natural regeneration whenever possible for stand replacement following prescribed management operations would enhance early root development and would ensure a local origin of the seed, which can reduce the chance of tip moth damage. In most cases, the resulting natural forest regeneration on the refuge will likely be dominated by pine, red maple, and sweet gum. Due to the many complications related to the germination of oak seeds, such as parasitism, predation, and other various site conditions, it is likely that natural oak regeneration in refuge forests will be minimal. The planting of oak or other hard mast producing species will ensure their replacement and continued occupancy of the stand. Additional future silvicultural treatments, as needed, will ensure survival and optimum growth of new trees, thus increasing their chances of achieving dominance in the stand. The overall benefits regarding regeneration and stand replacement, species composition diversity, forest health, and long-term sustainability of refuge forest habitats would far outweigh any temporary negative impacts of executing these prescriptions. Reforestation through tree planting will have a moderate direct impact on the composition of forest communities, through the use of desirable species suitable for that site. Whether natural or planted, the result of active forest management would be a long-term increase of desired forest vegetation communities.

Management of problem or undesirable vegetation prescribed under alternative B will help ensure optimum growth and survival of desired forest regeneration, whether natural or planted. Only approved chemicals that are labeled for these specific uses and have been shown to be most effective would be considered. Those substances, when used in accordance with their labeling, would have little to no impact on non-target fauna and flora. Extreme care would be taken to prevent drift to non-target areas as well as non-federal lands. All applications would be performed in accordance with current labeling and Federal, State, and local regulations.

Prescribed fire treatments prescribed under alternative B will have a moderate beneficial impact on forested communities on the refuge because burning as a timber stand improvement technique can improve natural regeneration, especially of oak species, through several means (Baker and Langdon 1990; Snyder 1992; Van Lear 1992). Fire removes excessive litter buildup from the forest floor, thereby preparing a favorable seedbed for seedlings from freshly germinated acorns, which are unable to emerge through a heavy litter cover. Fire also helps control infestations of insect consumers of acorns and new seedlings because many of these insects spend all or part of their lives on the forest floor. Impacts from prescribed burning to the understory vegetation, such as woody plants, will vary with frequency and season of burning conducted on the refuge (Baker and Langdon 1990; Wade and Lunsford 1989). The chance of fire escaping is always a factor, which could have an adverse impact on non-target vegetation on and adjacent to the refuge. Overall, the use of fire as a management tool will have negligible adverse impacts on upland vegetation.

Proposed salt marsh restoration in refuge impoundments would have a moderate-to-major long-term impact on wetland vegetation communities, as freshwater plant species are replaced by native high marsh and low marsh dominated, by halophytes such as glasswort, saltmeadow cordgrass, and smooth cordgrass. Refuge salt marsh wetland restoration efforts will allow for better sediment delivery, and higher sediment concentrations in the water column, which will allow refuge coastal wetlands to build more elevation and grow thicker stands of saltmeadow and smooth cordgrass (Williams and Orr 2002, Boumans et al. 2002, Burdick et al. 1997). Coastal wetland and sea level rise modelers (Kirwan et al. 2010) have suggested that under conservative sea level rise projections of 3 to 5 mm/yr, coastal marshes with small tidal ranges (less than 3 meters) and low sediment concentrations (less than 20 mg/l) will likely submerge in the next 30 to 40 years. Under scenarios of rapid ice-sheet melting (10 to 20 mm/yr sea level rates), only marshes with a tidal range of greater than 3 meters and sediment concentrations above 30 mg/l can survive (Kirwan et al. 2010). Refuge salt marsh restoration actions developed as part of Alternative B will focus on increasing the tidal range and sediment concentrations entering refuge coastal wetlands that will be needed to achieve these desired tidal range and sediment concentration thresholds. Salt marsh vegetation communities resulting from restoration strategies in alternative B will be more resilient to sea level rise and self-sustaining for the long-term (NOAA 2010, Kirwan et al. 2010, Cahoon et al. 2009, Reed et al. 2008).

The active restoration effort proposed in alternative B is more likely to have a long-term impact on the recovery of refuge's coastal wetlands than a passive return to salt marsh would (NOAA 2010, Smith et al. 2009, Teal and Weinstein 2002). Strategies such as the use of living shoreline techniques would reduce wind fetch across expanses of open water in the impounded wetlands, which subjects adjacent salt marsh vegetation to erosion (Morgan et al. 2009, Williams and Orr 2002, Weinstein et al 2000). In degraded marshes, salt marsh vegetation responds favorably to the placement of dredge material for restoration (La Peyre et al. 2009; Ray 2007; DeLaune 1990), and ecological functioning of salt marshes can be restored (Stagg and Mendelssohn 2010). Thus, the placement of dredged sediment throughout large portions of the impoundment complex to restore elevation would have a moderate-to-major impact on the establishment of salt marsh vegetation, as elevation is a primary limiting factor for growth of *Spartina* species (Weinstein et al. 2002, Morris et al. 2002, McKee et al 1989, Baca and Kana 1986). Planting of sprigs or seedlings will expedite salt marsh establishment once appropriate conditions are achieved through other techniques (Allen and Hardy 1980). If strategies to raise marsh elevations are not successful, some additional portions of the impounded wetland complex may convert to open water due to subsidence, peat collapse, and low accretion rates, resulting in open water where there had previously been stands of freshwater wetland vegetation (Smith et al. 2009, Pearsall and Poulter 2005, Weinstein et al. 2000, Portnoy and Giblin 1997, DeLuane et al. 1994).

The active salt marsh restoration strategies proposed in alternative B involve manipulations that may have short-term adverse impacts on vegetation. For example, the application of supplemental sediment within the impounded wetlands may temporarily cover emerging vegetation. If living shoreline structures are placed in the wetlands, or if internal or temporary dikes are necessary to create restoration cells, construction equipment may disturb beach grass or wetland vegetation and the dikes themselves may temporarily displace some existing vegetation. These adverse impacts would be very site-specific, relative to the size of the entire impounded wetland complex (ACOE 1996). In addition, an increase in wetland salinity through salt marsh restoration could stress forested wetlands adjacent to the impounded wetland complex, which are not adapted for saline conditions.

Through monitoring soil and water salinities and practicing intensive water level manipulations during the growing season, management of brackish impounded wetlands proposed in alternative B can produce stands of salt marsh bulrush *(Schoenoplectus robustus)* in some areas of the wetland complex. Maintaining salinity ranges at 10 to 20 ppt within impounded marshes and conducting appropriate drawdowns can encourage the production of dwarf spikegrass *(Eleocharis parvula)*, widgeongrass *(Ruppia maritima)*, and sea purslane *(Sesivium maritima)*. Periods of maximum drawdown and re-flood can also be coordinated with spring and neap tide cycles to maximize saltmeadow cordgrass in salt marsh restoration areas. Salinity management can also enhance habitat conditions used to control undesirable vegetation, i.e., invasive plants, but trade-offs may exist between controlling undesirable vegetation and promoting desirable waterfowl food plants. Such management must be carefully implemented to avoid developing hypersaline (greater than 50 ppt) conditions in marsh soils. Hypersaline soil conditions that persist during the summer will have moderate and potentially long-term adverse impacts on vegetation. Vegetative growth will be curtailed or not occur at all, or no annual recruitment of desirable wetland plants will be possible. This adverse impact can be mitigated through careful water level management strategies.

Public Use

The indirect beneficial impact on vegetation from expanded public use opportunities include staff and visitors' increased and enhanced awareness, appreciation, and protection of native plant communities, particularly those that contain high value for habitat, cover, or food resources. Another indirect benefit to vegetation from the refuge hunt programs is the increased potential to partner with hunting organizations that would assist in wildlife habitat enhancements projects such as seeking grants or donations for planting native trees, assisting in herbicide applications for controlling invasive plants, and restoring moist-soil impoundments.

We expect trampling of vegetation to increase due to proposed expansions in public use activities, including fishing, hunting, wildlife observation, wildlife photography, and environmental education and interpretation. However, impacts are expected to be negligible because visitor access is limited to designated areas and for reasons previously highlighted under actions that would not vary by alternative. Expanded hunting opportunities for deer, waterfowl, turkey, and upland game will cause a minor level of increased trampling and disturbance of terrestrial and aquatic vegetation. Given the large expanse of both upland and wetland acreage, anticipated dispersal of hunters across hunting areas, the inherent nature of hunters to only travel as far as needed to find a hunting location, and knowing that most vegetative species will have already undergone senescence or become dormant, the impacts to vegetation are expected to be negligible from hunting.

Furthermore, salt marsh habitats were found to be the most resistant to human trampling when compared to other habitats such as a natural dune, a man-made dune, and man-made coastal grasslands (Anderson 1995). This study analyzed the vegetation of five paths (one in each of the habitats) created and sustained by human trampling and reported that trampling of vegetation (estimated to be 1,815-3,630 passages per year) can be considered as very light. Even though it created paths and reduced vegetation cover and species diversity, the paths still retained a persistent vegetation (Anderson 1995). We predict that far fewer than 1,800 will free roam hunt in refuge salt marsh habitats, and therefore predict that the impact from the trampling of vegetation would be considered very light and consistent with the findings reported in Anderson (1995). Free roam areas for deer and waterfowl hunting opportunities will provide hunters greater access and increase the potential for vegetation trampling, particularly around blind sites in the Unit III impoundment. The possibility for new trails to be developed from repeated hunter entry will likely occur, especially in marshes where hunters will seek paths providing easiest access. Even using inflated and unlikely estimates of free roam use in refuge salt marsh habitats for deer and waterfowl hunting, the impact from the trampling of vegetation would be considered very light and consistent with the findings reported in Anderson (1995) and discussed earlier in “Impacts on Vegetation That Would Not Vary by Alternative.” The numbers of hunters that would be on the refuge at any time is not unlimited; we would only issue five or fewer turkey hunting permits, and the number of deer hunters that can free roam at any time would be limited by the capacity of the 13 parking areas found on or near the refuge that total approximately 72 vehicle spaces. Expanded fishing opportunities, particularly to Goose and Flaxhole Ponds, will create only negligible disturbance to vegetation because visitors will be required to remain on designated trail routes and established interior roads.

We expect negligible impacts from the construction of expanded facilities for environmental education and other visitor services programs. We will employ silt fencing and other best management practices during construction of any facilities in proximity of wetlands to avoid runoff of sediments. Negligible disturbance to vegetation is expected during the construction of new parking areas on Fowler Beach Road, Slaughter Beach Road, and Broadkill Beach Road to facilitate hunting and wildlife observation/photography activities because existing interior roads and access routes will be used. Negligible disturbance to vegetation is expected on proposed trails in these areas north and south of Fowler Beach Road, south of Broadkill Beach Road, on proposed extensions of the Blue Goose Trail, Deep Branch Road, and off of Slaughter Beach Road. Negligible disturbance to vegetation is expected for the proposed trail to the wheelchair-accessible photography blind. Negligible to minor impacts to vegetation are expected if removal of a few trees is necessary to reclaim an existing interior road and hunter access trail off of Slaughter Beach Road for use as a hiking trail. Similar impacts are expected if the construction of a new section of boardwalk is needed for the trail on the southside of Broadkill Beach Road, which may be rerouted and the existing boardwalk removed.

The direct, site-specific impact of new trails has the potential for increasing edge effects on adjacent vegetation communities, which provides inroads for invasive species to colonize. These effects depend upon the type of habitat, the type and placement of trail, and the amount of canopy. A narrow earthen or woodchip path through a closed-canopy forest is not likely to fragment or produce edge effects in such an upland forest environment. But a wide path mowed through a managed early successional area could fragment the habitat. Placing trails with care, such as utilizing existing interior roads, can avoid most adverse impacts. Quantifying the impacts on vegetation from trails depends exactly on their location, length, width, and type (gravel, dirt, wood chip, and boardwalk).

The phasing out and elimination of more than 130 deer hunting stands and waterfowl hunting blinds will remove disturbance to impacted vegetation and soils and alter the aesthetic view of the landscape for refuge visitors

Beach public use will also impact beach and dune vegetation. Vaske et al. (1992) reported that results from vegetation studies on beaches revealed that human traffic and off-road vehicle use were having adverse impacts on dunes and sandy beach habitats. Where people accessed dunes, vegetation cover and dune height were significantly lower than areas not used by visitors. Vegetation cover averaged 45 percent lower at disturbed sites than undisturbed sites. Dune damage was reported greatest when caused by off-road vehicles, next by human foot traffic (20 percent more cover), and least by deer (40 percent more plant cover) (Vaske et al. 1992). To minimize some of these adverse impacts, off-road vehicle traffic is not allowed on refuge.

Conclusion for Management Actions in Alternative B

Management actions under alternative B would have long-term moderate-to-major impacts and short-term negligible-to-minor impacts on refuge vegetation. No impairments of the refuge's BIDEH are expected. Through the restoration of freshwater impounded wetlands to salt marsh, the refuge may be giving up diversity at the local scale but providing diversity and biological integrity at the landscape and regional levels, and enabling coastal vegetation communities to naturally adapt to climate change and sea level rise.

This restoration will result in moderate-to-major long-term wetland vegetation changes, causing only negligible or minor short-term impacts in the process. Given the dynamic nature of the coastal system encompassing the refuge, the conversion prescribed by alternative B of vegetation communities from artificially managed freshwater vegetation to restored natural salt marsh is the most responsible and self-sustaining strategy for the refuge.

Upland management actions would restore and conserve native vegetation and create contiguous forest blocks by connecting currently fragmented forested parcels throughout much of the refuge with long-term impacts on upland vegetation communities, primarily forests.

Public use management actions would have negligible to minor adverse impacts on ecological processes and biological productivity would not be affected.

Impacts on Vegetation in Alternative C

Cooperative farming under alternative A involves the use, as approved, of glyphosate-tolerant corn and soybeans. The repeated use of glyphosate can be associated with the development of glyphosate resistance in weeds. This was first documented in horseweed in Delaware (VanGessel 2001). Overall, this poses only a negligible impact to native vegetation communities. Implementation of cooperative farming displaces native herbaceous, shrubby, or forested vegetation communities that would otherwise grow in the farmed fields.

Management of freshwater impoundments as described under alternative A would perpetuate freshwater vegetation wetland communities, provided the prescribed water levels can be reasonably achieved. Water level management impacts the production of annual and perennial vegetation within an impoundment based on the timing and frequency of drawdowns and reflooding schedules during the growing and non-growing seasons. However, if the prescribed salinity range (0 to 10 ppt) of impounded soils and water regimes cannot be maintained from April through the end of August, then freshwater moist-soil plant communities will not thrive. If the freshwater vegetation communities are impacted in a recurring manner, the impact could be a major long-term hindrance of freshwater vegetation in refuge impoundments, in spite of any impoundment management efforts. This moderate-to-major impact on freshwater vegetation in the long-term is likely, given the increasing rates of overwash and breaching along the Delaware Bay along Unit II. It is unclear whether an intact barrier island can be achieved,or how frequently it may be overwashed or breached in the future, given the long-standing history of shoreline migration at the refuge and the projections for increased storm intensity and climate change. Since a single breach or large overwash event could introduce sufficient salt water to kill much of the freshwater vegetation, the long-term sustainability of the fresh water marshes is uncertain, at best. Absent a very substantial and robust artificial barrier island and dune system north of the Prime Hook Community, and a low incidence of coastal storms washing saltwater through the low-lying community itself, it is unlikely that measures to maintain freshwater marshes in Units II and III will be fully successful over time.

Water level management and the timing of drawdowns in moist-soil management, when used, would have specific impacts on the composition and production of freshwater vegetation and moist-soil plants. For example, an early drawdown has been shown to produce more red-root flat sedge in highly organic soils, whereas later drawdowns produce more Walter’s millet. In mineral soils, early drawdowns would result in more smartweed species, whereas later drawdowns would result in more barnyard millet. The preferred method of a slow drawdown regime would create conditions favorable for moist-soil plant germination and establishment. For example, slow drawdowns on experimental plots result in seed yields of 700 pounds per acre, whereas fast drawdowns on similar units resulted in yields of only 50 pounds per acre (Fredrickson 1991). Other factors besides management technique, such as seed banks, soil types, soil temperatures, soil moisture levels, soil and water salinities, day length, and residual herbicides would also influence the composition and abundance of developing vegetation.

Proposed expansions in hunting opportunities are expected to cause more impacts to vegetation in alternative C than those outlined in alternative A, but less than alternative B. All other types of recreation will have fewer impacts than those in alternative A. Impacts are expected to be negligible as discussed under alternatives A & B.

Conclusions for Management Actions in Alternative C
Most management actions in alternative C will continue to have a baseline level of local short-term moderate impacts and local long-term minor-to-major impacts on vegetation communities. In upland habitats, current management actions will continue to promote native vegetation communities, except in fields enrolled in cooperative farming. Most direct impacts resulting from vegetation control and management actions will be temporary. Impacts on native vegetation in managed agricultural fields will be long-term, adverse, and moderate. In the impoundments, while retention of productive freshwater marshes with low amounts of invasive Phragmites would be considered of positive benefit on freshwater vegetation species, moist-soil management techniques are premised on maintaining freshwater conditions (0 to 0.5 ppt) or very low brackish conditions (5 to 10 ppt) that are needed to annually produce freshwater vegetation communities dominated by wild millet, sprangletop, panicgrasses, and smartweeds. Thus, failing impoundment infrastructure and more frequent and severe annual coastal storms are having and will continue to have moderate impacts on refuge vegetation with changes in the abundance, distribution, and composition of wetland vegetation, as freshwater wetlands remain difficult to consistently manage and sustain. Thus, a more likely outcome under Alternative C is that there will be continued and increasing incidents of salt water intrusion, resulting in partial or total loss of freshwater vegetation. Without effective restoration of conditions suitable for salt marsh survival, the impoundments are most likely to convert to open water which is why it is predicted that the long term impacts on vegetation in the impoundments would be major and adverse.

Impacts on Federal and State Endangered Species

We evaluated the proposed habitat management actions and strategies of all alternatives for their potential to affect, beneficially or adversely, the habitats required for population of Delmarva fox squirrel, where breeding, wintering, or migrating bald eagles concentrate, and for restoring numbers of state-listed endangered species. Our proposed management actions include conservation actions targeting Federal and State endangered species, such as reducing forest fragmentation and managing of beach habitats to reduce predation and disturbance to beach nesting birds. Habitat management actions focus on minimizing impacts and maintaining or enhancing barrier island habitats and sandy beach areas to aid in recovery of the federally threatened piping plover, benefit migrating red knots, and promote the recovery of other State endangered shorebird species.

Impacts on Endangered Species That Would Not Vary by alternative

Managing and Protecting Habitat and Public Use
The geographic distribution of treatments and quantities of pesticides used during invasive plant and mosquito control varies from year to year. This requires that the refuge identify potential impacts to federally endangered species in a section 7 interagency endangered species consultation as an integral part of the Service’s annual pesticide use proposal program.

Disturbance factors resulting from public use are always considered for all listed species. The Delmarva fox squirrel and piping plover are listed as endangered and threatened by the Service and the red knot was designated as a candidate species in 2006 for possible listing. Several other species listed as endangered by the Delaware Division of Fish and Wildlife include American oystercatcher, common tern, Forster’s tern, least tern, and bald eagle. Of these, the piping plover, red knot, American oystercatcher, common tern, Forster’s tern, and least tern will not be impacted by hunting because they would be unlikely to use the refuge’s forested habitats and their occurrence on the refuge is outside of the hunting season for deer, upland game, and waterfowl. Impacts on piping plover, red knots, American oystercatcher, common tern, Forster’s tern, and least tern will be minimized through the seasonal closure of designated beach dunes and overwash areas from March 1 through September 1 to all visitors. A section 7 evaluation has been conducted as part of this review, and it was determined that proposed activities in any alternative would not likely affect Delmarva fox squirrel or piping plover. Furthermore, the hunting of any squirrel species is prohibited on the refuge to further minimize impacts to this endangered species.

While the bald eagle is no longer a federally listed species, the refuge uses the national bald eagle management guidelines for bald eagle management to implement time-of-year restrictions for nesting eagles. The guidelines do not permit any activity within 330 feet of an active nest during the breeding season, particularly where eagles are unaccustomed to such activity (U.S. Fish and Wildlife Service 2007c).

Fishing, hunting, and wildlife observation and photography on or near Turkle Pond were existing activities prior to nesting by bald eagles on adjacent Horse Island. When bald eagles were listed as endangered, the section 7 evaluation conducted on the refuge concluded that these activities in Turkle Pond would not likely affect this species and the uses were permitted. We will monitor use in Turkle Pond to determine if there is an impact on the eagle nest on Horse Island, which is currently abandoned.

We have consolidated the placement of the majority of trails to one area (headquarters area) and tried to incorporate the edges of forest, grasslands, and wetlands to reduce fragmentation of large blocks of habitat. This maintains less-disturbed areas for species sensitive to fragmentation. Establishing permanent trails helps to reduce disturbance by pedestrians to wildlife on the refuge, including the Delmarva fox squirrel. Because animals show greater flight response to humans moving unpredictably than humans following a distinct path permanent trail establishment helps to mitigate some of the adverse effects of human disturbance (Gabrielsen and Smith 1995).

Impacts on Endangered Species in Alternative A

Impacts on threatened and endangered under Alternative A (“No Action”) serve as a baseline for comparing and contrasting Alternatives B and C to the refuge’s existing management activities.

The primary feature of alternative A is passive habitat management in both refuge upland and wetland habitats. The passive conversion of open areas and old fields to revert to forest will have considerable benefits for Delmarva fox squirrels, bald eagles, and other State-listed species dependent on the same forest habitat requirements, although desired forest conditions may not be achieved as readily or as quickly than with active reforestation and forest management.

The unimpeded return of tidal flow throughout the wetland complex, will permit natural overwash processes which has the potential to create new suitable habitat for the piping plover and red knots. In the absence of proactive restoration, more of the refuge’s impounded wetland complex will convert to open water, possibly limiting habitat for state or federally listed shorebird species.

Under projected climate change scenarios the Delaware Bay is predicted to lose 60 percent or more of intertidal feeding habitats used by both breeding and migrating shorebirds by 2100 (Galbraith et al. 2002), and the refuge specifically is predicted to experience substantial loss (Scarborough 2009). Shorebird species of state or federal concern, such as piping plovers and red knots, that are dependent on coastal dunes, sandy beach and intertidal flats may experience additional adverse impacts and threats to survival and reproductive success.

Conclusions for Management Actions in Alternative A
Management actions in alternative A would result in short-term local minor beneficial impacts and would also have local minor-to-moderate adverse impacts. No impairment of the refuge's BIDEH is expected unless the impounded areas revert to open water. The loss of marsh to open water would have a negative effect on diversity and biological integrity.

Impacts on Endangered Species in Alternative B

Managing and Protecting Habitat and Public Use
With more intensive forest management than in alternative A (mechanical thinning, prescribed fire, and other stand improvement techniques) and the conversion of open fields to mixed hardwood forest through proactive reforestation projects, there will be considerable benefits for Delmarva fox squirrels, bald eagles, and other State-listed species dependent on the same forest habitat requirements. Performing forest management on refuge complex lands would be instrumental in addressing the following Delmarva fox squirrel recovery tasks, identified in the recovery plan (Moncrief et al. 1993): (4.1) determine effects of timber management and other land use practices on the DFS; (4.2) develop and refine guidelines for prescriptive habitat management for the DFS; (4.3) develop and implement guidelines for habitat management on public lands occupied by the DFS; and (4.4) monitor the outcome of prescriptive habitat management.

Whiteman and Onken (1994) suggest that the enhancement of Delmarva fox squirrel habitat can be accomplished primarily through silviculture. Because a combination of forest management techniques would be implemented as determined to be necessary for forest health, a combination of the associated impacts would result. Hardwood mast production will be maximized in refuge forests and a sparse understory will be maintained by promoting large crown development of mast producers in the overstory. The rate at which immature stands reach the desired conditions for Delmarva fox squirrel will be expedited by identifying potential hard and soft mast crop trees and performing a light thinning around these trees to encourage crown development. Performing regeneration harvests in some of the mature and over-mature stands throughout the refuge will reduce the potential for forested habitats to become stagnant. The selective removal of dominant and co-dominant canopy trees that are nearing the end of their life will allow necessary light to reach the forest floor to facilitate seed germination and free up additional resources to enhance the growth of new regeneration. The planting of oak or other hard mast producing species may be required in openings created through forest management in order to ensure their replacement and continued occupancy of the stand, which might otherwise be dominated by pine, red maple, and sweetgum.

Small clearcuts surrounded by forest are not likely to cause problems for Delmarva fox squirrel. Paglione (1996) and Bocetti and Pattee (2003) noted that Delmarva fox squirrel shifted their home ranges away from the timber harvested sites and into adjacent forest with no observable negative effects. It appears that Delmarva fox squirrel respond to 30 to 40 acre timber harvests by shifting into adjacent habitat if it is available. Larger clearcuts may cause problems when they are more isolated and cause Delmarva fox squirrel to move greater distances to find new habitat. Commercial thinning of timber stands that are 25 years old or less are not likely to cause problems for Delmarva fox squirrel because timber stands of this age are not considered their habitat. Even though Delmarva fox squirrel may move through these stands at times, the removal of understory or portions of the stand are not considered to reduce its suitability as corridor or area occasionally used.

Tree selection techniques would focus on healthy trees with well-formed crowns and should include species from both the red and white oak groups along with beech and pine. The crop tree species diversity would promote a more consistent mast crop. Creating openings in the canopy will not only enhance natural regeneration but will also enhance growth and mast production of remaining trees, much like a crop tree release. The perpetuation of the stand through promoting regeneration and the associated improvements in mast production will have significant long-term benefits for Delmarva fox squirrel. Future implementation of timber stand improvement techniques will ensure the species composition of these stands is not significantly altered.

In summary, performing simple forest management practices will enhance the quality and quantity of the existing Delmarva fox squirrel habitat.

Prescribed burning, which would be used throughout all forest cover types and age classes as a form of timber stand improvement, would aid in creating and maintaining open understory conditions favored by Delmarva fox squirrel, and promoting habitat diversity and food availability (Weigl et al. 1989). Carefully performed prescribed burning on the refuge will benefit the endangered Delmarva fox squirrel by enhancing habitat and reducing hazardous fuel buildup. Prescribed burning in woodlands would aid in creating and maintaining open understory conditions favored by Delmarva fox squirrel, and promoting habitat diversity and food availability. In contrast to the gray squirrel *(Sciurus carolinensis)*, the Delmarva fox squirrel often travels on the ground (Moncrief et al. 1993) and has been shown to prefer mature forests with a minimum of underbrush (Moncrief et al. 1993), closed canopies, open understories, and a high proportion of forest edge (Dueser et al. 1988). Authors have suggested that habitat for Delmarva fox squirrel in general may be improved by leaving mature and large-crowned trees in managed forests, encouraging nut-bearing trees, and opening up the forest understory by burning or light grazing (Chapman, et al. 1982). Fox squirrels have been found to prefer sites where understory closure is 30 percent or less (Allen 1982).

Protecting, retaining, and enhancing super canopy trees and not removing large standing and downed snags and dead wood, or any tree used by nesting bald eagles, will also benefit many State and federally listed species. Protecting all active and historic nest sites and areas and also partially constructed nest trees with 330-foot no buffer zones during critical life cycle stages will also be highly beneficial for endangered species. Improving stand condition of roosting and breeding forested areas on the upland islands (Oak Island, First Hill, Second Hill, Negro Island, and Horse Island), which serves as the core bald eagle management area will also benefit other State-listed bird species.

Conservation and enhancement of washover and ephemeral inlet areas, mudflats, sandflats, wrack lines, and shorelines of coastal ponds, lagoons, or salt marshes will maximize annual survival and production for breeding and migrating piping plovers and migrating red knots. Loss and degradation of barrier island habitats due to extensive development on the East Coast and shoreline stabilization have been major contributors to both species declines. Refuge management strategies aimed at the restoration of natural processes on the barrier island ecosystem are likely to have the greatest long-term benefits for piping plovers, red knots and other rare shorebird species by correcting and mitigating for past adverse habitat practices (USFWS 1996, USGS 2005, USFWS 2007).

If not prevented or minimized through management, human disturbance can be a notable factor in plover nesting success. Seasonal beach closures on the refuge will minimize impacts from disturbance. Dogs also are a disturbance factor for piping plovers, because they may chase adults, kill chicks, and eat eggs. Prohibiting dog use on the refuge reduces or eliminates the adverse impact from dogs.

With the restoration of salt marsh in Unit II, natural overwash processes will be permitted to occur unimpeded. This has the potential to create new suitable habitat for the piping plover and red knots. Melvin 1991 stated that natural beach and overwash processes should be encouraged. The deposition of dredged material on beaches can substantially improve quality and availability of plover habitat (USFWS 1996, Melvin 1991). This type of beach nourishment is considered beneficial in the short-term when the beach is severely eroded (USFWS 1996). It is unlikely that the restoration of the salt marsh would have a significant adverse impact to piping plover or red knots.

However, the placement of dredge material on beaches may adversely affect plover habitat if the substrate is not suitable and the timing of disposal is inappropriate. If sediment quality standards and time of year restrictions (mid-August to mid-March) are utilized, they can minimize any adverse impacts. Direct impacts associated with salt marsh restoration would include short-term, local disruption of individuals during construction activities. Construction activities would be scheduled at times to avoid impacts as much as possible.

The impacts of public use on Federal and State-listed species would be the same as described above in Impacts on Federal and State-Listed Species That Would Not Vary by Alternative.

Conclusions for Management Actions in Alternative B

Management actions in alternative B would result in short-term local moderate beneficial impacts and it would also have local short-term minor-to-moderate adverse impacts. No impairment of the refuge's BIDEH is expected.

Impacts on Endangered Species in Alternative C

Managing and Protecting Habitat

The impacts on federal and state listed species would be the same as described above in impacts on Federal and State-listed Species That Would Not Vary by Alternative.

Public Use

The impacts on Federal and State-listed species would be the same as described above in Impacts on Federal and State Listed Species That Would Not Vary by Alternative.

Conclusions for Management Actions in Alternative C

Management actions in alternative C would result in short-term local minor beneficial impacts and have local short-term minor-to-moderate adverse impacts. No impairment of the refuge's BIDEH is expected.

Impacts on Waterfowl

Focal waterfowl species include:

Northern pintail
American black duck
Fall migrating and wintering dabbling ducks
Spring migrating dabbling ducks
Snow geese

Wetland conservation and management is the highest priority of the refuge, consistent with the original establishment purposes for migratory birds. It is our utmost conservation priority because wetlands constitute close to 80 percent of our refuge land base and support Service trust species, such as migratory birds that include waterfowl, shorebirds, secretive marsh birds, waterbirds, and passerines species, as well as anadromous and interjurisdictional fish and the habitats on which these trust species depend.

We evaluated the management actions for each of the CCP alternatives for their potential to benefit or adversely impact all of the various wetland communities on the refuge that provide habitat for waterfowl:

- Restoring impounded wetland areas to a tidal salt marsh community
- Restoring prior-converted wetlands that were farmed to moist-soil units
- Reducing numbers of snow geese to meet Service population goals across state and flyway landscapes and mitigate negative impacts of heavy herbivory on refuge marshes
- Establishing or increasing the width and extent of vegetated buffers (preferably trees) around wetlands
- Managing to prevent the expansion or proliferation of invasive plant species
- Maximizing annual native plant production, conserving and protecting insect and other invertebrate food resources for waterfowl
- Regulating hunting pressure on waterfowl
- Access by visitors and other users that might impact wetland habitats or disturb migrating waterfowl
- Mitigating mosquito control treatments that might reduce food resources for waterfowl

Impacts on Waterfowl That Would Not Vary by Alternative

Managing and Protecting Habitat
Across all of the alternatives, controlling invasive plant species, particularly *Phragmites*, is an important management activity conducted in refuge wetland habitats. Migrating and wintering dabbling ducks and Canada geese would experience direct benefits from the reclamation of *Phragmites* areas that quickly revert to native plant foods (spikerushes, millet, smartweeds, and grasses). Since these native plants are also associated with specific native insect community assemblages that do not exist in *Phragmites*' stands, invertebrates would provide additional food sources that supplement waterfowl plant foods. Because we spray *Phragmites* from mid-August to the end of September, fall migrating and wintering waterfowl would mostly avoid any impacts from disturbance. By that time, blue-winged teal, the earliest fall migrant waterfowl species, are just starting to arrive. The herbicides and surfactants approved for wetland use are not toxic to birds, fish, or invertebrates. Therefore, even if birds do get wet, it would only be a temporary impact.

Forested buffers surrounding refuge wetlands also provide indirect benefits by preventing the marshlands from receiving elevated levels of pesticides and pesticide residuals, nutrients, or solids from run-off from off-refuge sources that negatively impact the quality of feeding habitats for waterfowl.

Adverse short-term, long-term, and indirect impacts to waterfowl results from gradual or rapid acreage losses of freshwater wetland communities, especially emergent and swamp cover types, resulting from salt water intrusion that is very likely to occur under all alternatives because of changing coastal conditions, increased storm activity and sea level rise.

Mosquito Management
Across all alternatives, chemical mosquito control will be conducted on refuge wetland and beach strand habitats. With the exception of chironomids, which may suffer direct mortality, Bti or methoprene larvicides may have negligible to minor indirect adverse impacts on non-target wildlife, including waterfowl.

Insects are an important component in the diet of migrating and wintering waterfowl. Forty-three percent of all ducks and geese are primary insectivores and 54 percent are partially insectivorous (Losey and Vaughan 2006). During the breeding season, insectivory can be especially important to adult ducks as well as ducklings (Reinecke 1979; Reinecke and Owen 1980). Waterfowl species breeding in refuge wetland habitats, such as black ducks and mallards, consume insect species, such as dragonfly and chironomid larvae, which may be directly or indirectly impacted by pesticides use to control mosquitoes at that time of the year.

To the extent that refuge waterfowl consume non-target aquatic and terrestrial invertebrates, waterfowl may be adversely impacted by mosquito control under all three alternatives. The degree to which adulticides and larvicides will impact waterfowl food resources will likely vary by time, location, chemical used, concentration, treatment interval and number of treatments. The ability of waterfowl to move to alternate feeding sites or shift their diet within the treatment site to alternative food resources is unknown. Site-specific direct and indirect adverse impacts from mosquito control to the local waterfowl populations are unknown. To the extent that refuge waterfowl feed on or are dependent on target species, such as mosquitoes and mosquito larvae as a food resource, is likely to be more pronounced unless the birds are able to shift food preferences within a treatment site, or move to alternative feeding sites (Krapu 1974, Reinecke and Owen 1980, Reinecke 1979, Swanson et al. 1974, WMH 1995, Kaminski and Prince 1981).

Administration and Public Use
Since the refuge consists of 80 percent wetlands, all recreational activity has the potential of impacting waterfowl feeding or resting near the refuge's hunting area(s). Conflicts arise when migratory birds and humans are present in the same areas (Boyle and Samson 1985). Response of wildlife to human activities includes departure from site (Owen 1973, Burger 1981, Korschgen et al. 1985, Henson and Grant 1991, Kahl 1991, Klein 1993), use of suboptimal habitat (Erwin 1980, Williams and Forbes 1980), altered behavior (Burger 1981, Korschen et al. 1985, Morton et al. 1989, Ward and Stehn 1989, Havera et al. 1992, Klein 1993), and increased in energy expenditure (Morton et al. 1989, Belanger and Bedard 1990). McNeil et al. (1992) found that many waterfowl species avoid disturbance by feeding at night instead of during the day.

During the period of September 1 to March 15, which is when most wintering and migrating waterfowl are on the refuge, adverse impacts to these birds could result from unregulated human disturbance in optimum waterfowl habitats at the refuge. This conclusion is based on the role of disturbance as it relates to waterfowl life history requirements and behaviors such as feeding, flight, metabolic processes, molting, preening, and resting. These daily waterfowl maintenance activities are costly from an energetic standpoint and require that waterfowl have undisturbed access to quality habitats with diverse food resources to meet their daily and seasonal energy requirements. Since these activities are critical to the survival of waterfowl, a discussion of their behaviors and metabolic processes is appropriate.

Feeding: Waterfowl have complex feeding strategies, which are conducted at optimum levels only in an environment void of disturbance. Feeding is the only activity that provides energy to birds, and the amount of time allocated to feeding is dependent upon relationships between energy-nutrient requirements and foraging strategies used in meeting these needs (King 1974). Feeding on readily available and easily consumed foods requires less time than feeding on dispersed resources or foods that require searching, e.g., mobile invertebrates or complex foraging behavior, e.g., underground tubers (Rapport 1980).

Generally, feeding periods for wintering waterfowl are early morning and late evening. Morton et al. (1989) found that American black ducks *(Anas rubripes)* spent an average of 4.49 hours per day feeding, with the majority of feeding activity occurring either during the first three hours after daylight, or the last three hours of the day, the remainder of the day was spent engaging in resting (4.54 hours), swimming (1.83 hours), or several other maintenance activities (balance of the day). This suggests that waterfowl, when undisturbed, prefer to feed early and late, while spending the remainder of the day in maintenance activities such as resting, preening, or courtship.

Mallards *(Anas platyrhynchos)* generally do not feed in water deeper than 40 cm (Thomas 1976) but prefer to feed in water depths of 10 cm or less (Fredrickson and Taylor 1982), which is indicative of the habitat provided in the refuge's managed impoundment complex. Unregulated access in these provided habitats could adversely impact the feeding strategies of waterfowl using the refuge.

Flight: Many research projects have been conducted on the basic energy requirements of waterfowl, and these projects emphasize the importance of readily available food resources. As birds arrive in Delaware during fall migration, they need areas to rest and feed to replenish energy reserves. It is important to recognize that approximately 90 percent of the migration period is spent in a stationary mode at successive stopover sites (Hedenstrom and Alerstam 1998). Birds at stopover sites spend their time resting and foraging as they rebuild protein and energy stores in preparation for their next migratory flight (McWilliams et al. 2004). It is also important to recognize that flight is a very expensive activity from a metabolic perspective and forcing birds into flight creates the need to replace lost energy reserves that could have been used for other activities. Protection is needed to allow waterfowl the opportunity to forage and replenish energy reserves depleted during migration and avoid the energetic costs associated with being forced into unnecessary flight.

Metabolic processes: Along with rebuilding protein and energy stores, and in addition to flight, there exist basic energy maintenance requirements of birds. These daily requirements, which include the energy costs of thermoregulation, maintenance of basal metabolic rate, and other activities, combine to account for 40 to 60 percent of a bird's annual energy budget (Walsberg 1983). Without reliable access to high quality food resources, waterfowl must either migrate to better habitats or suffer reduced fat reserves, which can result in below-optimum body condition. As an illustration of the food resources required to maintain body condition, Magee (1996) found that, in waterfowl, the energetic cost of flight for one hour would require enough foraging effort to consume 19.6 grams of corn (75 kernels) or 117.8 grams of amphipods (6,250 individuals) to replace lost energy reserves. From the standpoint of how fat deposition relates to reproductive potential, Heitmeyer (1985) discovered that hen mallards in the Mingo Basin of Missouri needed to reach a minimum weight threshold of 1360 grams (greater than 3 pounds) when they left the wintering grounds to ensure there would be adequate fat reserves to initiate nesting activities upon arrival at the breeding grounds. At Chincoteague NWR, Morton et al. (1989) found that wintering black ducks experienced reduced energy intake while doubling energy expenditure by increasing the time spent in locomotion in response to disturbance. Black ducks consumed 10.4 times more energy in flight than at rest, and 1.8 times more energy in alert behavior or swimming than at rest, suggesting that human disturbance of wintering black ducks impaired their physiological condition, thereby reducing winter survival and/or nutrient reserves carried to the breeding grounds. During migration stopovers, waterfowl must be afforded the time and opportunity to forage in high quality habitat to attain the desired body mass and fat deposits, and replace lost energy reserves. To meet these metabolic demands, waterfowl rely on many Federal, State, and private wetlands, including Prime Hook NWR, to rest, feed, and reacquire lost fatty deposits.

Molting: Feather molts are very costly from a metabolic standpoint waterfowl convert from the alternate (summer) plumage to their basic (breeding) plumage and most feathers are replaced during this period when birds are preparing for courtship rituals and pair bonding. Heitmeyer (1985) describes the prebasic molt of female mallards as extensive and intense, requiring a substantial amount of energy reserves to complete, as these birds replace approximately 50 grams of feathers in a 6 to 7 week period. This increase in nutrient demand translates to the need for individual mallards to be afforded the opportunity for undisturbed foraging. Excess disturbance may negatively impact the ability of waterfowl to secure nutrients, thus disrupting molting processes and associated reproductive strategies.

Preening: Maintenance of feathers by preening has been previously correlated to molt activity and is undoubtedly influenced by molt chronology. Male mallards preen most often during autumn; preening declines throughout early winter, which corresponds with declining molt activity (Combs 1987). Adverse impacts to preening activities would be similar to those associated with the molting process.

Resting: Resting appears to be a complementary activity to feeding, molting, and preening. As feeding declines from morning to afternoon, resting increases, which is necessary to allow birds to digest food consumed during previous periods of feeding (Paulus 1984b, Clark et al. 1986), and rejuvenate muscle fibers that may have been damaged during periods of flight (McWilliams et al. 2004). The inability of waterfowl to rest may have a direct negative impact on the ability of waterfowl to digest foods and repair muscle fibers, thus impacting other necessary life history behaviors.

As discussed in the previous section, wintering waterfowl need access to areas that are free from human interruption to complete seasonal and annual life cycle events. These interruptions can be characterized as disturbance, which causes an animal to deviate from behavior patterns that normally transpire without human influence. To explain further, a disturbance stimulus is produced when a human-related presence or object, e.g., birdwatcher, motorized vehicle, or sound, e.g., seismic blast or gunshot, occurs that causes changes to the natural behavioral patterns of animals (Frid and Dill, 2002). Activities such as hiking, photography, jogging, hunting, fishing, boating, research and management activities, bicycling, and driving are among many types of disturbance that can and do occur on any national wildlife refuge. Because a disturbance-free sanctuary is critical to waterfowl during the period of September 1 to March 15, it is important to understand that if unimpeded access is allowed, the ability of the Prime Hook NWR sanctuary to meet the needs of waterfowl may be reduced. The following sections discuss the values and functions of waterfowl sanctuaries and illustrate the impacts of disturbance on the ability of waterfowl to utilize habitat.

Disturbance is a primary factor influencing avoidance behaviors in waterfowl (Paulus 1984b, Heitmeyer 1985, Austin 1987) as ducks and geese are highly sensitive to motor traffic and human disturbance (walking, bird viewing, vehicular traffic) along roads during fall and winter (Bartelt 1987, Belanger and Bedard 1989 and 1990, Bowles 1995, Dalhgren and Korschgen 1992, Gabrielson and Smith 1995, Heitmeyer 1985, Klein 1989, Knight and Cole 1991 and 1995, Madsen 1985, Van Der Zande et al. 1980, Raasch 1996). When waterfowl are in areas adjacent to roads, they reduce time spent foraging and spend more time alert and vigilant to disturbance. For instance, a research study examining disturbance effects conducted on Mingo NWR in southeastern Missouri showed that mallards became alert at a mean distance of 213 m (698 ft) and flew from the site at a mean distance of 173 m (568 ft) in response to vehicle disturbance (Raasch 1996). In another study in Virginia, Pease et al. (2005) described the responses of seven species of dabbling ducks to six different forms of disturbance and recorded whether the birds had no response, alert, swam, and flew. Analysis of the data from Virginia showed that 74.2 percent of birds responded (alert, swam, or flew) when birds were within 200 meters (656 feet) of a human caused disturbance. As a result, when birds exhibit avoidance behaviors, swimming and flying activities increase while resting and feeding activities decrease (Combs 1987), which creates the need for additional foraging effort, which in turn influences seasonal movements and habitat selection. Areas void of regulations can cause increased human-wildlife interactions that can negatively impact the life history behaviors and metabolic processes of migratory waterfowl.

Laskowski et al. (1993) studied behavior of snowy egrets, female mallards, and greater yellowlegs on Back Bay National Wildlife Refuge in Virginia within 91.4 meters of impoundment dikes used by the general public. Behavior of snowy egrets was recorded during August and September. Mallards were monitored during migration in November and January. Greater yellowlegs behavior was observed during the northward shorebird migration. Behavior was monitored during the typical public activities of walking, bicycling, and driving a vehicle past the sample sites.

The study found that snowy egret resting behavior decreased and alert behavior increased in the presence of humans. Preening decreased when humans were present, but this change was not significant. Feeding, walk/swim, and flight behaviors were not related to human presence. Female mallards in November decreased feeding, preening and alert behaviors in the presence of humans. Resting, walk/swim, and flight behavior were not influenced by human presence. In January, female mallard resting and preening behaviors were not influenced by the presence of humans. However, feeding, alert, walk/swim, and flight behaviors were related to human presence. Greater yellowlegs increased alert behavior in the presence of humans. No other behaviors were affected. Maintenance behavior (combined feeding, resting, and preening) decreased when humans were present for all study species. In addition, this decrease was accompanied by an increase in escape behavior by each species. Maintenance behavior of mallards in January decreased in the presence of vehicles and combined disturbance. Escape behavior increased when vehicles or bicycles were present. Maintenance behavior of greater yellowlegs declined when bicycles and vehicles were present but was not influenced by pedestrian presence. Snowy egrets and female mallards increased movement between subplots and to areas within the study area away from the disturbance.

Speed of approach by vehicles has also been identified as having detrimental effects to waterfowl, as objects that approach quickly tend to frighten birds more often than objects that approach at lower speeds (Frid and Dill 2002). Pease (2005), found that vehicles traveling more than 13 miles per hour but less than 30 miles per hour created the least amount of disturbance. As a contrast to speed, Pease noted that humans approaching waterfowl on foot had a greater disturbance impact than passing vehicles. Thus, research suggests that waterfowl are disturbed less by vehicles that pass at a moderate rate of speed and more distressed by vehicles going very fast, very slowly, or by humans on foot.

Non-motorized boating can affect refuge resources in a number of ways. Studies show that canoes and kayaks disturb wildlife (Bouffard 1982, Kaiser and Fritzell 1984, Knight 1984, Kahl 1991). They may affect waterfowl broods, wintering waterfowl, shorebirds, raptors, and wading-birds, but their low speed and their use primarily during the warmer months would mitigate those impacts, especially on wintering waterfowl and raptors. Air thrust boats and jet skis are not permitted.

When birds leave the refuge because of human disturbance, high quality habitat is left unexploited for the duration of time that the birds are displaced. The length of time that a bird is displaced from a feeding site determines how much additional foraging effort will be required to replace lost food resources, which impacts other maintenance activities such as molting, resting, and preening. There have been several research studies that examined how long it took waterfowl to return to habitats after being disturbed. For example, the return rate of mallards and Canada geese *(Branta canadensis)* at Mingo NWR following vehicular disturbance indicated that two-thirds of the birds were still displaced after 25 minutes. At the Russell Lakes State Wildlife Area in Colorado, mallards flew from a pond during disturbances and did not return within 1 hour (George et al. 1991). In Wisconsin, only 15 to 56 percent of canvasbacks *(Aythya valisineria)* returned to foraging sites following disturbances (Kahl 1991), and staging snow geese *(Chen caerulescens)* populations in Quebec were found to be lower the day after they had been disturbed at a rate of less than two disturbances per hour, and that vehicular disturbance and unobstructed visual sight planes of approximately 400 to 500 m (1312 to 1640 ft) are detrimental to waterfowl use and subsequent rates of return (Belanger and Bedard 1989). Repeated disturbances (more than 2 per hour), which could occur if unregulated access is permitted, can have serious detrimental impacts on the utilization of seasonal wetlands, which may ultimately cause birds to completely abandon a site, disperse to poorer quality habitat, or change feeding strategies.

Public use and access is important but must be managed so that disturbance to wildlife is minimized and habitat utilization is not compromised. With these objectives in mind, it becomes necessary to recognize that disturbance to waterfowl early and late in the day can negatively impact biological processes such as feeding, flight, metabolic processes, molting, preening, and resting. For example, birds are feeding early in the morning to obtain food resources, but are beginning to come to roost at sunset to begin a period of rest after returning from evening feeding forays. This period of rest is just as important as feeding, it permits the digestion of food ingested prior to roosting and allows the repair of muscle fibers damaged during flight. If measures to minimize or eliminate the cause of disturbance are not considered, the impacts from these activities can negatively affect the potential for wildlife to acquire the necessary resources needed to meet nutritional life history requirements throughout their annual life cycle (Raasch 1996, Fredrickson and Reid 1988).

Providing waterfowl sanctuaries will minimize some of these impacts and allow waterfowl to have undisturbed access to these areas during biologically critical periods of the day. Havera et al. (1992) and Dahlgren (1988) in comprehensive literature reviews of human disturbances to migrating and wintering waterfowl have noted that the use of sanctuaries (non-hunted areas) was the most common and effective solution to mitigating adverse disturbance impacts. Across all alternatives, a waterfowl sanctuary in Unit II (1,300 acres under alternative A; 1,800 acres under alternatives B and C) provides seasonal protection to wildlife from hunting and other recreational uses.

The use of sanctuaries as a management tool is an old concept. Bellrose (1954) wrote of the early 1900s when owners of duck lands found that providing non-hunted areas on their properties was of value in building and holding concentrations of waterfowl. The principal factor governing duck use of areas that were all hunted, half hunted/half unhunted, or not hunted was a sense of security. Waterfowl numbers averaged 16 times more abundant per acre on half hunted/ half unhunted areas than on areas that were completely hunted. Bregnballe et. al (2003) also reported that to ensure high species diversity, a waterbird reserve should include a non-shooting refuge that encompasses adjoining shooting marshland. Reducing hunting to a few hours on shooting days may be used to mitigate hunting disturbance in zones surrounding shooting-free refuges.

Other hunting measures that serve to mitigate adverse impacts to waterfowl:

- Provide adequate buffer areas and large enough sanctuaries to ensure full use by waterfowl

- Provide temporal respite for ducks by limiting hunts to half days or use an intermittent hunt program (3 to 4 hunts/week)

- Regulate hunter access limiting boat access and traffic to specific areas

The term “sanctuary”, as used in the context of the CCP, indicates an area free from hunting and other uses. A key feature of a sanctuary is to make it large enough that intrusions on it’s borders do not unduly disturb the normal lifecycle functions, e.g. feeding, resting, preening, courtship or cause the birds to take flight. The Service believes the areas designated for sanctuary are sufficiently large to reduce the detrimental effects of all forms of disturbance, including those resulting from hunting activity.

Sanctuaries also allow birds to have adequate escape distances (ED), which are defined as the shortest distance at which they flush or otherwise move away from the approaching person or other disturbing stimulus. Many factors influence EDs such as hunting, flock size, hunger, migratory motivation, etc. Laursen et al. (2005) suggested providing a mean ED of the largest ED of a bird species plus one to two standard deviations to calculate the size of the core area or buffer zone. In their study, the largest ED was 1000 meters for wigeon (other species included mallard, teal, pintail, waders, and gulls) and would be approximately 1700 meters with two standard deviations. Based on this information, refuge sanctuary areas can accommodate the ED’s of most species.

Disturbance to waterfowl in or adjacent to the refuge is not a new phenomenon. The Service agrees, in part, there is virtually no area of the refuge that is not susceptible to auditory and visual disturbance. The refuge is relatively narrow and is crossed by several county roads. Some days auto traffic on Route 1 can be clearly heard a couple miles to the west, aircraft fly overhead, patrons of the refuge drive the county roads, birders walk the trails, refuge staff run tractors and airboats as part of their management program, residents drive to and from the neighboring communities to the east, beach enthusiasts travel to the public beaches, kayakers paddle the creek, crabbers park along the roads, neighbors hunt right up to the refuge border, and refuge hunters occasionally fire guns. Unfortunately, this is the nature of NWRs in the heavily populated eastern United States. Most refuges on the east coast do not harbor qualities that we generally think of as constituting “wilderness” (e.g., quiet, or solitude). Under an official wilderness designation, refuge staff would not be permitted the use of many of the standard management tools used on Prime Hook NWR. Even so, hunting is in fact permitted on areas designated as wilderness.

More specifically, hunting on adjacent private property causes disturbance to waterfowl every year in the following areas: Unit I along the western boundary, Unit II along Cods Road and Fowlers Beach Road, Unit III along the southeastern portion near Broadkill Beach, along Prime Hook Creek, and in the state managed Prime Hook Wildlife Area, and Unit IV along the Broadkill River, Petersfield Ditch, and in salt marshes on the western boundary. Hunting has been open in all four units of the refuge and Unit I has been hunted for years by free-roaming hunters seeking deer and upland game in refuge salt marshes. Despite disturbance of waterfowl from vehicular traffic, refuge staff observe visitors year after year viewing and photographing waterfowl within 20 yards of vehicle even during the hunting season. Adding additional sanctuary areas on the refuge will only increase areas of respite for waterfowl and other wildlife and further enhance opportunities to enjoy them by refuge visitors.

Hunting is a priority, wildlife-dependent, consumptive activity with additional direct effects on waterfowl. General adverse impacts of waterfowl hunting are mortality, crippling, and disturbance. Belanger and Bedard (1995) concluded that disturbance caused by waterfowl hunting to waterfowl resources can:

- Modify the distribution and use of habitats by waterfowl.
- Affect their activity budget and decrease their foraging time.
- Disrupt pair and family bonds and contribute to increased hunting mortality.

The Service annually prescribes frameworks, or outer limits, for dates and times when hunting may occur and the number of birds that may be taken and possessed. These frameworks are necessary to allow State selections of season and limits for recreation and sustenance, aid Federal, State, and Tribal governments in the management of migratory game birds, and permit harvests at levels compatible with population status and habitat conditions. Because the Migratory Bird Treaty Act stipulates that all hunting seasons for migratory game birds are closed unless specifically opened by the Secretary of the Interior, the Service annually promulgates regulations (50 CFR Part 20) establishing the frameworks from which States may select season dates, bag limits, shooting hours, and other options for each migratory bird hunting season. The frameworks are essentially permissive, in that hunting of migratory birds would not be permitted without them; in effect, Federal annual regulations both allow and limit the hunting of migratory birds.

Migratory game birds are those bird species so designated in conventions between the United States and several foreign nations for the protection and management of these birds. Under the Migratory Bird Treaty Act (16 U.S.C. 703-712), the Secretary of the Interior is authorized to determine when “hunting, taking, capture, killing, possession, sale, purchase, shipment, transportation, carriage, or export of any bird, or any part, nest, or egg” of migratory game birds can take place, and to adopt regulations for this purpose. These regulations are written after giving due regard to “the zones of temperature and to the distribution, abundance, economic value, breeding habits, and times and lines of migratory flight of such birds,” and are updated annually (16 U.S.C. 704(a)). This responsibility has been delegated to the Service as the lead Federal agency for managing and conserving migratory birds in the United States. Acknowledging regional differences in hunting conditions, the Service has administratively divided the nation into four flyways for the primary purpose of managing migratory game birds. Each flyway (Atlantic, Mississippi, Central, and Pacific) has a Flyway Council, a formal organization generally composed of one member from each state and province in that flyway. Prime Hook NWR is in the Atlantic Flyway.

The process for adopting migratory game bird hunting regulations, located in 50 CFR part 20, is constrained by three primary factors. Legal and administrative considerations dictate how long the rule-making process will last. Most importantly, the biological cycle of migratory game birds controls the timing of data-gathering activities and thus the dates on which these results are available for consideration and deliberation. The process of adopting migratory game bird hunting regulations includes two separate schedules for the development of regulations, based on early and late hunting season regulations. Early hunting seasons pertain to all migratory game bird species in Alaska, Hawaii, Puerto Rico, and the Virgin Islands, migratory game birds other than waterfowl (e.g., dove, woodcock, etc.) and special early waterfowl seasons, such as for teal or resident Canada geese. Early hunting seasons generally begin prior to October 1. Late hunting seasons generally start on or after October 1 and include most waterfowl seasons not already established. There are basically no differences in the processes for establishing either early or late hunting seasons. For each cycle, Service biologists and others gather, analyze, and interpret biological survey data and provide this information to all those involved in the process through a series of published status reports and presentations to Flyway Councils and other interested parties. Though not as detailed as that for waterfowl, relevant data are collected and summarized for migratory bird species such as dove, woodcock, etc. Bird monitoring data are available through the Service's Division of Migratory Bird Management Website *(http://www.fws.gov/migratorybirds/*; accessed October 2012).

Because the Service is required to take abundance of migratory birds and other factors into consideration, the Service undertakes a number of surveys throughout the year in conjunction with the Canadian Wildlife Service, State and Provincial wildlife management agencies, and others. To determine the appropriate frameworks for each species, we consider factors such as population size and trend, geographical distribution, annual breeding effort, the condition of breeding and wintering habitat, the number of hunters, and the anticipated harvest. After frameworks are established for season lengths, bag limits, and areas for migratory game bird hunting, migratory game bird management becomes a cooperative effort of State and Federal governments. After Service establishment of final frameworks for hunting seasons, the States may select season dates, bag limits, and other regulatory options for the hunting seasons. States may always be more conservative in their selections than the Federal frameworks but never more liberal. Season dates and bag limits for national wildlife refuges open to hunting are never longer or larger than the State regulations. In fact, based upon the findings of an environmental assessment developed when a national wildlife refuge opens a new hunting activity, season dates and bag limits may be more restrictive than the State allows.

National Environmental Policy Act (NEPA) considerations by the Service for hunted migratory game bird species are addressed by the programmatic document, Final Supplemental Environmental Impact Statement: Issuance of Annual Regulations Permitting the Sport Hunting of Migratory Birds (FSES 88-14) filed with the Environmental Protection Agency on June 9, 1988. We published the Notice of Availability in the *Federal Register* on June 16, 1988 (53 FR 22582), and our Record of Decision on August 18, 1988 (53 FR 31341). Annual NEPA considerations for waterfowl hunting frameworks are covered under a separate environmental assessment, in which the FONSI is published generally in August of that hunt year. Further, in a notice published in the September 8, 2005, *Federal Register* (70 FR 53376), the Service announced its intent to develop a new supplemental environmental impact statement for the migratory bird hunting program. Public scoping meetings were held in the spring of 2006, as announced in a March 9. 2006, *Federal Register* notice (71 FR 12216). More information may be obtained from the Chief, Division of Migratory Bird Management., US Fish and Wildlife Service, Department of the Interior, MS MBSP-4107-ARLSQ, 1849 C Street, NW, Washington, DC 20240.

At Prime Hook NWR, the impacts of hunting of waterfowl are negligible when compared to the State's total waterfowl harvest. For example, from 1987 to 2011, the average annual waterfowl harvest at the refuge is 2.5 percent of Delaware's total waterfowl harvest (Table 5-4). Furthermore, in 2011, the refuge's harvest of ducks was only 2.3 percent of Delaware's total duck harvest, 0.06 percent of the Atlantic Flyway's duck harvest, and 0.01 percent of the entire United States' duck harvest (Table 5.5; Raftovich et al. 2012). Also in 2011, the refuge's harvest of geese (Canada and snow geese combined) was only 0.75 percent of Delaware's total goose harvest, 0.02 percent of the Atlantic Flyway's goose harvest, and less than 0.01 percent of the entire United States' goose harvest (Table 5.5; Raftovich et al. 2012).

The impacts of waterfowl hunting at the refuge are also negligible when compared to long-term trends in duck and goose populations at the refuge and across the State. Through monthly aerial surveys from October through November, the Delaware Division of Fish and Wildlife is able to evaluate long-term trends in duck and goose populations. The surveys give fairly accurate information about geese, but duck populations such as wood ducks and sea ducks are almost impossible to count. Furthermore, these surveys do not cover the entire state, but only the primary waterfowl habitat in Delaware, which is approximately the eastern half of the State. These figures represent the numbers of ducks and geese at the time of the survey, but do not reflect an actual annual estimate for the waterfowl population in Delaware due to the transitory nature of birds migrating through the State during the fall and winter months.

Based on the findings of these monthly surveys from 1987 to 2011, the average annual waterfowl harvest at the refuge is only 1.8 percent of the estimated peak waterfowl survey findings on the refuge (Table 5.6). During an individual season, the percent of the refuge's harvest on statewide and refuge populations may range greatly depending on the timing of refuge hunting activity and peak waterfowl migration. For example, during the 2011-2012 hunting season, the refuge harvested between 0.58 percent and 1.61 percent of the State's estimated monthly duck population and between 0.02 percent and 0.03 percent of the State's estimated monthly goose population (Table 5.6; October and November statewide waterfowl survey information was unavailable). Refuge hunters harvested between 1.60 percent and 7.04 percent of the refuge's estimated monthly duck population and between 0.04 percent and 0.08 percent of the refuge's estimated monthly goose population (Table 5.6).

Impacts of refuge hunting on snow geese and resident Canada geese are negligible. For resident Canada geese, hunters averaged 8.8 birds per year from 2001 to 2006 (Table 5.7). For snow geese in the late season (late January into March), hunters averaged 16.0 birds per year from 2001 to 2006 (Table 5.8). From 2000 to 2011, refuge hunters harvested between 0.03 percent and 0.43 percent of the refuge's estimated monthly snow goose population (Table 5.8).

Table 5-4. Waterfowl Harvest and Aerial Survey Estimates on Prime Hook NWR Compared to Statewide Harvest (waterfowl includes geese and ducks)

Year	Statewide Waterfowl Harvest*	Refuge Waterfowl Harvest	Refuge Waterfowl Survey**	Refuge Hunter Visits
1987	63,360	1,202	21,243	1,206
1988	62,160	771	21,814	826
1989	61,480	578	64,822	333
1990	59,510	1,241	49,611	1,065
1991	63,410	1,625	55,792	1,178
1992	46,600	1,155	55,238	1,291
1993	46,850	1,421	86,087	962
1994	53,290	2,053	155,096	1,604
1995	45,540	1,572	71,131	1,024
1996	44,170	1,980	104,447	1,630
1997	71,070	3,116	191,446	1,904
1998	118,560	2,964	193,617	1,530
1999	96,410	1,987	224,693	1,403
2000	94,610	2,047	134,156	1,250
2001	76,210	2,679	107,919	1,683
2002	95,170	1,936	102,690	1,330
2003	88,800	2,546	203,615	1,486
2004	73,190	1,573	69,737	1,422
2005	71,740	1,624	111,544	1,301
2006	64,630	2,389	132,088	1,750
2007	81,620	2,989	44,086	1,850
2008	107,120	1,634	90,875	1,253
2009	86,600	1,934	79,263	1,453
2010	84,130	1,604	58,960	874
2011	56,370	1,050	138,894	908

* *Statewide waterfowl harvest data from: http://www.flyways.us/regulations-and-harvest/harvest-trends;* accessed October 2012.

** *Waterfowl estimates were derived from peak numbers found during aerial surveys. Zone 7 was used to estimate waterfowl numbers for the refuge, which covers the area from Big Stone Beach to the Broadkill River and east of Route 1. Some monthly surveys were incomplete in 2007, 2010, and 2011, which may not have reflected the peak (http://www.fw.delaware.gov/Hunting/Pages/Waterfowl%20Surveys.aspx;* accessed October 2012).

Table 5-5. Comparison of Waterfowl Harvest at Prime Hook NWR to State, Flyway, and United States Harvest in the 2011 Hunting Season

Waterfowl Harvest Area	Ducks	Geese
Prime Hook NWR	934	116
Delaware*	41,000	15,400
Atlantic Flyway*	1,672,900	580,400
United States*	15,931,200	2,879,900

**Harvest estimates from (Raftovich et al. 2012)*

Table 5-6. Comparison of Duck and Goose (Canada and Snow Geese) Harvest at Prime Hook NWR to State Waterfowl Surveys during the 2011 to 2012 Hunting Season

Month	Refuge Duck Harvest	Refuge Duck Population Estimates*	Statewide Duck Survey Results*	Refuge Goose Harvest	Refuge Goose Population Estimates*	Statewide Goose Survey Results*
October 2011	219	6,236	Data Unavailable	11	16,823	Data Unavailable
November 2011	126	7,857	Data Unavailable	12	15,540	Data Unavailable
December 2011	217	8,707	37,185	45	99,869	174,992
January 2012	372	5,287	23,053	48	133,634	199,204

* *Waterfowl estimates were derived from peak numbers found during aerial surveys. Zone 7 was used to estimate waterfowl numbers for the refuge, which covers the area from Big Stone Beach to the Broadkill River and east of Route 1 (http://www.fw.delaware.gov/Hunting/Pages/Waterfowl%20Surveys.aspx;* accessed October 2012).

Table 5-7. Resident Canada Goose Harvest in Prime Hook NWR

Year	Resident Canada Goose Harvest	Refuge Hunter Visits
2001	14	33
2002	6	15
2003	10	13
2004	14	10
2005	0	0
2006	9	2

Table 5-8. Snow Goose Harvest and Aerial Survey Estimates at Prime Hook NWR

Year	Total Snow Goose Harvest*	Hunted in Late Season**	Snow Goose Harvested in Late Season**	Refuge Hunter Visits in Late Season**	Refuge Snow Goose Survey***
2000	174	No	n/a	n/a	96,112
2001	242	Yes	37	42	67,840
2002	48	Yes	7	9	72,200
2003	118	Yes	33	24	124,500
2004	121	Yes	3	5	55,330
2005	36	Yes	4	8	86,627

Year	Total Snow Goose Harvest*	Hunted in Late Season**	Snow Goose Harvested in Late Season**	Refuge Hunter Visits in Late Season**	Refuge Snow Goose Survey***
2006	73	Yes	12	12	132,088
2007	130	No	n/a	n/a	30,500
2008	56	No	n/a	n/a	84,520
2009	43	No	n/a	n/a	27,000
2010	15	No	n/a	n/a	52,451
2011	60	No	n/a	n/a	103,301

** Includes snow geese harvested in February/March when applicable*

*** Late season includes late January to mid-March*

**** Snow goose estimates were derived from peak numbers found during aerial. Zone 7 was used to estimate snow goose numbers for the refuge, which covers the area from Big Stone Beach to the Broadkill River and east of Route 1. Some monthly surveys were incomplete in 2007, 2010, and 2011, which may not have reflected the peak (http://www.fw.delaware.gov/Hunting/Pages/Waterfowl%20Surveys.aspx;* accessed October 2012).

Migratory bird hunters may also disturb migratory birds and other wildlife as they travel to and from their hunting sites or when retrieving downed birds. Depending on the location and the number or species of migratory birds in the area, a disturbance can be temporary, with displaced birds moving to nearby backwaters, or more substantial, as in the case of motoring through a large flock of snow geese. For some species like bald eagles and other predators, migratory bird hunting creates a readily available food source due to birds lost or wounded.

Other measures to minimize disturbance to waterfowl are through seasonal closures of designated areas. Under all alternatives, the eastern portion of Prime Hook Creek and associated ditches are closed until March 15 to all users after the hunting season.

Direct disturbance to waterfowl occurs during white-tailed deer hunting seasons as hunters flush deer through wetlands, creeks, and open water habitats. Deer hunters have been free roam hunting in Unit I of the refuge for years and upland game hunters free roam hunt in areas in Unit I, Unit II, and Unit III. Free roam hunting of deer was permitted in all deer hunting areas between 9am and 3pm up until the 2002-2003 hunting season, but was prohibited due to complaints of unethical hunting behavior such as harvesting deer from the stands of other hunters. Dogs running at large during upland game hunting seasons will also flush wintering waterfowl resting and feeding in both wetland and upland areas. Fishing activities also pose potential direct adverse impacts to waterfowl, specifically from hooks, lures, and litter. The ingestion of lead sinkers or lead shot is another concern; however, the impacts are lessened from refuge regulations requiring the use of non-toxic shot for upland hunting, except for slugs for deer hunting.

Federal Aviation Administration have permission to access the VORTAC tower located on the refuge as needed. Onsite visits by these personnel may disturb feeding geese during the period from October to March and may disturb nesting osprey from March to July. The birds are expected to habituate or return to feeding or nesting once the vehicle has passed (Klein 1993).

Research activities may disturb fish and wildlife and their habitats. For example, the presence of researchers can cause waterfowl to flush from resting and feeding areas, cause disruption of birds on nests or breeding territories, or increase predation on nests and individual animals as predators follow human scent or trails. Efforts to capture animals can cause disturbance, injury, or death to groups of wildlife or to individuals. To wildlife, the energy cost of disturbance may be appreciable in terms of disruption of feeding, displacement from preferred habitat, and the added energy expended to avoid disturbance.

Impacts to Waterfowl in Alternative A

There are minor-to-moderate adverse impacts to waterfowl under alternative A associated with the loss of freshwater impoundments. Freshwater moist soil vegetation has already been lost in Units II and III over recent years. This vegetation will be replaced by native salt marsh vegetation in some areas, and by open water in areas where the peat collapses and elevation is lost. It is difficult to predict the impacts on waterfowl as nature takes its course and reshapes impounded wetland areas connected to barrier island habitats. Waterfowl use may change when more open water and less emergent marsh areas are in a transitional phase. A reduction in floral food resources may be substituted with increases in faunal (invertebrate) food resources altering the species. Although salt marsh vegetation still provides quality waterfowl habitat, some species, such as northern pintails, will likely not utilize the newly developed salt marsh areas as extensively as they had utilized the freshwater impoundment that have been lost. This tidal conversion eventually will permanently alter the current habitat conditions for some of waterfowl species and, where it is possible; cause them gradually to shift to appropriate habitats. It is not likely that salt marsh plants would be able to naturally re-colonize impounded wetland areas, without active restoration, due to known marsh platform accretion deficiencies. The amount of open water is likely to be greater under alternative A than under alternative B, and while open water habitats are not without value for waterfowl, they do not meet the same life history needs that are met by wetlands, including salt marsh.

Impacts on waterfowl from public use proposed under alternative A would also be the same as those listed in Impacts on Waterfowl That Would Not Vary by Alternative and in alternative B. Additional impacts would be the same as those listed in Impacts on Waterfowl That Would Not Vary by Alternative.

Conclusion for Management Actions in Alternative A

Management actions under alternative A will result in local moderate-to-major impacts on waterfowl due to the greater degree of open water conversion and loss of freshwater emergent wetland vegetation in impounded marsh areas. Based on the latest information we have about impounded marsh elevations, rapid saltwater re-introductions killing most of the non-halophytic vegetation and subsequent peat collapse in Units II and III, it is very likely that salt marsh vegetation cannot return naturally to impounded wetland areas without active restoration or a major infusion of sediments which, under natural conditions, can occur from hurricanes and major coastal storms. Wetland habitat stability is not possible when impounded marsh surfaces have sunk below the point where salt marsh cordgrass and other halophytic plants could naturally re-colonize through tidal flows of saltwater. Current open water areas are most likely to remain open.

It is difficult to predict impacts on waterfowl use given the higher ratios of open water to emergent marsh, but it is very likely that transitioning to more marine aquatic environments introduces greater diversity and quantity of invertebrate food resources. We would expect fall migrating and wintering ducks may not stay long once they arrive on the refuge due to a significant reduction in plant resources. It is very likely we would see a shift in more black duck use and less pintail use and little change in green winged teal use. However there is a high degree of uncertainty as to how waterfowl use will change under alternative A management actions.

Public use proposed under alternative A results in negligible to minor adverse impacts associated with disturbance.

Impacts to Waterfowl in Alternative B

Managing and Protecting Habitat

Reducing the use of adulticides and preferentially restricting larvicide use to Bti products and methoprene, under appropriate conditions, may have direct beneficial impacts on insect populations with indirect beneficial impacts on waterfowl by providing high-quality protein food resources during spring migration, increasing waterfowl body condition and reproductive potential when arriving on the breeding grounds (Devries et al. 2008).

Additional salt marsh created through restoration within impounded wetland areas will provide valuable habitat of a different kind for many waterfowl species. In particular, American black ducks utilize salt marsh communities heavily during the winter, and will benefit from added salt marsh acreage. Furthermore, salt marsh will be more self-sustaining than freshwater impoundments. Freshwater wetland communities would be subject to periodic die-back from saltwater intrusion resulting from increasing storm activity, and the tidal restriction associated with impoundment management would continue to deprive the wetlands on which the waterfowl depend of the sediment accretion necessary to help keep pace with sea level rise into the future. Under alternative B, waterfowl will have the minor to moderate benefit of stable wetland communities for feeding, resting, and other activities.

Restoration of salt marsh within impounded wetland areas will reduce the annual moist soil vegetation available to waterfowl, relative to historic managed impoundment conditions. This vegetation shift will be replaced by native salt marsh vegetation, which will result in a minor to moderate local adverse impact on waterfowl use of the refuge. Although salt marsh vegetation still provides quality waterfowl habitat, some species, such as northern pintails, will likely not utilize the newly restored salt marsh areas as extensively as they had utilized the freshwater impoundments. Tidal restoration eventually will permanently alter the current habitat conditions for some waterfowl species and, where it is possible; cause them gradually to shift to appropriate habitats. It is likely that waterfowl species composition will shift somewhat, and that waterfowl abundance will be lower than the historically high concentrations of waterfowl that used the freshwater impoundments when they were fully functioning. Potential adverse impacts at the regional scale from the restoration of freshwater impoundments back to salt marsh are unknown.

Large expanses of open water will attract more snow goose use of these marsh areas. Coupled with more mild winter weather and no ice formation, large numbers of snow geese will stay on the refuge for six months or more, resulting in major negative impacts in already stressed marsh areas.

Heavy snow goose herbivory has negative impacts on marsh health as their grubbing and rooting for marsh plant tubers and roots destroy marsh soil structure and integrity. Their feeding methods can also cause significant loss of sediments as unconsolidated soil particles are loaded into the water column and flushed out of the marsh in heavily grazed areas. This further complicates the problems for impounded areas that are already highly degraded due to accretion deficiencies and intensifies the degree of subsidence of the marsh platform. The refuge will offset this impact by controlling snow goose populations locally through hunting and full participation in the state's snow goose conservation order, which provides modified hunting regulations to maximize snow goose harvest. This will have a minor-to-moderate impact on local snow goose population levels.

During restoration phases of marsh rehabilitation when new wetland plants are re-established, this new plant growth will be highly attractive to both migrating and wintering snow geese and resident Canada geese that will quickly destroy all young shoots and roots of desired vegetation. This will pose significant challenges to deal with an over-abundance of certain goose species. The refuge will need to implement resident goose control strategies including lethal methods to reduce the impact to the marsh.

Public Use
In alternative B, increasing designated waterfowl sanctuaries from 1,300 acres (Unit II) to 3,185 acres (portions of Units II, III, and IV) will benefit migrating and wintering waterfowl on the refuge by providing significantly large, areas for undisturbed resting, feeding, and loafing. These designated approximately 3,185 acres of waterfowl sanctuaries will be closed to hunting and other recreational uses on a seasonal or annual basis. Given the dominant role of the refuge in the Atlantic Flyway migration corridor, this closed area system will provide waterfowl with a better network of resting and feeding areas and also disperse waterfowl hunting opportunities on the refuge. These sanctuaries lie in Unit II (approximately 1,800 acres), the southern half of Unit III (approximately 390 acres), and in Unit IV (approximately 995 acres). The northern portion of Unit IV, which contains a proposed trail and observation platform, will be closed from the Monday before Thanksgiving to March 15 to minimize disturbance to wildlife in this area. The southern portion of Unit IV will not be open to any public use. Waterfowl hunting will stop at 3pm in all hunting areas and will be limited to four days per week to reduce disturbance to waterfowl feeding patterns, which in turn will result in high quality hunting experiences. Literature reviews of visitor use and its relationship to disturbance to waterbirds support the time restriction and are reflected in the hunting regulations of other refuges, particularly in the Southeast Region of the Service (DeLong 2002).

These waterfowl sanctuaries have a beneficial impact on waterfowl by aligning closed areas over existing preferred food sources and minimizing disturbance to feeding and resting waterfowl. Other seasonal closures associated with alternative B help to minimize public use disturbance to waterfowl and other wildlife.

In addition, we expect impacts to waterfowl to increase due to proposed expansions in public use activities including fishing, hunting, wildlife observation, wildlife photography, and environmental education and interpretation. These increased impacts are expected to be negligible because public activities will also be restricted to the areas outside of the 3,185 acres of designated waterfowl sanctuaries. Disturbance is also decreased by closing the Oak Island Area in Unit II, the area south of Fowler Beach Road in Unit II, and disabled deer hunting area in Unit IV in late November to hunting and by closing the Deep Branch Trail to non-consumptive users from September 1 through March 15.

Expanded hunting opportunities for deer and waterfowl will cause disturbance to waterfowl in proposed hunting areas and is expected to be negligible (see impacts earlier in “Impacts on Waterfowl That Would Not Vary By Alternative). Participating in the early teal, resident Canada goose, and snow goose conservation order will cause direct impacts to increase but will be negligible based on current refuge harvest contributions to Statewide and national harvests. Free roam areas for deer and waterfowl hunting (jump shooting) will provide hunters with greater access and also increase the potential for waterfowl disturbance. These disturbances are mitigated by creating sanctuary areas where no waterfowl hunting occurs.

Prior to the conservation order taking affect in late January, all snow goose hunting on-refuge will be isolated to the same areas/blinds and refuge specific hunting dates as other waterfowl hunting. A continuous period (except Sundays) from January 28 – April 13 (for 2012-2013 hunting season) will be open for hunting snow geese during the Conservation Order which will open all emergent wetlands on- refuge to snow goose hunting only, once all other waterfowl seasons have closed. Snow geese present a fairly unique issue, finding themselves on the Service's Migratory Bird Program focal species list for actually being over abundant. It is the desire of the USFWS, Canadian Wildlife Service and all Provinces and States to drastically reduce the size of the current continental populations of light (snow) geese, primarily because of the dramatic damage excessive numbers of snow geese have inflicted on very fragile arctic breeding grounds, areas that are important to other breeding migratory species, as well. Seasons, bag limits and methods of take have been liberalized for the purpose. Opening all available habitats on the refuge from January 28–April 13 is specifically designed to reduce damage sustained from overbrowsing of refuge saltmarshes.

Unfortunately, the Service projects, based upon documented history of similar hunts on-refuge, that very few hunters will take advantage of the snow goose hunting opportunity. The hunting season starts October 1, several weeks before any number of birds arrive on Delmarva, and while many hunters are more interested in deer hunting instead. Snow geese are difficult to hunt and there may be an incidental few killed during the regular duck and migratory Canada Goose season.

Over the period 2001–2006, when the refuge was open to late season snow goose hunting, 100 hunters harvested 96 snow geese over a shortened season extending from late January to mid-March and averaged 16.0 birds per year. The hunter success rate averaged 0.96 birds per hunt. Because of the difficulty of hunting snow geese, hunting parties were likely composed of a minimum of 2 hunters. Thus a maximum of 50 total parties hunted over a combined total of approximately 216 days available over the 6 year period with each party potentially having several thousand acres upon which to hunt. From 2000 to 2009, refuge hunters harvested between 0.04 percent and 0.43 percent of the refuge's estimated monthly snow goose population (Table 5-8). Besides being a priority public use, snow goose hunting is also one of the strategies discussed under alternative B, objective 1.3 that addresses salt marsh habitat. The Service projects negligible impacts to other refuge resources from snow goose hunting.

In addition, non-refuge areas in Delaware will also be open to snow goose hunting during the same period. It appears anecdotally that the few hunters that attempt snow goose hunting during the late season are likely to do so from agricultural fields, alleviating most waterfowl hunting pressure on Delaware's tidal marshes and impoundments.

Proposed waterfowl hunting in Unit I salt marshes have the potential to increase adverse impacts and disturbance on refuge wintering American black ducks. Since black ducks are a focal species of conservation concern, monitoring and evaluation of impacts of increased recreational use of salt marsh habitats will be required to identify and respond to unacceptable impacts. Unit IV salt marshes will continue to be a sanctuary area.

The American Black Duck was selected as a" focal" or indicator species by the refuge because of its listing on Federal and State conservation lists, but more importantly for its close association with native salt marsh. Targeting conservation actions to a few focal species, specifically in habitat management objectives, is made with the assumption that hundreds of other fish, wildlife and native plant species will benefit.

From the larger Service perspective, the USFWS, Migratory Bird Program, has generated its own list of Birds of Management Concern and "Focal" Species. The Birds of Management Concern is a list of species, subspecies, populations or geographic segments of populations that warrant management or conservation attention. Birds of Management Concern are drawn from the list of species afforded protection under the Migratory Bird Treaty Act (50 CFR Part 10) and therefore fall under Federal jurisdiction. To be of management concern, a bird must be a high priority gamebird, on the Birds of Conservation Concern 2008 list, a federal threatened or endangered species listed in the U.S. (T/E), or overly abundant (OA) leading to management conflicts. Full species are considered of management concern throughout their U.S. range (including Caribbean and Pacific islands) unless specific subspecies populations, or geographic units (e.g., U.S. Fish and Wildlife Service Regions or Bird Conservation Regions) are designated.

The Migratory Bird Program's "focal" species or "focal" populations are covered under the Migratory Bird Treaty Act, are a subset of the Birds of Management Concern, and are those the program believes need additional investment of resources to address pertinent conservation or management issues. Also included in the list are species occurring in the U.S. that are listed under the Endangered Species Act (ESA) or are on the Bird of Conservation Concern (BCC) 2008 list but are not protected under the Migratory Bird Treaty Act (MBTA).

Within the Migratory Bird Program's list of "focal" species, not to be confused with the PHNWR specific list generated by the refuge for this CCP, are some species of game birds, including the American Black Duck. The Migratory Bird Treaty Act, grants the Secretary of the Interior the authority to establish hunting seasons for any of the migratory game bird species. For waterfowl management specifically, the US and Canada are divided into four flyways; the Atlantic, Mississippi, Central, and Pacific. In the US, the Flyway Councils, consisting of representatives from state and provincial game-management agencies, recommend regulations to the U.S. Fish and Wildlife Service (Service) for waterfowl and for most migratory, shore and upland game birds.

The Councils are advised by flyway technical committees consisting of state and provincial biologists. These technical committees evaluate species and population status, harvest, and hunter-participation data during the development of the Council recommendations.

The Service's Office of Migratory Bird Management (MBMO), with advice from biologists in the Service's Regional Offices, evaluates the Council recommendations, considering species status and biology, cumulative effects of regulations, and existing regulatory policy, and makes recommendations to the Service's Regulations Committee to set hunting seasons for migratory birds that ensure healthy game populations in years to come and fair distribution of hunting opportunities throughout the migration routes.

The Service Regulations Committee considers both the Council and MBMO recommendations, then forwards its recommendations for annual regulations to the Service Director

Once regulatory proposals are approved, they are published in the Federal Register for public comment. After the comment period, final regulations are developed, which are then signed by the Assistant Secretary of the Interior for Fish, Wildlife, and Parks. From this federal framework, individual States may select hunting seasons and bag limits. Once the States have adopted their respective seasons and bag limits, individual refuges may choose to adopt State regulations in-whole, or the refuge may choose additional refuge specific regulations.

In an effort to reduce undesirable impacts on refuge resources and management programs, Prime Hook NWR has adopted more restrictive regulations than those adopted by either the Service's MBMO or the State of Delaware. These regulations include area closures (sanctuaries), hunting 4 of 7 days/week instead of 6 of 7, and ending the hunt day at 3:00 PM instead of sunset.

As indicated above, black ducks and black duck hunting are managed on a state, flyway and continental scale. The process of setting hunting regulations is a deliberative one, based on substantial data. Regulations are set with the full knowledge and desire that a proportion of the population will be removed by hunters, whether on or off of NWRs. Within the northeastern US and eastern Canada particularly, the black duck is considered a valuable recreational and economic resource. The apparent 50% decline in black duck numbers over the last half of the last century, has raised concern for the long-term sustainability of a currently viable, albeit reduced, population. Thus, the American Black Duck has received the designation of "focal" species by the Service's Migratory Bird Program for some reasons other than those presented by PHNWR .

Under both the Administration Act, as amended, and 43 CFR 24, the Director as the Secretary of the Interior's designee will ensure that Refuge System regulations permitting hunting and fishing are, to the extent practicable, consistent with State laws, regulations, and management plans (605 FW 2). The Service and the State of Delaware consider the black duck population capable of sustaining harvest; so PHNWR will comply with State seasons and bag limits.

Conclusion for Management Actions in Alternative B

Habitat management under alternative B has local minor-to-moderate beneficial impacts whenever moist-soil and salinity management is possible to achieve and local minor-to-moderate adverse impacts where impounded marsh degradation and subsidence is rapidly occurring. The benefit of restoring degraded marsh areas and future sustainability of coastal marsh platforms in relation to local sea level rise rates offsets the minor to moderate adverse impact associated with the loss of the freshwater impoundments. It is very likely we would see a shift in more black duck use and less pintail use and little change in green winged teal use.

In terms of the refuge's BIDEH and the restoration of the impoundments to salt marsh, the refuge will be sacrificing diversity at a local scale for biological integrity at the regional or landscape scale, but increasing the integrity and environmental health of all our degraded impounded areas at the local level. Waterfowl will benefit from the long term stability and sustainability of a restored salt marsh relative to a vulnerable managed impoundment. However, heavy snow goose use and resident Canada use will have negative implications for the maintenance or enhancement of BIDEH of any restoration. Heavy snow goose use will also continue to have major negative impacts on marsh elevations in areas that are heavily browsed, requiring that snow goose control strategies be implemented, which will have a negligible-to-minor impact on local snow goose population numbers.

Public use proposed under alternative B results in negligible to minor adverse impacts associated with disturbance, but also minor-to-moderate beneficial impacts resulting from a redistribution of waterfowl hunting and designation of additional sanctuary areas.

Impacts to Waterfowl in Alternative C

Managing and Protecting Habitat

Intensive moist-soil management, as practiced from 1992 to 2008 is not currently possible due to significant changes in barrier island and impounded wetland habitats because of severe coastal storm forcing processes and sea level rise. To return the refuge to its pre-2008 freshwater impoundment management capabilities, Alternative C proposes to re-engineer an intact barrier dike system separating the freshwater impoundments from bay waters and to upgrade and repair water management infrastructure. Annual moist-soil production can be an important factor that attracts and holds waterfowl during the fall and winter. Waterfowl undergo processes each year (molt, migration, reproduction) that elevate their energy requirements and other nutritional needs. Moist-soil management units support those needs by increasing the annual seed production of native wetland plants that offer excellent nutrition (Frederickson et al. 1988). In addition, moist-soil ecosystems are endowed with an invertebrate food base that supplements plant food resources. Compared to agricultural cover crops, moist-soil crops attract and support more waterfowl species year-round, are easier and more cost-efficient to produce, and increase the capacity of wetland habitats to provide the most nutritious foods to meet annual life cycle requirements of waterfowl and other species (Fredrickson and Taylor 1982). A key to successful moist-soil management is maintaining soil and water salinities below 10 ppt. Moist-soil management cannot be practiced where salinity management is no longer viable.

The use of approved glyphosate tolerant corn and soybeans on the refuge is considered by most experts to be more environmentally friendly than other herbicide technologies employed by farmers (Cerdeira and Duke 2006). Browse and cover crops planted as part of the refuge's cooperative farming program provide a limited supplemental source of food for certain waterfowl species, primarily geese. The cooperative farming program in alternative A involves the use, as approved, of glyphosate-tolerant corn and soybeans.

Even under an impoundment management regime, periodic salt water intrusion into impounded marsh areas, likely due to the unstable and dynamic shoreline along Unit II, makes the practice of moist-soil management unachievable at times. When such intrusion occurs, freshwater plants that provide food for waterfowl die, with no other vegetation species taking its place quickly enough to meet the needs of the waterfowl as they arrive. The inherent instability of the freshwater impoundments could lead to minor adverse impacts to waterfowl, which may use open water areas for loafing but would need to seek food resources elsewhere during such times.

Public Use

Proposed expansions in hunting opportunities have the potential to cause more adverse impacts to waterfowl in alternative C than those outlined in alternative A, but less than alternative B because hunting opportunities are reduced in alternative C from those proposed on alternative B (less days and further time restrictions for hunting and less trails for non-consumptive users). All other types of recreation will have similar impacts to those in alternative A. Adverse impacts are expected to be negligible.

Conclusion for Management Actions in Alternative C

There would likely be local short-term moderate beneficial impacts on waterfowl resulting from freshwater impoundment management proposed under alternative C. If fully successful, impacts on waterfowl use of the refuge impounded wetlands could be major. However, the obstacles associated with such management are substantial, rendering such benefits unreliable, and adverse impacts resulting from the inherent instability of the freshwater impoundments could offset the beneficial impacts considerably. Lost elements of coastal wetland integrity and environmental health of impounded marsh areas due to significant accretion deficiencies indicate that impounding refuge coastal areas cut off sediment supplies needed for marsh platforms to keep up with local sea level rise rates.

Maintaining an equilibrium position within the Delaware Bay coastal landscape requires that marshes accrete vertically as the sea level rises and the marsh surface sinks because of subsidence. The current degraded physical conditions of these impounded areas imply that impoundment management may no longer be impossible and detracts from maintaining the BIDEH of these areas in the near future in the face of sea level rise and climate change. There is a great deal of uncertainty in predicting how waterfowl use will change as our impounded marsh areas transition from one state to another.

Public use under alternative C is likely to have adverse impacts that are either comparable to those in alternative A, or are more than alternative A, but less than alternative B. Alternative C provides more hunting opportunities than alternative A but less opportunities for other public uses.

Impacts on Shorebirds

The conservation and protection of barrier beach island, coastal North Atlantic salt marsh, and impounded wetland habitats for shorebirds are high management priorities for the refuge (see inset).

Focal shorebird species:

Barrier beach island and salt marsh habitats:

- American oystercatcher
- Sanderling
- Whimbrel
- Willet

Impounded wetland habitats:

- Dunlin
- Short-billed dowitcher
- American avocet
- Greater/Lesser yellowlegs

Impacts on Shorebirds that would not vary by Alternative

Under all three alternatives, varying degrees of mudflats are likely to occur within refuge wetlands, which will benefit shorebirds foraging at all times of the year, but especially during spring and fall migrations. Indirect benefits to shorebirds are gained by educating the public about special beach closures with news releases and other outreach mechanisms to engage the public understand the needs of nesting shorebirds.

Public awareness and appreciation of the refuge’s efforts to conserve and protect shorebirds would possibly inspire some to volunteer or in other ways support refuge needs in the conservation and protection of critical habitats required to protect continental and hemispheric shorebird resources in perpetuity. See Impacts on Waterfowl That Would Not Vary by Alternative in the Impacts to Waterfowl Section for information on benefits to shorebirds.

Mosquito Management

The aerial and ground applications of insecticides on the refuge may have local adverse impacts on breeding and migrating shorebirds in the form of disturbance, reduction of critical insect food resources used by shorebirds, and disruptions of natural aquatic food web function. Disturbance associated with mosquito monitoring and spraying activities may cause a range of behavioral changes, including nest abandonment, or changes in food habits and foraging, to physiological changes such as elevated heart rates due to fright and flight, or even death. Recurring disturbance is a potential factor in long-term declines of shorebird populations (Pfister et al. 1992, Burger 1995).

Insecticide treatments for mosquito larvae may also kill other closely related dipteran insect species, like chironomids, that make up a large portion of food resources in salt marsh and impounded wetland habitats on the refuge and are very important food resources for migrating and breeding shorebirds. Application of insecticides, both larvicides and adulticides, may have adverse site-specific impacts on wetland and aquatic food-webs and adverse impacts on non-target insect species (Brown 1998, Cook and Hill 2000 and 2001).

The application of Bti and methoprene on the refuge are non-toxic to birds at EPA approved application rates. The extent to which the use of Bti and methoprene will limit the food resources for individual birds or local avian populations is unknown. Integrated pest management strategies will be designed to limit impacts to local invertebrate populations when the mosquito-borne disease risk to humans is low.

As horseshoe crab populations decline in the Delaware Bay, food resources provided by refuge impounded wetland and salt marsh habitats may become more critical in providing food resources for spring and fall migrating shorebirds, including species of concern such as the piping plover and red knot. Mosquito larvae are a component of the diets of other aquatic invertebrates such as dragonfly, damselfly, and beetle larvae and back swimmers, which are consumed by shorebirds (Skagen and Oman 1996). Thus protecting and conserving insect and other invertebrate food resources directly benefits shorebirds.

Public Use

All of the alternatives predict some increase in annual visitation. However, adverse impacts from increased visitation will vary with the type of habitat management and visitor use each alternative proposes. Public use activities are expected to have negligible adverse short-term, long-term, or cumulative impacts on shorebirds.

Seasonal closures of designated beach dunes and overwash areas from March 1 through September 1 are in place to minimize disturbance to nesting shorebirds such as American oystercatchers and potentially piping plovers. See Impacts on Waterfowl That Would Not Vary by Alternative in the Impacts to Waterfowl Section for additional information on impacts to shorebirds.

Pfister et al. (1992) investigated human disturbance as a factor that might limit the capacity of appropriate staging areas to support migrating shorebirds. Results indicate that adverse impacts from human disturbance will be greater on shorebird species using the front side of beach habitats and that the local abundance of impacted species may be reduced by 50 percent. Such disturbance is implicated as a potential factor in long-term declines in shorebird abundance during migration periods at disturbed sites. Disturbance to shorebirds on the refuge beaches will be minimized through seasonal beach closures to public use.

Disturbance by refuge hunters to shorebirds is expected to be negligible since most shorebird species have completely passed through Delaware by peak hunting season in November through January. Some hunting occurs when these species may be migrating before and after this peak hunting time. Shorebirds using refuge marsh habitats that are also open to hunting may be disturbed by hunters traveling in these areas or by their gunshots; however, established sanctuaries provide disturbance-free areas for migrating birds during the hunting season.

Disturbance of shorebirds becomes a very crucial issue during incubation or nesting periods. Direct adverse impacts of displacement caused by human disturbance during nesting periods include egg exposure to temperature extremes, predation of eggs when the nest is vacated by the adult, and predation at a later time due to predators following human trail or scent (Korschgen and Dahlgren 1992). Protection of nesting colonial shorebirds is easier than protection of solitary nesters, like the American oystercatcher and piping plover, because much larger beach areas must be protected, managed, and patrolled. Public education, active protection methods (small fences around nests, signs, wardens), legal measures (beach use regulations, active enforcement patrols), and well-advertised closures of portions of the beach are management actions that often successfully reduce the adverse impacts of human disturbance when shorebirds are most vulnerable. Protection of nesting colonies using fences and wardens has markedly decreased reproductive losses of least tern colonies in New Jersey (Burger 1995).

Impacts on Shorebirds in Alternative A

Managing and Protecting Habitat
The absence of active restoration, such as is proposed in alternative B, has already resulted in a higher ratio of open water in impounded wetland areas under alternative A. Due to rapid saltwater re-introductions, Unit III has started to converted to open water with some mudflat areas. This could result in minor-to-moderate local adverse impacts to shorebirds. Galbraith (2002) outlined one scenario for the Delaware Bay that predicts losing 60 percent or more of intertidal shorebird feeding habitats by 2100 due to coastal changes and sea level rise.

Public Use
Requiring a leash on all dogs in designated areas of the beach will help to minimize impacts to feeding and nesting shorebirds.

Conclusion for Management Actions in Alternative A
Management actions under alternative A would have local short-term minor-to-moderate benefits and local long-term minor-to-moderate adverse impacts. Mosquito management associated with alternative A could lead to a negligible-to-minor local adverse impact on shorebirds, primarily through disruption of the invertebrate food supply. The conversion of the impounded wetlands to open water will reduce the mudflat habitat, resulting in a minor-to-moderate adverse impact to shorebird use of the refuge. This may be partly offset by the local minor-to-moderate benefit of sandy overwash areas created along the shoreline, as coastal processes are permitted to proceed unimpeded. The most notable potential adverse impact from public use under alternative A would result from the continuing lack of proactive public use management to protect shorebirds from disturbance.

Impacts to Shorebirds in Alternative B

Managing and Protecting Habitat
Reducing insecticide use through the reduction of the use of adulticides associated with mosquito control efforts will likely have minor-to-moderate beneficial impacts to local breeding shorebirds by reducing disturbance, especially along beach strand habitats, and reducing adverse impacts on non-target insect food resources and aquatic food webs.

Conserving and protecting insect and other invertebrates on refuge habitats provides direct beneficial impacts to migrating and wintering shorebirds that can exploit quality habitats during non-breeding periods of their life cycle. Insect nutrition is essential to the life cycle requirements of shorebirds. Forty-seven percent of all shorebird species are primary insectivores and 20 percent are partially insectivorous, with the dietary requirements dependent on other invertebrate species for the remaining shorebird species (Skagen and Oman 1996).

Under alternative B, the refuge proposes to implement a limited predator control program. Red fox, raccoon, gull, crow, rice rat, feral cat, and other species have been documented as effective predators upon nesting shorebirds, eggs, and chicks. Control will result in a minor-to-moderate beneficial impact on shorebirds that nest on the refuge. Some shorebirds, such as the federally threatened piping plover and colonial beach nesting bird populations, are especially vulnerable to loss of suitable nesting habitat due to high sensitivity to human disturbance. Given the plight of migratory birds, especially those requiring the limited beach or island nesting habitats, the refuge may utilize a predator management program to benefit these species. Predator management programs have proven effective elsewhere for sustaining or increasing avian productivity (Greenwood et al. 1990, Guillemette and Brousseau 2001, Lokemoen and Woodward 1993, Sanz-Aguilar 2009, USDA 2011, USFWS 1996, USFWS 2007e). Not permitting dog walking in the refuge will also minimize impacts to feeding and nesting shorebirds.

In conjunction with restoration of salt marsh in the refuge's impounded wetlands, natural coastal processes, such as the creation of overwash fans, will be permitted to occur unimpeded. This will eventually create valuable bayfront shorebird habitat, particularly in Unit II, suitable for foraging for many species of interest, such as red knots. Restoration efforts that promote more rapid sediment accretion, or involve the deposition of supplementary sediment such as from dredging, will create mudflats by increasing wetland elevation in areas where it has been lost through peat collapse. Such mudflats may mostly become vegetated with salt marsh plants, but some open areas would likely remain and would provide the minor local benefit of more suitable foraging habitat for shorebirds (ACOE 1996). Salt marsh restoration programs attempt to be timed to reduce impacts to wildlife, so much of this activity may be conducted outside of the breeding season.

The current salt water intrusion in Units II and III and the proposed restoration of salt marsh within refuge impounded wetlands, would likely increase open water habitats and decrease mudflat acreage relative to the freshwater impoundment management regime in alternative A, with minor local adverse impacts on shorebirds as mudflat habitats disappear. Restoration, such as the placement of supplementary sediment to restore elevation, may have site-specific and short-term adverse impacts. Where such activities occur, the presence of humans, equipment, and noise may displace birds from very discrete areas, and only temporarily (ACOE 1996). Galbraith (2002) stated the reductions in foraging habitat may lead to declines in shorebird numbers and summarized Evans and Pienkowski, which reported large reductions in shorebirds with the loss of mudflats. Eertman (2002) observed a decline in dunlins and oystercatchers as vegetation succession progressed where mudflats were reduced from 75 percent to 10 percent of the area.

Public Use

We expect impacts to shorebirds to increase due to proposed expansions in public use activities, including fishing, hunting, wildlife observation, wildlife photography, and environmental education and interpretation. Impacts are expected to be negligible and are mitigated by not allowing dog walking on the refuge. See the Waterfowl Section for more information on adverse impacts to shorebirds.

Conclusion for Management Actions in Alternative B

Management actions under alternative B would have a local short-term and long-term moderate impacts and opposing local short-term and long-term minor impacts. As with the other alternatives, mosquito management associated with alternative B could lead to a negligible-to-minor local adverse impact on shorebirds, primarily through disruption of the invertebrate food supply. The salt marsh restoration proposed under alternative B may also reduce the mudflat habitat that is made available to shorebirds through water level management in freshwater impoundments, resulting in a minor adverse impact to shorebird use of the refuge. This may be offset by the local moderate benefit of sandy overwash areas created along the shoreline as coastal processes are permitted to proceed unimpeded, and by the creation of new mudflat areas as restoration efforts attempt to increase elevation in areas that have converted to open water.

Ultimately, shorebirds will benefit from the restoration of stable and healthy salt marsh habitats. Negligible adverse impacts may result from proposed public use but are mitigated by prohibited dog walking on the refuge. No impairment of the refuge's BIDEH is expected. The decline in shorebird numbers may result in a loss of diversity at the local level but the restoration of the impoundments provides biological integrity and diversity at the landscape level.

Impacts to Shorebirds in Alternative C

Managing and Protecting Habitat

Under alternative C, the management of freshwater impoundments and moist-soil management units would promote invertebrate production, which would provide critical protein-rich food resources required by shorebirds (Frederickson 1991). Shorebirds undergo processes each year (molt, migration, reproduction, etc.) that elevate their energy requirements and other nutritional needs. Moist-soil management programs help meet those needs (Frederickson et al. 1988). The percentage of protein composition of common invertebrates in moist soil impoundments, such as water boatmen, back swimmers, midges, and amphipods, ranges from 50 percent to more than 70 percent. Refuge management of moist-soil vegetation in freshwater impoundments and moist-soil areas would produce mudflat habitats with water depths ranging from 0 to 10 cm deep and invertebrate densities of greater than or equal to 4 gm/m^2. When water is discharged slowly from an impoundment or moist-soil unit, invertebrates are trapped and become readily available to birds foraging along the edge or in shallow water zones.

A potential adverse impact to shorebirds from alternative A stems from the fact that freshwater impoundment management would continue to be challenging, given changes in the coastline along the impoundment and increased storm activity, which lead to overwashes and saltwater intrusion periodically. When such intrusion occurs, peat collapse can lead to the conversion to open water of areas that previously functioned as mudflats, rendering them less suitable to shorebirds for foraging. The inherent instability of the freshwater impoundments could lead to minor adverse impacts to shorebirds, which would need to seek food resources elsewhere during such times.

Public Use

Proposed expansions in hunting opportunities are expected to cause more impacts to shorebirds in alternative C than those outlined in alternative A, but less than alternative B. All other types of recreation will have similar impacts to those in alternative A. Impacts are expected to be negligible.

Conclusion for Management Actions in Alternative C

Management actions under alternative C would have local minor-to-moderate impacts and opposing local short-term and long-term minor impacts. Freshwater impoundment management under alternative C would have a minor-to-moderate beneficial local impact on shorebirds through promotion of mudflats and invertebrate food resources. However, minor adverse impacts could also result from impoundment management, as it would be less reliable and more unstable, possibly resulting in the loss of mudflats during salt water intrusion events. As with the other alternatives, mosquito management associated with alternative C could lead to a minor local adverse impact on shorebirds, primarily through disruption of the invertebrate food supply. Negligible adverse impacts may result from proposed public use.

However, the continued conversion to open water may have negative impacts on the BIDEH of the refuge's coastal impounded marsh areas. Those wetlands that are unable to accrete sufficient substrate as sea level rises will rapidly convert to deep open water, and eliminate considerable acres of habitat for shorebirds.

Impacts on Landbirds

The conservation and management of wetland, upland shrub, and forested habitats is focused on conserving and benefiting migrating and breeding landbirds. We evaluated the management actions of each of the alternative proposals for their potential to benefit or adversely affect shrub, forested wetland, and upland habitats and their contributions to conserve and protect targeted focal landbird species (see inset).

Focal landbird species and their associated habitats include the following:

Forested upland (breeding species):

Wood thrush
Black and white warbler
Scarlet tanager
Kentucky warbler
Great crested flycatcher
Northern flicker
Whip-poor-will

Forested wetland habitats (breeding species):

Acadian flycatcher
Prothonotary warbler
Yellow-throated vireo

Early successional habitats (breeding species):

Prairie warbler
Blue-winged warbler
Brown thrasher
Whip-poor-will
Willow flycatcher
Eastern towhee
Field sparrow
Northern bobwhite
Henslow's sparrow

North Atlantic high and low marsh (breeding species):

Seaside sparrow
Salt marsh sharp-tailed sparrow
Coastal plain swamp sparrow

We evaluated the benefits of our actions that would conserve or restore these habitat types and enhance the numbers of breeding and migrating focal species. The key actions include:

- Phasing out agriculture
- Restoring more acreage to trees
- Improving interior forests and wetland forests
- Conserving insect food resources
- Controlling invasive species
- Increasing public awareness and appreciation of refuge habitat management to benefit focal species and other landbirds that are found on the refuge
- Restoring salt marsh communities in impounded wetlands

We also evaluated the potential of proposed actions to cause adverse effects on these same habitat types or dependent wildlife species:

- Public use disturbing wildlife
- Placement of facilities affecting habitat quality
- Mosquito control chemical use
- Chemical spraying to treat invasive species and mechanical treatments to maintain early successional habitats or improve forest stand quality

Impacts on Landbirds That Would Not Vary by Alternative

Managing and Protecting Habitat and Public Use
Area-sensitive focal landbird species will benefit from increasing forested patch sizes of current refuge forested areas. Forested landbirds would also benefit by the expansion of the widths of forested riparian and wetland buffer zones proposed under all three alternatives, which would create more habitat for roosting, foraging, breeding, or seeking cover. The treatment of invasive species proposed under all alternatives can be one source of potential disturbance to breeding landbirds during aerial or ground applications. Application of insecticides to refuge forested or emergent wetland habitats may reduce

populations of non-target invertebrate species, have negative impacts to food webs, and therefore impact breeding landbirds. Passerines are primary insectivores, and measures taken to protect and conserve insects on the refuge could mitigate the potential adverse impacts of reducing nutritional resources required to sustain and increase landbird populations. Studies conducted along riparian zones during early spring migration have documented the importance of adult chironomid swarms as a food resource for migrating landbirds (Smith et al. 1998, Smith et al. 2007).

Although much of the literature suggests that little to no impacts on bird species are sustained from open marsh water management (OMWM) construction, most bird species studied were generalists; there was little focus on obligate salt marsh bird species. The State performed some surveys of both Seaside Sparrow and Saltmarsh Sharp-tailed Sparrow populations at Bombay Hook NWR in the early 1980s, involving a long-term control plot never treated with OMWM in which sparrow populations were assessed over time, along with a study plot where sparrow populations were assessed both before any OMWM work was done and then after extensive OMWM systems were installed. Following treatment, sparrow populations declined in the OMWM-treatment plot during the first growing season following treatment, (when OMWM-generated spoil still covered a large portion of the treatment plot before much vegetation recovery could occur). By the second growing season following OMWM treatment (and in conjunction with good vegetation recovery) sparrow populations in the treatment plot had rebounded to levels similar to both pre-OMWM levels in the treatment plot and to levels similarly found in the control plot, indicating little apparent long-term effects on total numbers sparrows (DMCS, written communication).

Research conducted in 2006 and 2007 focused on areas of Prime Hook NWR with varying degrees of OMWM alterations, all conducted a number of years prior to the research being conducted. Study results suggested that marsh areas with extensive OMWM excavations and ditching have lower marsh bird community integrity. Heavily ditched and excavated open marsh water management areas were found to support lower breeding densities and abundance of seaside sparrows, as well as lower reproductive output (Pepper 2008). Areas with lower OMWM intensity may have more available breeding habitat than extensive sites. Limitations in the study design prevent any definitive cause-and-effect conclusion, which underscores the need for more research on the effects of OMWM on salt marsh obligate productivity.

There is concern about the impacts of OMWM on black rail, a species of concern associated with tidal high marsh, which prompted the state of Maryland to cease such management in the early 1990s (DNREC 2005). Circumstantial evidence from at least one site in Delaware supports this concern, and the issue warrants further study. No OMWM construction has been permitted on the refuge since 2002, and no new construction is proposed at this time. Any ongoing impacts from OMWM to the local ecology are limited to extant sites. The refuge considers maintenance of extant sites to pose minimal additional impact, if any.

Public Use

All of the alternatives predict some increase in annual visitation; however, the impact varies with the types of habitat management and visitor use in each alternative proposal. We can expect direct, adverse impacts on landbirds by disturbance wherever humans have access on the refuge, and the degree of that disturbance may vary depending on the type of habitat. In general, the presence of humans disturbs most wildlife, which typically results in temporary displacement without long-term effects on individuals and populations.

The location of recreational activities on the refuge will impacts species in different ways, depending on the bird’s proximity to refuge trails. Miller et al. (1998) found that nesting success for landbirds was lower near recreational trails, where human activity was common, than at greater distances from the trails. A number of species have shown greater reactions when pedestrian use occurred off-trail (Miller 1998). Disturbance to landbirds in areas open to wildlife observation, photography, and fishing is expected to be negligible since all visitors are required to be on designated access routes. Some other species, such as wood thrush, will avoid refuge areas frequented by people, such as near trails and buildings, while other species, particularly highly social species such as tufted titmouse, Carolina chickadee, or Carolina wren, will likely be unaffected or even drawn to the human presence. For songbirds, Gutzwiller et al. (1997) found that singing behavior of some species was altered by low levels of human intrusion. When visitors approach too closely to nests, or go off the trail, they may cause the adult bird to flush, exposing the eggs to weather events or predators. Provided that visitor use is confined to refuge trails, which are not placed in area-sensitive habitat interiors, disturbance during the breeding season will be limited to the trail area. The extent of this disturbance on either side of the trail also depends on visibility and the density of vegetation through which the trail is laid.

Disturbance to non-hunted migratory birds could have local, regional, and flyway impacts. Regional and flyway effects would not be applicable to species that do not migrate such as most woodpeckers, and some songbirds including cardinals, titmice, wrens, and chickadees. The continual effects of disturbance to non-hunted migratory birds under this plan are expected to be negligible because the hunting season would not coincide with the nesting season. Long-term impacts that could occur if reproduction were reduced by hunting are not likely for this reason. Disturbance to the daily wintering activities of birds might occur, such as feeding and resting and are lessened by the establishment of sanctuary areas, seasonal closures, and hunting hour restrictions.

The limited amount of hunting resident game species on the refuge, such as turkey and quail does, may negligibly impact local populations, but does not have any regional impact on their respective populations due to their restricted home ranges. Delaware Division of Fish and Wildlife periodically reviews populations of all harvested resident species, and has determined that populations are adequate to support hunting efforts throughout the State. The refuge contributes minimally to the State's total harvest for resident game species. For example, the number of quail taken per year has been no more than 14 per year on the refuge in recent years (Table 5.9).

For migratory birds such as mourning dove, an estimated 14,700 birds were harvested in Delaware during the 2011 season (Table 5.10; Raftovich et al. 2012) when only nine were taken on the refuge. Similarly, very few snipe and woodcock were harvested. Direct, indirect, and cumulative impacts on these species on the refuge are negligible. See Impacts to Waterfowl for a description of how the Federal and State migratory bird hunting frameworks are established.

Table 5-9. Number of Upland Game, Small Game, and Webless Migratory Birds Harvested and Hunter Visits on Prime Hook NWR

Year	Dove Harvest	Snipe Harvest	Woodcock Harvest	Quail Harvest	Rabbit Harvest	Refuge Hunter Visits*
1996	110	0	0	5	83	126
1997	77	0	0	0	117	169
1998	30	0	0	0	46	112
1999	90	0	0	0	98	123

Year	Dove Harvest	Snipe Harvest	Woodcock Harvest	Quail Harvest	Rabbit Harvest	Refuge Hunter Visits*
2000	13	0	0	0	29	81
2001	6	0	0	0	65	128
2002	58	0	0	0	163	114
2003	13	0	0	0	79	81
2004	12	0	0		75	53
2005	6	0	0	0	257	129
2006	20	0	0	14	115	106
2007	22	0	0	11	145	178
2008	0	0	1	10	176	171
2009	0	0	6	1	163	149
2010	4	0	1	3	108	129
2011	9	0	1	0	76	100

**Hunter visits include all species combined; majority are hunting rabbits*

Table 5-10. Comparison of Mourning Dove, Woodcock, and Snipe Harvest at Prime Hook NWR to State, Flyway, and United States Harvest in the 2011 Hunting Season

Harvest Area	Dove	Woodcock	Snipe
Prime Hook NWR	9	1	0
Delaware*	14,700	500	500
Eastern Management Unit*	6,666,900	77,000	57,500
United States*	16,580,900	308,700	136,300

**Harvest estimates from (Raftovich et al. 2012); Estimates for snipe are from the Atlantic Flyway*

The hunting of deer can be a beneficial impact to landbirds because the reduction of the vegetation's physical structure and diversity due to overbrowsing by deer also can negatively impact landbirds. Casey and Hein (1983) have found greatly reduced bird species diversity in areas with long term, high density populations of deer. These changes were mainly attributed to habitual landscape alteration with pronounced browse line and sparse cover caused by overbrowsing.

Impacts on Landbirds in Alternative A

Impacts on landbirds under Alternative A ("No Action") serve as a baseline for comparing and contrasting Alternatives B and C to the refuge's existing management activities.

Managing and Protecting Habitat

Allowing natural succession to continue across refuge upland landscapes, representative of a mixed hardwood forest matrix with a 10 to 20 percent shrubland component typical of Delmarva coastal plain ecosystem, will result in an increase in native vegetation communities available to migrating and breeding landbirds. However, the passive management approach will result in a potentially lower quality forest to occur in the next 15 years compared with alternative B, because desired forest conditions may not be met. Alternative A would also contribute to achieving Statewide landbird population objectives more than alternative C but not as much as alternative B.

Landbird species that prefer dense understory and early successional forest vegetation would experience direct benefits in the short term as agricultural fields and other open areas undergo a slower successional process to climax into woodland habitats. Breeding landbird species such as prairie warbler, blue-winged warbler, brown thrasher, whip-poor-will, willow flycatcher, eastern towhee, field sparrow, and northern bobwhite would gain additional acreage for a longer period of time compared to alternative B.

These breeding landbird species, plus other migrating landbirds, would receive maximum benefits as diverse flowering and fruiting shrub and young tree species develop during successional seral stages. Beneficial impacts to landbirds include the provision of a greater abundance of fruit and insect food resources during the migrating and breeding seasons compared to agricultural vegetation. Indirectly, the long term beneficial impacts for canopy forest birds would accrue beyond the 15-year planning horizon of this CCP, when successional forested habitats start to mature 45 to 75 years from now.

An increase in salt marsh acreage through passive return of salt marsh in Unit II and eventual conversion of Unit III, would benefit salt marsh obligate passerines, such as seaside sparrows and salt marsh sharp-tailed sparrows, which are of tremendous conservation concern. However, the restoration of tidal flow may initially increase the amount of surface water on a marsh and eliminate breeding habitat for birds that nest on or near the marsh surface. In the absence of active salt marsh restoration, there may be less habitat available for landbirds that breed in salt marsh wetlands, but which make only limited use of persistent open water areas.

Public Use

Beneficial impacts on landbirds from public use are the same as those described in Impacts on Landbirds That Would Not Vary by Alternative.

The presence of dogs accompanying refuge visitors may flush incubating birds from nests alongside trails (Yalden and Yalden 1990), disrupt breeding displays (Bayback 1986), disrupt foraging activity in shorebirds (Hoopes 1993), and disturb roosting activity in ducks (Keller 1991). Many of these authors indicate that people with dogs on a leash and loose dogs provoked the most pronounced disturbance reactions from their study animals. The greatest stress reaction resulted from unanticipated disturbance; animals show greater flight response to humans moving unpredictably than to humans following a distinct path (Gabrielsen and Smith 1995). Dogs that are unleashed or not under the control of their owners may disturb or potentially threaten the lives of some wildlife. In effect, off-leash dogs increase the radius of human recreational influence or disturbance. Continuing to restrict dog walking to the established trail and educating dog walkers on these expectations will reduce the potential disturbance of landbirds.

Conclusions for Management Actions in Alternative A

Management actions in alternative A would result in short-term local minor impacts, such as increased landbird use as former agricultural fields proceed through natural succession, but would also have opposing local minor-to-moderate impacts because the loss of marsh to open water would reduce habitat available for salt marsh obligate passerines. No impairment of the refuge's BIDEH is expected unless the impounded wetland areas revert to open water. Impacts from public use are expected to be negligible.

Impacts on Landbirds in Alternative B

Managing and Protecting Habitat

The direct benefits to landbirds would resemble those in alternative A, but there would be additional impacts due to the increase of 1,000 acres of restored native plant habitats as agricultural fields undergo reforestation or revert to shrubland

and other early successional cover-types and other open areas are reforested to create two contiguous patches of 450 acres of mixed hardwood habitats. Native vegetation acreage increases enhance habitat connectivity on the refuge, enabling landbirds to move between habitat patches and subpopulations. Restoring and widening riparian buffer zones near water courses and wetlands with native shrubs and trees will provide direct beneficial impacts for both breeding and migrating landbirds. Reducing habitat fragmentation on refuge forested habitats will have direct impacts on forest interior dwelling landbirds by increasing breeding niches and occupancy rates.

We have considered how our proposed alternative actions can contribute to the continental population objectives of the North American Landbird Conservation Plan, as down-stepped to State population objectives. We identified refuge focal landbird species to manage for to help prioritize management actions with limited resources and maximizing beneficial impacts for landbird species with the greatest conservation need (Appendix D). The habitat management strategies and proposed conservation actions in alternative B would have direct beneficial impacts on State populations by providing habitat to help support Delaware-wide population objectives for numerous focal landbird species.

Effective management of forest interior breeding bird populations means effective management of forests in tracts large enough so different successional stages can occur (Anderson and Robbins 1981). Management for land birds and forests can be compatible provided it fits into a regional strategy to maintain the proper mixture of older and younger stands. Some approaches to forest management may need modifying to achieve forest conditions needed by interior specialists, but these modifications will not drastically alter current forestry management practices. There is no single management strategy that will benefit all species, and as Lynch and Whigham (1984) pointed out, almost any conceivable habitat enhancement strategy will have negative impacts on some species. As with all forest management activities, particularly concerning the removal of trees or wood products from the site, the implementation of best management practices would minimize or eliminate negative impacts on overall landbird communities. Whenever possible, forest alterations would not occur during the breeding season, due to the sensitivity of nesting birds to any disturbances. Because a combination of forest management techniques would be implemented as determined to be necessary for forest health, a combination of the following impacts would result.

Timber stand improvement techniques, such as thinning, that encourage or enhance understory development will be beneficial for certain forest interior birds, particularly those species that nest or forage in the shrub layer, such as hooded warbler (Whitcomb et al. 1981). Other species that may benefit include Louisiana waterthrush, prothonotary warbler, worm-eating warbler, and Kentucky warbler. There should be minimal negative impacts of light thinning on many of the forest interior specialists such as the red-eyed vireo, yellow-throated vireo, Swainson's warbler, and others (James 1976, Collins et al. 1982, Eddleman et al. 1980), because proposed canopy cover is >80%. Prescribed burning used throughout all forest cover types and age classes as a form of timber stand improvement, would have similar impacts on understory development, with the similar associated bird species responses.

Timber stand improvement practices that result in standing dead trees, or snags, will be beneficial for hairy and pileated woodpeckers, prothonotary warbler, and barred owl (Conner 1978, Evans and Conner 1979). Standing dead wood not only provides nesting sites for cavity nesters, but also acts as reservoirs for insects on which many forest interior species feed. Snags protruding above the forest canopy will be removed, as they serve as perches for nest predators and brown-headed cowbirds (Robbins 1979).

Regeneration cuts, involving the removal of most or all of the timber from an area, may be tolerated by many forest interior birds depending on the size and shape of the cut, number and type of trees left uncut, and rotation length. Webb et al. (1977) found that clearcutting caused overall population declines in only 1 of 9 forest interior specialists on their study areas in New York, while 3 species increased in numbers. Small or narrow clearcuts of 5 to 25 acres (2 to 10 ha) in larger woods may be tolerated by birds that accept a partially open canopy (Crawford et al. 1981). These include yellow-throated vireo, black-and-white warbler, worm-eating warbler, Kentucky warbler, hooded warbler, northern parula, and scarlet tanager. Bird species associated with more open woods, such as whip-poor-will, may tolerate even larger clearcuts.

Many warbler species are able to inhabit a clearcut area earlier if small trees are left uncut (DeGraaf 1992). Conner and Adkisson (1975) found hairy woodpeckers and hooded warblers utilizing a 3-year-old clearcut in Virginia when several hardwood trees 3 inches (7cm) dbh and greater were left at the time of cutting. They also found whip-poor-will, worm-eating warbler, and Kentucky warbler in a 7-year-old clearcut, and red-eyed vireo, black-and-white warbler, and scarlet tanager in a 12-year-old clearcut where small trees had been left during cutting. A regeneration cut does not need to grow to maturity before it is inhabited by forest interior birds. Birds such as scarlet tanager, Kentucky warbler, and black-and-white warbler, which are most abundant in medium-aged stands, may benefit from regenerating mature forests and allowing them to progress through this stage. However, Crawford et al. (1981) reported closed-canopy obligatory species, such as ovenbird and American redstart, would decline with any intermediate or harvest cutting that opens the canopy.

Selective cutting, such as single-tree selection, diameter-limit cutting, and group selection involves removal of fewer trees than in regeneration cuts, but harvesting may take place more often. While regeneration cuts generally produce even-aged stands, selective cutting tends to produce uneven-aged stands. Selective cutting may open the canopy to varying degrees or improve a closed canopy, with the understory vegetation density and bird response varying accordingly (Adams and Barrett 1976; Whitcomb et al. 1977). The practice of selective cutting is conducive to many forest interior birds.

Leaving uncut buffers along streams and roadsides benefits cavity nesters (Conner et al. 1975, Evans and Conner 1979) and other birds that use those habitats. Examples of such species are prothonotary warbler, Swainson's warbler, Louisiana waterthrush, and northern parula. Leaving dead, dying, and decaying trees standing and a 0.25-acre (0.1 ha) clump of trees permanently uncut in each 5 acres (2 ha) of clearcut will greatly benefit cavity-nesting birds (Conner et al. 1975, Conner 1978, Evans and Conner 1979).

As the canopy is opened through selective cutting, increased sunlight reaches the forest floor encouraging understory growth. As with certain timber stand improvement practices, this may enhance the habitat for species preferring moderate to dense shrub and understory levels. Whitcomb et al. (1977) found a greater number of territorial male hooded warblers and Kentucky warblers in a selectively logged area 4 and 5 years after cutting, compared to an undisturbed forest. Conversely, Adams and Barrett (1976) found fewer breeding pairs of Kentucky warblers in a selectively logged forest then in an undisturbed tract. They attributed this to the presence of more spicebush *(Lindera benzoin)* in the undisturbed forest, which Kentucky warblers selected to nest in. But, not all interior specialists will benefit from encouraging development of a moderate to dense understory. Whip-poor-will, Acadian flycatcher, and ovenbird prefer fairly open understories. Crawford et al. (1981) reported a decrease in black-and-white warbler populations with an increase in the density of shrubs 6 to 15 feet

(2 to 5 m) tall. Species dependent on a closed canopy, such as Acadian flycatcher, ovenbird, and American redstart, may experience declines with selective cutting that opens the canopy. Red-eyed vireo numbers have also reported to decline in selectively logged forests (Adams and Barret 1976, Whitcomb et al. 1977). Forest interior birds that require an open understory may be negatively impacted by selective harvesting practices. Adams and Barrett (1976) found fewer Acadian flycatchers in a selectively logged woodland, but observed more ovenbirds. In contrast, Whitcomb et al. (1977) found fewer ovenbirds on their selectively logged study area than on their control site, which is the predicted response.

In general, forest management actions conducted to increase patch sizes with a greater diversity of species composition and structure of existing forest stands, reduce forest fragmentation by reforestation of certain areas, and improve forest health and biological integrity of existing forest stands will have beneficial long-term impacts on focal forest management bird species.

Temporary adverse impacts, particularly on migrating and wintering landbird species, would result from setting back succession and maintaining grassland and shrubland habitats, as when we burn prescribed fires and mow to remove biomass or set back succession, or brush-hog woody growth or spot-treat young trees and stumps in the winter months. However, staggering treatments between years can reduce disturbance factors for landbird-use during the late winter and early spring, and areas would be available again for breeding landbirds after winter treatments.

An increase in salt marsh acreage through restoration would benefit several high priority tidal creek and salt marsh-dependent species, such as salt marsh sharp-tailed sparrows and seaside sparrows (USFWS2006), through an increase of nesting habitat (*Spartina*-dominated marsh) and foraging opportunities (estuarine fish). Other species, including but not limited to osprey, northern harrier, and belted kingfisher, will benefit from the restoration of foraging habitat. Although impounded marshes may support a greater diversity of birds, they represent unsuitable habitat for declining marsh species such as willets and seaside and saltmarsh sharp-tailed sparrows (Brawley). Burger (1982) noted that species restricted to salt marshes only occurred in unimpounded study sites. In addition, important stopover habitat would be created or restored for migratory birds. The restoration of the salt marsh would reduce storm surge and erosion impacts on upland forest habitats, which are especially critical habitats during the migration (Dawson and Buler 2010).

The restoration of tidal flow may initially increase the amount of surface water on a marsh and therefore eliminate breeding habitat for birds that nest on or near the marsh surface. Direct minor-to-moderate impacts to migratory birds may result from construction activities associated with disposal of dredge material for marsh restoration, such as the installation of temporary retention dikes to contain dredged material in shallow open water or low elevation marshes (USACOE 2010). Birds utilizing these areas would be temporarily displaced to adjacent habitats.

Efforts to reduce predation pressure on migratory birds of concern, especially to benefit species that nest on beaches and overwash habitats, would entail lethal removal of individual predatory birds from suitable nesting and brood rearing habitat. We have placed predatory birds within the landbird segment of this EIS, even though potential predatory birds are representative of several guilds, e.g., crows (American and fish), gulls (laughing, herring, ring-billed and great black-backed), grackles (common, boat-tailed), black-crowned night herons, great-horned owls and others. The removal of a few individual birds from within localized nesting areas would be designed to remove offending (problem) animals, and would have very limited impact on each avian predator population as a whole.

Public Use
Not permitting dog walking in the refuge is one action that will reduce impacts to landbirds.

We expect indirect impacts to landbirds to increase due to proposed expansions in public use activities including fishing, hunting, wildlife observation, wildlife photography, and environmental education and interpretation. Direct impacts to landbirds such as quail, woodcock, and snipe are expected to be similar to those in alternative A since no increase in upland game hunting is expected. Impacts are expected to be negligible.

The level of recreation use and ground-based disturbance from visitors would largely be concentrated at trails and other access points. This, combined with the addition of increased hunting opportunities, may have a negative effect on nesting bird populations. However, the hunting season (except for spring turkey hunt) is during the winter and not during most birds' nesting periods.

Under this alternative, the refuge proposes to open 3,729 acres for wild turkey hunting. This additional acreage includes many of the areas for deer hunting under this alternative. Turkey hunting was permitted on the refuge in Unit I west of Slaughter Canal from 1993 up until 1998. Turkey is a resident game species that is managed by DNREC's Division of Fish and Wildlife. The refuge falls within Zone 9 of DNREC's Wild Turkey Management Regions and the refuge will work closely with DNREC to evaluate the status of the turkey population and its hunting potential. Zone 9, which includes the state-owned Prime Hook Wildlife Area that is adjacent to the refuge, is currently open during the spring turkey hunting season. To ensure a sustainable harvest of the state's turkey population, DNREC biologists track their health, distribution and reproductive success. Current efforts include a volunteer-based survey used to generate an index of annual turkey productivity and recruitment, monitoring turkey harvest and hunter efforts, tracking turkeys with radio transmitters to evaluate their reproductive ecology, habitat use, and survival, and evaluating the genetic diversity of turkeys. Impacts from turkey hunting on turkeys and other non-target wildlife, which occurs in April and May, are expected to be negligible since only a very small number of hunters (five or fewer) will be permitted to hunt. The number of permitted hunters may be adjusted (increased or decreased) based on changes in turkey population data.

Turkey hunting is not expected to have direct, indirect, and cumulative impacts on refuge salt marsh habitats because hunter numbers are limited to less than five and are scattered over 1,732 acres. The preferred habitat of Eastern wild turkeys is mature or old growth forests due to both the structural characteristics and food production in such habitats. We believe that the salt marsh in Unit I would be a seldom utilized habitat by turkey during any stage of its life-cycle and consequently seldom hunted. Wild turkeys take advantage of different habitats throughout the year based on their food and nesting needs. In the fall, turkeys forage in mast-producing stands of oak/hickory, oak/pine, and hardwoods. Hardwood stands with south-facing slopes are favored in winter. Large softwood or hardwood trees are needed for roosting. In winter, turkeys often forage on agricultural lands. The Service is aware that free roam areas for turkey hunting will provide hunters greater access and may also increase the potential for marsh disturbance. However, hunters are aware of the species habitat preferences and would direct their hunting efforts accordingly within the defined hunt unit. Any potential disturbances are mitigated by creating salt marsh sanctuary areas where no hunting occurs

Conclusions for Management Actions in Alternative B
Management actions in alternative B would result in short- and long-term local moderate-to-major impacts, such as increased landbird use by restoring and

protecting wintering and migrating habitat and restoring a large acreage of salt marsh habitat for landbird species of conservation concern. However, it would also have opposing local short-term minor impacts during management or restoration efforts. No impairment of the refuge's BIDEH is expected unless the impounded areas revert to open water, which would have a negative effect on diversity and biological integrity. Through the restoration of the impounded marshes to salt marsh, the refuge may be sacrificing diversity at the local scale for biological integrity and diversity at the regional or landscape scale. Impacts from public use are expected to be negligible.

Impacts on Landbirds in Alternative C

Managing and Protecting Habitat

The direct, long-term benefits for landbirds under Alternative C stem from the availability of 775 acres of mature upland forested cover-types with some patches greater than 250 acres for area-sensitive forest interior dwelling bird species in addition to 2,200 acres of salt marsh habitats, 1, 238 acres of forested wetland habitats, and some early successional habitats that would have beneficial impacts on focal species of breeding landbirds. All these habitat cover-types are also suitable for migrating and wintering landbirds. Indirect beneficial impacts for continental landbird populations would be the continued refuge contribution to State and regional populations to sustain healthy populations over the long term.

Alternative C's management of upland fields using cooperative farming would render 600 acres of potential native forest or early successional habitats unavailable for focal breeding grassland, shrubland-dependent, or forest-interior dwelling landbird species and migrating and wintering landbirds. The cooperative farming program in alternative C involves the use, as approved, of glyphosate-tolerant corn and soybeans. This is considered by most experts to be less toxic to wildlife than other herbicide technologies employed by farmers. However, the use of these crops can affect landbirds indirectly by altering habitat and food sources, such as by reducing weed seed biomass or changing weed species composition (Cerebra and Duke 2006).

Public Use

Proposed expansions in hunting opportunities are expected to cause more impacts to landbirds in alternative C than those outlined in alternative A, but fewer than alternative B. All other types of recreation will have similar impacts to those in alternative A. The reduction in hunting days for deer and waterfowl will decrease disturbance to landbirds from that in alternative B.

<u>Conclusions for Management Actions in Alternative C</u>

Management actions in alternative C would continue to result in short-term local minor impacts, such as continued landbird use by providing wintering and migrating habitat, but it would also have local long-term minor-to-moderate opposing impacts by limiting some upland areas from use by landbirds, and by limiting habitat available for salt marsh obligate passerines. No impairment of the refuge's BIDEH is expected.

Impacts on Secretive Marsh and Waterbirds

As previously mentioned, marsh management and conservation are compelling priorities for the refuge as reflected in our wetlands habitat management goals 1 and 3. Each refuge alternative has included an emphasis on wetlands in the objectives and strategies. Focal species include Virginia rail and least and American bitterns.

We evaluated the benefits of the following actions for their potential impact on open water and wetland habitats for secretive marsh and waterbirds:

- Maintaining quality migrating and wintering habitats for waterbirds (September to March)

- Conserving insect and other invertebrate food resources to provide high quality habitats for breeding secretive marsh and waterbirds
- Managing 800 acres of shallow water habitats (5 to 15 inches deep) within patches of perennial wetland plants that also support fish, aquatic invertebrates, amphibians, and other prey food sources for nesting bitterns, coupled with drier marsh areas required by rails during summer for brood foraging
- Managing to prevent and control the growth and proliferation of invasive plant species
- Restoring salt marsh communities within Unit II
- Invasive species treatments that might adversely affect nesting and migrating waterbirds
- Activities of visitors and users that might directly impact wetland habitats or disturb breeding focal species (rails and bitterns) or migratory waders

Impacts on Secretive Marsh and Waterbirds That Would Not Vary by Alternative

In addition to gradual losses of wetland acreage due to sea level rise and climate change, we expect any impacts on secretive marsh and wader habitats would most likely result from changes in local vegetation, water quality, flood, droughts, direct human disturbance, or an influx of invasive species.

Managing and Protecting Habitat
Across all of the alternatives, controlling invasive plant species will increase the availability of preferred nesting substrate and associated insects of native plant communities for forage during breeding season periods.

Most invasive plant treatments would occur in late August and September, which would preclude any impact to breeding secretive marsh birds or waders. By that time most waterbirds have completed their breeding cycles, and disturbance factors due to spraying activities would be minimal.

Insecticides used in refuge wetland habitats may have adverse impacts on insects and other non-target invertebrates important for breeding, secretive marsh birds like black rail, clapper rail, Virginia rail, least bittern, and American bittern. To the extent that secretive marsh birds and waders consume non-target aquatic and terrestrial insects, the birds may experience negligible-to-minor reduction in food availability under all three alternatives. The degree to which adulticides and larvicides will impact food resources will likely vary by time, location, chemical used, concentration, treatment interval, and number of treatments. The ability of these birds to move to alternate feeding sites or shift their diet within the treatment site to alternative food resources is unknown. Certainly, fish or crustaceans available will be readily consumed. However, site-specific indirect impacts to pre-fledging secretive marsh birds, in particular, are unknown. Mosquito spraying activities that commence in April and end in October can also have site-specific adverse disturbance impacts from both monitoring and spraying activities.

There is concern over the impacts of open marsh water management (OMWM) on black rail, a species of concern associated with tidal high marsh, which prompted the state of Maryland to cease OMWM in the early 1990s (DNREC 2005). Circumstantial evidence from at least one site in Delaware supports this concern, and the issue warrants further study. No OMWM construction has been permitted on the refuge since 2002, and no new construction is proposed at this time. Any ongoing impacts from OMWM to the local ecology are site-specific, and limited to extant sites. The refuge considers maintenance of extant sites to pose negligible additional impacts to secretive marsh and other waterbirds, if any.

Public Use
Resident waterbirds tend to be less sensitive to human disturbance than are migrants, and thus will be less impacted by disturbance from public use on the refuge. However, wading birds have been found to be extremely sensitive to disturbance in the northeastern U.S. and may be adversely impacted by disturbance from public use on the refuge (Burger 1981). The impacts of intrusion through public use are generally negligible for this group of birds, but can vary by species and between years (Gutzwiller and Anderson 1999).

Direct disturbance to secretive marsh birds and waders from waterfowl hunting would start in September and usually end in January. Waterfowl hunting pressure may disturb migrating or wintering waterbirds, but these negligible impacts would be mitigated by bird sanctuary areas that secretive marsh birds and waders would utilize to avoid hunting disturbance factors. Furthermore, the refuge proposes limited hunting days and restricted hunting hours. Disturbance is also decreased by closing the Oak Island Area in Unit II, the area south of Fowler Beach Road in Unit II, and disabled deer hunting area in Unit IV in late November to hunting and by closing the Deep Branch Trail to non-consumptive users from September 1 through March 15.

Visitors at designated fishing areas may flush wading birds and secretive marsh birds that are within view of a trail, boat launch, beach, or pier. We anticipate less public use at these locations in the winter.

Bank fishing by anglers is restricted to designated areas off State-maintained highways at Slaughter Creek, Slaughter Canal, and Petersfield Ditch. These areas are also accessible to wildlife observers and photographers. Higher rates of public use would occur during the warmer months, but there are protected and secluded areas nearby where disturbed birds can relocate. Adverse impacts resulting from disturbance are therefore anticipated to be minor, temporary, and infrequent.

A potential direct adverse impact exists for wetland and open waterbird species, such as osprey, herons, and waterfowl, from lost fishing gear, specifically, hooks, lures, and litter become entangled in fishing line or hooks and ingestion of lead sinkers are sources of concern throughout the region. The extent to which these bird species are currently impacted by fishing tackle is unknown. Discarded fishing line and other fishing litter can entangle migratory birds and marine mammals, causing injury and death. We will continue to work with our fisheries assistance office and the State in implementing a public education and outreach program on these issues. Increased law enforcement is also planned.

For additional impacts, refer to the previously discussed section on Impacts to Waterfowl.

Impacts to Secretive Marsh and Waterbirds in Alternative A

Impacts on secretive marsh and other waterbirds under Alternative A (“No Action”) serve as a baseline for comparing and contrasting Alternatives B and C to the refuge’s existing management activities.

Managing and Protecting Habitat
Permitting the natural return of salt marsh into the degraded impounded wetlands may potentially result in an increase of open water, which could increase

foraging areas used by long-legged wading birds such as great blue heron, great egret, snowy egret, and glossy ibis. This minor beneficial impact would be local and potentially short-term, as salt marsh vegetation may eventually colonize open areas. Shorter-legged birds may be displaced by the higher water levels likely to occur under alternative A, and may experience a decrease in food availability. The vegetation and water quality will be changed unless and until the salt marsh system is established.

Public Use
Same as those discussed in Impacts to Secretive Marsh Birds and Waterbirds That Would Not Vary by Alternative.

Conclusions for Management Actions in Alternative A
Management actions in alternative A would result in minor-to-moderate local long-term adverse impacts and minor local beneficial impacts. No restoration or management of the marsh will likely increase the amount of open water and many areas will be eliminated for potential nesting sites for water birds. There would be minor local increase in foraging habitat for wading birds with the increased surface water available. Under the existing conditions of sea level rise and insufficient marsh accretion, we would anticipate local adverse impacts to waterbirds sometime in the future. As full daily tidal flow continues to impact the impounded wetlands, the vegetation composition, water quality, fish, invertebrate, and amphibian populations will be changed as the transition from fresh water to salt water takes place, potentially decreasing the food available for waterbirds.

Impacts to Secretive Marsh and Waterbirds in Alternatives B

Managing and Protecting Habitat
Secretive marsh and waterbirds nesting in the vicinity of beach and overwash habitats would likely have short-term direct benefits from the proposed active removal of predators.

Active restoration of salt marsh will benefit certain secretive marsh bird and waterbird species, such as clapper rails and willets. With the reintroduction of saltwater into the freshwater areas, some trees may die along the adjacent uplands, providing possible nesting habitat for wading birds such as herons and egrets. In addition, with reestablished tidal flow, fish can enter into the shallow waters and provide food to wading birds.

However, restoration of some areas from freshwater marsh to salt marsh may impact other secretive marsh bird species that prefer freshwater wetlands, such as bitterns and sora, to the extent they are present in refuge wetlands. Initially the restoration process will potentially have local adverse impacts for all secretive marshbirds and waterbirds in the area. The direct human disturbance, presence of construction equipment, presence of people, and noise may cause secretive marshbirds and water birds to temporarily leave the restoration area (ACOE 1996). Salt marsh restoration programs attempt to be timed to reduce impacts to wildlife, so much of this activity may be conducted outside of the breeding season.

Public Use
Disturbance to secretive marsh birds and waders from hunting would start in September and usually end in January, unless hunting is allowed during the snow goose conservation order into mid-April. This disturbance may have direct effects on migrating and wintering secretive marsh birds and waders. However, these birds would receive added benefits from the establishment of new sanctuary areas or zones, where 3,185 acres would be protected from hunting activities and other public use that cause disturbances to secretive marsh and waterbirds.

In addition to alternative A, we expect adverse impacts to secretive marsh and waterbirds to increase due to proposed expansions in public use activities including fishing, hunting, wildlife observation, wildlife photography, and environmental education and interpretation. Impacts are expected to be negligible. An increase in the number of hiking trails and new areas open to fishing and hunting, particularly in or near wetland areas, has the potential to increase disturbance to secretive marsh and waterbirds.

Conclusions for Management Actions in Alternative B

Management actions in alternative B would result in both short-term local minor impacts and opposing long-term local moderate impacts. The long-term impact would result from the sustainable salt marsh habitat provided to the local secretive marshbirds and waterbirds. However, actively restoring the freshwater system to a sustainable tidal salt marsh will change the vegetation composition and initially cause an increase in the amount of surface water and decrease the amount of breeding habitat on the marsh surface (Brawley et al. 1998), at least for the short-term.

Alternative B will also achieve a higher biological diversity of species and healthier natural structure and function of the marsh through the reestablished tidal exchange, which will ultimately improve habitat conditions for most secretive marsh birds and wading birds on the refuge. The restoration of the salt marsh may reduce diversity at the local scale but help maintain diversity and biological integrity at the landscape scale.

Impacts to Secretive Marsh and Waterbirds in Alternative C

Managing and Protecting Habitat

Secretive marshbirds and waterbirds would use the freshwater impoundments for migrating and wintering habitat. Alternative C would continue to provide appropriate structural habitat characteristics for waders and secretive marsh birds by managing shallow freshwater habitats within patches of annual and perennial wetland plants that also support fish, aquatic invertebrates, amphibians, and other prey food sources for nesting bitterns, coupled with drier marsh areas required by rails during summer for brood foraging. However, alternative C would provide unfavorable habitat for salt marsh species such as clapper rail and willet.

Public Use

Proposed expansions in hunting opportunities are expected to cause more impacts to secretive marsh and waterbirds in alternative C than those outlined in alternative A, but less than alternative B. All other types of recreation will have similar impacts to those in alternative A. Impacts are expected to be negligible. The reduction in hunting days for deer and waterfowl and the closure of waterfowl hunting until noon will decrease disturbance to secretive marsh and waterbirds from that in alternative B.

Conclusions for Management Actions in Alternative C

Management actions in alternative C would result in short-term local minor impacts, such as continued impoundment use by providing wintering and migrating habitat, but would also have opposing local minor-to-moderate impacts causing the naturally occurring salt marsh-dependent species to be displaced from the freshwater area. During times when the artificial dunes are breached and saline water enters the freshwater system the vegetation composition, water quality, fish, invertebrates and amphibian populations will be impacted, and potentially decrease the food availability for waterbirds.

Impacts on Mammals

We evaluated the management actions and public uses for each of the alternative proposals for their potential to beneficially or adversely affect large and small aerial, terrestrial, or wetland mammals:

- Conserving wetland and upland habitats
- Controlling invasive plant species or restoring native plant communities
- Managing and maintaining early successional habitats (grasslands and shrublands) using prescribed fire, brush-hogging, and other mechanical treatments
- Managing deer populations with hunting
- Controlling beavers and nutria
- Managing and protecting federally and State-listed beach-nesting birds from mammalian predators

Impacts on Mammals That Would Not Vary by Alternative

Managing and Protecting Habitat

The management actions that hold potential for minor-to-moderate beneficial impacts on mammals, and that would continue regardless of the alternative we select, are our strategies for conserving and maintaining biological integrity, diversity, and environmental health, restoring native plant communities, improving habitat conditions for the endangered Delmarva fox squirrel, and controlling invasive or nuisance species. Each of these actions directly or indirectly benefits mammalian populations over the long term by ensuring the continuation of quality natural habitats on the refuge for resident and migratory (bats) mammalian wildlife.

Habitat enhancement and creation of large continuous tracts of forested habitats and outreach programs to the public on our conservation practices are the best strategies for ensuring the continued availability of quality forest, riparian, early successional, and wetland habitat conditions for mammals. The carrying capacity of each of these habitat types with respect to the 34 native species of mammals found on the refuge will depend on the size of each tract, vegetation composition, corridor connectivity, surrounding land uses, weather patterns, availability of food resources, and the interactions of mammals with these habitats.

Some mammals exert a greater influence than others when considering mammalian-habitat relationships. For example, the largest mammalian species on the refuge, white-tailed deer, has been identified as a significant ecosystem engineer that plays a large role in physically structuring its habitat (Baiser et al. 2008). Native forested habitats in the eastern U.S. evolved with deer densities of approximately 20 per square mile. When densities exceed 25 per square mile or roughly one deer per 25 acres, signs of habitat degradation begin to appear (DeCalesta 1994). Continued management of the refuge deer herd through hunting will reduce these habitat impacts for the benefit of all terrestrial mammals, including deer, and other wildlife.

Controlling invasive plant species, particularly those that quickly colonize an area and form dense, monotypic stands, will benefit mammals by maintaining the balance of food resources and native vegetative communities with which they evolved or adapted to for cover, nesting, and diverse quality food resources. For smaller, insectivorous mammals, maintenance of native plant diversity and structural integrity by controlling invasive species will have a particular impact because those species rely on the biodiversity and availability of invertebrate food resources that are only associated with native floral assemblages.

Wetland mammals such as marsh rice rat, muskrat, beaver, and river otter benefit through our conservation and management of forested wetlands, bottomlands, and emergent wetland habitats, while the remaining 29 native species will thrive where the composition of refuge forests contains a diversity of mast-bearing species and other mixed hardwood resources. At the time of this writing, the population size of non-native mammals on the refuge are so small as to have negligible impact on any of the refuge's habitats or other mammal populations.

Occasional control of beavers where they are girdling and felling swamp cottonwood *(Populus heterophylla)* trees in coastal plain habitats would have only a negligible and local impact on the beaver population. Additionally, on occasion beavers and muskrats will be controlled where there is localized damage to refuge infrastructure, e.g. damage to dikes, or flooding of neighboring private property from within the refuge. Individual animals will be impacted, but the population as a whole will experience no long-term adverse impacts because these species are well-established statewide and beyond.

Public Use

In general, the presence of humans will disturb most mammals, which typically results in indirect negligible short-term adverse impacts without long-term effects on individuals and populations.

Adverse impacts on resident game populations from hunting would be negligible. The Delaware Division of Fish and Wildlife periodically reviews populations of all harvested resident species and has determined that populations are adequate to support hunting efforts throughout the State. Hunter visits and harvest of upland and small game such as rabbit on the refuge have been relatively low and thus impacts are expected to be negligible. The refuge does not allow hunting of eastern gray squirrel to minimize conflicts with endangered Delmarva fox squirrel.

Overall impacts from hunting on non-hunted mammals, such as voles, moles, mice, shrews, and bats, are expected to be negligible. Since small mammals are less active during winter when hunting season occurs, and since these species are mostly nocturnal, hunter interactions with small mammals are very rare. Vehicles are restricted to roads and harassment or taking of any wildlife other than legal game species is not permitted. Except for some species of migratory bats, these species have very limited home ranges and hunting would not affect their populations regionally. Impacts of hunting to migratory bat species would be negligible. These species are in torpor or have completely passed through Delaware by peak hunting season in November through January. Some hunting occurs during September-October and March-April when these species are migrating; however, hunter interaction would be commensurate with that of non-consumptive users.

The Delaware Division of Fish and Wildlife recently finalized a new statewide 10-year deer management plan (Rogerson 2010). The plan was created with input from a 22-member advisory group, a public phone attitude survey, a mail survey to hunters, comments solicited from the general public, and technical reviews from deer experts outside the division. The resultant plan identifies population objectives based on habitat capability and societal tolerances.

Prime Hook NWR is located in the State's deer management zone 9, which encompasses the northeastern coastal portion of Sussex County (Rogerson 2010). The Division of Fish and Wildlife manages deer populations, in part, through recreational hunting. Based on their monitoring programs, the Division of Fish and Wildlife adjusts hunting levels in terms of season length, sex ratio in the harvest, and number of hunters (tag availability) to move population levels toward desired objectives. Of course, other factors such as disease, severe weather, predation, and automobile collisions influence mortality are taken into account by annual monitoring.

Delaware deer herd statistics indicate that the deer density in zone 9 was estimated in 2009 at 22.5 deer per square mile with a variability of plus or minus 20.75 percent (Rogerson 2010). This is a decrease of 58 percent from the 2005 estimated density of 39.2 deer per square mile (Rogerson 2010). The total Statewide post-hunting season deer population in 2005 was estimated at 37,563 deer, while in 2009 it was estimated at 31,071 deer, a 17.3 percent Statewide reduction. Major land use changes over the last 100 years have created a deer herd that exceeds normal deer densities of 10 to 20 deer per square mile.

High deer numbers are associated with crop damage, reduction of some forest understory species, and reduction of reforestation seedling survival, which all impact habitat that is important for a variety of wildlife. White-tailed deer hunting is the single most important public use on the refuge that would impact mammals, including deer, and other forest-dependent wildlife. It serves both as a wildlife-dependent recreational use and a method to reduce and stabilize deer densities. This benefits other mammals, including the endangered Delmarva fox squirrel.

Based on a nationwide survey of all states (Krausman 1992), deer populations are effectively controlled with hunting and habitat manipulation in many areas where they were overpopulated. In a 10-year study in northwestern Pennsylvania examining the impacts of varying densities of deer on deer health and habitat, starvation mortality resulted when densities reached higher than 25 deer per square kilometer (247 acres). Also, no prevention or control of epizootic hemorrhagic disease exists to date except by keeping populations below the carrying capacity of their habitats. Such breakouts have occurred on the refuge in the past. Based on these considerations, it is anticipated that hunting would have short-term and long-term minor-to-moderate beneficial impacts on deer health and quality and habitat condition.

Hunting resident game species on the refuge, such as deer, will result in negligible impacts on their populations because of their restricted home ranges. The refuge contributes negligibly to the State's total harvest for resident game species (figure 5.1 and tables 5.11 and 5.12). For example, since 1999, deer harvest at the refuge has ranged from 0.5 percent to 1.5 percent of Delaware's total deer harvest each year. The current harvest level of deer on the refuge (66) has a negligible impact on the Statewide deer population, which was last estimated at 31,071 deer in 2009 (Table 5-12). Given the low numbers of animals harvested from the refuge in respect to the total Statewide harvest and deer population, no cumulative impacts to local, regional, or Statewide populations of white-tailed deer are anticipated from allowing hunting of the species on the refuge. Additional information on the status of the Delaware deer herd and the Delaware hunting program can also be found in the Refuge Hunt Plan (appendix C).

Figure 5-1. Delaware Annual Deer Harvest 1954 to 2008/09 Seasons (Rogerson 2010)

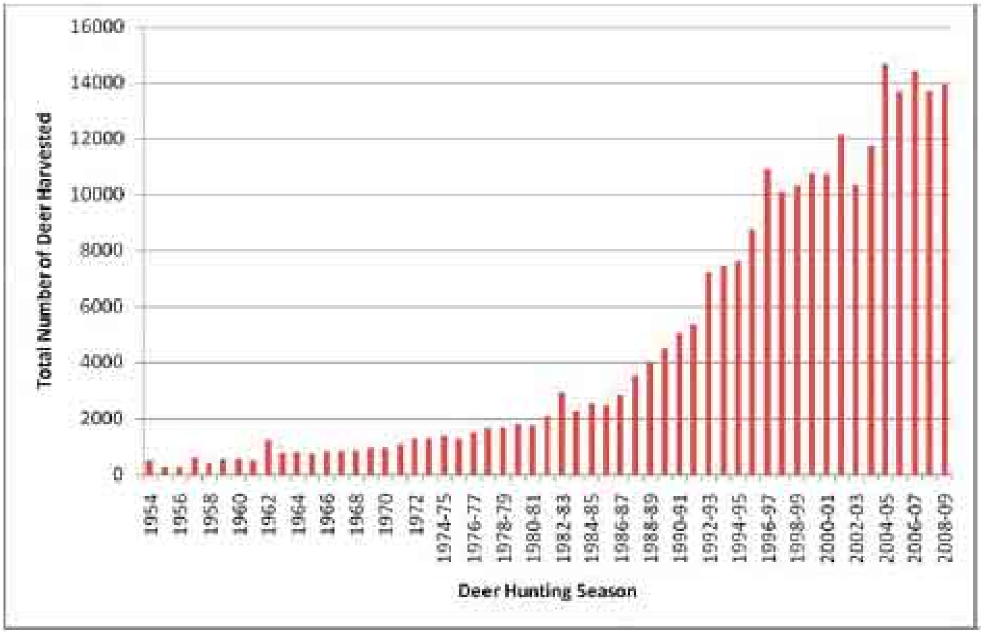

Table 5-11. Number of Deer Harvested and Hunter Visits on Prime Hook NWR Compared to Statewide Harvest

(Source: DNREC 2010b, refuge harvest data, *http://www.dnrec.state.de.us/fw/deer.pdf)*

Year	Statewide Deer Harvest	Refuge Deer Harvest	Refuge Hunter Visits
1988	3,998	141	1,289
1989	4,504	155	1,131
1990	5,066	178	1,689
1991	5,336	163	1,703
1992	7,245	257	1,608
1993	7,465	219	1,616
1994	7,615	169	1,568
1995	8,781	217	1,184
1996	10,915	221	1,326
1997	10,091	187	1,510
1998	10,312	138	1,335
1999	10,756	114	870
2000	10,741	125	941
2001	12,133	188	1,003
2002	10,357	160	913
2003	11,712	175	891

Year	Statewide Deer Harvest	Refuge Deer Harvest	Refuge Hunter Visits
2004	14,669	143	841
2005	13,670	133	884
2006	14,401	120	825
2007	13,369	108	790
2008	13,926	106	670
2009	12,400*	107	552
2010	14,183	114	549
2011	13,559	66	513

Table 5-12. Cumulative Impacts of Existing Deer Hunting on Prime Hook NWR/State Deer Management Zone 9 (2011-2012 data) Compared to Statewide Harvest

Hunt Location and Type	Harvest
Prime Hook NWR	66
State Deer Management Zone 9	852
Statewide Harvest (all 17 Deer Management Zones)	13,559

Delaware permits hunting for red fox, which assists State management efforts in reducing the incidence of mange outbreaks to maintain a healthy population and reducing the predatory impact of this species on migrating and breeding birds, particularly State and federally endangered or threatened species. Hunting would be opportunistic in most cases. In other states, the incidental harvest of fox occurs during other open seasons such as deer season and the pelts are often retained for personal use. Though no county-specific data are available, healthy populations of fox exist in the State and anticipated harvest rates would result in negligible impacts to local or State populations (Reynolds, personal communication 2010).

Impacts on Mammals in Alternative A

Impacts on mammals under Alternative A (“No Action”) serve as a baseline for comparing and contrasting alternatives B and C to the refuge’s existing management activities.

Natural conversion of upland fields to early successional habitat and forest cover would impact mammals by increasing natural habitat availability. Short-term and long-term minor-to-moderate beneficial impacts are expected for mammals such as voles, moles, shrews, mice, rabbits, groundhogs, and deer with increased acreage of these natural habitat types.

Bats will utilize managed open habitats on the refuge for nighttime aerial foraging as these habitats have high abundances of insect prey species. Grasslands, shrublands, wet meadows, and marshes that lie close to refuge forests where bats roost will provide critical foraging habitats. Upland forest-dependent mammals, especially Delmarva fox squirrel, would experience long-term moderate beneficial impacts due to increases in forest cover, although desired forest conditions may not be met as quickly or readily as under Alternative B. Bats also would gain increased roosting habitat when trees mature enough to form cavities and crevices in their bark. Along riparian buffer zones, increased forest cover would benefit otter, mink, weasel, and beaver

Indirect short-term and long-term minor-to-moderate beneficial impacts would result from the long-term persistence of patches of grasslands across the refuge landscape. Such habitat patterns contribute to the enhanced survival and population growth of small mammals with limited home ranges. A continuous supply of palatable herbaceous plants also contributes to the overall health of the deer herd. Carnivores and omnivores such as fox, skunk, mink, long-tailed weasel, coyote, opossum, and raccoon, which feed on small mammals, will thrive at the interface between refuge field and forest habitats.

Conclusions for Management Actions in Alternative A

Passive habitat management associated with alternative A would result in short-term and long-term minor-to-moderate direct impacts to mammals through increases and improvements in natural habitats Hunting provides short-term and long-term minor-to-moderate impacts on deer herd health and forest-dependent wildlife, such as the Delmarva fox squirrel, by stabilizing deer densities and enhancing forest health. Alternative A would contribute negligible short-term, site-specific, local, and regional adverse impacts on hunted and non-hunted species.

Impacts on Mammals in Alternative B

Managing and Protecting Habitat

Overall, beneficial impacts to mammals would be the same as under Alternative A, although desired forest conditions most suitable for the Delmarva fox squirrel would be achieved sooner and more effectively.

Early successional habitat maintenance activities such as brush-hogging and burning prescribed fires carry a direct risk to some individuals among small mammals, but the adverse impacts are short-term and negligible at the population level. These activities never occur more than once a year in a given area and rarely during the breeding season. Most mammals can scurry out of the way or escape underground. Fire flashes across fields quickly, often burning only the top few centimeters of duff. Small mammals such as mice, shrews or voles escape injury. In addition, back-burning or stripping prescribed fire techniques used to better manage and control the rate of spread and intensity of heat provide opportunities for most non-burrowing mammals to flee.

Sometimes the removal of native mammalian predators is necessary to increase post-breeding numbers of targeted endangered, threatened, or rare beach-nesting shorebird species. Shorebird eggs and chicks are highly susceptible to depredation by numerous mammalian species, especially raccoons, foxes, feral and domestic cats, and dogs. Some form of mammalian predator management and control will be required to conserve these bird species locally and help achieve refuge bird nesting conservation and productivity objectives listed in alternative B goals and objectives. Predator management alternatives include lethal and non-lethal predator control. Lethal control of predators can be very controversial, time consuming, and temporary (USFWS 1988). The lethal removal of a few individual mammals from such localized areas would have a negligible adverse impact on the population as a whole.

The use of non-lethal methods, such as electric fencing, metal barriers, and wire mesh enclosures, will impact mammals by interfering with normal foraging behavior. However, non-lethal techniques will not promote self-sustaining bird populations in the long term because it does not eliminate predators (Johnson and Oring 2002).

Public Use
We expect negligible-to-minor short-term adverse impacts to mammals due to proposed expansions in public use activities, including fishing, hunting, wildlife observation, wildlife photography, and environmental education and interpretation. The level of use and ground-based disturbance from visitors would be largely concentrated at trails and other access points, which consist of previously maintained interior roads and access routes. Despite increased opportunities for hunting, hunter participation on the refuge and in the State is decreasing. Direct short-term, long-term, and cumulative adverse impacts to mammals are expected to be negligible.

Conclusions for Management Actions in Alternative B
Management actions in alternative B would result in short-term and long-term minor-to-moderate direct impacts to mammals through increases and improvements in natural habitats. Alternative B would contribute negligible-to-minor short term indirect adverse impacts from expansion of public use, negligible-to-minor indirect adverse impacts from removing protective cover through maintenance activities such as mowing, forest management activities, or prescribed fires, and negligible short-term, long-term, and cumulative impacts due to hunting. Alternative B contributes to the BIDEH of the refuge through habitat improvement and enhanced natural ecological processes which will improve the quality and quantity of soil, water, plant, and invertebrate resources that should benefit healthy and thriving mammalian populations.

Efforts to reduce predation pressure on migratory birds of concern, especially to benefit species that nest on beaches and overwash habitats, would entail a combination of non-lethal control methods and lethal removal of individual mammals from suitable nesting, brood rearing, or foraging habitat. The removal of a few individual mammals from such localized areas would have negligible-to-minor adverse impacts on refuge populations as a whole of raccoons or gray or red foxes.

Impacts on Mammals in Alternative C

Managing and Protecting Habitat
Overall, alternative C would have the same impacts as reviewed in Impacts on Mammals That Would Not Vary by Alternative. In addition, the cooperative farming program in alternative C involves the use, as approved, of glyphosate-tolerant corn and soybeans. This is considered by most experts to be less toxic to wildlife, especially regarding mammalian toxicity, than other herbicide technologies employed by farmers. However, the use of these crops can affect wildlife indirectly by altering habitat and food sources, such as by reducing weed seed biomass or changing weed species composition (Cerdeira and Duke 2006). Some mammal species may feed on waste grain in refuge farm fields, although this is negligible as a food resource.

Public Use
Impacts to mammals from hunting will be similar to those in alternative B and impacts from other public uses will be similar to those in alternative A.

Conclusions for Management Actions in Alternative C
Management actions in alternative A would result in indirect long-term minor-to-moderate benefits to mammals by ensuring the continuation of quality natural habitats on the refuge for resident and migratory mammalian wildlife through strategies for BIDEH, restoring native plant communities, improving habitat conditions for the endangered mammal, and controlling invasive or nuisance species. For hunting and all other public uses, alternative C would have impacts on mammals similar to alternative A. Alternative C contributes to the BIDEH of the refuge through habitat improvement.

Impacts to Reptiles and Amphibians

The conservation and protection of the refuge's reptiles and amphibians, collectively referred to as herpetofauna, is another wildlife management priority, which fits into all alternative goals and objectives for wetland, upland, and riparian habitats. Reptile and amphibian conservation management principles endorsed by Partners in Amphibian and Reptiles Conservation (PARC) will promote the sustainability and health of herpetofauna on refuge lands.

We evaluated the impacts of the following actions on the refuge's herpetiles species and communities:

- Augment forested habitat patch sizes and increase connectivity between patches.
- Expand riparian and wetland buffer zones.
- Managing habitat by mowing, brush-hogging and prescribed fire burning
- Restoration of freshwater impoundments to salt marsh
- Control of invasive plant and animal species.
- Public outreach and education on PARC habitat management guidelines and conservation practices
- Mosquito control
- Disturbing wildlife by recreation activities

Impacts on Reptiles and Amphibians That Would Not Vary by Alternative

Improving and enhancing existing habitat types to augment their patch size and connectivity, restore at least some areas to native vegetation, ensure adequate forest buffers around wetlands and waterways, control invasive species in all habitat types, and enhance access and opportunities for public use will occur regardless of the alternative selected and all of these actions will have impacts on reptiles and amphibians.

Managing and Protecting Habitat
Managing existing forested habitats for the long-term viability of the endangered Delmarva fox squirrel and augmenting effective interior size of these habitats for area-sensitive landbird species will also have a moderate beneficial impact on the herpetiles that require and use these same habitats. Upland mixed hardwood habitats will benefit red-backed salamander, spotted salamander, wood frog, Cope's gray tree frog, Fowler's toad, five-lined skink, water snake, rough green snake, milk snake, and eastern box turtle, while bottomland forests and creek courses are important areas for mud salamander, carpenter frog, and spotted and eastern painted turtles.

Large tracts of mature forest are more likely to contain vernal pool habitats and large tracts of wetlands hold more areas of still fresh water for breeding amphibians. Restoring and enhancing connectivity between refuge wetlands and uplands will facilitate movement of reptiles and amphibians that promotes better genetic mixing and avoids adverse impacts of inbreeding. Travel corridors will also reduce mortality during dispersal movements.

Under all alternatives, we will allow dead trees and other coarse woody debris to decompose naturally by leaving stumps, blowdowns, and standing snags. This will have a moderate beneficial impact on herpetofauna, as many reptiles and amphibian species nest, forage, seek shelter, or hibernate inside or underneath rotten logs, windblown trees, and stumps.

Shallow vernal pools shaded by canopy trees are crucial for breeding from February to late summer and for overwintering. Buffering is essential to protect these areas from drying out too quickly, and to absorb the runoff of nutrients, pesticides, and sediments before they reach wetland or vernal pool habitats. The same objectives and strategies for providing buffer zones around wetland and waterways for enhancing fish nurseries and wetland bird habitats will also provide moderate beneficial impacts to amphibians, turtles, and snakes.

Controlling invasive species will benefit herpetiles on the refuge by contributing to the restoration and propagation of native plants and the associated insects that are essential prey resources. Studies have shown that gray tree frogs declined in body mass and weight where habitats were degraded by invasive species and that *Phragmites* over time has negative impacts on the hydrology of wetland habitats (Blossey 1999). Controlling invasive species in uplands is important for tree frogs and box turtles that feed on some host-specific caterpillars associated with native tree species that thrive in mixed deciduous forests.

Applying herbicides to control invasive species can cause impacts to amphibians if herbicide chemicals and surfactants intended for terrestrial use are applied along roadsides and get into ditches or leach into vernal pools or wetland areas where they would be lethal to developing amphibian eggs, larval stages, and tadpoles. Similarly, disposing of waste water after rinsing tanks, backpacks, and other equipment is another potential source for adverse impacts on frogs and toads, which are attracted to rinsates. Great care will be taken to mitigate potential damage by adhering strictly to label directions and best management practices.

The potential use of insecticides for control of mosquitoes, gypsy moths and other invasive insects, can impact non-targeted insects, specifically native moths, in turn impacting the prey base of amphibians and reptiles. The refuge's use of pesticides for invasive plant control could have negative impacts on local herpetile populations, as there is a growing body of evidence highlighting the synergistic impacts of all forms of chemical pesticides on amphibians (Kiesecker 2002, Relyea 2005).

Public Use

We evaluated refuge public uses for their potential to benefit or adversely impact amphibians and reptiles or their habitats used for mating, reproduction, overwintering, and foraging. Although most species that occur on the refuge are very common and widespread, there is some concern for eastern box and spotted turtles populations. Because amphibians everywhere are considered to be experiencing a general decline, public outreach and education efforts by the refuge that emphasize buffering of wetlands, connectivity and easy access between forest, grassland, and wetlands, protection of vernal pools, and augmentation of patch size will benefit amphibians and reptiles on an even larger scale where embraced by other landowners.

Sometimes maintenance actions for public use may involve preparations or outcomes that have direct negative impacts to amphibians and reptiles. Mowing of grassy access roads and public use trails occasionally kills turtles, snakes, or frogs if conducted during times of movement (warm months). The refuge will minimize this direct type of negative impact by keeping public use and access roads mowed short so that they do not become attractive habitat.

Disturbance to basking or nesting turtles may occur where public use on the refuge is concentrated at points where land and water interface. Basking turtles can usually find alternate resting surfaces. Nesting turtles, once engaged in the act of digging usually will not allow their attention to be drawn to anything else, and at such times are vulnerable to predators. A turtle wishing to make landfall to attempt egg-laying, however, may be dissuaded by the presence of humans at the site.

The effects of hunting disturbance to non-hunted wildlife under this plan are expected to be negligible for several reasons. Hibernation or torpor by reptiles and amphibians also limits their activity during the hunting season when temperatures are low. Hunters would rarely encounter reptiles and amphibians during most of the hunting season. Non-hunted reptiles and amphibians include species such as snakes, skinks, turtles, lizards, salamanders, frogs, and toads. These species have very limited home ranges and hunting would not affect their populations regionally.

Because there will be ample wetland-forest-grassland interface elsewhere, we expect that the impact of roads, trails, and proposed recreational activities to amphibians and reptiles at the landscape scale will be negligible.

Impacts to Amphibians and Reptiles in Alternative A

Impacts on amphibians and reptiles under Alternative A (“No Action”) serve as a baseline for comparing and contrasting Alternatives B and C to the refuge’s existing management activities.

Managing and Protecting Habitat

The continued maintenance of early successional habitats proposed for some areas of the refuge under alternative A provides direct benefits for reptiles and some amphibians due to the abundance of natural food resources, particularly in older fields with a rich diversity of plant and invertebrate life and complex soil communities. A number of refuge snake species use these habitats for foraging, especially if they are located near woodlands with ample cover. Carnivorous reptiles such as snakes benefit from the abundance of small mammals, such as mice and voles, in refuge grasslands. Grassland habitats near forested vernal pools and wetlands will enhance the survival and weight gain of post-breeding amphibians on the refuge.

The passive conversion of upland fields to early successional and forested vegetation will increase the natural habitat available for reptiles and amphibians. The resulting decrease in refuge forest fragmentation and increase in connecting corridors benefits herpetile species that are subjected to exposure, desiccation, and predation when crossing spaces between habitat fragments.

In wetland and aquatic habitats, the exlusion of agricultural uses will maintain connectivity between wetlands and upland forest habitats that serve as travel corridors for herpetiles. Prescribed fire in open wetland areas embedded with fire maintained habitats (oak-dominated forests, grasslands, etc.) will encourage plant diversity, thus providing quality habitat for herpetiles. Restoration of natural surface water and ground water hydrology in prior converted freshwater wetlands will have a beneficial impact on herpetiles through an increase in habitat.

In impounded wetlands, return of tidal flow will create brackish/saline wetland habitat that will likely be colonized by the State-listed northern diamondback terrapin. However, the return of saltmarsh in Units II and III may have minor-to-moderate adverse impacts on individual reptiles and amphibians (mortality) if they are not capable of emigrating upstream to areas with reduced salinities.

Reptile and amphibian species that utilize the freshwater impoundments would be permanently displaced. The distribution of reptiles and amphibians on the refuge will shift in response to this wetland restoration, although impacts will be local and not affect these species at the population level.

Passive habitat management will provide less aggressive habitat management strategies and conservation actions than alternative B, with a slower progression and timeframe to achieve desired mature forest and salt marsh conditions.

Public Use

Impacts associated with public use are the same as those described under Impacts on Reptiles and Amphibians That Would Not Vary by Alternative.

Conclusion for Management Actions in Alternative A

Management actions in alternative A, including passive return of native vegetation to fields would, on the whole, result in local, long-term minor-to-moderate impacts to reptile and amphibian populations by increasing or restoring habitat availability. Salt marsh increases in the impounded wetlands may have minor-to-moderate adverse impacts on some local herpetofauna populations that require freshwater wetlands, while also providing a beneficial impact to the northern diamondback terrapin. However, the passive management of alternative A would require significantly more time than alternative B, possibly on the order of centuries, to achieve the same habitat conditions, and numbers and distribution of herpetiles.

Impacts to Amphibians and Reptiles in Alternative B

Habitat Management and Public Use

During forest thinning and other stand improvement operations, vernal pools will remain buffered by a least 500 to 1,000 feet to protect them from drying out. Forest management strategies aimed at maintaining >80% close canopy in refuge forests will include seasonal forested wetlands, which is especially important for adult amphibians that spend the non-breeding seasons in the surrounding forest. This constitutes the core terrestrial habitat necessary to ensure refuge amphibian population survival outside of the breeding season.

In mixed hardwood forests, protection of stands with older trees and maintaining a diversity of forest age classes, densities, and structure will have direct and indirect beneficial impacts on many mesic hardwood-related amphibians and reptiles. Many such species require mature forest stands, while others require a variety of habitat structure. Similarly, allowing limbs and snags to stay in place and decompose naturally conserves salamanders and their prey, notably invertebrates, which extensively use such microhabitats. Decreasing refuge forest fragmentation and creating connecting corridors benefits herpetile species that are subjected to exposure, desiccation, and predation when crossing spaces between habitat fragments.

The refuge will minimize the use of insecticides, particularly adulticides, for pest management to avoid killing non-target insects, which serve as an important food base of amphibians and reptiles. In wetland and aquatic habitats, the exclusion of agricultural uses will maintain connectivity between wetlands and upland forest habitats that serve as travel corridors for herpetiles. Prescribed fire in open wetland areas embedded with fire maintained habitats (oak-dominated forests, grasslands, etc.) will encourage plant diversity, thus providing quality habitat for herpetiles. Restoration of natural surface water and ground water hydrology in prior converted freshwater wetlands will have a beneficial impact on herpetiles through an increase in habitat.

In impounded wetlands, newly restored brackish/saline wetland habitat will likely be colonized by the State-listed northern diamondback terrapin. However, saltmarsh restoration of Units II and III may have minor-to-moderate adverse impacts on individual reptiles and amphibians (mortality) if they are not capable of emigrating upstream to areas with reduced salinities. Reptile and amphibian species that utilize the freshwater impoundments would be permanently displaced. The distribution of reptiles and amphibians on the refuge will shift in response to this wetland restoration, although impacts will be local and not affect these species at the population level.

In addition to Impacts on Reptiles and Amphibians That Would Not Vary by Alternative, we expect impacts to amphibians and reptiles to increase due to proposed expansions in public use activities, including fishing, hunting, wildlife observation, wildlife photography, and environmental education and interpretation. Impacts are expected to be negligible.

Conclusion for Management Actions in Alternative B

Management actions in alternative B, including restoring native vegetation to agricultural fields, restoring hydrology in former farmed wetlands and preventing the use of agricultural chemicals (fertilizer and pesticides) would, on the whole, result in local, long-term minor-to-moderate impacts to reptile and amphibian populations by increasing or restoring BIDEH. Salt marsh restoration may have minor-to-moderate impacts on some local herpetofauna populations that require freshwater wetlands, while also providing increasing habitat to the northern diamondback terrapin. In terms of BIDEH, the refuge would be reducing diversity at the refuge scale, but contributing to biological integrity and diversity at the landscape scale.

Impacts to Amphibians and Reptiles in Alternative C

Managing and Protecting Habitat

Management of Unit II and Unit III wetlands as freshwater impoundments would have a moderate beneficial impact on a number of amphibian species that prefer freshwater wetlands.

The refuge farming program implemented under alternative C would have a moderate adverse impact on herpetofauna. Maintaining up to 600 acres of row cropped agricultural fields, continued drainage of farmed wetlands and fragmenting native habitats, essentially precludes optimal use of potential habitats by herpetiles, resulting in moderate local long-term adverse impacts on amphibian and reptile populations. Chemicals utilized in conjunction with the farming program could have an adverse impact on the quality of water in wetlands near farmed fields, thus impacting the health of amphibians breeding and feeding in those wetlands. Because the cooperative farming program utilizes, as approved, glyphosate-tolerant corn and soybeans, glyphosate is the primary means of crop pest control. The use of such herbicides has been associated with adverse impacts on amphibians (Cadreira and Duke 2008, Relyea 2005), but this can be mitigated by utilizing surfactant-free glyphosate products and adding a safer surfactant (those with a low LC50 value).

A potential adverse impact to herpetofauna from alternative C stems from the fact that freshwater impoundment management would continue to be challenging, given changes in the coastline along the impoundment and increased storm activity, which lead to overwashes and saltwater intrusion periodically. When such intrusion occurs, freshwater wetland communities preferred by many amphibians die back, and high water salinities render the wetlands inhabitable to most herpetiles. This inherent instability of the freshwater impoundments could lead to minor adverse impacts to herpetofauna, which would need to seek suitable habitat elsewhere during such times. This adverse impact would likely be recurring.

Public Use

In addition to Impacts on Reptiles and Amphibians That Would Not Vary by Alternative, we expect impacts to amphibians and reptiles to increase in alternative C from those outlined in alternative A, but less than alternative B. Impacts are expected to be negligible.

Conclusion for Management Actions in Alternative C

Management actions under alternative C would result in short-term local minor-to-moderate benefits and long-term local minor-to-moderate adverse impacts to existing herpetiles. Due to their vulnerable long-term sustainability, the freshwater impoundments provide only short-term benefits to herpetiles, with periodic adverse impacts when saltwater intrusion occurs.

Impacts on Fisheries

Wetland and aquatic resource management to protect water quality and habitats for trust fishery resources is a priority at the refuge. Refuge aquatic resources provide important nursery and foraging habitats for native anadromous and catadromous fish. Targeted refuge focal species include river herring (alewife and blueback herring), American eel, and striped bass.

We evaluated the management actions and public uses for each of the alternative proposals for their potential to benefit or adversely affect wetland and aquatic habitats used for nurseries, foraging, migrating, and wintering areas. Fishing, which is one of the six priority wildlife-dependent public uses, is a consumptive activity with additional direct effects on fisheries resources.

Evaluation of beneficial conservation activities that would enhance or improve water quality and aquatic resources included the following actions:

- Maintain fish weir passages in Unit II and III water control structures to allow the unimpeded passage of river herring and other anadromous fish species and priority resources of concern.
- Repair, replace, and upgrade water control structures, fish weirs, and flapgates to improve or restore water circulation in ditched systems of all the refuge’s impounded wetland areas.
- Maintain or improve water quality by establishing or widening existing forested upland buffers parallel to all refuge waterways and protect all wetland habitats with vegetated buffer areas.
- Protect and conserve insect and other invertebrate food resources for fish.
- Control the growth and spread of invasive plant species.
- Restore saltmarsh in impounded wetlands.

Evaluation of activities of alternatives A, B & C that would potentially cause adverse effects on fisheries resources include the following actions:

- Management actions to clean existing ditch systems
- Management actions to maintain freshwater marshes or restore them to tidal salt marshes

- Accidental introductions of non-native fish by anglers
- Accidental introductions of invasive plants, pathogens, or exotic invertebrates attached to fishing boats and trailers
- Use of pesticides to control mosquitoes and nuisance and non-native invasive plant species which may might adversely affect fisheries resources

Impacts on Fisheries That Would Not Vary by Alternative

Managing and Protecting Habitat
Many best management practices from refuge management activities will provide beneficial impacts to the fisheries resource. Many of these actions for protecting wetlands, such as controlling non-native invasive plants and providing and increasing forested buffers around wetland-upland interfaces and refuge waterway edges, will filter out contaminants from off-refuge sources and benefit wetland and aquatic resources and fish nursery habitats by protecting good water quality and well-functioning wetland ecosystems.

Refuge ditch maintenance will improve water circulation and quality. The mechanical means of cleaning existing ditch systems within refuge impoundments would be through the use of a cookie cutter or rotary ditcher. To minimize disturbance and adverse impacts to fishery and migratory bird resources, the cookie cutter will be operated only during certain seasons when water temperatures and water levels are at or below recommended thresholds.

Ditch maintenance would occur between February 1 and March 15, when impoundment water levels are below half pool levels and water temperatures are below 60^{o} F. Lower water levels are necessary to assure that an acceptable transport of silt and particulate matter from the ditch is removed during cookie cutter operation since this timeframe (late winter) occurs when water temperatures are at or below 60°F, it precedes the peak spawning migration of anadromous fish and resident warm water fish (sunfish). This temperature threshold minimizes the potential adverse impacts of depleted oxygen levels from decomposition of vegetation and from silt suspension.

The use of the cookie cutter or rotary ditcher may have some short-term minor adverse impacts . Sediment redistribution and temporary increases in turbidity and total suspended solids in the water column around the machine will be higher during operation but should return to normal several weeks after work is completed. This increase in total suspended solids and turbidity causes a higher biological oxygen demand, which reduces the available oxygen to fish and may cause stress or mortality. The magnitude of increases in biological oxygen demand is dependent on the rate of decay of the particulate matter, which is dictated by water temperature.

Through routine ditch maintenance, short-term adverse impacts will be followed by long-term beneficial consequences for wetland systems and aquatic resources with improved water circulation, enhanced water level management capability, and improved water quality.

If used according to label directions, the mosquito adulticide naled should not directly impact fishery resources. However naled, as well as the larvicides Bti and methoprene (under all alternatives), may have indirect adverse impacts due to their ability, under proper conditions, e.g., chemical concentration, humidity, wind, suspended organic material, and light intensity, to kill non-target insects. Insects are crucial food components in aquatic habitats for foraging fish species on the refuge.

Public Use
Use of boats and canoes will cause increased suspension of bottom sediments, which should have negligible impacts on the biological oxygen demand for fisheries resources, because the impacts would be localized when they occur. Similarly, boat motors may harm submerged or emergent vegetation, which would cause negligible impacts to protective cover for fisheries.

Fishing seasons and limits are established by the State of Delaware and adopted by the refuge. These restrictions ensure the continued well-being of overall populations of fish. Fishing results in the taking of many individuals within the overall population, but restrictions are designed to safeguard adequate populations and recruitment from year to year.

Important concerns of any refuge fishing program are accidental or deliberate introductions of non-native fish (used for bait), accidental introduction of invasive plants, pathogens, or exotic invertebrates attached to fishing boats, and overharvesting. Another common concern is the reduction or alteration of prey base important to fish-eating wildlife. Refuge-specific regulations address this concern by following the Delaware regulations and would adopt any State harvest limits that should become applicable to the fish species in refuge waterways. These limits are set to ensure that harvest levels do not cumulatively impact native fish resources to the point they are no longer self-sustainable. We also follow recommendations of Service fisheries biologists who conduct periodic sampling of refuge ponds and waterways. Effects on interjurisdictional fishes, those which migrate beyond an individual state and/or national boundaries, are expected to be negligible from hunting because the majority of the refuge will experience minimal, transitory use by hunters.

Impacts on Fisheries in Alternative A

Managing and Protecting Habitat
Habitat management proposed in Alternative A would have many of the same impacts as those described in alternative B. For example, with the return of tidal flow to the impounded wetlands and conversion of the refuge's impounded marshes to tidal marsh, the refuge would expect increases diversity and abundance of species as noted by Able et al. (2004). However, in the absence of active salt marsh restoration as proposed in alternative B, there is likely to be a greater amount of non-vegetated open water habitat for marine species. A vegetated marsh appears to have a higher nursery value than a non-vegetated marsh (Minello 2003). The inability of emergent wetland species to colonize impounded wetland areas of the refuge due to lack of substrate and excessive water depths would fail to provide the necessary cover utilized by fisheries resources during their life cycle. Additionally, the open water fetch potential of this system would promote shoreline erosion on the western edge of the open water system, likely causing an increase in turbidity and suspended solids within the water column.

Additional adverse impacts in alternative A include:

- Loss of freshwater marsh habitat would result in a decline in abundance of freshwater fish species such as largemouth bass, sunfish, and other piscivores, and forage species including amphibians and invertebrates.

- Open water habitat would have a limited high quality juvenile fishery component as suitable nursery and foraging areas.

- Shallow, semi-enclosed, sparsely vegetated open water habitat has the potential to capture nonpoint source pollution which could negatively impact fisheries resources, e.g., fish kills due to low dissolved oxygen and eutrophication.

Conclusions for Management Actions in Alternative A

Management action in alternative A would result in a measurable or perceptible effect on freshwater fisheries as stated above. Long-term minor-to-moderate impacts and opposing local long-term minor-to-moderate impacts on fisheries within or near the refuge are expected. Although alternative A contributes to the BIDEH of the refuge, the loss of salt marsh vegetation and subsequent conversion of the habitat to open water would result in a decrease in diversity and integrity of the system for the short to intermediate term.

Impacts on Fisheries in Alternative B

Managing and Protecting Habitat

Impacts on fisheries resources in Alternative B ("Preferred Alternative") through proposed habitat management changes meet habitat and wildlife objectives through the maintenance, enhancement, or restoration of natural wetland ecosystems.

Refuge salt marshes provide critical nursery habitat for fish and shellfish (Tiner 1985; *http://www.dnrec.delaware.gov/Admin/DelawareWetlands/Pages/DelawareWetlandTypesSaltBrackish.aspa*; accessed February 2012). Estuarine aquatic beds provide important cover for juvenile fishes and other estuarine organisms (Tiner 1985). Tiner (1985) reported that 98 percent of Delaware's commercially important fishes are wetland-dependent. Common fishes in Delaware's tidal marshes and estuaries include American eel, alewife, American shad, blueback herring, carp, white catfish, channel catfish, brown bullhead, white perch, striped bass, yellow perch, silver perch, sea trout, Atlantic croaker, summer flounder, winter flounder, menhaden, and spot (Tiner 1985). Increased tidal flushing into impounded areas may increase water column aeration, reduce summertime oxygen stress, and promote survival of all aquatic animals, including migratory river herring (Full Report of Herring River Technical Committee 2006).

Restoration of impounded marsh areas to tidal salt marsh and its impacts on fish species in the Delaware Bay have been well documented. Able et al. (2004) reported that the return of tidal flow and creation of creeks during the restoration of salt marshes in the Delaware Bay provided an immediate, dramatic increase in fish species diversity and abundance, particularly by resident and transient young-of-year fish species that once again have access to the marsh area. With the restoration of the refuge's impounded marshes to tidal marsh, the refuge would expect increases diversity and abundance of species as noted by Able et al. (2004). However, the uncertainty of the success of the restoration effort, the refuge acknowledges only moderate success may be achievable. The refuge may expect short-term moderate beneficial impacts. Able et al (2004) found the most abundant species included bay anchovy *(Anchoa mitchilli)*, weakfish *(Cynoscion regalis)*, spot *(Leiostomus xanthurus)*, Atlantic croaker *(Micropogonias undulatas)*, Atlantic silverside *(Menidia menidia)*, American eel *(Anguilla rostrota)*, mummichog *(Fundulus heteroclitus)*, and Atlantic menhaden *(Brevoortia tyrannus)*. With access to these marsh habitats, productive fish species such as mummichog thrive; they also serve as prey for other species such as young-of-year *M. undulatas* or larger predators such as striped bass *(Morone saxatilis)*.

Returning tidal action will allow degraded marshes to restore ecological attributes and functions, reconnect these wetlands to the larger estuarine-coastal ecosystem, and result in a self-maintaining tidal salt marsh. Frisk et al. (2011) concluded through model simulations of recent field studies of fish assemblages in restored salt marshes in the Delaware Bay that restoring this type of habitat likely resulted in increased system biomass of a wide range of fish species including important forage and commercially important species. This biomass increase most likely changed the structural composition of the Delaware Bay ecosystem, potentially increasing its long-term health and stability. Tupper and Able (2000) further concluded that the movement, habitat use, and diet composition of striped bass *(M. saxatilis)* in restored salt marshes were similar to reference or restoration target salt marshes, signifying the importance these restored sites in the management of commercially important large predators in the Delaware Bay. The refuge can expect long-term moderate beneficial results as suggested by the above research along the Delaware Bay.

The use of the cookie cutter or rotary ditcher will be utilized under Alternative B as a refuge management tool to sustain tidal flushing and circulation in the restored marshes, which can benefit marsh restoration, refuge hydrology and fisheries. However, if the marsh restoration plan determines that existing ditches and drainage channels are inappropriate in particular locations, then this activity is anticipated to be reduced or eliminated.

Under alternative B, changes in mosquito integrated pest management practices and strategies with more restrictions on adulticide use will result in minor-to-moderate indirect beneficial impacts for refuge fisheries resources by reducing minor-to-moderate adverse impacts to insect communities and other non-target invertebrates that provide diverse food sources to fish, and maintaining and enhancing healthy fish populations.

In an effort to minimize fishing mortality and increase the quality of fishing, the refuge proposes to adopt catch-and-release regulations, including mandatory use of barbless hooks, for Turkle Pond, Fleetwood Pond, Goose Pond, Flaxhole Pond, and Prime Hook Creek.

During the marsh restoration process, short-term minor adverse impacts may occur when a thin layer of silt is applied to the marsh surface, potentially causing an increase in the suspension of sediments and affecting the biological oxygen demand on fisheries resources. These adverse impacts would be followed by long-term moderate beneficial impacts by providing additional nursery and foraging habitat for fish species.

The refuge may experience short-term minor-to-moderate direct adverse impacts to certain fish species in restored marshes if these fish become restricted to areas of low dissolved oxygen and elevated temperatures. Tupper and Able (2000) found during a comparison of a restored and a reference salt marsh in the Delaware Bay that striped bass did not migrate far upstream from the creek mouth due to low dissolved oxygen concentrations in upstream areas of the reference marsh. Tupper and Able (2000) also noted that a series of creeks and ditches were designed in the restoration marsh habitat to provide the proper hydroperiod for revegetation by *Spartina alterniflora*. The restored tidal flushing provides an exchange and mixing of water that helps to buffer fish species from extremes in temperature and dissolved oxygen.

Public Use

Expanded freshwater and saltwater fishing and crabbing opportunities could coincide with increased adverse effects on fish populations and habitat degradation due to increased public use. New opportunities for night fishing at Fowler Beach and daytime fishing at Goose Pond, Flaxhole Pond, and at the pulloffs along Prime Hook Beach Road are expected to have negligible impacts on the fisheries resource. Goose and Flaxhole Ponds will not be open until fishery surveys are completed and management recommendations made. Direct fishing impacts to fisheries resources on Prime Hook Creek are negligible and fisheries populations will be monitored every five years.

The refuge proposes to allow fishing and crabbing at the pulloffs along Prime Hook Road due to increased visitor demand in this area and existing pulloffs already provide safe parking areas for wildlife observers and photographers. Access is restricted to only the pulloff area to provide safety for visitors and to avoid traffic issues. The refuge will consider fishing and crabbing along Broadkill Road and Fowler Beach Road in the future if there is a demand and if visitor safety and adequate parking can be guaranteed. Adequate parking and visitor safety along State-maintained roads have historically been an issue. Crabbing decreased significantly from 3,644 visits in 1976 to 880 visits in 1977 as a result of new regulations making State highway bridges into refuge waterways off-limits in an effort to increase pedestrian safety along these roads.

Proposed increases in hunting will cause increased suspension of bottom sediments from boat motors. Since hunting occurs during the fall and winter months, the impacts of this sediment suspension would be negligible and would not adversely affect biological oxygen demand for fisheries resources. Early season hunters may harm submerged or emergent vegetation by accessing small ditches, which may cause negligible impacts to protective cover for fisheries.

Recreational gill-netting, commercial fishing, crabbing using pots or trot lines, and food fishing with equipment other than hook and line are not permitted on the refuge. The use of gill netting by commercial or recreational fishermen has occurred in the tidal waterways of Slaughter Canal for over 30 years by a small number of fishermen. These activities, whether commercial or recreational, are not consistent with goals and objectives in any refuge management plan, conflict with rod and reel recreational fishermen and wildlife observers using canoes and kayaks, and have the potential to harm non-targeted fisheries through incidental by-catch. Fishing for bait fish is permitted for recreational uses only, subject to regulations stated in title 7 (Conservation) of the Delaware State Code.

Conclusions for Management Actions in Alternative B

Management action in alternative B would result in short-term minor-to-moderate impacts and opposing long-term moderate local and regional beneficial impacts on fisheries resources as described above. Alternative B would contribute a short-term minor-to-moderate direct adverse impact on fisheries resources as the marsh is being restored. Local long-term moderate beneficial impacts on fisheries within or near the refuge are expected as the restored salt marsh provides its ecosystem services. Alternative B contributes to the BIDEH of the refuge through the restoration of salt marsh function and value resulting in an increase in diversity and integrity of the system. Maintaining, enhancing, and restoring native salt marsh vegetation, biological diversity, and ecological integrity of refuge marsh habitats will create a mosaic of native salt marsh species conducive to providing nursery ground habitat(s) for both juvenile and adult fish species, thus maximizing long-term benefits for priority trust fisheries resources.

Impacts on Fisheries in Alternative C

Managing and Protecting Habitat and Public Use Habitat

The focus of the Refuge would remain the same as occurred prior to 2008: to provide habitat and maintain current active management practices and continue to manage and provide habitat for trust fisheries resources. Impacts on fisheries resources in Alternative A ("No Action") serve as a baseline for comparing and contrasting Alternatives B and C to the refuge's existing management activities.

Upstream freshwater systems (impounded marshes and Prime Hook Creek) provide spawning habitat for anadromous fish such as adult alosids (shad and river herring) and semi-anadromous fish such as white perch, and as nursery habitat for juvenile fish. Freshwater systems also support habitat for a multitude of freshwater fish species, including largemouth bass, white and black crappies, yellow perch, bluegill, pumpkinseed, brown bullhead, and chain pickerel (Tiner 1985). These freshwater habitats provide food requirements for juveniles, such as cladocerans, copepods, and dipteran larvae (Dove and Nyman 1995).

The recent salt water intrusion into freshwater impounded marshes resulted in direct mortality or stress on freshwater fish species due to increased salinity. Large fish kills may result if saltwater intrusion is rapid. Love et al. (2008) reported that the abundance of freshwater-dependent fishes declined as salinity increased seasonally in the Little Blackwater River in Cambridge, Maryland. The stress of salt water on freshwater marsh vegetation may result in the loss of vegetative cover and subsequent decrease in dissolved oxygen levels due to decaying biomass. Love et al. (2008) also reported that identifying and protecting processes that enhance connectivity among spatially distinct ecosystems, such as brackish and freshwater habitats of coastal wetlands, are essential for managing fish populations and maintaining healthy ecosystems.

Adverse impacts under alternative C are expected to be similar to those in alternative B. Negligible impacts to fisheries resources such as sedimentation from the motors of visiting boaters affecting biological oxygen demand and damage to submerged or emergent vegetation are expected. Increased sediment in the water can bury or block sunlight from reaching submerged aquatic vegetation. Submerged aquatic vegetation (SAV) produces dissolved oxygen that fish need to survive, filters pollution, and serves as a food source, hiding place, and home for fish, shellfish and crustaceans. SAV is valued at about $12,000 per acre per year because of its importance to overall aquatic health and fisheries *(http://water.epa.gov/type/oceb/nep/challenges.cfm)*. Open water, shallow, non-vegetated habitat would have local long-term minor-to-moderate adverse impacts to the fisheries component of the BIDEH on the refuge.

Conclusions for Management Actions in Alternative C

Management actions in alternative C would result in local long-term minor to moderate impacts and opposing local long-term minor adverse impacts on fisheries within or near the refuge. Alternative C contributes to the BIDEH of the refuge through the improved water quality of 4,000 acres of impounded marsh, aquatic habitats, and delineated buffer zones that will ultimately provide clean water to safeguard and enhance the quality of breeding and nursery habitats for river herring (alewife, blueback herring), American and hickory shad, striped bass, American eel, and other fishery resources.

Impacts to Invertebrates

Invertebrates are by far the most numerous animals on the refuge and play significant roles that link abiotic elements in all native habitat types to ecological processes and to biological integrity, diversity, and environmental health. Invertebrates are part of every food chain and represent the most important component of food webs responsible for directly maintaining birds, fish, amphibians, reptiles, mammals, insects, and native plant resources on the refuge. As such, invertebrate community health and diversity are directly linked to our conservation of trust resources, such as all guilds of migratory birds. Invertebrates also provide many essential ecosystem services on the refuge, such as pollination, nutrient cycling through decomposition and herbivory, and can serve as indicator species of environmental health for specific habitats of interest. Benthic aquatic invertebrates are essential to the healthy functioning of wetland ecosystems, which account for 80 percent of the refuge's cover-types.

We evaluated the alternatives and various proposed actions and activities with respect to their beneficial impacts on invertebrates. We considered the value of the following actions for the conservation and maintenance of diversity of insect communities, long-term persistence, and overwintering survival of invertebrate species and communities in habitats where we are most certain to conduct the following management actions:

- Restoring and enhancing native plant communities
- Maintaining early successional habitats using prescribed fire, mowing, and brush hogging
- Manipulating water levels in impounded marshes
- Controlling invasive plant species with herbicides
- Reducing mosquito pesticide use to conserve and protect insects
- Proactively pursuing pollinator conservation on refuge lands
- Maintaining roads
- Mosquito control
- Artificial lighting around facilities

Impacts on Invertebrates That Would Not Vary by Alternative

Managing and Protecting Habitat

Strategic native plant restoration and refuge habitat management will provide a wide array of diverse microhabitat types that serve as foraging, breeding, overwintering, roosting, and stopover sites for many groups of invertebrates. Concern about the decline of pollinators, especially of wild native insect species, has prompted the Service to collaborate with the North America Pollinator Protection Campaign. The Refuge System is incorporating insect pollinator conservation into refuge habitat management planning, strategies, and conservation actions. Service staff in Region 5 have been directed to consider the needs of pollinators during our planning and habitat management activities. This will have a minor-to-moderate beneficial impact on these groups of invertebrates.

Because of the close ecological relationship between native plants and wild native pollinators, managing for one will often have a positive effect on the other. Herbicide control of invasive plants in all three alternatives will support pollinator insects by providing three main needs: a diversity of native flowers available throughout the growing season, egg-laying or nest sites for generalist pollinator species, and provision of certain native host plants for specialist insect pollinator species. In addition to controlling invasive plants, enhancing native plant diversity on the refuge will provide specialist pollinator species with sources of nectar and pollen found in specific host plants for their young. refuge examples include Delaware skippers that use big bluestem or switchgrass, marbled underwing whose host plant is swamp cottonwood, little wife underwing moth that uses only southern bayberry as a larval host plant, and the rare maritime sunflower borer moth that is completely dependent on the native giant sunflower found in early successional grassland habitats.

However, the use of chemical herbicides can have an adverse impact on invertebrates if native non-target plants are killed. To avoid invasive herbicide damage to host plants associated with pollinator insects, precautions will be taken, such the use of spot treatment or other similarly well-targeted techniques rather than broadcast spraying. This would allow for selective control of undesirable plants while avoiding negative impacts on non-target beneficial larval host plants required by insect pollinator species. In early successional habitats, targeted herbicide spraying, combined with mechanical removal of large shrubs is a very effective way of maintaining butterfly and arthropod habitats. Herbicide applications will be specific enough to avoid killing non-target forage plants for generalist pollinators and host plants for specialist pollinator insect species. Overall, adverse impacts to pollinators would be negligible.

Integrated pest management is also an integral part of forest management and protection. The primary strategy under our integrated pest management program will be to improve the overall health of forested habitats in an effort to reduce their susceptibility to forest insect pests and diseases. Until this objective is achieved, we will continue to rely on the latest and most effective control measures developed by the U.S. Forest Service. Currently, the most effective and widely used control tactics are the use of biological insecticides such as Bacillus thuringiensis and Gypchek. Gyspy moth surveys conducted on the refuge during the past 10 years have not detected any problems to date but, if the need arose to control these invasive moths, Btk would be used instead of the more detrimental insecticide, Dimilin, to reduce negative impacts to non-target invertebrates. This action would have the desired minor-to-moderate adverse impacts on target invertebrates (gypsy moths), but potentially have negligible-to-minor adverse impacts on non-target invertebrates.

The arachnid, *Limulus polyphemus* (horseshoe crab) is another very important refuge invertebrate species listed as a sensitive and significant Delaware keystone species in the Delaware wildlife action plan (DNREC 2005). It is also considered a species of conservation concern by the Atlantic States Marine Fisheries Commission. The horseshoe crab is listed as a managed species with its own ASMFC Interstate Fishery Management Plan for the mid-Atlantic to conserve and protect these unique invertebrates. Refuge beach habitats provide spawning habitats for horseshoe crabs and we participate in annual census activities to monitor population status which also benefits this species. The conservation of horseshoe crab spawning habitat is incorporated into all three alternatives.

Public Use

Both beneficial and adverse impacts to invertebrates associated with public use are expected to be negligible. Visitors participating in recreational activities other than hunting are restricted to designated trail routes and interior roads, which minimizes disturbance to invertebrates. Invertebrates such as butterflies, moths, other insects and spiders are not active during the majority of the hunting seasons due to cold weather and would have few interactions with hunters.

A refuge volunteer who is a professional entomologist partnered with the Friends of Prime Hook NWR on a 4-year insect appreciation project, which involved preparing an impressive collection of pinned and labeled invertebrates, cataloging more than 700 insects commonly found on the refuge. Under all three alternatives, this collection will be used for educational purposes and to provide scientific information to local communities, visitors, and the general public. Educating refuge users about the importance of invertebrates in conserving migratory birds, the need to improve pollinator conservation, and ecological services that invertebrates contribute to maintaining the refuge's biological integrity, diversity, and environmental health, will have an indirect beneficial impact on invertebrates.

Impacts on invertebrates under Alternative A ("No Action") served as a baseline for comparing and contrasting Alternatives B and C to the refuge's existing management activities.

Impacts on Invertebrates in Alternative A

Managing and Protecting Habitat

In contrast, invertebrate community structure is different in salt marsh areas of the refuge, which will continue to persist in a natural state under alternative A. The most abundant invertebrates are gastropods (snails), both in water column and benthic habitats; these are important food items for waterfowl, especially black ducks. Chironomids are usually the second most abundant invertebrate group, followed by shore flies *(Ephyridae)*, long-legged flies *(Dolichopodidae)*, and biting midges *(Ceratopongidae)*. Native invertebrate species also benefit from invasive plant control activities conducted on salt marsh habitats.

In alternative A, both aquatic and terrestrial invertebrates will be impacted by invasive plant control activities. Passive succession of open fields to natural vegetation in early successional seral stages surrounding open emergent wetland habitat provides hundreds of acres of flowering plants with plentiful nectar resources and beneficial direct and indirect impacts for both terrestrial and aquatic insect pollinator species.

Under alternative A, the activity with the greatest adverse impacts on invertebrates is chemical control of mosquitoes. Adulticides using the active ingredient naled are organophosphates, which are toxic to bees, terrestrial invertebrates, and aquatic invertebrates if subjected to sufficient concentration.

Mosquito adulticides are broad spectrum, i.e., they kill mosquitoes as well as non-target invertebrates, especially insects, if encountered in sufficient concentrations. Non-target adverse effects may be direct or indirect. Direct impacts result in the death or reproductive failure of unintended insects in wetland and upland habitats. Indirect adverse effects potentially ripple through the food chain. At times, the abundance and density of non-target insects may outweigh that of mosquitoes. The loss of mosquitoes, as well as non-target insects may have adverse impacts on food supplies for birds, fish, amphibians, bats, and other wildlife.

Another direct impact of mosquito insecticides is that they may kill non-target and aquatic invertebrates that are effective natural mosquito predators. Impounded emergent marsh habitats create environmental conditions that often favor chironomid production with, in some cases, limited mosquito production (Pinkney et al. 1998), Larvicides, including the permitted chemicals with the active ingredients methoprene and Bti, also have the potential to kill non-target invertebrates but to a much lesser extent, as they target specific insect taxa or are limited to larval control only.

Impacts to invertebrates associated with public use are the same as those described under Impacts on Invertebrates That Would Not Vary by Alternative.

Conclusion for Management Actions in Alternative A

Management actions in alternative A would result in local minor impacts and opposing local short-term and long-term minor-to-moderate impacts. Continued use of broad spectrum adulticides would have minor-to-moderate short term local adverse impacts to a wide range of invertebrates, with potential long-term adverse impacts to rarer species or those with restricted distributions.

The passive management of alternative A would require significantly more time than alternative B, possibly on the order of centuries, to achieve the same habitat conditions and numbers and distributions of invertebrate fauna. No impairment of the refuge's BIDEH is expected.

However, current degraded marsh conditions of impounded wetlands that have already reverted to open marsh conditions will remain in a degraded condition without pro-active restoration actions. It is uncertain as to the degree of impacts to invertebrate populations from allowing nature to take its course, but it is very likely that there will be significant decreases in terrestrial invertebrates and increases in aquatic invertebrates. It is also expected that large expanses of stable open water areas and significant reduction in emergent marsh areas will also result in a decline in mosquito production on refuge lands.

Impacts on Invertebrates in Alternative B

Managing and Protecting Habitat

An important direct benefit for refuge invertebrate populations is the conversion to native plant communities of several hundred acres of prior crop cultivation by ending the cooperative farming program. Eliminating the use of genetically modified crops on the refuge reduces adverse impacts to invertebrates, although biological contamination of invertebrates can occur from off-site sources (Rosi-Marshall et al. 2007). The restoration of native grassland, shrubland, and early successional forested habitats will significantly increase habitat acreage for pollinating, herbivorous, and predatory invertebrates by increasing the floral diversity lost to the agricultural practices of the past. Greater availability of suitable habitats has direct beneficial impacts on generalist and specialist insect pollinator species. In alternatives B and C, habitat management actions will incorporate the needs of native insect pollinators to proactively ensure the conservation of all pollinator species as well as other invertebrates.

Prescribed fire can have adverse impacts on invertebrates with substantial effects on local pollinator populations. To avoid undue mortality of insects, a number of considerations will be integrated into fire management protocols with respect to scale and timing of prescribed burns and maintaining invertebrate refugia adjacent to or near treatment areas. A habitat management program of rotational burning where small sections (30 percent or less of total habitat-type) are burned every 3 to 10 years will provide adequate colonization potential and refugium for insects to mitigate adverse impacts to insect pollinators (Black 2009). High intensity fires will be avoided as much as feasible. Low intensity prescribed burns conducted early or late in the day, or from late fall to early winter, are not only preferable for pollinators but also reduce impacts to other wildlife species such as reptiles and ground-nesting birds.

Similarly, the difference between causing beneficial or adverse impacts to invertebrates from mowing as a habitat management strategy is based on timing, scale, and techniques used. Because mowing can completely remove all floral resources from a treated area, it will not be conducted when flowers are in bloom, but rather when flowers have died back or are dormant. Mowing at these times will reduce adverse impacts to nesting and migrating insect pollinators. To minimize adverse impacts from mowing and allow sufficient space and time for pollinator populations to recover, mowing will occur in a mosaic of patches over several years, and no single areas will be mowed or burned more than once a year (Di Giulio et al. 2001).

Beach overwash processes would be permitted to occur unimpeded in alternative B, having a beneficial impact on invertebrates that utilize the intertidal area. Surf zones and tidal inlets are important nursery and foraging areas for fishes and waterbirds because of high densities of invertebrates (McLachlan 2006; Defeo et al. 2009). Storm surge channels that cut through foredune ridges move invertebrates from nearshore environments to the beach face and back-barrier environments. Horseshoe crabs will use natural beaches and overwash deltas as spawning sites. Blue crabs will use restored salt marsh as a nursery area. Restoration of salt marsh in impounded wetlands will benefit invertebrate species that favor salt marsh (Gratton and Denno 2005), though the shift in invertebrate species composition may lag behind the shift in vegetation communities by a decade or more (Craft et al. 1999).

Depending on the particular salt marsh restoration strategies employed under alternative B, there may be limited periods of heavy equipment operation in the wetlands or on the beach for manipulation of sediment, in order to facilitate the deposition of supplemental material in the wetland to restore elevation and promote revegetation. Such actions may have a temporary adverse impact on invertebrates, including crab species, by compacting sediment and disturbing the physical environment that supports invertebrates (Peterson et al. 2000), although research suggests invertebrates may experience more pressure during high tide than when equipment is overhead (Herrera et al. 2010). It is expected that due to the sheer volume of invertebrates, populations adversely impacted by any shoreline or wetland sediment manipulation would recolonize and recover quickly (Levisen and Van Dolah 1996, Nelson 1993, CSA 1991, Lankford et al. 1988, Baca and Lankford 1988, Lankford and Baca 1987).

In many specific instances on the refuge, we have chosen to use the presence or absence of a rare invertebrate species as an indicator of environmental health based on its highly specific habitat requirements and its sensitivity to the condition and health of that habitat type. Such indicator species have been incorporated into habitat management objectives for alternatives B and C. Examples include the long-horned beetle as an indicator of large, mature, and healthy southern red oak/heath forest habitats, or the beach dune tiger beetle found on overwash, grassland dune, and Atlantic coastal interdune swale communities.

Other rare invertebrates representative of the environmental health of rare native plant communities include the pitcher plant moth, elfin skimmer, sphagnum sprite, blueberry dart, and several fire fly species found only in twig-rush peat mat bog habitats, and little wife underwing associated with southern bayberry, an important shrub component of mid-Atlantic (G-2) maritime salt shrub habitats. Restoring and maintaining these habitats to enhance biological integrity and diversity will also have beneficial impacts on these rare invertebrate species.

Mosquito Control

A direct beneficial impact to invertebrates under alternatives B and C is the reduction of mosquito adulticide use on the refuge. This will minimize the potential adverse impacts of these chemicals on non-target insect species and other indirect impacts on aquatic invertebrates, fish, birds, and amphibians.

Under alternative B, the State of Delaware will still be permitted the limited use the larvicides Bti and methoprene. Use of Bti and methoprene on the refuge will result in the intended temporary reduction in larval mosquito density, and a subsequent temporary local reduction in gross numbers of adult mosquitoes and potential shift in mosquito diversity. There may be a temporary adverse impact on both aquatic non-target invertebrate density and diversity, as well as adult non-target invertebrate density and diversity, e.g., chironomids and dragonflies. There could be short-term or long-term indirect impacts within the aquatic or terrestrial ecosystem due to the reduced density or diversity of invertebrates, including shift in predator-prey relationships, altered rates of detrital decomposition, and shift in relative numbers and diversity within the pollinator community.

Bti is a stomach poison that must be ingested by the larval form of the insect in order to be effective. Bti is specific to certain primitive dipterans, especially mosquitoes, black flies, and some chironomid species (Boisvert and Boisvert 2000) and is not known to be directly toxic to nondipteran insects. When controlling salt marsh mosquitoes, Bti is most effective on larval instar stages 1 and 2, considerably less effective against instar stages 3 and 4, and does not affect pupae or adult mosquitoes. The concentration of Bti used is important with regard to adverse impacts on non-target organisms. Of particular concern is the potential for Bti to kill midge larvae (family *Chironominae)*, which are often the most abundant aquatic insect in wetland environments and form a significant portion of the food base for other wildlife (Batzer et al. 1993, Cooper and Anderson 1996, Cox et al. 1998). Laboratory and field studies have shown that Bti is toxic to some larval chironomids, particularly those species that are filter feeders or grazers. Other factors, such as temperature, water depth, aquatic vegetation, and suspended organic matter, may act to reduce its toxicity to chironomids in the environment (Charbonneau et al. 1994, Merritt et al. 1989).

The impacts of a single application of Bti are difficult to predict because of documented differences in toxicity due to formulation, potency, application rate, and timing. There is only one (Hershey et al. 1998; Niemi et al. 1999) published study that examined the long-term, non-target effects of Bti. In this study conducted in Minnesota, 27 wetlands were sampled for macroinvertebrates over a 6-year period. It appears from this study that any effects would most likely occur within the aquatic communities, as no effects were observed on the bird community (Niemi et al. 1999). In judging the potential for adverse ecological effects of Bti applications, one should consider the non-target aquatic organisms of concern that would be impacted from the potential loss of both mosquito and chironomid larvae. The refuge's mosquito management plan will apply this scientific information for creating the refuge's thresholds for treatment, types of control, and application plans.

Methoprene ranks as a toxicity class IV, and is considered slightly toxic to practically nontoxic (EPA 2001). Methoprene compounds like Altosid Liquid Concentrate and Altosid Single-Brood Granule product, all mimic the action of an insect growth hormone that is used to interfere with the normal mosquito maturation process, preventing mosquito larvae from pupating and reaching the adult stage. Methoprene is a contact insecticide that does not need to be ingested like Bti (Tomlin 1994). Methoprene products are more toxic than Bti products, killing a wider range of non-target larval insects. This makes methoprene more likely to have adverse impacts on non-target invertebrate populations and cause disruptions to invertebrate food webs.

Use of short-term residual methoprene formulations, and avoidance of briquets and other extended residual products, will help mitigate any adverse impacts to non-target species. Altosid was found to have very little effect, if any, on 35 species of exposed non-target organisms including earthworms, waterfleas, damselflies, snails, tadpoles, and mosquito fish when used at lower concentrations (Zoecon Corporation -1973). Stipulations on the use of these larvicides will be designed to limit non-target mortality and ecological integrity, as outlined in the mosquito management plan and annual special use permit.

The greatest concern the Service has with mosquito chemical use is the impact on biological integrity and diversity and disruption of vital food webs. Larvicide application can adversely affect non-target insects, especially chironomids (non-biting midges). Chironomid larvae are often the most abundant aquatic insect in freshwater wetlands and form a significant component in food webs for many wetland dependent wildlife (Miller 1987, Euliss et al. 1991, Helmers 1992, Skagen and Oman 1996). Chironomids also frequently comprise the largest proportion of wetland invertebrate biomass (Elridge 1992, Rehfisch 1994, Davis and Smith 1998). Under several water level management regimes, chironomids have been consistently found to be the most abundant invertebrate species found within refuge freshwater and brackish impounded marshes. They represent greater than 75 percent of total numbers of benthic insects from refuge impounded marshes (Larsen 1996, 1997, 1998).

Refuge-specific studies have provided staff with considerable information about dominant invertebrate taxa present in refuge salt marsh, impounded fresh and brackish marsh, stable pond environments, and creek habitats (Pinkney et al. 1998, Cook and Hill 2000, 2001, McGee et al. 2003), and about dominant invertebrate groups and invertebrate community structure present during summer months.

In these studies as well as in other refuge invertebrate monitoring efforts, mosquitoes commonly represented a very small portion of all invertebrate taxa sampled. Many of the taxa recorded also included predators of mosquitoes. Dominant invertebrate groups produced annually included the following:

- Oligochaeta (aquatic worms)
- Crustacea (copepods, shrimp)
- Gastropoda (snails)
- Amphipoda (scuds, side-swimmers, freshwater shrimp)
- Trichoptera (caddisflies)
- Ephemeroptera (mayflies)
- Odonata (dragon and damselflies)
- Lepidoptera (butterflies and moths)
- Diptera (mostly chironomids, some flies, a few mosquitoes)
- Hemiptera (water boatmen, backswimmers, water striders, other true bugs)
- Coleoptera (beetles)

Methoprene is likely to be lethal to non-target terrestrial invertebrates in their larval stages (including pollinating species), if they come into direct contact with this chemical. Lepidopterans (butterflies and moths) may be highly susceptible. However, larval stages that develop in tree tissues or underground are unlikely to come in contact with methoprene, thus adverse impacts to that group are expected to be negligible.

Insects of the order Diptera are among the most common flower visitors, and many are known pollinators. Mosquitoes are dipterans; the male mosquito is a nectar feeder and the female mosquito, which only requires blood to produce eggs, also feeds on flowers. In addition, there are at least 200 species of native bees recorded in Delaware (Sarver 2007); many of these species likely inhabit the refuge and may be exposed to some negligible adverse impacts from chemical mosquito control.

Methoprene and Bti also have the potential to negatively affect the local chironomid (midge) population. Though often discounted as inefficient pollinators, some researchers have suggested that the efficiency of pollinating flies (dipterans), mosquitoes (dipterans), and midges can exceed that of bees (NBII 2010). Further, dipterans appear to be crucial for the pollination of certain flowers in some habitats. Although plants in Delaware are not currently considered to be dependent upon mosquitoes for pollination, the importance of dipteran pollination is poorly understood (Kearns 2001).

Insecticide applications will also avoid areas that are known to contain butterfly and moth host-plants in order to conserve and protect rare or specialist insect pollinators and ensure that adequately buffered habitat around host plants or refugia is available during and after insecticide spraying.

The refuge has no jurisdiction over mosquito control on lands outside the refuge boundary. The Service recognizes that spray drift will likely enter the refuge from the three neighboring barrier island communities during mosquito control on those lands. Since the State employs best management practices and follows the EPA-approved label directions, the Service expects impacts to refuge resources to be negligible.

Public Use

Impacts in alternative B are very similar to the same as alternative A and as Impacts on Invertebrates That Would Not Vary by Alternative.

Conclusion for Management Actions in Alternative B

Management actions in alternative B, including reducing use of broad spectrum adulticides for mosquito control, restoration of row cropped agricultural fields to native vegetation communities, restoration of wetland hydrology, and restoration of impounded freshwater wetlands to native salt marsh would, on the whole, result in moderate local, long-term impacts to invertebrate populations by increasing or restoring the refuge's BIDEH. Restoration of salt marsh will result in a local aquatic invertebrate community shift from organisms adapted to fresh water to brackish or saline conditions. Permitting use of larvicides for mosquito control will continue to result in local short-term adverse impacts to dipteran species.

Impacts on Invertebrates in Alternative C

Managing and Protecting Habitat

The management of macro-aquatic invertebrates, especially benthic invertebrates, is an important impoundment objective under alternative A to supply food resources for waterfowl and shorebirds during critical migration and wintering periods. Refuge impoundment management includes producing diverse native wetland plants that have beneficial direct and indirect impacts on invertebrates. Since 1996, the refuge has studied and monitored invertebrate responses to water level management to enhance annual invertebrate production as reliable food resources for migratory birds. Such invertebrate information and data collected in all three impoundments revealed that irrespective of the impoundment, midge larvae (Chironomidae) were the most dominant and abundant invertebrate group in all years at all seasons (table 5-13; Prime Hook NWR Marsh and Water Management Programs 1996, 1997, 1998). Impoundment management has a substantial impact on this particular group of invertebrates.

Table 5-13. Invertebrate Taxa and Relative Abundance Collected in Units III and IV Impounded Wetlands at Prime Hook NWR, Milton Delaware

Emerging insects collected in 1997 were identified by Dr. Leonard C. Ferrington, Department of Entomology, University of Kansas.

	Unit III-D	Unit IV-A
DIPTERA	(Relative Abundance)	
Chironimidae		
Chironomus spp.	0.56	0.90
Glyptotendiptes spp.	0.26	0.02
Parachironomus spp.	0.04	----
Tanytarsini spp.	0.03	----
Chironomini spp.	0.02	0.01
Zavereliella spp.	0.01	----
Tanypus neopunctatus	----	0.005
Cricotopus spp.	----	0.005
Polypedilium spp.	0.01	----
Dolichopodidae	0.02	----
Ceratopogonidae	----	0.005
Aedes spp.	0.005	0.005
Ephydridae	0.03	0.005
ODONATA		
Libelludidae	0.02	----
Coenagrionidae	0.03	----

	Unit III-D	Unit IV-A
COLEOPTERA		
Hydrophilidae	0.01	----
Berosus spp.	----	0.01
Troposternus laterallis	----	0.005
HEMIPTERA		
Saldidae	0.01	----
Corixidae	----	0.04

In contrast, invertebrate community structure is different in salt marsh areas of the refuge, which will continue to persist in a natural state in Unit I and Unit IV under alternative C. The most abundant invertebrates are gastropods (snails), both in water column and benthic habitats; these are important food items for waterfowl, especially black ducks. Chironomids are usually the second most abundant invertebrate group, followed by shore flies (Ephyridae), long-legged flies (Dolichopodidae), and biting midges (Ceratopongidae). Native invertebrate species also benefit from invasive plant control activities conducted on salt marsh habitats.

In alternative C, both aquatic and terrestrial invertebrates benefit from water level management and invasive plant control activities in freshwater environments. Restoration or maintenance of open fields in native vegetation in early successional seral stages surrounding open emergent wetland habitat provides hundreds of acres of flowering plants with plentiful nectar resources and beneficial direct and indirect impacts for both terrestrial and aquatic insect pollinator species.

Cooperative farming practices under alternative C involve the use of glyphosate-tolerant soybean and corn, which are genetically modified. No direct impacts of glypohsate resistance transgenes in plant material have been found on insects (Cerdeira and Duke 2006). However, general management actions associated with the farming program, including maintaining up to 600 acres of row cropped agricultural fields, continued drainage of farmed wetlands, and fragmenting native habitats, preclude optimal use of potential habitats by invertebrates.

The beneficial impacts to invertebrates associated with alternative C are largely the same as those associated with alternative B, particularly with regard to limiting the use of adulticides for mosquito control and restoring native vegetation communities. However, in the absence of proactive restoration of salt marsh habitat, the benefits of salt marsh for certain invertebrates will not be realized as quickly, or possibly to the same extent.

The adverse impacts to invertebrates associated with Alternative C are also largely the same as those associated with Alternative B. Under Alternative C, the State of Delaware will still be permitted restricted use of the adulticide naled, and the limited use the larvicides Bti and methoprene, thus would still result in the adverse impacts to invertebrates described above. In the absence of proactive restoration of salt marsh, there would be no adverse impacts associated with mechanical restoration activities, as there would be in Alternative B.

Impacts associated with public use are the same as alternative B and as Impacts on Invertebrates That Would Not Vary by Alternative.

Public Use

Adverse impacts associated with public use are the same as alternative A and as Impacts on Invertebrates That Would Not Vary by Alternative.

Conclusion for Management Actions in Alternative C

Management actions in alternative C will have mainly the same moderate local, long-term impacts on invertebrates as alternative B, and mosquito control under alternative C will have the same minor local short-term adverse impacts on invertebrates.

The land management associated with the farming program will have minor-to-moderate local long-term adverse impacts on invertebrate populations.

Maintenance of freshwater impoundments would have minor beneficial impacts to existing freshwater invertebrate populations. However, because we know that alternative A is not sustainable under the existing conditions of sea level rise and insufficient marsh accretion, we would anticipate a minor-to-moderate local long-term shift in the invertebrate community occurring in the future. The impairment to refuge's BIDEH with the use of adulticides is minimized through the use of best management practices and special use permit conditions.

Impacts on Public Use and Access

As described previously, the Delmarva Peninsula is a major attraction for outdoor enthusiasts. Although the refuge is not typically the primary destination of most visitors, it does enhance the experience by offering public access to premiere sites with outstanding opportunities for wildlife-dependent recreational activities. Since refuge lands are held in the public trust by the Service, we seek to permit access for compatible, priority wildlife-dependent public uses unless, Federal trust resources would be impacted, the activity would detract from achieving refuge purposes or the Refuge System mission, or administrative resources are not available to ensure a safe, quality experience. As discussed in Chapter 3 Affected Environment, Prime Hook NWR is currently open to all six priority public uses (hunting, fishing, wildlife observation and photography, environmental education and interpretation) with hunting, wildlife observation, and wildlife photography designated as areas of emphasis.

We evaluated the following management actions for their potential beneficial or adverse impacts on public use and access that would result from implementing each alternative as described in detail in chapter 4:

- Opening existing refuge areas for approved public access and appropriate, wildlife-dependent activities
- Improving or constructing visitor infrastructure
- Collaborating in partnerships with local, regional, and state recreation interests
- Improving outreach and Service visibility

We considered the following potential short- and long-term direct, indirect, and cumulative impacts on public use and access that could result from the actions above:

- Conflicts among users—both actual (e.g., consumptive vs. non-consumptive) and perceived (e.g., outreach for one activity may deter the interest of other users)
- Conflicts among uses (e.g., conflicts about safety and access)
- Changes in use (e.g., existing non-wildlife-dependent uses may cease)
- More informed public (e.g., about species, their habitats, and their conservation)

- More supportive public (e.g., of the refuge, the Refuge System, and the Service)
- Increases in visitation and its associated effects on the quality of the experiences and our ability to meet the demand

Impacts on Public Use and Access That Would Not Vary by Alternative

Below is a breakdown of impacts that affect public use and access including visitor facilities, existing priority public use opportunities, hunting, fishing, wildlife observation & photography, environmental education & interpretation, and non-priority public uses. In all the alternatives, we will continue to open the refuge for public use from one-half hour before sunrise to one-half hour after sunset, seven days a week. However, emergency situations may arise on the refuge resulting in closures that are not anticipated at this time. Impacts of these hours of operation are expected to be negligible based on past observations by refuge staff.

Visitor Facilities

Having well-maintained visitor facilities is important for encouraging and welcoming visitors to public lands. It reflects on the Service's responsibility to spend taxpayer dollars effectively and efficiently. It is also important to protect public safety and refuge resources, both of which can be directly impacted or compromised when facilities deteriorate. Under all alternatives, we would continue to take this responsibility seriously and insure all facilities are up to Service standards and safe conditions.

Existing Priority Public Use Opportunities

In all alternatives, the Refuge would be promoting wildlife-oriented recreational opportunities that are compatible with the purpose for which the refuge was established. The public would have an increased awareness of the refuge and the National Wildlife Refuge System. The beneficial impacts of providing the existing level of wildlife-dependent activities, with some modest increases, include helping meet existing and future demands for outdoor recreation and education, as documented in the State comprehensive outdoor recreation plan (DNREC 2009) and in our visitor and community survey (Sexton et al. 2007). Visitors interested in wildlife-dependent recreation would find high quality opportunities to engage in their favored pastimes. Visitor use is increasing over time as local residents and visitors become more aware of refuge opportunities, and as we progress in creating new facilities and programs. The economic benefits of increased tourism likely would also benefit local communities. There are also opportunities for disabled individuals such as wheelchair-accessible trails, an observation platform, and fishing pier.

Over time, it is reasonable to believe that public awareness of the refuge would increase, and, in turn, visitation would increase on the areas open for public use. The refuge may or may not be capable of meeting the demand as it increases: providing programs, maintaining facilities, and providing adequate facilities for increased numbers of visitors, e.g., parking areas. Whether the refuge would be capable of meeting increasing demand depends on our coinciding levels of staffing or the availability of partners and volunteers to assist.

Eventually, the level and means of use resulting from this increase in visitation could change the nature of the experience for many visitors. Some may choose either to forgo these recreational opportunities due to issues of crowding or behavior, or to go elsewhere. Because the refuge provides opportunities now for only a small portion of the area's visitors, if that shift occurs, it is not imminent and would likely occur outside the 15-year period of this plan. If it does occur, it could put additional strains on other public lands, or diminish the refuge's contribution to the mission of the National Wildlife Refuge System. We would work to avoid that by continuing to distribute our programs and facilities to minimize conflicts among users.

As public use levels expand across time, unanticipated conflicts between user groups may occur. The refuge's visitor use programs would be adjusted as needed to eliminate or minimize each conflict and provide quality wildlife-dependent recreational opportunities. The Service's law enforcement efforts will be increased.

Hunting
In all alternatives, annual refuge hunts would continue for deer, waterfowl, and upland game on designated areas of the refuge. Those areas would be open for hunting during designated times during the State hunting season, which is usually from September through January.

Hunters would also have the opportunity to harvest a renewable resource in a traditional manner, which is culturally important to the local community. Under all alternatives, the public will be able to enjoy hunting at no or little cost in a region where private land is leased for hunting, often costing a person several hundred to several thousand dollars per year for membership. We also make special accommodations for mobility-impaired hunters and youth hunters, which will provide the opportunity to experience a wildlife-dependent recreation, instill an appreciation for and understanding of wildlife, the natural world, and the environment, and promote a land ethic and environmental awareness.

We may close the refuge to other public uses on those areas during hunt days, unless we can safely sequester the locations of those uses from the locations of hunting activity. Experience has proven that time and space zoning (e.g., establishment of separate use area, use periods, and restriction on the number of users) is an effective tool in eliminating conflicts between user groups. Currently, we restrict other wildlife-dependent recreation on days when we allow hunting on the refuge, and impacts are negligible. Seasonal closures on Prime Hook Creek minimize conflicts between anglers, wildlife observers, and hunters and minimize disturbance to waterfowl. The headquarters area, which contains the visitor contact station, hiking trails, and fishing opportunities, is open 363 days per year and only closed for one to two days to facilitate a deer hunt. Closed areas of the refuge along Slaughter Beach Road, Cods Road, Prime Hook Beach Road, and Broadkill Beach Road are open only to permitted hunters during designated times of the hunting season.

Fishing
In all alternatives, recreational fishing and crabbing would continue on designated areas of the refuge except for seasonal closures on Prime Hook Creek.

We would reevaluate the fisheries populations in waterbodies open to fishing, such as Turkle Pond, Fleetwood Pond, Prime Hook Creek, and any proposed areas every five years or as necessary to ensure the continued health of the fish population. Should those populations demonstrate unhealthy conditions, we could close or otherwise restrict the program until we studied the problem further or corrected it. However, we would make every effort to prevent confusion by explaining the situation to the public through the refuge Web,site, signs, and news releases.

Wildlife Observation and Photography
In all alternatives, wildlife observation and photography will be provided in designated areas on the refuge, except for seasonal closures for hunting in designated areas. Hiking is limited to the trail proper and may not range into adjacent areas. Conflicts between user groups offer the primary potential for adverse impacts, which are discussed in the impacts of hunting.

Guided tour activities may also conflict with other refuge users. For example, commercial or non-commercial tours will most likely use the same areas as independent wildlife viewers, kayakers and canoeists, and hunters and anglers during open seasons. Unregulated or inadequately regulated commercial guiding operations may adversely affect the safety of other refuge users, the quality of their experience, and the equity of opportunity. Stipulations for commercial guides should mitigate these concerns by volume and space restraints. Guide operations may increase use of some refuge facilities, such as boat launch ramps, but, if regulated, the impacts of this increase would be negligible.

Environmental Education and Interpretation
Providing environmental education and interpretive programs in the refuge auditorium, environmental education pavilion, and public use areas is expected to continue with negligible impacts, regardless of the alternative.

As regional tourism and coastal populations increase, the demand for local outreach and environmental education and interpretation programs is also increasing. In all of the alternatives, we would continue to provide at least limited environmental education and outreach, as staffing is a limiting factor in the refuge's ability to provide these opportunities. Programs will continue to include providing outdoor classroom sites or programs for visiting school groups, taking part in local events, speaking to local organizations, releasing newspaper articles, and providing refuge brochures to Chambers of Commerce and information centers upon request. The continued involvement of the Friends of Prime Hook NWR, Inc., volunteers, and partners is essential to the long-term success of this wildlife-dependent activity.

Non-Priority Public Uses
Canoeing, walking, hiking, and jogging are uses allowed across all alternatives. These uses were individually found compatible in alternative A, but were considered as a means of access under the compatibility determinations in alternatives B and C. Specialized uses such as commercially guided tours for wildlife observation (including commercially guided tours for continuing education) are also permitted.

Activities previously and currently being evaluated by the refuge manager and determined not to be appropriate or compatible on refuge lands include recycling trash using State-sponsored recycle containers located on the refuge, ice skating, camping, horseback riding, geocaching/metal detecting, off-road and mountain biking, off-road vehicles including ATVs, commercial dog walking, operation of model boats and airplanes, swimming and sunbathing, waterskiing, personal watercraft, air thrust boats, soliciting funds (per 50CFR 27.97 for private operations and per 50CFR 27.86 for begging), and other activities identified in 50CFR Part 27. Of these uses, the only one with a documented appropriateness finding is recycling trash using State-sponsored recycle containers on the refuge. The other uses listed here were never formally evaluated and documented under current management; however, it is our professional judgment that these uses were never allowed. Very few complaints have been received by not allowing these activities.

Impacts on Public Use and Access in Alternative A

Demand and Access
Alternative A would maintain the current level of programs and types of public use opportunities on the refuge. We would not expand permitted uses, programs, or facilities. Visitation may increase in alternative A and impacts are expected to be negligible based on past observations by Refuge staff of fluctuations in annual visitation levels.

Failing impoundment infrastructure and more frequent and severe annual coastal storms are having and will continue to have moderate adverse impacts on refuge vegetation with changes in abundance, distribution, and composition of wetland vegetation. The response of fish and wildlife resources to these habitat changes may affect the quality of priority public uses such as hunting, wildlife observation & photography, and fishing. Impacts are uncertain at this time.

Hunting
Public opportunities to hunt on the Delmarva Peninsula are decreasing with increasing private land development. Refuge lands are thus become increasingly important in the region as a place to engage in this activity. A recent study found that 78 percent of hunters in Delaware hunt on private land (U.S. Department of the Interior 2006). When asked the importance of hunting activities in the U.S. Geological Survey visitor and community survey (Sexton et. al 2007), a little over half of the responses rated them as moderately to very important.

This alternative would have negligible impacts on current hunting opportunities on the refuge as discussed in the previous section. The current annual refuge hunts for deer (4,020 acres), waterfowl (1,722 acres), and upland game (1,995 acres) would continue on designated areas of the refuge. Since this alternative involves little to no change in regulations and hunting methods and practices, hunters would find little disruption to their expectation and routines.

Fishing
Public opportunities for tidal and non-tidal fishing abound on the Delmarva Peninsula. We are currently able to meet the demand for fishing according to staff observation of the level of use on the refuge. The use is steady, but not crowded. However, the demand for public fishing is growing quickly in the immediate area of the refuge. Delaware's comprehensive outdoor recreation plan identified that providing fishing areas is a high priority for Sussex County (DNREC 2009). Providing canoe and kayak access is listed as a moderate priority. The U.S. Geological Survey visitor and community survey also supports these findings (Sexton et. al 2007). When asked the importance of angling activities, all were rated as moderately important.

This alternative would have negligible impacts on current fishing program as discussed in the previous section. Since this alternative involves little or no change in the regulations that affect fishing, anglers would encounter little or no disruption of their expectations or routines.

Wildlife Observation, Photography, Environmental Education, and Interpretation
According to the Delaware's comprehensive outdoor recreation plan, three of the top ten needs for outdoor recreation are walking and hiking trails, fishing areas, and passive recreation (DNREC 2009). The Geological Survey visitor and community survey report further reveals that most visitor and community residents visit the refuge for wildlife observation (Sexton et al. 2007). Being in a natural, undeveloped area and experiencing a serene environment are equally important to their refuge experience as well as the trails that afford this opportunity (Sexton et al. 2007). These activities are equally important to consumptive and non-consumptive use visitors. Furthermore, survey respondents reported that they would like to see increases or improvements in wildlife viewing opportunities, environmental education, interpretive exhibits, and hiking and nature trails (Sexton et al. 2007). Our present facilities meet the existing demand; however, that will not be the case if populations and subsequent demands considerably increase. Furthermore, as failing infrastructure and vegetation is subsequently reduced, any reduction in viewable wildlife would be likely seen as an adverse impact.

In alternative A, opportunities for wildlife-dependent activities would continue and impacts would continue to be negligible.

Non-Priority Public Uses
The following non-priority public use activities are allowed: commercial fishing, commercial trapping of muskrat, raccoon, etc., turtle trapping, picnicking, 5K road race, beekeeping, waterfowl retrieval permits, dog walking, roller blading, competitions or organized group events, and non-competitive organized events.

Activities not allowed are discussed under Impacts on Public Use and Access That Would Not Vary by Alternative.

Conclusion for Management Actions in Alternative A
Management actions in alternative A in the short-term and long-term would result in site-specific, negligible impacts on public use and access. The response of fish and wildlife resources to habitat changes may affect the future quality of priority public uses such as hunting, wildlife observation and photography, and fishing.

Impacts on Public Use and Access in Alternative B

Demand and Access
Alternative B would increase opportunities for wildlife-dependent public use and access by enhancing those programs and facilities at the refuge. A net increase in all public use will occur from current management despite seasonal closures, which will minimize conflict between user groups and minimize wildlife disturbance. Providing new public recreation opportunities would enable people to participate in outdoor activities where they otherwise could not. Increased public awareness, improved community relations and enhanced support of the refuge mission would result as a byproduct of this new interaction. We would help meet demands from the communities where we are located, and from tourists, for outdoor recreation and education, as documented in the Delaware comprehensive outdoor recreation plan and our visitor and community survey. By attracting visitors from outside the area, local communities should experience economic benefits from sales of food, lodging, and supplies.

The level and means of use resulting from this increase in visitation would change the overall experience for some visitors and could result in their changing their patterns of activity or site preferences due to issues of crowding or behavior. Again, given that the refuge provides opportunities for a small portion of the area's visitors, if that shift occurs, it would not be imminent, and could occur outside the 15-year period of this plan. If it does occur, it could put additional strains on other public lands.

Alternative B proposes to expand or enhance wildlife observation and photography opportunities for non-consumptive users by creating seven new trails totaling 3.7 miles using existing and already maintained trail and road networks. The total number of refuge trails becomes 14 with 9.9 miles.

Overall, alternative B would have moderate adverse impacts on a certain segment of the public that does not desire any change in public use programs and regulations, or that may hold differing views on the course of action. In addition, while new visitors become familiar with those changes, violations could increase. Some conflict between refuge users is expected to result in short-term moderate adverse impacts, which will be managed through seasonal closures. Temporary or seasonal closures to non-consumptive users in specific areas will likely result in an increased use of areas and trails that would not be closed. These seasonal closures are highlighted below and apply mostly to non-consumptive users during the hunting season. Other seasonal closures are in place to minimize wildlife disturbance.

- Designated beach dunes and overwash areas: open year round with seasonal closures from March 1 through September 1 due to nesting State endangered least terns and American oystercatchers, and the potential for use by federally threatened piping plovers. Areas may be reopened if no nesting activity occurs or when nesting ends for the season.

- Deep Branch Road Trail (includes Goose and Flaxhole Ponds), Eastern Prime Hook Creek (from Foord's Landing to the headquarters ramp), and hiking trail on Fowler Beach Road (southside in Unit II): Open with seasonal closures of every day from September 1 through March 15 and if necessary during the snow goose conservation order or turkey hunting seasons. If and when the photography blind is available on the southside of Fowler Beach Road, this portion of the trail will be open year round and open every Sunday during the hunting season.

- Headquarters area (includes Turkle and Fleetwood Ponds): open 363 days a year (closed for two deer hunts) and portions may be closed for turkey hunts.

- The northern portion of Unit IV (includes trail overlooking Vergie's Pond): open with a seasonal closure from the Monday before Thanksgiving through March 15 and if necessary during the snow goose conservation order hunting season.

- Hiking Trails on Fowler Beach Road (northside in Unit I), Prime Hook Road, and Slaughter Beach Road and Slaughter Canal: opportunities available year round but only open every Sunday during the hunting season.

- Roadside pull-offs and water control structures, fishing areas at Petersfield Ditch, Slaughter Canal, and Cods Road, and western Prime Hook Creek (from Foord's Landing to Waples Pond): open year-round.

Negative reactions by some visitors may be caused by the closure of the eastern end of Prime Hook Creek from September 1 through March 15 and the temporary closure of the general public use area near the refuge headquarters to conduct deer and turkey hunts. The closure of the eastern end of Prime Hook Creek in September is only one month earlier than current management. In fact, for the last few years, the eastern end has been closed in early September for safety reasons due to the opening of the early teal hunting season on the adjacent state-owned Prime Hook Wildlife Area. The deer hunts in the refuge headquarters are the same as current management and only portions of this area will be closed for one-half day for turkey hunting. Seasonal closures for hunting occur during the fall and winter months, which is typically a slower period of use due to weather conditions. Refuge officers would enforce these and other current refuge regulations, where appropriate, and would seek the assistance and cooperation of Delaware Division of Fish and Wildlife in enforcing common regulations to provide a safe environment for refuge visitors and promote activities that are compatible with protecting the resources.

At first glance, these seasonal closures give the appearance that opportunities for wildlife observation and photography are being significantly reduced or totally eliminated for over eight months during the proposed expanded hunting activities. To the contrary, the majority of the refuge would remain open to wildlife observation and other non-consumptive uses and provide more opportunities and open areas than under current management. More specifically, opportunities for wildlife observation and photography have been expanded to include seven new trails totaling 3.7 miles throughout the refuge in all four management units on existing maintained trails or interior refuge roads, bringing the total number of trails to 14 and 9.9 miles. The Headquarters area, which contains six trails covering six of the nine total miles of refuge trails, remains available 363 days a year for non-consumptive uses, but portions may be closed for turkey hunting. All other areas except for the Deep Branch Trail, Fowler Beach Road trail (southside), and Prime Hook Creek are open on every Sunday during the hunting seasons. The Deep Branch Trail, the Fowler Beach Road trail (southside), and Prime Hook Creek are open with seasonal closures of every day from September 1 through March 15 and if necessary during the snow goose conservation order or turkey hunting seasons. If and when the photography blind is available on the southside of Fowler Beach Road, this portion of the trail will be open year round and open every Sunday during the hunting season. The majority of the hunting will occur during the main hunting season, which typically runs for five months from September through January, with additional hunting opportunities for rabbit through the end of February. Hunting during the snow goose conservation order, which will occur for 2 ½ months from late January through mid-April, will take place mostly in the wetland areas, leaving the upland areas open to other uses. This hunt is not anticipated to bring large numbers of hunters, but is beneficial to the species and other wildlife due to overpopulation. With five or less turkey hunting permits issued in April and May, a vast majority of the refuge would still remain open to wildlife observation and other non-consumptive uses.

Currently, the public can travel to the Delaware Bay at Fowler Beach via Fowler Road, which is a State-maintained road. If this roadway from the bridge at Slaughter Canal to Fowler Beach becomes impassable or unsafe due to environmental conditions such as water erosion, public access (vehicular and pedestrian) would be lost, as the road surface would eventually become marsh. Loss of public access to this area would result in a loss of opportunities for wildlife observation, wildlife photography, and fishing. These recreational opportunities may still exist at the bridge area, where there is currently a parking lot and unimproved boat launch, pending the extent of environmental conditions on public use infrastructure.

The proposed restoration of freshwater impounded wetlands to salt marsh and proposed reforestation of uplands will have long-term moderate-to-major beneficial impacts and negligible-to-minor short-term adverse impacts on refuge vegetation. The response of fish and wildlife resources to these habitat changes may affect the quality of priority public uses such as hunting, wildlife observation & photography, and fishing. Impacts are uncertain at this time, but are expected to be beneficial.

Alternative B proposes to reduce nearly all hunting permit fees (except for lottery hunts) and boat launching fees. This change should be well received by hunters, anglers, and wildlife observers and photographers. For the hunting program, this alternative reduces the administrative burden and minimizes the amount of staffing resources needed to conduct the hunt by 54 staff days and $17,890 from current management in alternative A. The reduction in the cost to hunt provides a minor beneficial impact to the hunter.

Fees will still be required to manage the lottery hunts for deer, waterfowl, and turkey. The Refuge Recreation Act requires that funds are available for the development, operation, and maintenance of the permitted forms of recreation. The proposed permit fee ($10 for deer and turkey; $15 for waterfowl), preseason application fee ($5/hunter), and processing fee for permits acquired after the preseason drawing ($2 to 3 per hunt) are the minimal amounts needed to offset the cost of facilitating the preseason drawings and manage the lottery hunts. Due to the uncertainty in the level of hunter participation with these new program changes, permit fees may need to be adjusted (increased or decreased) and therefore will be evaluated. New fees for preseason application for waterfowl and turkey hunting, new processing fees for standby permits, and charging a flat blind fee for waterfowl rather than an individual fee are anticipated to be unpopular with the hunting public. Application and permit fees for turkey hunting may be waived if the lottery drawing is administered by the State.

Visitor Facilities

The proposed expansion of facilities for environmental education and visitor services programs is expected to increase public awareness of, and visitation to, the refuge and enable staff to provide better customer service. Constructing new interpretive and informational signs and small pavilions on new and existing tracts is expected to provide greater opportunities for conveying conservation messages to visitors, thus increasing their awareness, and possibly their support of the refuge. Minor beneficial impacts to visitors are expected.

We would expect a certain level of inconvenience during the construction of refuge facilities; however, our use of practices that alert and safeguard refuge visitors should mitigate these effects. The minor adverse impacts generally are short-term, and more than offset by the long-term gains in public education and appreciation.

Hunting

Alternative B proposes to expand hunting on refuge lands to offer quality opportunities for hunting deer, waterfowl, upland game and webless migratory birds (dove), and turkey, which will provide moderate beneficial impacts to hunters. The hunting program provides an administratively simple program that balances other public use activities. The program supports the Presidential executive order #13443: facilitation of hunting heritage and wildlife conservation and regional directives, and parallels State hunting regulations. In addition, it provides seasonal closures to minimize wildlife disturbance and avoid conflicts with other uses (see previous section on demand and access for more information), eliminates hunting fees except for lottery hunts, enhances disabled hunting opportunities, further develops an appreciation for fish and wildlife, and expands public hunting opportunities.

Increases in proposed hunting acreages will provide new hunting opportunities from current management; however, many of these proposed “new” hunting areas are currently open to some type of hunting or have been previously open either under refuge management or private ownership. For example, Unit I is currently open for deer and upland game hunting (including dove hunting) and is now proposed to be open for waterfowl hunting - same land, but with a new opportunity. The only refuge land proposed to be open for any type of hunting that is not currently being hunted for any species includes: an area located north of Prime Hook Road commonly referred to as Oak Island (deer only), an area north of Route 16 referred to as the Millman Tract (deer and turkey), an expanded area of the existing Jefferson Lofland Area and Headquarters Area (deer & turkey), an expanded area of the Unit III waterfowl hunt area (waterfowl only), and an area west of Petersfield Ditch in Unit 4. Of these areas, Oak Island was previously hunted under refuge management up until 1995 and the Millman Tract was hunted under private ownership up until the Service purchased it in 2001. The expanded areas of the Jefferson-Lofland Area, Headquarters Area, and nearly all of the proposed Unit III waterfowl hunt area were previously hunted under refuge management. No prior hunting of the area west of Petersfield Ditch is known.

Due to an increase in new hunting areas and by allowing hunters to free roam, an increase in violations may occur until hunters become familiar with the refuge boundaries and regulations. As a result, short-term minor adverse impacts may occur with some landowners due to hunter trespassing. These impacts will be minimized through enhanced law enforcement efforts. We anticipate some conflict between concurrent hunting programs (i.e., waterfowl, deer, and upland game hunting seasons overlapping). For the majority of the hunting seasons, the Delaware Division of Fish and Wildlife has made efforts to avoid these overlaps in the various hunting programs.

Although the refuge provides hunting maps and refuge-specific regulations, it is ultimately the responsibility of the hunter to know and obey them. Unfortunately, not all do. The Service will ensure that refuge boundaries are and continue to be properly posted to notify both refuge visitors and private landowners. Private landowners will be encouraged to contact either refuge and/or state law enforcement when these trespassing incidents occur and every effort will be made to respond in an efficient and timely manner. The Service also encourages private landowners to post their own property. Restricting hunter access within a 100 yard buffer to private property was discussed and it was concluded that too much hunting area would be lost by this zone and that there are already sufficient laws and regulations in place to discourage boundary shooting. Furthermore, neighboring landowners would benefit by having easy access to designated areas open to hunting on the refuge.

Visitor safety at refuges is a high priority when developing compatible wildlife-dependent recreation programs, such as hunting; however, it is ultimately the responsibility of every hunter to be safe. An accident involving hunter safety results from either a lack of hunting ethics or a violation of hunting regulations. Use of portable deer climbing stands will be recommended but not required. For hunters who may be unable to climb trees using portable deer stands or who may wish to hunt from permanent deer stands or duck blinds, the state-owned Prime Hook Wildlife Area, which adjacent to the Refuge, will continue to provide these opportunities.

Provision of elevated deer stands, and to a lesser degree waterfowl blinds, is relatively unique to Delaware. There are many areas on the Delmarva Peninsula, other than Prime Hook NWR, that offer public hunting opportunities in free-roam areas where the hunter is required to provide the blind or stand, if desired.

The Service conducted a web-search for public lands within the three states making up the Delmarva Peninsula in order that we evaluate the prevalence of permanent waterfowl blinds or deer stands on public hunting lands. A wide assortment of ownership and management regimes was evident across 215 tracts managed or described by 19 different designations, e.g. State Park, National Park Service, State Forest, Chesapeake Forest Lands, Natural Resources Management Area. For waterfowl hunting, 131 of the 215 tracts examined permitted waterfowl hunting. Of the 131, only 36 provided either a pit or standup blind somewhere on the tract. The Service makes this qualifying statement because some areas, Tuckahoe State Park for example, provide four pit blinds but also allow free roaming along the Tuckahoe River. Of the 36, 28 were located in Delaware, 8 in Maryland, and none in Virginia. Twenty tracts required hunters to hunt at a stake or within some designated distance from a blind site where the hunter would provide the blind (if desired), including nine in Delaware, 11 in Maryland, and none in Virginia. A total of 84 tracts permitted free-roam hunting where the hunter would provide the blind (if desired), 17 in Delaware, 60 in Maryland, and seven in Virginia.

For deer hunting, of the 215 tracts examined, 181 permitted some form of deer hunting. Unfortunately, the Service did not make a distinction between the various methods, i.e. some tracts may be limited to bow hunting only. Of the 181 tracts, 95 were located in Delaware, 77 in Maryland and nine in Virginia. A total of 51 of the 181 tracts required hunters to use stands that were provided, all of which were located in Delaware. Free-roam hunting was permitted on 165 tracts, including 80 in Delaware, 76 in Maryland, and nine in Virginia. The Service acknowledges that some free roam areas were for bow hunting only, however such a distinction would only apply in Delaware; all deer hunting tracts in Maryland and Virginia permitted free-roam hunting regardless of hunting method.

For the 85 tracts located in Maryland and Virginia where no stands are provided, only two require an elevated stand, which the hunter must provide. For areas immediately adjacent to the building complex on Blackwater NWR, the hunter must use an assigned blind site where the hunter erects a stand with a platform minimum of eight feet above the ground. All other tracts on Blackwater NWR are free-roam where ground-hunting is permitted.

The second site where elevated deer hunting is required is on Chincoteague NWR, around the tour loop. Here the hunter must erect his/her own stand with a platform minimum of 14 feet above the ground. All other areas on Chincoteague

NWR permit free-roam hunting. The Service should also add that rifle hunting, as well as deer drives, are permitted on most public hunting lands on the lower eastern shore of Maryland and the eastern shore of Virginia.

Preseason lottery drawings at the refuge provide hunting opportunities for local, in state, and out-of-state hunters. Advance knowledge of a hunting opportunity allows hunters to prepare, plan, and scout, which ultimately helps to provide a quality hunting experience.

We should note that, according to the U.S. Geological Survey visitor and community survey (Sexton et al. 2007) the overall mean desirability of additional hunting opportunities was not as high as that of other public use activities. However, upon further breakdown between hunters and non-hunters, the additional hunting opportunities listed were very desirable to the hunting community. We detail below the impacts that may result from the different types of hunting: white-tailed deer, waterfowl, upland game and webless migratory birds (dove), and wild turkey.

<u>White-tailed deer hunting</u>: A total of 5,221 acres is open for deer hunting, which includes archery (to include the use of crossbows), muzzleloader, handgun, and shotgun hunting. Seasonal closures would occur to protect wildlife and minimize conflicts between different hunting activities and other non-consumptive recreational uses (e.g., minimize conflict with anglers on Prime Hook Creek and close hunting in late November in designated areas to minimize bald eagle and waterfowl disturbance). Disabled hunting areas in Unit IV would limit access to individuals who are permanently confined to a wheelchair, which ensures quality opportunities for hunters with limited mobility.

The Refuge proposes to open 1,201 additional acres for deer hunting under alternative B. Additional acreage proposed for hunting includes an area located north of Prime Hook Road commonly referred to as Oak Island, an area west of the existing Headquarters Area, an area north of Route 16 referred to as the Millman Tract, and an expansion of the Headquarters Area and Jefferson Lofland Tract. Hunter numbers are expected to initially increase based on the opening of these areas and the opportunity for hunters to free-roam; however, cumulative impacts are expected to be negligible.

Permanent deer hunting stands will be phased out over a 5-year period in all areas except the disabled hunting area. We will limit the number of permits to no more than 30 in the lottery hunt area to minimize hunter conflict in an area historically known to attract large hunter numbers. In the regular hunt area, hunting will be open every day during designated seasons (except the October antlerless and handgun seasons).

The phasing out of all permanent deer hunting stands (except non-ambulatory hunt blinds) will require hunters to find a suitable hunting location within designated hunting areas through effective scouting. Use of portable deer climbing stands is recommended but not required. Hunters have expressed an interest in scouting and choosing their hunting locations to enhance the quality of their hunt. Maintenance mowing will no longer occur to provide trails to facilitate hunting. Minor-to-moderate short-term adverse impacts are expected among hunters over desired hunting locations and we will continue to encourage proper hunting ethics.

<u>Waterfowl hunting</u>: A total of 3,432 acres is open to migratory bird hunting, which is 40 percent of the refuge (includes lands purchased with Land and Water Conservation Funds which are excluded from the 40 percent rule). Seasonal closures would occur to not only protect wildlife, but also to minimize conflicts between different hunting activities and other non-consumptive recreational uses (e.g., close hunting in late November in designated areas to minimize bald eagle and waterfowl disturbance and provide access for non-consumptive users only

on Sundays in designated areas during the hunting season). In all hunt areas, hunting will occur four days per week and cease at 3pm, which is the same as current management.

An additional 1,710 acres are proposed to be open under alternative B including: an area between Slaughter Beach Road and Fowler Beach Road referred to as Unit I, an area located south of Prime Hook Road, and a reconfiguration of the existing waterfowl hunt area in Unit III. Hunter numbers are expected to initially increase based on the opening of these areas and the opportunity for hunters to free-roam in the regular waterfowl areas; however, cumulative impacts are expected to be negligible.

Although the permanent waterfowl blinds on the refuge will be phased out over a 5-year period, we still require hunters in the lottery hunt area to hunt within a defined area around a designated blind site (marker). This will minimize hunter conflict in an area historically known to attract large hunter numbers. In past years for daily drawings on opening days, it was common to see more than 60 to 80 duck hunting parties compete for 25-27 available hunting opportunities.

The phasing out of all permanent waterfowl hunting blinds (except non-ambulatory blinds) in lieu of blind sites in the lottery hunt area will now require hunters to provide their own means to camouflage themselves (e.g., boat blind, pop-up blind, etc.). Hunters would be required to find a suitable hunting location within a specified area around the blind site marker. Hunters have expressed an interest in scouting and having the flexibility to adjust their hunting locations for weather conditions to enhance the quality of their hunt. In free roam areas, hunters may hunt anywhere in the designated area. Minor-to-moderate short-term adverse impacts are expected among hunters over desired hunting locations and we will continue to encourage proper hunting ethics.

Upland game and webless migratory bird hunting: A total of 1,995 acres is available for hunting upland game and webless migratory birds. Dove hunting will not be open on 110 of these acres, which should affect few hunters. Some conflict with concurrent hunting and the potential for trespassing on adjacent private land are expected and previously discussed in this section. As a result, some landowner conflicts may erupt due to hunter trespassing. These minor short-term adverse impacts will be minimized through enhanced law enforcement efforts.

Wild turkey hunting: A total of 3,729 acres is open for hunting wild turkey during legal hunting hours on selected hunt days. In recent years, hunter and staff observations indicate that a huntable population of turkeys may exist on the refuge (Refer to Impacts to Landbirds for more information). Limited opportunities exist on public lands to hunt turkey and the refuge may contribute to providing additional quality opportunities for hunters. Hunting of turkey will be permitted to a limited number of hunters (no more than five) and this number may be adjusted (increased or decreased) based on changes in turkey population data.

Fishing

Alternative B proposes to open Fowler Beach to night fishing by permit only and open Goose and Flaxhole Ponds as a primitive fishing area (boat-only access; manual propulsion only; boats must be ported in). Goose and Flaxhole Ponds have never been open to fishing. Fishery assessments and management recommendations will need to be conducted prior to their opening. Minor beneficial impacts are expected. Access for anglers at Fowler Beach may be affected by future decisions on maintenance by the State (see Demand and Access earlier in this section).

The Service proposes to allow fishing and crabbing at the pulloffs along Prime Hook Road due to increased visitor demand in this area and existing pulloffs already provide safe parking areas for wildlife observers and photographers. Access is restricted to only the pulloff area to provide safety for visitors and to avoid traffic issues. The refuge will consider fishing and crabbing along Broadkill Road and Fowler Beach Road in the future if there is a demand and if visitor safety and adequate parking can be guaranteed. Adequate parking and visitor safety along State-maintained roads has historically been an issue. Crabbing decreased significantly from 3,644 visits in 1976 to 880 visits in 1977 due to new regulations making state highway bridges into refuge waterways off limits in an effort to increase pedestrian safety along these roads.

Increasing fishing opportunities on the refuge would serve the demand for more fishing opportunities in Sussex County. The improving habitat quality resulting from ongoing habitat restorations on the refuge would likely result in improving water quality and increasing some fish populations. That could positively affect the fishing experience and fishing success.

Under alternative B, we would not allow recreational gill-netting, commercial fishing, crabbing using pots or trot lines, and food fishing with equipment other than hook and line on the refuge. The use of gill netting by commercial or recreational fishermen has occurred in the tidal waterways of Slaughter Canal for over 30 years by a small number of fishermen. These activities, whether commercial or recreational, are not consistent with goals and objectives in any refuge management plan, conflict with rod and reel recreational fishermen and wildlife observers using canoes and kayaks, and has the potential to harm non-targeted fisheries through incidental by-catch. Fishing for bait fish is permitted for recreational uses only, subject to regulations stated in title 7 (Conservation) of the Delaware State Code. Minor adverse impacts are expected.

The fishing program would not adversely affect people enjoying other, non-consumptive uses of the refuge. Some negative comments may be received by anglers not agreeing with catch-and-release regulations and the use of barbless hooks on designated waterways. Adverse impacts are expected to be minor and short-term.

Wildlife Observation and Photography

In alternative B, we propose to expand opportunities in wildlife observation, wildlife photography, and environmental education and interpretation by adding new trails using existing and already maintained trail and road networks off Slaughter Beach Road, Fowler Beach Road, Prime Hook Road, Deep Branch Road, and Broadkill Road. Seven new trails totaling 3.7 miles will be created. The total number of refuge trails becomes 14 with 9.9 miles. Using existing roads will minimize impacts to refuge resources.

Nature photographers and other visitors would benefit directly from those additional facilities and the new opportunities they would provide. To enhance wildlife viewing areas, trails, pull-offs, etc., that can be accessed from public roads and highways, an interpretive brochure outlining these areas would be created to enhance the enjoyment of the visitors' experience. The elimination of boat launching fees should be well received by visitors.

The expanded use of new areas will affect, and be affected by, visitors participating in the refuge hunting program. We will enact seasonal closures to ensure the safety of non-consumptive users, as well as the quality of both programs (see Demand and Access earlier in this section or in chapter 4 alternatives). Adverse impacts generally would be short-term and more than offset by the long-term gains in public awareness and support of refuge resource programs.

Environmental Education and Interpretation

Alternative B proposes that we increase educator-led programs, which will cause minor beneficial impacts and is an attempt to meet increasing demand. We also propose expanding the existing facility to accommodate increased environmental education and interpretive programs. This alternative also proposes that we continue to provide onsite and offsite interpretive programs, reaching out to civic groups, conservation organizations, and community events. In addition, we propose using a variety of public use materials, including signage, brochures, and kiosks with interpretive panels

More opportunities exist to provide public education and information for visitors. Those opportunities would foster increased public understanding and appreciation of resource issues and needs, which could lead to increased support and funding and positively affect fish and wildlife resources on the refuge. Increased outreach could also positively affect land use decisions by local governments and private landowners outside the refuge, and lead to increased populations of fish and wildlife over a broader area.

Impacts to other recreational activities are expected to be negligible, since most of the environmental education programs occur on trails adjacent to the refuge office. Visitors have several other trails to observe or photograph wildlife if school groups are present. Most likely, interpretive activities would be not performed in conjunction with other existing public use activities and therefore would not cause user-conflicts on these areas.

Non-Priority Public Uses

Commercial nature photography is allowed under alternative B. All allowed uses described in alternative A are not allowed under alternative B such as commercial fishing, commercial trapping of muskrat, raccoon, etc, turtle trapping, picnicking, 5K road race, beekeeping, and waterfowl retrieval permits. We expect substantial negative criticism of no longer allowing dog walking on the refuge, but it is an activity which causes disturbance and negative impacts to wildlife.

Conclusion for Management Actions in Alternative B

Management actions in alternative B in the short-term and long-term would result in site-specific, negligible to moderate beneficial impacts on public use and access due to expanded opportunities for both consumptive and non-consumptive users. Alternative B would contribute short-term minor-to-moderate adverse impacts to public use and access due to possible hunter conflicts and a perceived loss of opportunity for non-consumptive users from seasonal closures during the hunting season. The response of fish and wildlife resources to habitat changes may affect the future quality of priority public uses such as hunting, wildlife observation & photography, and fishing.

Impacts on Public Use and Access in Alternative C

Demand and Access

Alternative C would have similar opportunities for wildlife-dependent public use and access as alternative A, except for hunting which provides fewer opportunities than proposed in alternative B. Fees for visitor access are the same as alternative B.

The response of vegetative communities from refuge management under alternative C will be similar to alternative B except there will not be active reforestation and the potential for more wetlands to become open water is greater. The response of fish and wildlife resources to these habitat changes may affect the quality of priority public uses such as hunting, wildlife observation & photography, and fishing. Impacts are uncertain at this time.

Hunting
In alternative C, hunting overall is the same as alternative B except the number of days are decreased for deer and waterfowl hunting. Beneficial impacts are similar to alternative B. Minor short-term adverse impacts are expected due to hunter conflicts.

White-tailed deer hunting: The reduction in hunting days from every day during the State hunting season to three days per week is not expected to result in negative feedback from the hunting public because there is still an overall increase in hunting opportunity from current management under alternative A.

One less day of hunting in the headquarters area will provide non-consumptive users additional access to the public use infrastructure in the headquarters area.

Waterfowl hunting: The reduction in hunting days from four days per week until 3pm to three days per week until noon is not expected to result in negative feedback from the hunting public because there is still an overall increase in hunting opportunity from current management under alternative A.

Upland game and webless migratory bird hunting: Same as the impacts listed under alternative B in Impacts on Public Use and Access.

Wild turkey hunting: Same as the impacts listed under alternative A in Impacts on Public Use and Access.

Fishing
Similar to impacts listed under alternative A, except Slaughter Canal will only be open on Sundays from September 1 through the end of the hunting season.

Wildlife Observation and Photography
Similar to impacts listed under alternative A.

Environmental Education and Interpretation
Similar to impacts listed under alternative B.

Conclusion for Management Actions in Alternative C
Management actions in alternative C in the short-term and long-term would result in site-specific negligible-to-moderate beneficial impacts on public use and access due to expanded hunting opportunities. Alternative C would contribute short-term negligible-to-minor adverse impacts to public use and access due to possible hunter conflicts. The response of fish and wildlife resources to habitat changes may affect the future quality of priority public uses such as hunting, wildlife observation and photography, and fishing.

Cumulative Impacts

According to the CEQ regulations on implementing NEPA (40 CFR 1508.7), a cumulative impact is an impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes the other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over time.

Our cumulative impacts assessment includes the actions of other agencies or organizations, if they are interrelated and influence the same environment. This analysis considers the interaction of activities at the refuge with other actions occurring adjacent to the refuge and over a larger state and regional spatial and temporal frame of reference.

Cumulative Impacts of Climate Change on Refuge Lands

Department of the Interior Secretarial Order 3226 states that "there is a consensus in the international community that global climate change is occurring and that it should be addressed in governmental decision making. This order ensures that climate change impacts are taken into account in connection with Departmental planning and decision making." Additionally, it calls for the incorporation of climate change considerations into long-term planning documents, such as a CCP.

The Wildlife Society published an informative technical review report in 2004 titled Global Climate Change and Wildlife in North America (Inkley et al. 2004). It interprets results and details from publications such as the Intergovernmental Panel on Climate Change reports (1996 to 2002) and describes the potential impacts and implications on wildlife and habitats. It mentions that projecting the impacts of climate change is hugely complex because it is important to predict changing precipitation and temperature patterns, their rate of change, and the exacerbated effects of other stressors on the ecosystems. Those stressors include loss of wildlife habitat to urban sprawl and other developed land uses, pollution, ozone depletion, exotic species, disease, and other factors. Projections over the next 100 years indicate major impacts such as extensive warming in most areas, changing patterns of precipitation, and significant acceleration of sea level rise. According to the Wildlife Society report, "…other likely components of ongoing climate change include changes in season lengths, decreasing range of nighttime versus daytime temperatures, declining snowpack, and increasing frequency and intensity of severe weather events" (Inkley et al. 2004). The Wildlife Society report details known and possible influences on habitat and wildlife, including changes in primary productivity, changes in plant chemical and nutrient composition, changes in seasonality, sea level rise, snow, permafrost, and sea ice decline, increased invasive species, pests and pathogens, and impacts on major vertebrate groups.

The effects of climate change on populations and range distributions of wildlife are expected to be species specific and highly variable, with some effects considered negative and others considered positive. Generally, the prediction in North America is that the ranges of habitats and wildlife will generally move upwards in elevation and northward as temperature rises. Species with small or isolated populations and low genetic variability will be least likely to withstand impacts of climate change. Species with broader habitat ranges, wider niches, and greater genetic diversity should fare better or may even benefit. This will vary depending on specific local conditions, changing precipitation patterns, and the particular response of individual species to the different components of climate change (Inkley et al. 2004). The report notes that developing precise predictions for local areas is not possible due to the scale and accuracy of current climate models, which is further confounded by the lack of information concerning species-level responses to ecosystem changes, their interactions with other species, and the impacts from other stressors in the environment. In other words, only imprecise generalizations can be made about the implications of our refuge management on regional climate change.

Our evaluation of the proposed actions concludes that only two activities may contribute negligibly, but incrementally, to stressors regionally affecting climate change: our prescribed burning program and our use of vehicles and equipment to administer the refuge. We discuss the direct and indirect impacts of those activities elsewhere in this chapter. We also discuss measures to minimize the impacts of both. For example, with regard to prescribed burning, we follow detailed burn plans operating only under conditions that minimize air quality concerns. In addition, many climate change experts advocate prescribed burning to manage the risk of catastrophic fires (Inkley et al. 2004). With regard to our equipment and facilities, we are trying to reduce our carbon footprint wherever possible by using alternative energy sources and energy-saving appliances, and using recycled or recyclable materials, along with reduced travel and other conservation measures.

In our professional judgment, the majority of management actions we propose would not exacerbate climate change in the region or project area, and some might incrementally prevent or slow local impacts. We discuss our actions relative to the 18 recommendations in the Wildlife Society report to assist land and resource managers in meeting the challenges of climate change when working to conserve wildlife resources (Inkley et al. 2004).

- ***Recommendation #1:*** Recognize global climate change as a factor in wildlife conservation: this recommendation relates to land managers and planners becoming better informed about the consequences of climate change and the variability in the resources they work with.

  The Service is taking a major role among Federal agencies in distributing and interpreting information on climate change. There is a dedicated Web page to this issue at *http://www.fws.gov/home/climatechange/*; accessed February 2012. The Service's Northeast Region co-hosted a workshop in June 2008 titled Climate Change in the Northeast: Preparing for the Future. The goal of the workshop was "to develop a common understanding of natural and cultural resource issues and to explore management approaches related to climate change in the Northeast." Its primary target audience was land managers. Experts in climate change gave presentations and facilitated discussion. The stated outcomes were to have participants more fully understand the present and anticipated impacts from climate change on forested, ocean and coastal ecosystems, and to be able to identify effective management approaches that include collaboration with other local, state and Federal agencies. All of the Northeast Region refuge supervisors and planners attended, as did more than 20 refuge field staff.

- ***Recommendation #2:*** Manage for diverse conditions. This recommendation relates to developing sound wildlife management strategies under current conditions, anticipating unusual and variable weather conditions, such as warming, droughts, and flooding.

  Our proposed habitat management actions described in chapter 2 promote healthy, functioning native forests, shrublands, and grasslands. Protecting the integrity of wetlands and managing for fully functioning riparian areas is also a priority. We have identified monitoring elements, which will be fully developed in the inventory and monitoring step-down plan, to evaluate whether we are meeting our objectives and to assess changing conditions. We will implement an adaptive management approach as new information becomes available.

- ***Recommendation #3:*** Do not rely solely on historical weather and species data for future projections without taking into account climate change. This recommendation relates to the point that historical climate, habitat and wildlife conditions are less reliable predictors as climate changes. For example, there may be a need to adjust breeding bird survey dates if migratory birds are returning earlier to breed than occurred historically. A 3-week difference in timing has already been documented by some bird researchers.

  We are aware of these implications and plan to build these considerations into our inventory and monitoring plan and annual habitat work plans so that we can make adjustments accordingly. Our results and reports, and those of other researchers on the refuge, will be shared within the conservation community.

- ***Recommendation #4:*** Expect surprises, including extreme events. This recommendation relates to remaining flexible in management capability and administrative processes to deal with ecological surprises such as floods or pest outbreaks.

Refuge managers have flexibility within their operations funds to deal with emergencies. Other regional operations funds would also be redirected as needed to deal with an emergency.

- ***Recommendation #5:*** Reduce non-climate stressors on the ecosystem. This recommendation relates to reducing human factors that adversely affect resilience of habitats and species.

  Similar to our response to #2 above, the objectives of our habitat management program are to maintain and enhance the biological integrity, diversity, and health of refuge lands. Objectives to enhance riparian habitat for watershed protection and establish healthy, diverse native forests in large tracts will help offset the local impacts of climate change.

- ***Recommendation #6:*** Maintain healthy, connected, genetically diverse populations. This recommendation relates to the fact that small isolated populations are more prone to extirpations than larger, healthy, more widespread populations. Large tracts of protected land facilitate more robust species populations and can offer better habitat quality in core areas.

  We will continue to work with our many conservation partners at the State and regional levels to support and complement restoration and protection efforts.

- ***Recommendation #7:*** Translocate individuals. This recommendation suggests that it may sometimes be necessary to physically move wildlife from one area to another to maintain species viability. However, it is cautioned that this tool has potential consequences and should only be used as a conservation strategy in severely limited circumstances.

  Extensive salt water intrusion into our freshwater emergent and forested wetlands from even more rapid sea level rise than is predicted could result in the catastrophic loss of forested upland habitats and convert them to open water. This may warrant a rapid translocation of endangered Delmarva fox squirrels to inland national wildlife refuges as the only mitigation to avoid jeopardy.

- ***Recommendation #8:*** Protect coastal wetlands and accommodate sea level rise. This recommendation relates to actions that could ameliorate wetland loss and sea level rise, such as purchasing wetlands easements, establishing riparian and coastal buffers, restoring natural hydrology, and refraining from developments or impacts in sensitive wetlands and coastal areas.

  Our four habitat goals and associated objectives identify restoring natural hydrology in salt marshes and prior converted wetlands for croplands, protecting barrier beach island habitats from erosion, conserving sensitive wetlands and coastal maritime shrub and forest communities, establishing riparian and coastal buffers and reforesting open field areas.

- ***Recommendation #9:*** Reduce the risk of catastrophic fire. This recommendation acknowledges that fire can be a natural part of the ecosystem, but that climate change could lead to more frequent fires or greater likelihood of a catastrophic fire.

  Our plans to conduct prescribed burns to maintain grasslands, control invasive plants, and reduce fuel loading in overstocked forest stands would reduce the overall risk of a catastrophic event occurring on or near refuge lands.

- ***Recommendation #10:*** Reduce likelihood of catastrophic events affecting populations. This recommendation states that increased intensity of severe weather can put wildlife at risk. While the severe weather cannot be controlled, it may be possible to minimize the effects by supporting multiple, widely spaced populations to offset losses.

Our response to recommendations #2, #5, and #6 above describes the actions we are taking to minimize risks to wildlife.

- ***Recommendation #11:*** Prevent and control invasive species. This recommendation emphasizes the increased opportunities for invasive species to spread because of their adaptability to disturbance. Invasive species control will be essential, including extensive monitoring and control to preclude larger impacts.

  Invasive species control is a major initiative within the Service. The Northeast Region, in particular, has taken a very active stand. In chapter 2, we provide detailed descriptions of our current and future plans on the refuge to control existing invasive plant infestations. We also describe monitoring and inventorying strategies to protect against any new infestations.

  Our wildland urban interface program, established in 2002, has been an aggressive program to reduce heavy accumulations of dead fuels *(Phragmites* sprayed canes and other highly flammable vegetation) on the refuge and immediately adjacent to the refuge. We have been and will continue to work with many landowners in the refuge area to control *Phragmites* and other fire prone wildland vegetation to avoid catastrophic fire and aggressively treat any fuel hazards immediately.

- ***Recommendation #12:*** Adjust yield and harvest models. This recommendation suggests that managers may have to adapt yield and harvest regulations in response to climate variability and change to reduce the impact on species and habitats.

  We do not have plans for any significant harvest activities. We plan to phase out our cooperative farming program, and will only harvest trees in overstocked, naturally succeeding, forested habitats to improve forest diversity, composition, and health. Our monitoring program will include detecting population trends in focal species to alert us to any significant changes.

  Regarding animal harvest through hunting programs, the refuge does not set harvest regulations. For resident wildlife, regulations are established at the State level. For migratory game birds, the harvest framework is established at the flyway level, and further refined at the State level.

- ***Recommendation #13:*** Account for known climatic conditions. This recommendation states we should monitor key resources through predictable short-term periodic weather phenomena, such as El Nino, to aid us in future management efforts.

  We plan to develop a monitoring program that will help us evaluate our hypotheses, assumptions, and successes in achieving objectives, as well as help us make future management decisions. Any restoration activities or proactive habitat management actions will be carefully planned and their effectiveness monitored and documented so we can use the information in future management decisions.

- ***Recommendation #14:*** Conduct medium- and long-range planning. This recommendation states that plans longer than 10 years should take into account potential climate change and variability as part of the planning process.

  This 15-year CCP addresses climate change with its emphasis on restoring and maintaining healthy, contiguous, native habitat areas, reducing and mitigating human stressors on refuge lands, working with private landowners to improve the health, integrity, and fire safety of their lands, and pursuing larger conservation connections and corridors with partners to enhance protected core areas. Our monitoring program and adaptive management strategies will also facilitate our ability to respond to climate change.

- ***Recommendation #15:*** Select and manage conservation areas appropriately. This recommendation states that establishment of refuges, parks, and reserves is a conservation strategy to try to minimize the decline of wildlife and habitats in North America. Decisions on locating future conservation areas should take into account potential climate change and variability. For example, it is suggested that decisions on new acquisitions consider the anticipated northward migrations of many species, or the northern portion of species ranges. Managers of existing conservation lands should consider climate change in future planning.

  Our response to recommendation #14 also should be noted here.

- ***Recommendation #16:*** Ensure ecosystem processes. This recommendation suggests that managers may need to enhance or replace diminished or lost ecosystem processes. Manually dispersing seed, reintroducing pollinators, treating invasive plants and pests, are examples.

  While we plan to take an aggressive approach to treating invasive plants, we do not believe at this time there is any need to enhance or replace ecosystem processes. Further, none of our proposed management actions will diminish existing natural ecosystems processes. Should our monitoring results reveal that we should take a more active role in enhancing or replacing those processes, we will reevaluate or refine our management objectives and strategies.

- ***Recommendation #17:*** Look for new opportunities. This recommendation states that managers must be continually alert to anticipate and take advantage of new opportunities that arise. Creating wildlife conservation areas from abandoned or unusable agricultural land, and taking advantage of industry interest in investing in carbon sequestration or restoration programs are two examples.

  Refuge staff members have many conservation partners in the area who, in turn, are networked throughout the larger region. We hear about many opportunities for land protection or habitat restoration through that broad-based network. Our Northeast Region has field offices and a regional office that integrates the other Service program areas, including those that work with private entities. We have developed outreach materials and make ourselves available to interested organizations and groups to provide more detailed information on the Service and Refuge System missions, refuge goals and objectives, and partnership opportunities.

- ***Recommendation #18:*** Employ monitoring and adaptive management. This recommendation states that we should monitor climate and its effects on wildlife and their habitats and use this information to adjust management techniques and strategies. Given the uncertainty with climate change and its impacts on the environment, relying on traditional methods of management may become less effective.

We agree that an effective and well-planned monitoring program, coupled with an adaptive management approach, will be essential to dealing with the future uncertainty of climate change. We have built both aspects into our CCP. We will develop a detailed step-down inventory and monitoring plan designed to test our assumptions and management effectiveness in light of on-going changes. With that information in hand, we will either adapt our management techniques or reevaluate or refine our objectives as needed.

Cumulative Impacts on Climate Change-Vulnerable Species

For a more generalized consideration of sea level rise and anticipated cumulative impacts to climate-vulnerable species of the mid-Atlantic area, we reviewed the U.S. Climate Change Science Program's report Coastal Sensitivity to Sea Level Rise: A Focus on the Mid-Atlantic Region (USCCSP 2009). The findings of this report and how they relate to the refuge and climate change-vulnerable species are summarized below.

Refuge coastal ecosystems consist of a variety of environments, including tidal salt marshes, maritime shrubland and forest, tidal flats, sandy beach, overwash, and dune grassland habitats that will be very vulnerable to cumulative adverse impacts from climate change and sea level rise. Vulnerable species that rely on these habitats include an array of biota ranging from beach dune tiger beetle to commercially important fish and shellfish and from migratory birds to marsh plants and aquatic vegetation.

Artificial shore protection and development currently prevents the natural longshore transport of sand that protects Delaware Bay beach habitats from erosion. Artificial dune stabilization destroys natural beach development and processes that naturally replenish barrier beach island habitats and pace migration of wetlands inland. Three key determinants of future marsh acreage on the refuge will be:

- The capacity of a refuge marsh to raise its surface to match the rate of rising sea level
- The rate of erosion of the bayward boundary of the marsh by overwash and sand transport
- The availability of space for refuge marshes to migrate inland

The cumulative impacts of climate change will result in the following long-term effects on refuge coastal habitats within the next 50 to 100 years that will probably start to become evident within the lifespan of this CCP:

- Significant increase in open water and decrease in tidal salt marsh habitats because there is no available space (beyond refuge boundaries) for these marshlands to migrate inland
- Submersion of our tidal marsh habitats, causing populations of salt marsh-dependent species of fish and birds to be reduced in size
- Loss of tidal marsh areas and brackish impounded areas associated with submerged aquatic plant beds that serve as important nurseries and shelter areas for fish and shellfish, including anadromous river herring species, elvers, striped-bass, white-perch, and blue crab
- Loss of sandy beach, overwash, and dune grassland habitats, adversely impacting rare beetles, horseshoe crabs, diamondback terrapin, and shorebird nesting and foraging habitats
- Loss of interdunal swale habitats adversely impacts rare firefly species and other invertebrates, and breeding shorebirds dependent on these areas
- Degradation and loss of the refuge's isolated marsh islands, which are currently important as bald eagle nesting sites and for other nesting birds that rely on island habitats for protection from predators and human disturbance

- Degradation and loss of most of the refuge's freshwater emergent marsh habitat, rare peat bog communities, and freshwater forest ecosystems, with significant losses of biodiversity

- Potential loss or degradation of freshwater swamps, which are considered globally imperiled and are at very high risk from sea level rise threats; our 1,300 acres of red maple-seaside alder and Atlantic white cedar will not survive permanent salt water inundation

- Loss of tidal flats and emergent marsh areas, rich sources of invertebrate foods for shorebirds and waterfowl, which will gradually become less productive as they revert to open water habitats

- Loss of major ecological processes with the decline and degradation of emergent marsh ecosystems that benefit humans, such as fish and shellfish production, water purification and water storage capacities, delivery of pollination services, and loss of refuge recreational fishing opportunities

- Exacerbation of refuge onsite pollution problems resulting from increased frequency and duration of inundation of upland and wetland habitats that will amplify sources of contamination surrounding the refuge during flooding events

Unlike other estuaries in the mid-Atlantic, the tidal range of the Delaware Bay estuary is greater than the ocean tidal range, generally about two meters. Bay shoreline and tidal marshes appear to be at the low end of their potential elevation range, which increases their vulnerability to sea level rise (Kearney et al. 2002). Recent research indicates that 50 to 60 percent of the bay's tidal marshes have been degraded, primarily because the marsh surface is not rising as fast or keeping up with current rates of sea level rise. Reasons cited for this include channel deepening projects, artificial shoreline stabilization, and consumptive withdrawals of freshwater, which have significantly changed and will continue to thwart sediment supply to Delaware Bay marshes (Sommerfield and Walsh 2005).

Some of the most notable Delaware Bay species that will be the most vulnerable and suffer considerable cumulative adverse impacts from sea level rise and climate change will be shorebirds and horseshoe crabs. A sea level rise modeling study estimated that a 2-foot rise in relative sea level over the next century could reduce shorebird foraging areas in the Delaware Bay by 57 percent or more by 2100 (Galbraith et al. 2002).

As a major refueling stopover area for six species of migratory shorebirds, including most of the Western Hemisphere's population of red knots, shorebirds stand to lose major Delaware Bay invertebrate food resources in tidal flats and nutrient-rich horseshoe crab eggs of sandy beach and foreshore habitats. Human infrastructure along the entire bay coast leaves estuary beaches little to no room to migrate inland as sea level rises. This will cause substantial losses of horseshoe crab spawning habitat likely to occur within the next 50 to 100 years (Galbraith et al. 2002). University of Delaware scientists (Kraft et al. 1992) estimate this loss, along with subsequent wetland drowning, to be greater than 90 percent in Delaware Bay (about 33,000 ha).

The State is purchasing agricultural preservation easements in the coastal zone to conserve shoreline habitats for the future, and a significant portion of undeveloped shoreline habitats are located in Prime Hook and Bombay National Wildlife Refuges. But we will not be able to mitigate the loss of shoreline and barrier beach island habitats in front of our salt marshes as bay water levels flood these sandy habitats, permanently causing cumulative negative impacts to ecosystem functioning of these areas and disruption to critical food webs.

The most abundant beach organisms are microscopic invertebrates that live between sand grains, feeding on bacteria and single-celled protozoa where two billion organisms can occur in a single meter of sand (Bertness 1999). These invertebrates play a critical role in beach food webs as a link between bacteria and larger consumers such as sand diggers, fleas, ghost crabs, and other macroinvertebrates that burrow in sandy sediments or accumulate in wracklines.

Many insects and crustaceans found in deposits of wrack are important food sources for nesting piping plover, American oystercatcher, sandpiper, whimbrel, and other migratory shorebirds (Dugan et al. 2003). With sea level rise, these bird food resources will be irreversibly lost, resulting in declines of many migratory bird species. Methods or plans to mitigate these adverse cumulative impacts to barrier beach island habitats and permanent losses of focal species are currently unknown.

Other cumulative environmental consequences and implications to the long-term irreplaceable loss of refuge salt marsh and impounded wetland habitats will be cumulative adverse impacts to waterfowl, waterbirds, and shorebirds. Particularly at low tide, the areas in our impounded marsh complex that provide forage for herons, egrets, plovers, dunlin, dowitchers, pintails, black ducks, green-winged teal and other waterfowl and shorebirds will be lost.

The incremental disappearance of salt marsh nesting habitats due to habitat fragmentation and conversion to open water would further compound declines for bird species that are already of conservation management concern to federal and state agencies, including American black duck, salt marsh sharp-tailed sparrow, seaside sparrow, coastal plain swamp sparrow, black rail, Forster's tern, American oystercatcher, and black skimmer (Ervin et al. 2006).

Transient estuarine fish and shellfish species that move in and out of salt marsh and impounded wetlands with the tides and take advantage of the abundance of detritus and invertebrate prey will decline and disappear from refuge habitats. Forage fish such as spot and perch will start to disappear, and populations of eels, ghost shrimp, gastropods, ribbed mussels, and blue crabs will decline. These are all important food sources for fish and migratory birds, and are also the base for a healthy recreational fishery.

The greatest loss to biological diversity and wildlife on refuge lands resulting from cumulative sea level rise and climate change will occur in freshwater forested and emergent wetlands. Many ecologists suggest that freshwater wetlands support the greatest diversity of native flora, invertebrates, amphibians, fish, and bird species of any marsh type and this is very evident in our freshwater impoundment complex.

Freshwater emergent and forested wetlands will be influenced by sea level rise along the entire mid-Atlantic coast. Limited primarily by their requirements for very low-salinity water, they will sustain cumulative adverse impacts from saltwater intrusion. Forested wetlands support a variety of unique wildlife including breeding prothonotary warbler, Acadian flycatcher, yellow-throated vireo, migratory songbirds, bald eagles, and other raptor species. The freshwater impounded wetland complex supports large numbers of migrating and wintering waterfowl and anadromous fish that depend on freshwater to spawn. Herring, shad, and other fish species like striped bass will permanently lose spawning habitats.

The best climate change, sea level rise mitigation solution to adverse cumulative and long-term habitat losses on the refuge would be to allow the migration of salt marsh and freshwater wetland habitats to naturally proceed inland. However, this is not a viable solution for Prime Hook NWR because our CCP has no contingency for future land purchases that go beyond the current land acquisition boundary.

Cumulative Impacts on the Physical Environment

Air Quality
Air quality is generally good around the refuge in winter and spring, with some problems in late summer and fall. We would expect short-term, negligible, localized effects on air quality from the emissions of motor vehicles used by staff and refuge visitors, from refuge equipment such as mowers or heavy equipment used by staff and volunteers, and from prescribed burning. We would mitigate all possible negative impacts from prescribed fire by not conducting burns during periods when the county has non-attainment for national ambient air quality standards during the summer and fall.

We expect none of the refuge activities to contribute to any measurable adverse impacts that would increase ozone levels or other negative air quality parameters. We expect none of the alternatives to cause anything greater than negligible cumulative adverse impacts on air quality locally or regionally. Projected restoration of native upland forest, shrublands, and wetland vegetation should generate beneficial impacts to air quality locally. These beneficial impacts will derive from the refuge's capacity to continue to filter out many air pollutants harmful to humans, wildlife, and the environment. We will also strive to reduce energy consumption with green infrastructure and products associated with refuge activities.

In addition, with the new Service goal of achieving carbon neutrality by 2020, the refuge will be undertaking aggressive efforts to reduce the energy use and carbon footprint of our buildings, facilities, vehicle fleet, and workforce to the maximum extent possible. We will also be exploring ways to offset our residual carbon footprint by increasing carbon sequestration through our habitat management activities, especially afforestation projects. Integrating carbon sequestration awareness into conservation actions for wildlife and other habitat management activities will also have cumulative beneficial impacts for the air quality and humans within the local environment.

Water Quality
None of the alternatives would produce significant adverse cumulative impacts on water quality. We would continue to use best management practices and measures to control erosion and sediments in all ground-disturbing operations to ensure their impacts are minimal.

Alternatives B and C, and to a much lesser extent A, call for increased attention to habitat restoration, passive natural succession, or native vegetation enhancement projects, which would result in improvements in water quality in terms of chemistry, reduced sediment, and mitigation of contaminated run-off from off-refuge sources. Collectively and over time, those actions would improve the ability of refuge upland and wetland systems to process nutrients and store carbon and contribute to other State watershed regulations and initiatives that are geared to improve water quality in the Broadkill River and improve the health of the Delaware Bay.

Management actions would also be adaptive to address climate change and sea level rise cumulative impacts on the physical environment. Restoring and managing more upland forest and riparian habitats on the refuge will improve the health of refuge watercourses and aquatic resources, resulting in greater diversity and functionality of refuge habitats that will also benefit adjacent watersheds and the Delaware Bay.

In slightly varying degrees, all the alternatives emphasize maintaining the biological integrity, diversity, and environmental health of lands within the refuge boundaries, which also contributes to conserving a scenic landscape. Actions taken to ensure the long-term health of freshwater wetlands and forested habitats, preserve and enhance rare native plant and animal communities, and conserve state and federally listed species, will serve as a model for conservation planning use and zoning near the refuge and in the county.

In addition, when the conservation actions on the refuge are combined with actions by State wildlife managers, non-profit organizations, private landowners, local communities, and the State's Livable Delaware Initiative, there will be considerable cumulative progress in stemming and mitigating the urbanization and development changes that detract from good water quality and productive habitats of Delaware's wildlands and the Delmarva Coastal Plain ecosystem.

Soils

The greatest past and present adverse impacts on refuge soils occurred from land clearing activities for agriculture, intensive farming techniques, and development. With the cessation of intensive agricultural practices and return of salt marsh, refuge soils should improve in natural fertility and productivity, as native soil biota recovers in those habitats where native plant and invertebrate communities are restored either by reverting to natural selection (alternative A) or by proactive restoration (alternative B), with invasive plant species treatments as needed for all alternatives. Natural coastal and wetland sediment processes would be returned under alternatives A and B.

We will continue to use best management practices when improving forest stands, maintaining or setting back succession in native grassland and shrubland habitats, mowing, brush-hogging, prescribed burning, or selecting various silvicultural methods to ensure cumulative beneficial impacts for soils.

Under all alternatives, we expect to reclaim areas dominated by non-native crops or invasive species and restore them to native plant communities, which should improve nutrient recycling, restore native soil biota and soil fertility, and return soils to natural productivity regimes. Remediation of drained wetlands used for croplands and restored hydrology in appropriate areas with hydric soils will also improve functioning of these soils, yielding ecosystem benefits.

Positive consequences and beneficial cumulative impacts of managing soils in native vegetation for the long term are increasing capacity for carbon sequestration from the environment. Biological sequestration can be enhanced in managing natural habitats that increase the natural absorption of atmospheric carbon in soils. The long-term cumulative potential is limited to how the land is used and managed.

Carbon storage potentials of soils with various habitat types have been estimated by the Congressional Budget Office (2007). On pasture and grassland habitats, the equilibrium level of carbon in an acre of soil varies from 73 metric tons of carbon dioxide to 159 tons. Mature never-harvested forests have even higher equilibrium levels per acre of soil varying from 286 to 1,179 metric tons of carbon dioxide and averaging 465 metric tons per acre. In contrast, harvested forests have decreased levels, as the average stand of timber harvested on a 30-year rotation holds the equivalent of 203 metric tons of carbon dioxide per acre at the beginning of the rotation (that is, at the start of regrowth) and 256 metric tons at the end of the rotation.

No new adverse impacts to the refuge's high marsh are anticipated, though adverse impacts to the physical environment may persist where historical (2002 and earlier) open marsh water management (OMWM) excavations have altered salt marsh elevations. In some areas, insufficient soil settling resulted in spoil piles being colonized by invasive *Phragmites*. Other areas that were excessively drained resulted in lowered water tables. These physical environmental conditions resulted in losses of high marsh zones dominated by *Spartina patens*, which were converted to less desirable plants like *Iva* and *Baccharis*. These physical changes to marsh surface elevations may be more prevalent on refuge salt marsh habitats due to soil types that are low in organic content and have higher mineral or sandy consistency that make spreading them out to meet OMWM guidelines too difficult to achieve.

Future salt marsh conservation and management actions will be focused on protecting the few areas of high salt marsh left on the refuge, by not constructing any new OMWM systems, maintaining and enhancing tidal flow into existing salt marsh habitats, and controlling invasive plants on spoil piles and other invaded areas within existing OMWM systems. Maintenance excavations in existing systems will occur only if there are documented reasons for failures, including considerations of soil types, mosquito production data, and other information as needed. The refuge anticipates that OMWM areas requiring clean-out will be largely filled with fine silts and organic material. This material should be spread over the marsh at the appropriate thickness. OMWM excavations must also restore a more natural hydrology and function to the impacted salt marsh areas to reduce cumulative adverse impacts to the physical environment.

Alternatives A and B would permit natural overwash processes along the refuge shoreline to proceed unimpeded. This has cumulative beneficial impacts on sediment accretion and transport of the coastal ecosystem. Long-term maintenance of artificial dunes under alternative C could have long-term and cumulative negative impact of significantly narrowing barrier island shoreline strands. This can ultimately lead to the collapse and disappearance of these ribbons of sand, and significantly increase the vulnerability of back-barrier marshes to sea level rise by limiting accretion of sediments (Coch 2009, Riggs et al. 2009, Levine et al. 2009).

Cumulative Impacts on the Biological Environment

Managing and Protecting Habitat

All of the alternatives would maintain or improve native biological resources on the refuge, in the State of Delaware, and in the Delmarva Coastal Plain and mid-Atlantic ecosystems. The combination of our management actions with those of other conservation partners, organizations, and landowners would result in beneficial cumulative impacts on the biological environment by:

- Improving the protection and management of Federal trust species, State-listed endangered species, and migratory birds
- Using structured decisionmaking and enhancing monitoring to improve wildlife management and conservation actions
- Restoring and conserving native flora, pollinators, and other wildlife
- Protecting and improving upland and wetland habitats that are declining at the state and regional levels or threatened by development
- Controlling invasive plants and animals
- Controlling nuisance or destructive animals
- Improving avian productivity through limited use of predator management
- Revising mosquito integrated pest management strategies to conserve and protect pollinators and non-target invertebrates
- Enhancing and restoring biological integrity, diversity, and environmental health of refuge lands

Certain biological resources that we would manage to control, prevent, or eliminate, such as invasive plants, nutria, mute swans, or resident Canada geese, are not natural components of our managed wildland areas. We do not consider the loss of these biotic elements to be an adverse impact. However, not controlling invasive and nuisance species would create adverse cumulative impacts to the biological environment.

Controlling exotic and invasive plants may involve the use of chemical herbicides. The selective use of herbicides will be based upon an integrated pest management strategy that incorporates pest ecology, the size and distribution of the population, site-specific conditions, known efficacy under similar site conditions. Best management practices will reduce potential effects to non-target species, sensitive habitats, and quality of surface and groundwater. Herbicide applications will be targeted to control discreet pest populations in localized areas. Combinations of two or more herbicides at labeled rates would not likely result in additive or synergistic adverse effects to non-target fish, wildlife, plants, or their habitats. The Forest Service (2005) found that mixtures of herbicides commonly used in land (forest) management likely would not cause either additive or synergistic effects to non-target species based upon a review of scientific literature regarding toxicological effects and interactions of agricultural chemicals (ATSDR 2004). Moreover, combined herbicides with different modes of action may be used more effectively, likely requiring less retreatment over the long term. Herbicides applied on the refuge would be short-lived, resulting from environmental and microbial breakdown to less or non-hazardous degradation products.

Habitat enhancement and restoration under alternatives A and B, and revised mosquito integrated pest management strategies under alternatives B and C, will limit negative cumulative effects on the biological environment by limiting invertebrate mortality, sustaining and enhancing invertebrate trophic linkages and food webs for wildlife, and potentially increasing avian diversity and abundance within native plant communities. Cumulative beneficial impacts on the refuge's biological environment will also accrue from reducing habitat fragmentation across the refuge.

The phasing out of the cooperative farming program and restoration of cropland acres to native plant communities will have cumulative beneficial impacts for endangered species management and forest interior dwelling birds. Cumulative beneficial impacts to the biological environment will also occur by reducing pesticide use, increasing the refuge's capacity and conservation potential for a greater number of focal bird species, and enhancing native plant resources and associated invertebrate foods that are the foundation for migratory bird and other wildlife nutrition.

Eliminating the cooperative farming program will not detract from waterfowl management or have cumulative negative impacts on waterfowl resources. The cumulative impacts of managing native vegetation in the form of moist-soil crops will continue to increase the carrying capacity of our wetland habitats for migrating and wintering waterfowl, with beneficial cumulative impacts for the biological environment.

Compared to agricultural crops (both row and cover crops), moist-soil crops (annual vegetation with high seed production, such as wild rice and smartweeds) are more efficient to produce each year with less fossil fuel use and a lower carbon footprint on the biological environment as a whole, and provide other cumulative benefits for waterfowl which include:

- Higher nutritional value for waterfowl

- Easier and cheaper to consistently produce high seed yields (800 to 1,800 lbs of moist soil seeds per acre per year)

- Zero negative inputs into ecosystems (no nitrates, phosphates, or pesticides)
- Greater resiliency to wet and dry weather extremes than agricultural crops
- Provide year-round availability of food resources for waterfowl and other wildlife

Mississippi State University scientists have reported that moist-soil seeds such as wild millet, foxtail, and panic grasses may provide even more energy for waterfowl than corn, based on feeding trials with Canada geese (Kross et al. 2007). With or without water, moist-soil plant foods are available for waterfowl consumption. Moist-soil native plants can be consumed by Canada geese as green browse without flooding, or mainly as seeds, roots, and tubers after flooding.

Turning away from single species management (farming cover-crops for Canada geese) and restoring the same land based acres to native vegetation increases our capability to manage for multiple bird species simultaneously. Multiple focal species management of former croplands will have cumulative benefits on the biological environment as a wider array of wildlife (migratory bird species, fish, reptiles, amphibians, invertebrates, and other resident wildlife) will benefit from enhanced biological integrity and diversity of native plant communities.

Although all the alternatives either maintain or increase monitoring and controlling invasive plants and animals, we expect infestations to continue to increase and expand to new areas, especially due to increased cumulative impacts from climate change. Alternatives B also has stronger biological monitoring components with increased efforts in surveying wildlife species and habitats and research coordination with others.

Additional information will facilitate structured decisionmaking with wide-ranging cumulative benefits for fish and wildlife populations. Building models and using them for conservation and wildlife management, using structured decisionmaking, and enhancing monitoring studies will add to the body of knowledge the Service will collect and share with other conservation partners to influence and improve natural resource decisions with cumulative benefits on the biological environment over a broader landscape.

In general, native habitat management will have considerable cumulative impacts on the biological environment as we expect to increase population numbers of many more breeding and migrating shorebird species, salt marsh passerines, migrating and wintering waterfowl, Delmarva fox squirrels, bald eagles, forest interior dwelling bird species, and breeding and migrating early successional landbird and waterbird species. Native plant management cumulatively benefits the biological environment by increasing and enhancing healthy soil biota, restoring and enhancing native plant resources, increasing resident wildlife populations of mammals, fish, reptiles, and amphibians, and enhancing invertebrate production to sustain and perpetuate migratory bird resources.

Alternatives A and B would also make considerable progress in restoring native habitats that will increase opportunities and capabilities to improve pollinator conservation with cumulative beneficial impacts on native plants and other biological resources both on refuge and off-refuge.

Mosquito Control
Mosquitoes are a wildlife species and a natural component of the ecosystem. We are mandated to conserve, and if possible, enhance habitat for federal trust resources, especially migratory birds, and maintain or restore BIDEH. This implies that we manage for the benefit of all components of a healthy habitat or ecosystem. It is our understanding of ecology, or more appropriately, our inadequate understanding of ecological processes, that makes it imperative that

we maintain all the components of the ecosystem. Mosquitoes therefore have intrinsic value.

However, in the interest of public health, some potentially detrimental impacts to the natural environment will continue to be permitted, i.e., use of the adulticide naled, and the larvicides Bti and methoprene for mosquito control. Alternative B, the preferred alternative, makes three substantive decisions regarding current and future mosquito management on the refuge by the State of Delaware: the Service will permit the use of adulticides as a management tool once the DMCS surveillance program has detected a mosquito-borne human health threat on the refuge or within the flight range of vector mosquitoes, the average of which, according to the Rutgers Center for Vector Biology, is generally considered to be less than 5 miles for the eastern saltmarsh mosquito, Ochlerotatus sollicitans; permitting the maintenance of existing open marsh water management systems when warranted; and leaving open the potential for additional open marsh water management construction after monitoring, research, and analysis provide sufficient cause to alleviate the refuge's concern regarding open marsh water management's response to rising sea levels and potential impacts on migratory birds of concern.

The limited use of adulticides will restore a measure of BIDEH to the refuge. At a minimum, terrestrial invertebrate mortality, including mosquito mortality, will likely be reduced. Non-target invertebrates will receive an added measure of protection, though mosquitoes (obviously) and non-target species, especially some species of chironomids, will still be vulnerable to larvicide treatments. Reducing impacts to invertebrates should strengthen natural ecological processes that affect refuge resources of concern, especially migratory birds. Direct short-term impacts from adulticides will be reduced, and any long term indirect ecological impacts that may have occurred over previous years should be ameliorated. However, it should be understood that there is a considerable lack of studies, local and otherwise, on the long-term ecological effects of repeated larvicide treatments over an extended period of time. Our position is based upon our analysis of current literature, the probability of short-term impacts to the local refuge ecology by adulticides, and current refuge policy. The impacts of larvicides may be lessened further by monitoring and treatment criteria to be specified within the refuge mosquito management plan.

No new open marsh water management (OMWM) excavations have been permitted since 2002. Allowing State maintenance of existing systems, but disallowing any additional OMWM at this time should not further impact the marsh. Given sufficient analysis of OMWM response to sea level rise and other ecological factors, especially salt marsh passerine and secretive marsh bird impacts, the refuge may consider additional construction in the future. Careful evaluation of refuge policy will be required. Restoration and long-term BIDEH of the salt marsh may ultimately require filling existing OMWM configurations, as well as old grid-ditched systems.

Managing Exotic or Nuisance Species

Mute swans and nutria are highly invasive of wetland habitats. The refuge will have a zero tolerance policy for these exotic species. Preventing establishment of viable populations of these animals on the refuge will preserve existing BIDEH.

Beaver and muskrats are native aquatic rodents that are a natural component of the refuge ecosystem. However, on occasion individual animals or small colonies will damage valuable refuge infrastructure, burrow into dikes or cause flooding conditions on neighboring private land. Beaver damming and flooding of refuge managed habitats may impact the refuge's ability to achieve an optimal management regime for Federal trust resources, particularly migratory birds. In addition, beaver have damaged a small stand of swamp cottonwood, the host plant for the globally rare marbled underwing moth (S1, G3). Under these circumstances, the refuge may employ lethal removal of specific individuals to lessen damage. Individual animals will be impacted, but the population as a whole will experience no long-term impacts.

Management of Predation Pressure on Trust Avian Resources
The refuge proposes to implement a limited predator control program. Red fox, raccoon, gull, crow, rice rat, feral cat, and other species have been documented as effective predators upon nesting birds, eggs, and chicks (Erwin et al. 2001, Greenwood et al. 1990, USDA 2005, USFWS 1996, USFWS 2007, Winter and Wallace 2006). Predation is a natural process and is not normally considered a management issue for the continued productivity and survival of species across a biologically diverse and healthy landscape. However, some habitats have been so fragmented and reduced by human impacts that intervention is considered critical for the continued survival of some species. Some shorebirds, such as federally threatened piping plover and colonial beach nesting bird populations, are especially vulnerable to loss of suitable nesting habitat due to high sensitivity to human disturbance. Limited predator control has proven effective in improving productivity

Control would be limited to discreet geographic locations inside nesting habitat or within corridors to nesting habitat. The predator population as a whole across the refuge would not be impacted. Locally, predator populations would reestablish themselves shortly after control, and would return to average densities shortly after the nesting season.

Public Use
The land use immediately adjacent to the refuge is agricultural and residential. Urban development is changing a formerly rural area as more farms are sold for large scale town house communities and apartments. Within 15 to 20 years, the refuge will have some of the largest expanses of contiguous native forested and wetland habitats accessible to the public in Sussex County. The increased demand for public use may have cumulative impacts on the biological environment.

All alternatives with respect to public use will have cumulative impacts on biological resources because we expect that the demand for all types of wildlife recreation will grow on the refuge as the amount of natural habitats and open space will decrease off-refuge due to increasing development pressures while the amount of refuge space and natural resources remain relatively constant. The management objectives presented in alternatives B and C are our attempts to strike a feasible balance that ensures the refuge remains a destination of choice for both wildlife and people, while also protecting the biological environment for the long term.

Two of the public use programs we offer, hunting and fishing, result in the direct loss of individual wildlife. We describe the site-specific impacts of our hunting and fishing programs earlier in this chapter and in Appendix E, Compatibility Determinations. A detailed cumulative impact analysis on hunting provides further information later in this document.

Fishing seasons and limits are established by the State of Delaware and adopted by the refuge. These restrictions ensure the continued well-being of overall populations of fish. Fishing results in the taking of many individuals within the overall population, but restrictions are designed to safeguard adequate population and recruitment from year to year. Specific refuge regulations address equity and quality of opportunity for anglers, and help safeguard refuge habitat. Disturbance to other fish and wildlife does occur, but this disturbance is generally short-term and adequate habitat occurs in adjacent areas. Loss of plants or increases in water turbidity from boat motors is minor or temporary, and is generally not concentrated since fishing pressure is well distributed.

Another common concern is the reduction or alteration of prey base important to fish-eating wildlife; however, refuge-specific and State regulations address this concern to ensure that harvest levels do not cumulatively impact native fish resources to the point they are no longer self-sustainable.

Cumulative impacts from research activities are not expected, but could occur if multiple research projects were occurring on the same resources at the same time or if the duration of the research was excessive.

We do not anticipate any significant cumulative effects on biological resources by other wildlife-dependent recreational activities. Impacts caused by these activities can be found earlier in this chapter.

Cumulative Impacts on the Socioeconomic Environment

We expect significant cumulative beneficial impacts on the socioeconomic environment that will result from maintaining and enhancing wildlife populations, improving native wildland habitats, and managing biological integrity, diversity, and environmental health (BIDEH) of refuge lands, which sustain and provide numerous ecosystem services that benefit wildlife and humans.

Ecosystem services provided by refuge habitats include purification of air and water, mitigation of floods and drought, dispersal of seeds, pollination services and natural pest control. Carbon sequestration will contribute to stabilization of climate, and increased opportunities will enable the public to enjoy biological resources unique in the county, State, and nation. Our proposed alternatives would yield increases in these ecosystem services over time.

It should be understood however, that increased BIDEH will not necessarily equate with reduced nuisance mosquito complaints. Mosquitoes are an integral component of the ecology of coastal wetlands, as are natural mosquito predators. The ability of natural predation pressure to reduce certain species of mosquitoes substantially, if environmental conditions are appropriate, is perhaps limited. The ability of chemical mosquito treatment alone to substantially reduce the threat of periodic pulses of mosquitoes is also limited. Mosquitoes have evolved successfully to overcome mass mortality, regardless of the cause.

The human threshold for mosquito tolerance is largely cultural in origin, and varies considerably across the landscape. It varies largely upon one's frame of reference. Humans who are raised in a relatively urban or suburban landscape generally have little experience with persistent mosquito annoyance. Individuals born into or having lived a substantial period of time in mosquito country are more likely to take the natural pulses in mosquito (or no-see-um, deer fly, blackfly) numbers in stride. Regardless of where one resides, actual mosquito-borne disease outbreaks are spotty and rare. The refuge expects that there may be increased local complaints from the public regarding nuisance mosquitoes. The refuge does not expect an increased incidence of mosquito-borne disease in the human population.

We expect none of the management actions in the three proposed alternatives to have a significant adverse cumulative impact on the economy of local towns or the county in which the refuge lies. We would expect none of the alternatives to alter the demographic or economic characteristics of the local community. The actions we propose would neither disproportionately affect any communities nor damage or undermine any businesses or community organizations. All of the alternatives would maintain the beauty and aesthetics of the refuge's natural landscape, enhance biological resources available for consumption, and provide wildlife experiences that promote a pleasurable quality of life for humans.

These varying alternatives will have cumulative impacts, because we expect the demand for nearly all recreation to grow while the amount of refuge space and natural resources stays relatively constant. In alternative A, current uses would continue without much change. Alternative B attempts to strike a reasonable balance to ensure that the refuge remains a destination of choice for both wildlife and people. If successful, that integrated approach may prove more sustainable, with more positive long-term impacts on natural resources on the refuge, and social and economic impacts on the communities beyond. Alternative C strikes a balance between the needs of wildlife and the public while reducing active management of refuge habitats.

Our working relationships with area colleges and universities, private landowners and others should improve in terms of responsiveness to inquiries and speed of joint projects under alternative B. That improvement mainly would result from the increased staffing in key areas such as biology, public use, and maintenance. The overall coordination and communication with the public should improve under alternative B, because a new staff position would deal with public use and public information. Because some may oppose changes in one or more of the alternatives, and some support them, the cumulative impact on the public perception of the refuge and the Service could be negative or positive.

More emphasis on public education, outreach activities, and information in alternative B and C should foster greater understanding and appreciation of resource issues and needs, leading to increased support and funding, which would positively affect fish and wildlife resources on the refuge. The increased outreach of these alternatives could also positively affect land use decisions outside the refuge by local governments and private landowners, and lead to increased fish and wildlife populations over a broader area.

Cumulative Impacts on Cultural Resources

The activities in each alternative have the potential to impact cultural resources, either by direct disturbance during construction of habitat projects and facilities related to public use or administration and operations, or indirectly by exposing artifacts during actions such as managing grassland and prescribed burning. For compliance with section 106 of the National Historic Preservation Act, the refuge staff will, during the early planning stages of proposed new actions, provide the regional historic preservation officer with a description and location of all projects, activities, routine maintenance and operations that affect ground and structures, details on requests for compatible uses, and the range of alternatives considered. That office will analyze those undertakings for their potential to affect historic and prehistoric sites, and consult with the State historic preservation officer and other parties as appropriate. We will notify the State and local government officials to identify concerns about the impacts of those undertakings.

We expect none of the alternatives to have significant adverse cumulative impacts on cultural resources on the refuge. Depending on the alternative, beneficial effects would vary, because of the changes proposed in habitat management (e.g., allowing some or all of the intensively managed grasslands to transition to shrub and forest habitat), increasing environmental education and interpretation programs, training in cultural resource identification and protection by refuge staff, and increasing field surveys to identify and protect any undiscovered sites.

Cumulative Impact Analysis of Hunting

Cumulative impact is a term that refers to impacts on the environment that result from the incremental impact of a proposed action when added to other past, present and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. Cumulative impacts of hunting on resident wildlife, migratory birds, non-hunted wildlife, endangered species, refuge environment, and other wildlife recreation were analyzed for all three alternatives. Because of the regulatory process of harvest management of migratory birds in place within the Service, the setting of the hunting seasons largely outside the breeding seasons of resident and migratory wildlife, and the ability of individual refuge hunt programs to adapt refuge-specific hunting regulations to changing local conditions, we anticipate no direct or indirect cumulative effects on resident wildlife, migratory birds, non-hunted wildlife, endangered species, refuge environment, and other wildlife recreation from hunting on Prime Hook National Wildlife Refuge.

Anticipated Cumulative Impacts of Alternative A: Current Management (No Action)

Resident Big Game

White-tailed Deer

The Delaware Division of Fish and Wildlife recently finalized a new statewide 10-year deer management plan (Rogerson 2010). The plan was created with input from a 22-member advisory group, a public phone attitude survey, a mail survey to hunters, comments solicited from the general public, and technical reviews from deer experts outside the division. The resultant plan identifies population objectives based on habitat capability and societal tolerances.

Prime Hook NWR is located in the State's deer management zone 9 of Sussex County, Delaware (Rogerson 2010). The Delaware Division of Fish and Wildlife has the ability to manage deer populations, in part, through recreational hunting because these animals have a k-selection population strategy. This means that reproductive rates are low, adults invest a tremendous amount of energy bringing young to maturity, and survival rates are relatively high compared to more prolific breeders (such as rabbits). Based on their monitoring programs, the Delaware Division of Fish and Wildlife adjusts hunting levels in terms of season length, sex ratio in the harvest, and number of hunters (tag availability) to move population levels toward desired objectives. Of course, other factors such as disease, severe weather, predation, and automobile collisions influence mortality, and are taken into account by the annual monitoring. Their analysis of populations and hunting on populations, habitat, and communities is cumulative.

Delaware deer herd statistics indicate that the deer density in zone 9 is estimated in 2009 at 22.5 deer per square mile with a variability of plus or minus 20.75 percent (Rogerson 2010). This is a decrease of 42.6 percent from the 2005 estimated density of 39.2 deer per square mile (Rogerson 2010). The total Statewide post-hunting season deer population in 2005 was estimated at 37,563 deer, while in 2009 it was estimated at 31,071 deer, a 17.3 percent Statewide reduction. Major land use changes over the last 100 years have created a deer herd that exceeds normal deer densities of 10 to 20 deer per square mile. High deer numbers are recognized as a problem causing crop damage, reducing some forest understory species, and reducing reforestation seedling survival. Hunting is a viable solution to keep the deer herd and other resident wildlife in balance, resulting in long-term impacts on wildlife habitat.

White-tailed deer hunting is the single most important public use that would affect mammals and other forest-dependent wildlife on the refuge. It serves both as a wildlife-dependent recreational use and a method to reduce and stabilize deer densities. This not only benefits other mammals, but also benefits endangered species management for Delmarva fox squirrels, conserves migratory landbird habitats, and lessen impacts to adjacent agricultural lands. Reducing deer densities is best accomplished by means of the refuge deer hunting program.

Deer overabundance can affect native vegetation and natural ecosystems and has been well-studied (Tilghman 1989, Nudds 1980, Hunter 1990, Behrend et al. 1970). White-tailed deer selectively forage on vegetation (Strole and Anderson 1992), and thus can have substantial impacts on certain herbaceous and woody species and on overall plant community structure (Waller and Alverson 1997). These changes can lead to adverse impacts on other wildlife species that depend on this vegetation for food or shelter. Several studies have shown that over browsing by deer can decrease tree reproduction, understory vegetation cover, plant density, and plant diversity (Warren 1991). Heavy deer populations in the Great Smokey Mountains National Park in Tennessee caused a reduction in the number of plant species, a loss of hardwood species, and a predominance of conifer species compared to an ecologically similar control area with fewer deer (Bratton 1979).

The alteration and degradation of habitat from overbrowsing deer can have a detrimental effect on deer herd health and may displace other wildlife communities (e.g., neotropical migrant songbirds and small mammals such as the endangered Delmarva fox squirrel) that depend on the understory vegetation habitat destroyed by deer browsing (VDGIF 1999). Deer browsing also affects vegetation that songbirds need for foraging, escape cover, and nesting (DeCalesta 1997). DeCalesta (1997) also found that species richness and abundance of intermediate canopy nesting songbirds was reduced in areas with higher deer densities. Intermediate canopy-nesting birds declined 37 percent in abundance and 27 percent in species diversity at higher deer densities. Five species of birds were found to disappear at densities of 38.1 deer per square mile and another two disappeared at 63.7 deer per square mile. Casey and Hein (1983) found that three species of birds were lost in a research preserve stocked with high densities of ungulates and that the densities of several other species of birds were lower than in adjacent areas with lower deer density. Waller and Alverson (1997) hypothesize that by competing with squirrels and other fruit-eating animals for oak mast, deer may further affect many other species of animals and insects.

Based on a nationwide survey of all states (Krausman 1992), deer were effectively controlled with hunting and habitat manipulation in many areas where they were overpopulated. The remaining overpopulated herds were either not hunted, had an inadequate doe harvest, or an inadequate general harvest. Because the refuge boundary area is open, with numerous tracts and corridors for movement and contact with other herds, it is unlikely that hunting will reduce the population to such low levels as to place it at risk of becoming genetically bottlenecked. Also, no prevention or control of epizootic hemorrhagic disease exists to date except by keeping populations below the carrying capacity of their habitats. In a 10-year study in northwestern Pennsylvania examining the impacts of varying densities of deer on deer health and habitat, starvation mortality resulted when densities reached higher than 25 deer per square kilometer (247 acres). Species richness and abundance of shrubs and herbaceous vegetation also has been shown to decline when deer densities reach between 4 to 8 deer/km2 (DeCalesta 1997). At high densities, deer may act as a host reservoir for Lyme disease-bearing ticks (Jones et al. 1998) and reducing the deer population will reduce the potential for Lyme disease transmission. Based on these considerations, it is anticipated that hunting would have a positive impact on deer health and quality and habitat condition.

High densities of deer have also been recognized as vectors for spreading invasive species like Japanese stiltgrass. Deer consume the seed and fruits of many plant species and when excreted, a large percentage of seeds remain viable. In some areas more than 50 percent of seeds eaten represent highly invasive plant species (Williams and Ward 2006). Stiltgrass invasions serve to prevent the shrub layer from returning which decreases or eliminates these forest structural components used by songbirds and interferes with native plant successional dynamics.

Reducing the deer population will also benefit the surrounding human community by reducing damage to agricultural crops and residential landscape vegetation and by reducing deer-vehicle collisions. The average estimated economic impact from deer depredation to high-value agricultural crops from 1994 to 2000 in Delaware was $375,966 (Drake et al. 2005). High-value agricultural crops included fresh market and processed vegetables including, but not limited to, snap beans, sweet corn, leafy vegetables, tomatoes, and peppers. Fruits such as apples and peaches were also included as high-value crops (Drake et al. 2005).

The average estimated economic impact from deer depredation to grain crops from 1994 to 2000 in Delaware was $867,937 (Drake et al. 2005). Grain crops included corn (silage and grain), soybeans, wheat, and oats. The average annual vehicle damage from deer-vehicle collisions in Delaware from 1986 to 2000 is estimated at $592,000. This does not include costs of human fatalities associated with deer collisions or costs associated with disposal of deer carcasses.

Hunting resident game species does not have any regional impact on their respective populations due to their restricted home ranges. The refuge contributes negligibly to the State's total harvest for resident game species For example, since 1999, deer harvest at the refuge has ranged from 0.5 percent to 1.5 percent of Delaware's total deer harvest each year.

The current harvest of deer on the refuge (66) has a negligible impact on the statewide deer population, which was last estimated at 31,071 deer in 2009 (Figure 5-12). Hunting license sales in Delaware have declined from 29,994 in 1975 to 18,746 in 2007 (Rogerson 2010). Based on the decline in the number of hunters and the relatively few numbers of animals harvested from the refuge in respect to the total Statewide harvest and deer population, no cumulative impacts to local, regional, or Statewide populations of white-tailed deer are anticipated from allowing hunting of the species on the refuge.

Upland Game or Small Game

Cottontail rabbit is the primary small game species sought on the refuge, and to a much lesser extent, northern bobwhite quail, mourning dove, woodcock, snipe, and ring-necked pheasant. Mourning dove, woodcock, and snipe have been addressed in the migratory bird section of this analysis.

Hunting resident game species such as quail, rabbit, and pheasant does not have any regional impact on their respective populations due to their restricted home ranges. Delaware Division of Fish and Wildlife periodically reviews populations of all harvested resident species, and has determined that populations are adequate to support hunting efforts throughout the State.

Hunter visits and harvest of upland and small game such as rabbit have been relatively low, and the number of quail taken per year has been 0 to no more than 14 per year on the refuge in recent years (Table 5.9) The refuge does not allow hunting of eastern gray squirrel to minimize conflicts with the endangered Delmarva fox squirrel.

Given the relatively few numbers of animals harvested from the refuge, no cumulative impacts to local, regional, or Statewide populations of small game are anticipated from allowing hunting of these species on the refuge.

Migratory Birds

Migratory birds are managed on a flyway basis by the Service. The process of surveying populations and setting regulations is, inherently, a cumulative impact analysis. The following paragraphs describe this process.

The Service annually prescribe frameworks, or outer limits, for dates and times when hunting may occur and the number of birds that may be taken and possessed. These frameworks are necessary to allow state selections of season and limits for recreation and sustenance; aid Federal, State, and Tribal governments in the management of migratory game birds; and permit harvests at levels compatible with population status and habitat conditions. Because the Migratory Bird Treaty Act stipulates that all hunting seasons for migratory game birds are closed unless specifically opened by the Secretary of the Interior, the Service annually promulgates regulations (50 CFR Part 20) establishing the frameworks from which States may select season dates, bag limits, shooting hours, and other options for each migratory bird hunting season. The frameworks are essentially permissive in that hunting of migratory birds would not be permitted without them. In effect, Federal annual regulations both allow and limit the hunting of migratory birds.

Migratory game birds are those bird species so designated in conventions between the United States and several foreign nations for the protection and management of these birds. Under the Migratory Bird Treaty Act (16 U.S.C. 703-712), the Secretary of the Interior is authorized to determine when "hunting, taking, capture, killing, possession, sale, purchase, shipment, transportation, carriage, or export of any bird, or any part, nest, or egg" of migratory game birds can take place, and to adopt regulations for this purpose. These regulations are written after giving due regard to "the zones of temperature and to the distribution, abundance, economic value, breeding habits, and times and lines of migratory flight of such birds," and are updated annually (16 U.S.C. 704(a)). This responsibility has been delegated to the Service as the lead Federal agency for managing and conserving migratory birds in the United States. Acknowledging regional differences in hunting conditions, the Service has administratively divided the nation into four flyways for the primary purpose of managing migratory game birds. Each flyway (Atlantic, Mississippi, Central, and Pacific) has a Flyway Council, a formal organization generally composed of one member from each State and Province in that flyway. Prime Hook NWR is in the Atlantic Flyway.

The process for adopting migratory game bird hunting regulations, located in 50 CFR part 20, is constrained by three primary factors. Legal and administrative considerations dictate how long the rule-making process will last. Most importantly, the biological cycle of migratory game birds controls the timing of data-gathering activities and the dates on which these results are available for consideration and deliberation. The process of adopting migratory game bird hunting regulations includes two separate schedules, based on early and late hunting season regulations. Early hunting seasons pertain to all migratory game bird species in Alaska, Hawaii, Puerto Rico, and the Virgin Islands, migratory game birds other than waterfowl (e.g., dove, woodcock, etc.), and special early waterfowl seasons, such as for teal or resident Canada geese. Early hunting seasons generally begin prior to October 1. Late hunting seasons generally start on or after October 1 and include most waterfowl seasons not already established. There are basically no differences in the processes for establishing either early or late hunting seasons. For each cycle, Service biologists and others gather, analyze, and interpret biological survey data and provide this information to all those involved in the process through a series of published status reports and presentations to Flyway Councils and other interested parties. Though not as detailed as that for waterfowl, relevant data are collected and summarized for migratory bird species such as dove, woodcock, etc. Bird monitoring data are available through the Service's Division of Migratory Bird Management Web site *http://www.fws.gov/migratorybirds/*; accessed October 2012.

Because the Service is required to take abundance of migratory birds and other factors into consideration, the Service undertakes a number of surveys throughout the year in conjunction with the Canadian Wildlife Service, State and Provincial wildlife management agencies, and others. To determine the appropriate frameworks for each species, we consider factors such as population size and trend, geographical distribution, annual breeding effort, the condition of breeding and wintering habitat, the number of hunters, and the anticipated harvest. After frameworks are established for season lengths, bag limits, and areas for migratory game bird hunting, migratory game bird management becomes a cooperative effort of State and Federal governments. After Service establishment of final frameworks for hunting seasons, the States may select season dates, bag limits, and other regulatory options for the hunting seasons. States may always be more conservative in their selections than the Federal frameworks but never more liberal. Season dates and bag limits for national wildlife refuges open to hunting are never longer or larger than the State regulations. In fact, based upon the findings of an environmental assessment developed when a national wildlife refuge opens a new hunting activity, season dates, and bag limits may be more restrictive than the State allows.

National Environmental Policy Act (NEPA) considerations by the Service for hunted migratory game bird species are addressed by the programmatic document, Final Supplemental Environmental Impact Statement: Issuance of Annual Regulations Permitting the Sport Hunting of Migratory Birds (FSES 88-14), filed with the Environmental Protection Agency on June 9, 1988. We published the Notice of Availability in the *Federal Register* on June 16, 1988 (53 FR 22582), and our Record of Decision on August 18, 1988 (53 FR 31341). Annual NEPA considerations for waterfowl hunting frameworks are covered under a separate environmental assessment, in which the FONSI is published generally in August of that hunt year. Further, in a notice published in the September 8, 2005, *Federal Register* (70 FR 53376), the Service announced its intent to develop a new supplemental environmental impact statement for the migratory bird hunting program. Public scoping meetings were held in spring 2006, as announced in a March 9, 2006, *Federal Register* notice (71 FR 12216). More information may be obtained from the Chief, Division of Migratory Bird Management, U.S. Fish and Wildlife Service, Department of the Interior, MS MBSP-4107-ARLSQ, 1849 C Street, NW, Washington, DC 20240.

Waterfowl at Prime Hook NWR
Impacts to hunting waterfowl are further minimized from State and Federal frameworks by limiting hunting to 4 days per week during the hunting season with a 3:00 pm closure.

At Prime Hook NWR, the impacts of hunting of waterfowl are negligible when compared to the State's total waterfowl harvest. For example, from 1987 to 2011, the average annual waterfowl harvest at the refuge is 2.5 percent of Delaware's total waterfowl harvest (Table 5-4). Furthermore, in 2011, the refuge's harvest of ducks was only 2.3 percent of Delaware's total duck harvest, 0.06 percent of the Atlantic Flyway's duck harvest, and 0.01 percent of the entire United States' duck harvest (Table 5.5; Raftovich et al. 2012). Also in 2011, the refuge's harvest of geese (Canada and snow geese combined) was only 0.75 percent of Delaware's total goose harvest, 0.02 percent of the Atlantic Flyway's goose harvest, and less than 0.01 percent of the entire United States' goose harvest (Table 5.5; Raftovich et al. 2012).

The impacts of waterfowl hunting at the refuge are also negligible when compared to long-term trends in duck and goose populations at the refuge and across the State. Through monthly aerial surveys from October through November, the Delaware Division of Fish and Wildlife is able to evaluate long-term trends in duck and goose populations. The surveys give fairly accurate information about geese, but duck populations such as wood ducks and sea ducks are almost impossible to count. Furthermore, these surveys do not cover the entire State, but only the primary waterfowl habitat in Delaware, which is approximately the eastern half of the State. These figures represent the numbers of ducks and geese at the time of the survey, but do not reflect an actual annual estimate for the waterfowl population in Delaware due to the transitory nature of birds migrating through the State during the fall and winter months.

Based on the findings of these monthly surveys from 1987 to 2011, the average annual waterfowl harvest at the refuge is only 1.8 percent of the estimated peak waterfowl survey findings on the refuge (Table 5.6). During an individual season, the percent of the refuge's harvest on statewide and refuge populations may range greatly depending on the timing of refuge hunting activity and peak waterfowl migration. For example, during the 2011-2012 hunting season, the refuge harvested between 0.58 percent and 1.61 percent of the State's estimated monthly duck population and between 0.02 percent and 0.03 percent of the State's estimated monthly goose population (Table 5.6; October and November statewide waterfowl survey information was unavailable). Refuge hunters harvested between 1.60 percent and 7.04 percent of the refuge's estimated monthly duck population and between 0.04 percent and 0.08 percent of the refuge's estimated monthly goose population (Table 5.6).

Hunting license sales in Delaware have declined from 29,994 in 1975 to 18,746 in 2007 (Rogerson 2010). Based on the decline in the number of hunters and the relatively low numbers of waterfowl harvested from the refuge in respect to total Statewide, flyway, and national harvests, no cumulative impacts to local, regional, or flyway waterfowl populations are anticipated from allowing hunting waterfowl on the refuge. Impacts to waterfowl using the refuge would be localized to the area being hunted (which can be no more than 40 percent of the refuge) and due to the short temporal nature of these types of disturbance (from day and time restrictions), no cumulative indirect impacts from shooting, walking, boats, or vehicles are anticipated.

Managing Resident Canada Geese

Canada goose herbivory during the growing season is a relatively new impact upon wetlands. In 2002, a research study conducted at neighboring refuges suggested that higher levels of use by geese may cause a long-term change in wetland community structure (Laskowski et al. 2002). The study measured the impact of foraging by resident Canada geese on biomass and species composition of wetland vegetation at Bombay Hook and Chincoteague National Wildlife Refuges in Delaware and Virginia, respectively. Resident geese reduced the amount of plant biomass that would be available to migrant birds at the end of the growing season. Biomass of several species of vegetation was significantly impacted by feeding resident Canada geese at both refuges.

Resident geese directly damage agricultural resources by eating grain crops and trampling spring seedlings. Heavy grazing by geese can result in reduced yields and in some instances a total loss of the grain crop. A single heavy grazing event by Canada geese in the fall, winter, or spring can reduce the yield of winter wheat by 13 to 30 percent (Allen et al. 1985, Flegler et al. 1987). In the mid-Atlantic, the Maryland Department of Natural Resources reported that 23 percent of all complaints were related to agricultural damage by geese and estimated agricultural damage exceeds $200,000 per year (USFWS FEIS, 2005).

To address well-documented concerns regarding the impacts of resident Canada geese on habitats as well as public property, the Service issued new regulations for control of resident geese [vol#71 *Federal Register* page#45964-45993 (2006)]. We expect that the use of resident Canada goose control and management activities, particularly lethal control methods, would increase significantly. Such lethal and nonlethal activities would be expected to significantly decrease the number of injurious resident Canada geese in specific localized areas, thus reducing adverse impacts on vegetation. The long-term viability of goose populations would not be affected, however. Over time, we expect the cumulative impacts to become less evident and significant as goose populations are reduced.

The impact of refuge hunting on resident Canada geese is negligible. For resident Canada geese, hunters averaged 8.8 birds per year from 2001 to 2006 (Table 5-7).

Managing Snow Geese

In the nearly three decades since the original snow goose management plan of 1981, the greater snow goose population, as indexed by the spring survey, has undergone a five-fold increase to over 1 million birds. Various light goose populations in North America have experienced rapid population growth, and have reached levels such that they are damaging habitats on their Arctic and subarctic breeding areas (Abraham and Jefferies 1997, Alisauskas 1998, Jano et al. 1998, Didiuk et al. 2001). Habitat degradation in arctic and sub-arctic areas may be irreversible, and has negatively impacted light goose populations (Abraham and Jefferies 1997) and other bird populations dependent on such habitats (Gratto-Trevor 1994, Rockwell 1999, Rockwell et al. 1997). Natural marsh habitats on some migration and wintering areas have been impacted by light geese (Giroux and Bedard 1987, Giroux et al. 1998, Widjeskog 1977, Smith and Odum 1981, Young 1985). In addition, goose damage to agricultural crops has become a problem (Bedard and Lapointe 1991, Filion et al. 1998, Giroux et al. 1998, Delaware Div. of Fish and Wildlife 2000).

The increasing numbers of light geese are viewed as a continental problem, with real local consequences. A common feeding strategy of snow geese on refuge wetlands is to grub for underground roots and tubers. Primary marsh vegetation species exploited in this fashion are salt marsh cordgrass *(Spartina alterniflora)*, salt meadow cordgrass (S. patens), Olney's bulrush *(Scirpus americanus)*, black needlerush *(Juncus romerianus)*, and cattail *(Typha* sp). Grubbing for rhizomes of these species, especially in salt marshes, results in areas denuded of vegetation, typically referred to as eat-outs. Presently, eat-outs occur on four national wildlife refuges within the Northeast Region: Forsythe, Bombay Hook, Prime Hook, and Blackwater.

Snow goose eat-outs in salt marshes tend to revegetate during the subsequent growing season, however, at a reduced vegetative density. Vegetation density at these eat-outs may increase after several years to pre-eat-out levels, if left alone. However, at most NWRs where eat-outs occur within salt marsh habitats, snow geese return each winter to the same areas to feed. This may be a result of the vegetative growth being at an earlier stage of development, being more nutritious, or having a less dense root mat and therefore easier to grub. It is also speculated that during the time snow geese are feeding in a salt marsh, much of the soil and sediment may be loosened and placed into suspension. This material may then be washed away during high or flood tide periods. After several years of successive eat-outs at the same location, a lowering of ground elevation may occur, causing a more permanent impact to the site.

Most agree that salt marsh eat-outs are detrimental to habitat integrity and other wildlife species. This is a result of the radical change of habitat structure from dense vegetation to mudflat. Undoubtedly, this conversion negatively impacts invertebrate communities, species such as rails, and waterfowl that feed on these invertebrates and rely on the dense vegetative structure for cover. However, some refuge staff report increased use of snow goose eat-outs by numerous shorebirds during migration and by some species of waterfowl. This is particularly the case at Prime Hook NWR, Forsythe NWR, and Bombay Hook NWR.

Reducing the acreage in cropland habitats in favor of more native vegetation supports the preferred alternative for snow goose management on refuge lands identified in the final environmental impact statement for snow goose management along the Atlantic Flyway. Reducing the use by snow geese of these upland habitats will also benefit a variety of wildlife species that tend to be absent from agricultural habitats, and will also reduce the numbers of snow geese staying on the refuge. Reducing snow goose numbers on the refuge will also diminish adverse impacts of snow goose herbivory on salt marsh habitats.

Prior to the conservation order taking affect in late January, all snow goose hunting on-refuge will be isolated to the same areas/blinds and refuge specific hunting dates as other waterfowl hunting. A continuous period (except Sundays) from January 28–April 13(for 2012-2013 hunting season) will be open for hunting snow geese during the Conservation Order which will open all emergent wetlands on-refuge to snow goose hunting only, once all other waterfowl seasons have closed. Snow geese present a fairly unique issue, finding themselves on the Service's Migratory Bird Program focal species list for actually being over abundant. It is the desire of the USFWS, Canadian Wildlife Service and all Provinces and States to drastically reduce the size of the current continental populations of light (snow) geese, primarily because of the dramatic damage excessive numbers of snow geese have inflicted on very fragile arctic breeding grounds, areas that are important to other breeding migratory species, as well. Seasons, bag limits and methods of take have been liberalized for the purpose. Opening all available habitats on the refuge from January 28 – April 13 is specifically designed to reduce damage sustained from overbrowsing of refuge salt marshes.

Unfortunately, the Service projects, based upon documented history of similar hunts on-refuge, that very few hunters will take advantage of the snow goose hunting opportunity. The hunting season starts October 1, several weeks before any number of birds arrive on Delmarva, and while many hunters are more interested in deer hunting instead. Snow geese are difficult to hunt and there may be an incidental few killed during the regular duck and migratory Canada Goose season.

Over the period 2001 – 2006, when the refuge was open to late season snow goose hunting, 100 hunters harvested 96 snow geese over a shortened season extending from late January to mid-March and averaged 16.0 birds per year. The hunter success rate averaged 0.96 birds per hunt. Because of the difficulty of hunting snow geese, hunting parties were likely composed of a minimum of 2 hunters. Thus a maximum of 50 total parties hunted over a combined total of approximately 216 days available over the 6 year period with each party potentially having several thousand acres upon which to hunt. From 2000 to 2009, refuge hunters harvested between 0.04 percent and 0.43 percent of the refuge's estimated monthly snow goose population (Table 5-8). The Service projects negligible impacts to other refuge resources from snow goose hunting.

In addition, non-refuge areas in Delaware will also be open to snow goose hunting during the same period. It appears anecdotally that the limited few hunters that attempt snow goose hunting during the late season are likely to do so from agricultural fields, alleviating most waterfowl hunting pressure on Delaware's tidal marshes and impoundments.

Managing Non-Native Mute Swans

Mute swans are highly invasive of wetland habitats, impact native species of fish and wildlife, damage commercial agricultural crops, and pose a threat to human health and safety. As such, they cause serious nuisance problems and property damage, including economic loss. Because of their consumption of large quantities of submerged aquatic vegetation and their aggressive behavior, mute swans compete directly with many other water birds and fisheries for critical habitats. Due to their strong territorial defense, some pairs will vigorously defend nest and brood sites from intrusion by other wildlife and have attacked humans, causing serious harm. They do provide some aesthetic value for public enjoyment. But, as populations of mute swans have grown in various states and expanded into new areas, there is a need to coordinate management actions among State, Provincial, and Federal wildlife agencies to reduce numbers to desirable levels (AFC 2003).

Consequently, the Atlantic Flyway Council has adopted the Atlantic Flyway mute swan management plan 2003 to 2013. The mute swan is not federally protected under the Migratory Bird Treaty Act, and is listed as an unprotected-invasive species by the State of Delaware. As such, mute swans, their nests, and eggs have been routinely removed from national wildlife refuges, State wildlife management areas and (with landowner permission) from private lands in Delaware since the early 1970s (AFC 2003).

Other Migratory Birds at Prime Hook NWR
Other migratory birds hunted at Prime Hook NWR include mourning dove, woodcock, and snipe. For mourning dove, an estimated 14,700 birds were harvested in Delaware during the 2011 season (Table 5-10; Raftovich et al. 2012) when only nine were taken on the refuge. Similarly, very few snipe and woodcock were harvested (tables 5.9 and 5.10).

Given the low numbers of birds harvested from the refuge, no cumulative impacts to local, regional, flyway, or nationwide populations of other migratory birds are anticipated from allowing hunting of these species on the refuge.

Non-Hunted Wildlife
Non-hunted wildlife would include resident and migratory birds (songbirds, wading birds, shorebirds, etc.); small mammals such as voles, moles, mice, shrews, and bats; reptiles and amphibians such as snakes, turtles, salamanders, frogs and toads; and invertebrates such as butterflies, moths, insects, and spiders. Except for migratory birds and some species of butterflies, moths, and bats, these species have very limited home ranges and hunting could not affect their populations regionally; thus, only local effects will be discussed.

Disturbance to non-hunted migratory birds could have regional, local, and flyway effects. Regional and flyway effects would not be applicable to species that do not migrate such as most woodpeckers, and some songbirds including cardinals, titmice, wrens, and chickadees. The continual effects of disturbance to non-hunted migratory birds under this plan are expected to be negligible because the hunting season would not coincide with the nesting season. Long-term future impacts that could occur if reproduction were reduced by hunting are not relevant for this reason. Disturbance to the daily wintering activities of birds might occur, such as feeding and resting and are lessened by the establishment of sanctuary areas, seasonal closures, and hunting hour restrictions.

Disturbance of resident birds would increase slightly, but displacement is usually brief, infrequent, and short distance. Disturbance would be unlikely for many small mammals, such as bats, which are inactive during fall and winter when hunting season occurs, and are nocturnal. Hibernation or torpor by cold-blood reptiles and amphibians also limits their activity during the hunting season when temperatures are low, making encounters with reptiles and amphibians infrequent and inconsequential to local populations. Invertebrates are also not active during cold weather and will have few interactions with hunters during the hunting season. The Service anticipates no measurable negative cumulative impacts to resident non-hunted wildlife populations locally, regionally, or globally. The cumulative impact of wildlife and habitat management when considered at the flyway scale may benefit the health of migratory birds by maintaining the diversity and native components of the habitats they use. In summary, hunting has little or no impact on non-hunted wildlife due to temporal and spatial separation due to timing of the season and migration.

Threatened and Endangered Species
Disturbance factors resulting from public use are always considered for all listed species. The Delmarva fox squirrel (Sciurus niger cinereus) and piping plover (Charadrius melodus) are listed as endangered and threatened by the U.S. Fish and Wildlife Service and the red knot was designated as a candidate species in 2006 for possible listing. Several other species listed as endangered by the Delaware Division of Fish & Wildlife include American oystercatcher (Haematopus palliates), common tern (Sterna hirundo), Forster's tern (Sterna forsteri), least tern (Sterna antillarum), and bald eagle (Haliaeetus leucocephalus). Of these, the piping plover, red knot, American oystercatcher, common tern, Forster's tern, and least tern will not be impacted by hunting because they would be unlikely to use the Refuge's forested habitats and/or their occurrence on the Refuge is outside of the hunting season for deer, upland game,

and waterfowl. Impacts on the piping plover, American oystercatcher, common tern, Forster's tern, and least tern will be minimized through the seasonal closure of designated beach dunes and overwash areas from March 1 through September 1 to all visitors. A Section 7 Evaluation has been conducted as part of this review and it was determined that proposed activities would not likely affect the Delmarva fox squirrel or piping plover. Furthermore, the hunting of any squirrel species is prohibited on the Refuge to further minimize impacts to this endangered species.

While the bald eagle is no longer a federally listed species, the refuge uses the National Bald Eagle Management Guidelines for bald eagle management to implement time-of-year restrictions for nesting eagles. The guidelines do not permit any activity within 330 feet of an active nest during the breeding season, particularly where eagles are unaccustomed to such activity (U.S. Fish and Wildlife Service 2007).

Fishing, hunting, and wildlife observation/photography on or near Turkle Pond was an existing activity prior to nesting by bald eagles on the adjacent Horse Island. When bald eagles were listed as endangered, the Section 7 Evaluation conducted on the Refuge concluded that these activities in Turkle Pond would not likely affect this species and the uses were permitted. The Service will continue to monitor use in Turkle Pond to determine if there is an impact on the eagle nest on Horse Island, which is currently abandoned.

Anticipated Direct and Indirect Impacts of Proposed Action on Refuge Programs, Facilities, and Cultural Resources

Other Wildlife-Dependent Recreation

The opportunities for recreational sport hunting, a wildlife-dependent priority public use, would be available to the hunters, meeting a demand. Hunting on the refuge would contribute to the State's wildlife management objectives and allow a traditional use to continue.

We may close the refuge to other public uses on certain areas during hunt days, unless we can safely sequester the locations of those uses from the locations of hunting activity. Experience has proven that time and space zoning (i.e., establishment of separate use area, use periods, and restriction on the number of users) is an effective tool in eliminating conflicts between user groups. Currently, we restrict other wildlife-dependent recreation on days when we allow hunting on the refuge. Seasonal closures on Prime Hook Creek minimize conflicts between anglers, wildlife observers, and hunters and minimize disturbance to waterfowl. The headquarters area, which contains the visitor contact station, hiking trails, and fishing opportunities and is open year-round, is closed for limited days to facilitate a deer hunt. Closed areas of the refuge along Slaughter Beach Road, Cods Road, Prime Hook Beach Road, and Broadkill Beach Road are open only to permitted hunters during designated times of the hunting season. For the remainder of the year, these areas are closed to the public.

Refuge Facilities

Facilities most utilized by refuge visitors are roads, parking lots, trails, and boat launching ramps. Maintenance or improvement of these facilities will cause negligible short term impacts to localized soils and waters and may cause some wildlife disturbances and damage to vegetation. The facility maintenance and improvement activities described are periodically conducted to accommodate daily refuge management operations and general public uses such as wildlife observation and photography. These activities will be conducted at times (seasonal or daily) that result in the least amount of disturbance to wildlife. Siltation barriers will be used to minimize soil erosion, and all disturbed sites will be restored as close to pre-disturbance condition as possible. During times when roads are impassible due to flood events or other natural causes, those roads, parking lots, trails, and boat ramps impacted by the event will be closed to vehicular use.

Cultural Resources
With a relatively small number of hunters dispersed across the Refuge during the hunting season, direct or indirect cumulative impacts would be negligible on the refuge's cultural resources based on our observations of past hunting impacts. Refuge lands are vulnerable to looting, despite our best efforts at outreach, education, and law enforcement. Upland areas adjacent to wetland areas have been identified for high potential for cultural resources. In addition, Refuge visitors may inadvertently or even intentionally damage or disturb known or undiscovered cultural artifacts or historic properties. We would continue our vigilance in looking for this problem, continue our outreach, and use law enforcement where necessary.

For compliance with section 106 of the National Historic Preservation Act, the Refuge staff will provide the regional historic preservation officer a description and location of all projects, activities, routine maintenance and operations that affect ground and structures, details on requests for compatible uses, and the range of alternatives considered. That office will analyze those undertakings for their potential to affect historic and prehistoric sites, and consult with the State Historic Preservation Officer and other parties as appropriate. We will notify the State and local government officials to identify concerns about the impacts of those undertakings.

Anticipated Impacts of Proposed Hunt on Refuge Environment and Community
The refuge expects no sizeable adverse impacts of the proposed action on the refuge environment, which consists of soils, vegetation, air quality, water quality, and solitude. Some disturbance to surface soils and vegetation would occur in areas used by hunters; however, impacts would be minimal. Hunting would benefit vegetation as it is used to keep many resident wildlife populations in balance with the habitat's carrying capacity.

The refuge expects impacts to air and water quality to be negligible. The effect of these refuge-related activities, as well as other management activities, on overall air and water quality in the region are anticipated to be relatively negligible, compared to the contributions of industrial centers, power plants, and non-refuge vehicle traffic on nearby public roads.

The refuge would work closely with State, Federal, and private partners to minimize impacts to adjacent lands and associated natural resources; however, no indirect or direct impacts are anticipated. The hunts result in a net gain of public hunting opportunities positively affecting the general public, nearby residents, and refuge visitors. The refuge expects a minimal increase in visitation, but any additional use will add some revenue to local communities.

Other Past, Present, Proposed, and Reasonably Foreseeable Actions and Anticipated Impacts
Cumulative effects on the environment result from incremental effects of a proposed action when these are added to other past, present, and reasonably foreseeable future actions. While cumulative effects may result from individually minor actions, they may, viewed as a whole, become substantial over time. Hunting on the refuge has been designed to be sustainable through time given relatively stable conditions.

Due to history of low hunter use and harvest for resident geese and late season snow geese, the refuge has been closed during these seasons but will consider reopening if demand and opportunity exist and conflicts are minimized.

Greater snow geese *(Chen caerulescens atlantica)* have undergone a dramatic increase in recent decades, to current population estimates of over 1 million birds. Natural marsh habitats on some migration and wintering areas have been impacted by the destructive feeding strategies of overabundant light geese (Giroux and Bedard 1987, Giroux et al. 1998, Widjeskog 1977, Smith and Odum 1981, Young 1985). In addition, goose damage to agricultural crops has become a problem (Bedard and Lapointe 1991, Filion et al. 1998, Giroux et al. 1998, Delaware Div. of Fish and Wildlife 2000). Snow geese use the refuge wetland habitats extensively, and are not subjected to any hunting disturbance or mortality on the refuge. Impacts to refuge wetlands and impacts to wetland-dependent wildlife compound over time as long as the population is not adequately controlled at the flyway level through the coordinated efforts of individual agencies.

Similarly, resident Canada geese have been shown to cause changes in wetland community structure (Laskowski et al. 2002). Resident geese can reduce the amount of plant biomass that would be available to migrant birds at the end of the growing season. Direct damage to agricultural resources by resident geese includes eating grain crops and trampling spring seedlings. Heavy grazing by geese can result in reduced yields and in some instances a total loss of the grain crop (Allen et al. 1985, Flegler et al. 1987). Uncontrolled Canada goose populations on the refuge can impact migratory bird populations utilizing the refuge as well as contribute to agricultural losses on lands surrounding the refuge.

The refuge will consider participating in the October antlerless season only if an overabundance of deer arises, as determined the Delaware Division of Fish and Wildlife and concurrence by the refuge (refer to Resident Wildlife Section for impacts of deer overabundance).

If visitation levels expand in the unforeseen future, unanticipated conflicts between user groups may occur. Service experience has proven that time and space zoning (establishment of separate use areas, use periods, and restrictions on the number of users) and limiting visitations are effective tools in eliminating conflicts between user groups.

Anticipated Impacts if Individual Actions are Allowed to Accumulate

National wildlife refuges, including Prime Hook NWR, conduct hunting programs within the framework of State and Federal regulations. Hunting at the refuge is at least as restrictive as the State of Delaware regulations and in some cases more restrictive. By maintaining hunting regulations that are as, or more, restrictive than the State, individual refuges ensure they are maintaining seasons that are supportive of management on a more regional basis. Additionally, the refuge coordinates with the Delaware Division of Fish and Wildlife annually to maintain regulations and programs that are consistent with the State's management programs.

The cumulative impact of hunting on migratory and resident wildlife populations at Prime Hook NWR is negligible. As described in the previous sections, the proportion of the refuge's harvest of waterfowl, deer, and small game is negligible when compared to local, regional, and flyway populations and harvest.

Because of the regulatory process for harvest management of migratory birds in place within the Service, the setting of hunting seasons largely outside the breeding seasons of resident and migratory wildlife, the ability of individual refuge hunt programs to adapt refuge-specific hunting regulations for changing local conditions, and the wide geographic separation of individual refuges, we anticipate no direct or indirect cumulative effects on resident wildlife, migratory birds, and non-hunted wildlife of hunting on Prime Hook NWR.

Anticipated Cumulative Impacts of Alternative B: Service-Preferred Alternative

Resident Big Game

White-tailed Deer

The cumulative impacts of this alternative on white-tailed deer would be similar to those discussed under alternative A. The refuge proposes to open 1,201 additional acres for deer hunting for a total of 5,221 acres. This additional acreage includes an area located north of Prime Hook Road commonly referred to as Oak Island, an area west of the existing Headquarters Area, an area north of Route 16 referred to as the Millman Tract, an expansion of the Headquarters Area and Jefferson Lofland Tract, and an area west of Petersfield Ditch in Unit 4 (For more information about hunting on these areas, refer to the hunting section for alternative B in the Impacts to Public Use).

Hunter numbers are expected to initially increase based on the opening of these areas and the opportunity for hunters to free roam; however, cumulative impacts are expected to be negligible. The current harvest of deer on the refuge (66) has a miniscule impact on the statewide deer population, which was last estimated at 31,071 deer in 2009 (Table 5.12). Hunting license sales in Delaware have declined from 29,994 in 1975 to 18,746 in 2007 (Rogerson 2010). Based on the decline in the number of hunters and the relatively low numbers of animals harvested from the refuge in respect to the total Statewide harvest and deer population, no cumulative impacts to local, regional, or Statewide populations of white-tailed deer are anticipated from allowing hunting of the species on the refuge.

Wild Turkey

Under this alternative, the refuge proposes to open 3,729 acres for wild turkey hunting, which was permitted on the refuge in Unit I west of Slaughter Canal from 1993 up until 1998. This additional acreage includes many of the areas for deer hunting under this alternative. Turkey is a resident game species that is managed by DNREC's Division of Fish and Wildlife. The refuge falls within Zone 9 of DNREC's Wild Turkey Management Regions and the refuge will work closely with DNREC to evaluate the status of the turkey population and its hunting potential. Zone 9, which includes the state-owned Prime Hook Wildlife Area that is adjacent to the refuge, is currently open during the spring turkey hunting season. To ensure a sustainable harvest of the state's turkey population, DNREC biologists track their health, distribution and reproductive success. Current efforts include a volunteer-based survey used to generate an index of annual turkey productivity and recruitment, monitoring turkey harvest and hunter efforts, tracking turkeys with radio transmitters to evaluate their reproductive ecology, habitat use, and survival, and evaluating the genetic diversity of turkeys. Impacts from turkey hunting, which occurs in April and May, are expected to be negligible since only a very small number of hunters (five or fewer) will be permitted to hunt. The number of permitted hunters may be adjusted (increased or decreased) based on changes in turkey population data.

Upland Game or Small Game

The cumulative impacts of this alternative on small game would be similar to those discussed under alternative A. No expansions of hunting acreage are proposed.

Given the low numbers of animals harvested from the refuge, no cumulative impacts to local, regional, or Statewide populations of small game are anticipated from allowing hunting of these species on the refuge.

Delaware permits hunting for red fox, which assists State management efforts in reducing the incidence of mange outbreaks to maintain a healthy population and reducing the predatory impact of this species on migrating and breeding birds, particularly State and federally endangered or threatened species. Hunting would be opportunistic in most cases. In other states, the incidental harvest of fox occurs during other open seasons, such as deer season, and the pelts are often retained for personal use. Though no county-specific data are available, healthy populations of fox exist in the State and anticipated harvest rates would result in negligible cumulative impacts to local or State populations (Reynolds, personal communication 2010).

Migratory Birds
Migratory birds are managed on a flyway basis by the Service. The process of surveying populations and setting regulations is, inherently, a cumulative impact analysis. The cumulative impacts of this alternative on migratory birds would be similar to those discussed under alternative A.

Waterfowl at Prime Hook NWR
The cumulative impacts of this alternative on waterfowl would be similar to those discussed under alternative A. Under this alternative, the refuge proposes to open 1,710 additional acres for waterfowl hunting for a total of 3,432 acres. This additional acreage includes an area between Slaughter Beach Road and Fowler Beach Road referred to as Unit I, an area located south of Prime Hook Beach Road, and a reconfiguration of the existing waterfowl hunt area in Unit III. Of these new areas, Unit I was already open to deer and upland game (including dove) hunting.

To minimize waterfowl disturbance, the refuge has designated about 3,185 acres as waterfowl sanctuaries that will be closed to hunting and other recreational uses on a seasonal or annual basis. Given the dominant role of the refuge in the Atlantic Flyway migration corridor, this closed area system was established to provide waterfowl with a network of resting and feeding areas and to disperse waterfowl hunting opportunities on the refuge. These sanctuaries lie in the Unit II (approximately 1,800 acres), the southern half of Unit III (approximately 390 acres), and in Unit IV (approximately 995 acres). The northern portion of Unit IV, which contains a proposed trail and observation platform, will be closed from the Monday before Thanksgiving to March 15 to minimize disturbance to wildlife in this area. The southern portion of Unit IV will not be open to any public use. Furthermore, all waterfowl hunt areas will be open four days per week until 3pm during the hunting season, which is the same as current management.

The term “sanctuary”, as used in the context of the CCP, indicates an area free from hunting and other uses. A key feature of a sanctuary is to make it large enough that intrusions on it’s borders do not unduly disturb the normal lifecycle functions, e.g. feeding, resting, preening, courtship or cause the birds to take flight. The Service believes the areas designated for sanctuary are sufficiently large to reduce the detrimental effects of all forms of disturbance, including those resulting from hunting activity.

Sanctuaries also allow birds to have adequate escape distances (ED), which are defined as the shortest distance at which they flush or otherwise move away from the approaching person or other disturbing stimulus. Many factors influence EDs such as hunting, flock size, hunger, migratory motivation, etc. Laursen et al. (2005) suggested providing a mean ED of the largest ED of a bird species plus one to two standard deviations to calculate the size of the core area or buffer zone. In their study, the largest ED was 1000 meters for wigeon (other species included mallard, teal, pintail, waders, and gulls) and would be approximately 1700 meters with two standard deviations. Based on this information, refuge sanctuary areas can accommodate the ED’s of most species.

Disturbance to waterfowl in or adjacent to the refuge is not a new phenomenon. The Service agrees, in part, there is virtually no area of the refuge that is not susceptible to auditory and visual disturbance. The refuge is relatively narrow and is crossed by several county roads. Some days auto traffic on Route 1 can be clearly heard a couple miles to the west, aircraft fly overhead, patrons of the refuge drive the county roads, birders walk the trails, refuge staff run tractors and airboats as part of their management program, residents drive to and from the neighboring communities to the east, beach enthusiasts travel to the public beaches, kayakers paddle the creek, crabbers park along the roads, neighbors hunt right up to the refuge border, and refuge hunters occasionally fire guns. Unfortunately, this is the nature of NWRs in the heavily populated eastern US. Most NWRs on the east coast do not harbor qualities that we generally think of as constituting “wilderness” (e.g., quiet, or solitude). Under an official wilderness designation, refuge staff would not be permitted the use of many of the standard management tools used on PHNWR. Even so, hunting is in fact permitted on areas designated as wilderness.

More specifically, hunting on adjacent private property causes disturbance to waterfowl every year in the following areas: Unit 1 along the western boundary, Unit 2 along Cods Road and Fowlers Beach Road, Unit 3 along the southeastern portion near Broadkill Beach, along Prime Hook Creek, and in the state managed Prime Hook Wildlife Area, and Unit 4 along the Broadkill River, Petersfield Ditch, and in salt marshes on the western boundary. Hunting has been open in all four units of the refuge and Unit 1 has been hunted for years by free-roaming hunters seeking deer and upland game in refuge saltmarshes. Despite disturbance of waterfowl from vehicular traffic, refuge staff observe visitors year after year viewing and photographing waterfowl within 20 yards of vehicle even during the hunting season. Adding additional sanctuary areas on the refuge will only increase areas of respite for waterfowl and other wildlife and further enhance opportunities to enjoy them by refuge visitors.

Hunter numbers are expected to initially increase based on the opening of these areas and the opportunity for hunters to free roam in the regular waterfowl areas; however, cumulative impacts are expected to be negligible. Hunting license sales in Delaware have declined from 29,994 in 1975 to 18,746 in 2007 (Rogerson 2010). Based on the decline in the number of hunters and the relatively low numbers of waterfowl harvested from the refuge with respect to the total Statewide, flyway, and national harvests, no cumulative impacts to local, regional or flyway waterfowl populations are anticipated from allowing hunting of waterfowl on the refuge. Impacts to waterfowl using the refuge would be localized to the area being hunted (which can be no more than 40 percent of the refuge) and, due to the short temporal nature of these types of disturbance (from hunting day and time restrictions), no cumulative indirect impacts from shooting, walking, boats, or vehicles are anticipated.

Other Migratory Birds at Prime Hook NWR
The cumulative impacts of this alternative on other migratory birds would be similar to those discussed under alternative A.

Given the low numbers of birds harvested from the refuge, no cumulative impacts to local, regional, flyway, or nationwide populations of other migratory birds are anticipated from allowing hunting of these species on the refuge.

Non-Hunted Wildlife
The cumulative impacts of this alternative on non-hunted wildlife would be similar to those discussed under alternative A. Additionally, spring turkey hunting will negligibly affect non-target wildlife since only a very small number of hunters (no more than five) will be permitted to hunt on the 3,729 designated acres of the refuge.

Threatened and Endangered Species
The cumulative impacts of this alternative on threatened and endangered species would be similar to those discussed under alternative A.

Anticipated Direct and Indirect Impacts of Proposed Action on Refuge Programs, Facilities, and Cultural Resources

Other Wildlife-Dependent Recreation

The opportunities for recreational sport hunting, a wildlife-dependent priority public use, would be available to the hunters, meeting a demand. Hunting on the refuge would contribute to the State's wildlife management objectives and allow a traditional use to continue.

Expanded hunting opportunities are expected to have adverse impacts on a certain segment of the public that does not desire any change in public use programs and regulations, or that may hold differing views on the course of action. In addition, while new visitors become familiar with those changes, violations could increase. Some conflict between wildlife observers, photographers, students, and other refuge users is expected to be short-term and negligible and will be managed through seasonal closures. Negative reactions by some visitors may be caused by the closure of the eastern end of Prime Hook Creek from September 1 through March 15 and the temporary closure of the general public use area near the refuge headquarters to conduct deer and turkey hunts. The closure of the eastern end of Prime Hook Creek in September is only one month earlier than current management. In fact, for the last few years, the eastern end has been closed in early September for safety reasons due to the opening of the early teal hunting season on the adjacent state-owned Prime Hook Wildlife Area. The deer hunts in the refuge headquarters are the same as current management and only portions of this area will be closed for one-half day for turkey hunting. Seasonal closures for hunting occur during the fall and winter months, which is typically a slower period of use due to weather conditions. Refuge officers would enforce these and other current refuge regulations, where appropriate, and would seek the assistance and cooperation of Delaware Division of Fish and Wildlife in enforcing common regulations to provide a safe environment for refuge visitors and promote activities that are compatible with protecting the resources.

At first glance, these seasonal closures give the appearance that opportunities for wildlife observation and photography are being significantly reduced or totally eliminated for over eight months during the proposed expanded hunting activities. To the contrary, the majority of the refuge would remain open to wildlife observation and other non-consumptive uses and provide more opportunities and open areas than under current management. More specifically, opportunities for wildlife observation and photography have been expanded to include seven new trails totaling 3.7 miles throughout the refuge in all four management units on existing maintained trails or interior refuge roads, bringing the total number of trails to 14 and 9.9 miles. The Headquarters area, which contains six trails covering six of the nine total miles of refuge trails, remains available 363 days a year for non-consumptive uses, but portions may be closed for turkey hunting. All other areas except for the Deep Branch Trail, Fowler Beach Road trail (southside), and Prime Hook Creek are open on every Sunday during the hunting seasons. The Deep Branch Trail, the Fowler Beach Road trail (southside), and Prime Hook Creek are open with seasonal closures of every day from September 1 through March 15 and if necessary during the snow goose conservation order or turkey hunting seasons. If and when the photography blind is available on the southside of Fowler Beach Road, this portion of the trail will be open year round and open every Sunday during the hunting season. The majority of the hunting will occur during the main hunting season, which typically runs for five months from September through January, with additional hunting opportunities for rabbit through the end of February. Hunting during the snow goose conservation order, which will occur for 2 ½ months from late January through mid-April, will take place mostly in the wetland areas, leaving the upland areas open to other uses. This hunt is not anticipated to bring large numbers of hunters, but is beneficial to the species and other wildlife due to overpopulation. With five or less turkey hunting permits issued in April and May, a vast majority of the refuge would still remain open to wildlife observation and other non-consumptive uses.

We anticipate some conflict between concurrent hunting programs (e.g., waterfowl, deer, and upland game hunting seasons overlapping). For the majority of the hunting seasons, the Delaware Division of Fish and Wildlife has made efforts to avoid these overlaps in the various hunting programs. As public use levels expand across time, unanticipated conflicts between user groups may occur. The refuge's visitor use programs would be adjusted as needed to eliminate or minimize each conflict and provide quality wildlife-dependent recreational opportunities. The Service's law enforcement efforts will be increased. Conflicts among hunters over desired hunting locations are expected and we will continue to encourage proper hunting ethics.

Refuge Facilities
Minimal infrastructure, which includes the addition of two to three parking areas, enhancement of existing boat ramps, and placement of informational signs, is anticipated in support of this priority public use. There would be some costs associated with these programs in the form of road maintenance, law enforcement, and boat ramp maintenance. These costs should be minimal relative to total refuge operations and maintenance costs and would not diminish resources dedicated to other refuge management programs. Impacts to refuge resources are expected to be negligible.

Cultural Resources
The cumulative impacts of this alternative on cultural resources would be similar to those discussed under alternative A.

Anticipated Impacts of Proposed Hunt on Refuge Environment and Community
In addition to cumulative impacts discussed in alternative A, increases in proposed hunting acreages will provide new hunting opportunities from current management; however, many of these proposed "new" hunting areas are currently open to some type of hunting or have been previously open either under refuge management or private ownership. For example, Unit I is currently open for deer and upland game hunting (including dove hunting) and is now proposed to be open for waterfowl hunting - same land, but with a new opportunity. The only refuge land proposed to be open for any type of hunting that is not currently being hunted for any species includes: an area located north of Prime Hook Road commonly referred to as Oak Island (deer only), an area north of Route 16 referred to as the Millman Tract (deer and turkey), an expanded area of the existing Jefferson Lofland Area and Headquarters Area (deer & turkey), an expanded area of the Unit III waterfowl hunt area (waterfowl only), and an area west of Petersfield Ditch in Unit 4. Of these areas, Oak Island was previously hunted under refuge management up until 1995 and the Millman Tract was hunted under private ownership up until the Service purchased it in 2001. The expanded areas of the Jefferson-Lofland Area, Headquarters Area, and nearly all of the proposed Unit III waterfowl hunt area were previously hunted under refuge management. No prior hunting of the area west of Petersfield Ditch is known.

Due to an increase in new hunting areas and by allowing hunters to free roam, an increase in violations may occur until hunters become familiar with the refuge boundaries and regulations. As a result, short-term minor adverse impacts may occur with some landowners due to hunter trespassing. These impacts will be minimized through enhanced law enforcement efforts. We anticipate some conflict between concurrent hunting programs (i.e., waterfowl, deer, and upland game hunting seasons overlapping). For the majority of the hunting seasons, the Delaware Division of Fish and Wildlife has made efforts to avoid these overlaps in the various hunting programs.

Although the refuge provides hunting maps and refuge-specific regulations, it is ultimately the responsibility of the hunter to know and obey them. Unfortunately, not all do. The Service will ensure that refuge boundaries are and continue to be properly posted to notify both refuge visitors and private landowners. Private landowners will be encouraged to contact either refuge and/or state law enforcement when these trespassing incidents occur and every effort will be made to respond in an efficient and timely manner. The Service also encourages private landowners to post their own property. Restricting hunter access within a 100 yard buffer to private property was discussed and it was concluded that too much hunting area would be lost by this zone and that there are already sufficient laws and regulations in place to discourage boundary shooting. Furthermore, neighboring landowners would benefit by having easy access to designated areas open to hunting on the refuge.

Visitor safety at refuges is a high priority when developing compatible wildlife-dependent recreation programs, such as hunting; however, it is ultimately the responsibility of every hunter to be safe. An accident involving hunter safety results from either a lack of hunting ethics or a violation of hunting regulations. Use of portable deer climbing stands will be recommended but not required. For hunters who may be unable to climb trees using portable deer stands or who may wish to hunt from permanent deer stands or duck blinds, the state-owned Prime Hook Wildlife Area, which adjacent to the Refuge, will continue to provide these opportunities.

Provision of elevated deer stands, and to a lesser degree waterfowl blinds, is relatively unique to Delaware. There are many areas on the Delmarva Peninsula, other than Prime Hook NWR, that offer public hunting opportunities in free-roam areas where the hunter is required to provide the blind or stand, if desired.

The Service conducted a web-search for public lands within the three states making up the Delmarva Peninsula in order that we evaluate the prevalence of permanent waterfowl blinds or deer stands on public hunting lands. A wide assortment of ownership and management regimes was evident across 215 tracts managed or described by 19 different designations, e.g. State Park, National Park Service, State Forest, Chesapeake Forest Lands, Natural Resources Management Area. For waterfowl hunting, 131 of the 215 tracts examined permitted waterfowl hunting. Of the 131, only 36 provided either a pit or standup blind somewhere on the tract. The Service makes this qualifying statement because some areas, Tuckahoe State Park for example, provide four pit blinds but also allow free roaming along the Tuckahoe River. Of the 36, 28 were located in Delaware, 8 in Maryland, and none in Virginia. Twenty tracts required hunters to hunt at a stake or within some designated distance from a blind site where the hunter would provide the blind (if desired), including nine in Delaware, 11 in Maryland, and none in Virginia. A total of 84 tracts permitted free-roam hunting where the hunter would provide the blind (if desired), 17 in Delaware, 60 in Maryland, and seven in Virginia.

For deer hunting, of the 215 tracts examined, 181 permitted some form of deer hunting. Unfortunately, the Service did not make a distinction between the various methods, i.e. some tracts may be limited to bow hunting only. Of the 181 tracts, 95 were located in Delaware, 77 in Maryland and nine in Virginia. A total of 51 of the 181 tracts required hunters to use stands that were provided, all of which were located in Delaware. Free-roam hunting was permitted on 165 tracts, including 80 in Delaware, 76 in Maryland, and nine in Virginia. The Service acknowledges that some free roam areas were for bow hunting only, however such a distinction would only apply in Delaware; all deer hunting tracts in Maryland and Virginia permitted free-roam hunting regardless of hunting method.

For the 85 tracts located in Maryland and Virginia where no stands are provided, only two require an elevated stand, which the hunter must provide. For areas immediately adjacent to the building complex on Blackwater NWR, the hunter must use an assigned blind site where the hunter erects a stand with a platform minimum of eight feet above the ground. All other tracts on Blackwater NWR are free-roam where ground-hunting is permitted.

The second site where elevated deer hunting is required is on Chincoteague NWR, around the tour loop. Here the hunter must erect his/her own stand with a platform minimum of 14 feet above the ground. All other areas on Chincoteague NWR permit free-roam hunting. The Service should also add that rifle hunting, as well as deer drives, are permitted on most public hunting lands on the lower eastern shore of Maryland and the eastern shore of Virginia.

The elimination of nearly all hunting permit fees (except for lottery hunts) should be well received by hunters and changes to the hunting program reduce the administrative burden and minimize the amount of staffing resources needed to conduct the hunt by 54 staff days and $17,890 from current management. The benefit to the hunter is a reduction in their cost to hunt.

Cumulative impacts to vegetation communities resulting from hunter access are expected to be negligible, as most species will have already undergone senescence or become dormant. Salt marsh habitats were found to be the most resistant to human trampling when compared to other habitats such as a natural dune, a man-made dune, and man-made coastal grasslands (Anderson 1995). This study analyzed the vegetation of five paths (one in each of the habitats) created and sustained by human trampling and reported that trampling of vegetation (estimated to be 1,815-3,630 passages per year) can be considered as very light. Even though it created paths and reduced vegetation cover and species diversity, the paths still retained a persistent vegetation (Anderson 1995). Additional impacts to vegetation are minimized by not permitting hunters to cut vegetation for shooting lanes or for use as camouflage. Impacts to vegetation are further minimized because hunting from a stand that has been attached with nails, wire, screws, or permanently attached to a tree in any other way is prohibited.

Other Past, Present, Proposed, and Reasonably Foreseeable Actions and Anticipated Impacts
Cumulative impacts are the same as discussed under alternative A.

Anticipated Impacts if Individual Actions are Allowed to Accumulate
Cumulative impacts are the same as discussed under alternative A.

Anticipated Cumulative Impacts of Alternative C: Historic Habitat Management with Modified Public Use

The cumulative impacts of this alternative would be very similar to and in some cases less than those discussed under alternative B. Cumulative impacts of hunting on the refuge would be the same as alternative B except that the number of hunting days would be reduced and turkey hunting would be closed to reflect a reduction in staff size. More specifically, all hunt areas will be restricted to three days per week, waterfowl hunting will be restricted until noon, and hunting will be closed for early teal season, resident Canada goose season, and the snow goose conservation order. Cumulative impacts of upland game and webless migratory bird hunting would be the same as under alternative A. The cost of the hunting program would be $1,300 less than the annual hunting program proposed under alternative B.

Relationship Between Short-Term Uses of the Human Environment and the Enhancement of Long-Term Productivity

In this section, we examined the relationship between local, short-term uses of the human environment and maintaining the long-term productivity of the environment. By long-term, we mean that the impact would extend beyond the 15-year period of this CCP.

Under all alternatives, our primary aim is to maintain or enhance the long-term productivity and sustainability of natural resources on the refuge, in the State of Delaware, and in the Delmarva Coastal Plain ecosystem, along with migratory birds, interjurisdictional fish, and other far-ranging wildlife species, across their whole range.

Habitat protection and restoration actions across all alternatives may entail short-term negative impacts to ensure the long-term productivity of the refuge. Many of the cyclic management actions in the alternatives, namely, prescribed burning, controlling invasive plants and animals, proactively managing forests, and restoring native plant communities can have dramatic short-term impacts. These include direct mortality of some plants and animals, displacement of species, and temporary displacement or cessation of certain types of public use.

However, the long-term benefits of those actions generally offset their short-term impacts. Habitat management practices that mimic ecological and sustainable processes optimize the maintenance and enhancement of the biological diversity, integrity, and environmental health of those habitats for the long term. Long-term productivity is especially enhanced when the ecological and sustainable management actions that are proposed in the preferred alternative would best support and improve links between nutrient cycling, ecological processes and ecosystem function.

The nutrient cycling of the refuge's habitats is closely linked to other ecological processes discussed in this document. The dominant presence of wetlands and their distribution in the refuge's landscape strongly influences the transport of nutrients, usually in conjunction with hydrological patterns. Vegetative structural diversity in the forms of dead wood, leaf litter, senesced wetland vegetation, and detritus contributes to terrestrial and aquatic invertebrate resources that maximize sustainable nutrient recycling which in turn enhances the long-term productivity of the refuge's natural resources to people and wildlife.

Diverse and wide-ranging wildlife recreational opportunities for public use should provide the best long-term positive economic impacts to local communities. That mirrors the widely accepted premise that maintaining biological diversity in natural ecosystems helps ensure their long-term resiliency. We would design our proposed public use programs to heavily rely on outreach and environmental education to explain all of our management actions to visitors and the public that would encourage everyone to be better stewards of our natural environment.

In summary, we predict that the alternatives would contribute positively to maintaining and enhancing the long-term productivity of the refuge's natural resources, with sustainable beneficial cumulative and long-term benefits to the environment surrounding the refuge with minimal inconvenience or loss of opportunity for the American public.

Unavoidable Adverse Effects

Unavoidable adverse effects are the effects of those actions that could cause harm to the human environment and cannot be avoided, even with mitigation measures. All the alternatives would result in some minor, localized, unavoidable adverse effects. For example, any new construction, burning of prescribed fires, or control of invasive species would produce minor, short-term, localized adverse effects. However, none of those effects would rise to a significant level. Furthermore, all of those impacts would be mitigated with best management practices, so none of the alternatives would cause significant, unavoidable cumulative impacts.

Some habitat types on the refuge will be adversely affected. In alternative C, increased salinity into Unit II may cause rapid reversion from a freshwater marsh to a saltwater marsh. That would affect the wildlife that depends on freshwater systems. However, it is important to recognize that in virtually all situations where this conversion from freshwater to salt marsh might happen, the original, historic habitat was tidal salt marsh.

Forest habitat is also likely to undergo changes in species composition and structure as we create a more natural forest composition representative of the Delmarva Coastal Plain ecosystem, consisting of mixed hardwood oak-dominated systems. We do not expect significant adverse consequences from treating invasive plant species, improving current forest stand conditions, or conducting proactive reforestation projects.

All these unavoidable adverse effects on the physical and biological environment will be relatively local and more than offset by the long-term benefits of cleaner air, cleaner water, and making rare wildlife species more common across the landscape, while providing quality wildlife-dependent recreation.

As we noted previously, many of the habitat and facility construction projects in the alternatives have a certain level of unavoidable adverse effects, especially during the actual construction. Those effects are mitigated to some degree by the use of practices and precautions that safeguard water quality, avoid sensitive or irreplaceable habitats, or time the actions or include features to avoid or minimize impacts on fish and wildlife. The adverse effects generally are short-term and more than offset by the long-term gains in habitat quality and fish, wildlife, and plant productivity.

All the alternatives, in varying degrees, will have adverse impacts to a certain segment of the public that does not desire any change in current habitat management or public use programs. Some may be concerned about increased visitation to the refuge or others may not like us to open new tracts for public use adjacent to their residences. Some of these impacts on certain individuals or neighbors are unavoidable. Our responsibility is to provide equal opportunities to the American public. We believe we have sought a fair balance in minimizing and mitigating adverse impacts while optimizing wildlife conservation and providing excellent recreational opportunities to the public.

Potential Irreversible and Irretrievable Commitments of Resources

Irreversible commitments of resources are those that cannot be reversed, except perhaps in the extreme long term or under unpredictable circumstances. One example is an action that contributes to a species' extinction. Once extinct, it can never be replaced. By comparison, irretrievable commitments of resources are those that can be reversed, given sufficient time and resources, but represent a loss in production or use for a time. An example of an irretrievable commitment is maintaining grassland areas adjacent to salt marsh habitats for Henslow's sparrow in alternative B. If for some reason, Henslow's sparrow conservation was no longer an objective, those acres would revert gradually to maritime scrub shrub and forest, or we may determine it best to expedite that reversion by planting shrubs and trees. We do not consider small visitor facilities, such as photo blinds and information kiosks, irretrievable commitments of resources. We can dismantle those facilities and restore the sites if resource damage is occurring.

Environmental Justice

President Clinton signed Executive Order no. 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations on February 11, 1994, to focus Federal attention on the environmental and human health conditions of minority and low-income populations, with the goal of achieving environmental protection for all communities.

The order directs Federal agencies to develop environmental justice strategies to aid in identifying and addressing disproportionately high adverse human health or environmental effects of their programs, policies, and activities on minority and low-income populations. The order is also intended to promote nondiscrimination in Federal programs substantially affecting human health and the environment, and to provide minority and low-income communities access to public information and participation in matters relating to human health or the environment.

The United States EPA Office of Environmental Justice defines it as follows:

> "Environmental Justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental law, regulations, and policies. EPA has this goal for all communities and persons across this Nation. It will be achieved when everyone enjoys the same degree of protection from environmental and health hazards and equal access to the decision-making process to have a healthy environment in which to live, learn, and work." *(http://www.epa.gov/environmentaljustice*; accessed February 2012)

Overall, we expect none of the alternatives to place disproportionately high, adverse environmental, economic, social, or health effects on minority or low-income persons. Before we make any decisions to make major changes in habitat management or the environment, we always inform all of our publics, equally, and our programs and facilities are open to all who are willing to adhere to the established refuge rules and regulations. We do not discriminate in our responses for technical or practical information on conservation issues or when providing technical assistance in managing private lands.

Table 5-14. Summary Comparing the Effects of Management Alternatives at the Prime Hook NWR

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
General Impacts of Public Use on Refuge Resources of Concern	Direct, indirect, and cumulative impacts affect refuge resources. Direct impacts are those impacts immediately attributable to an action. Indirect impacts are those impacts that are farther in time and in space. Effects that are minor when considered alone, but collectively may be important are known as cumulative impacts. Effects are minimized through restrictions on time and place for public entry such as hours of operation, restriction to designated trails, or seasonal closures. Require a special use permit for groups of 6 or more cyclists or groups of 15 or more pedestrian travelers to minimize wildlife disturbance. Maintenance or improvement of refuge facilities may cause short-term impacts and will be conducted at times that cause the least disturbance to wildlife and their habitats. Illegal activities that may disturb and displace wildlife or trample vegetation include littering, vandalism, ATV use, camping, fires, exceeding the daily bag or creel limit, taking non-target species, or hunting in a closed area. Research activities contribute positively to refuge goals and objectives, but may cause short-term disturbance to wildlife resources.		
Socioeconomic Environment	The general consequences of managing native plant resources to maintain, enhance, and restore elements of biological integrity, diversity, and environmental health (BIDEH) have direct, indirect, and cumulative beneficial effects on people and wildlife. Ecological services derived from refuge wildlands and natural habitat management have the following beneficial impacts on the socioeconomic environment: • Purification of air and water • Mitigation of droughts and flood • Generation and preservation of soils and renewal of their fertility • Detoxification and decomposition • Cycling and movement of nutrients • Dispersal of seeds • Pollination services: pollination of farm crops and native vegetation to sustain native plant diversity in natural habitats and increase yields of farm crops • Carbon sequestration and partial stabilization of climate • Protection of coastal shores from erosion • Moderation of weather extremes and their impacts • Increased avian diversity on refuge lands from managing for BIDEH that generates greater capacity for disease prevention		

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Socioeconomic Environment (cont.)	Continue to make small contributions to local economy, in terms of refuge purchases of goods and services within the local community, refuge personnel salary spending, and spending in the local community by refuge visitors. Contribution to local economy based on 88,000 visitors each year and their expenditures that support refuge activities. Accounting for direct, indirect, and induced effects, all refuge activities would generate total economic impacts of $3.9 million in local output, 33 jobs, and $1.1 million in labor income. The hunting program requires 95 staff days and costs $30,955, with a recovery of $12,025. The adverse impact to agriculture if the marsh is not restored is the increase of saltwater intrusion, erosion of the coast, and increased damages from storms. As salinity levels increase with continued marsh loss, the risk of storm damage to agricultural resource may increase. There would be an adverse affect to recreational resources with the loss of wetlands and habitat diversity. Conversion of emergent marsh to large unvegetated open water would result in a diminished capacity of the area to support fish and wildlife populations, which may reduce recreational opportunities. The continued loss of these coastal barrier systems would result in the reduction and eventual loss of natural protective storm buffering.	Forest management activities proposed would have some direct beneficial impact on the socioeconomic environment of the region, as many of these techniques would require the contracted services. Wetlands in many locations play an important role in flood protection. Wetlands can prove a significant and potentially sustainable buffer for wind wave action and storm surge generated by storms. Wetlands protect water quality by trapping sediments and retaining excess nutrients and other pollutants such as heavy metals. A badly degraded wetland can lose its capacity to remove excess sediments, nutrients, and other pollutants, and can lose its habitat value for fish and wildlife. When wetlands lose their value as wildlife and fish habitat, this value is difficult to replace, and the consequent losses to the recreational and commercial industries may be significant. Examples include recreational and commercial fishing, hunting, birding, and photography. Restoring wetlands and reducing the land loss rates may protect nearby recreational infrastructure such as parking areas, roads, piers, and observations towers. Adding five refuge staff would minimally increase benefits for the local economy in jobs, income, and expenditures. Eliminating co-op farming would negligibly affect the agricultural sector in Sussex County, since contribution is relatively small. Enhancing refuge visitor services programs would increase visitation, thereby increasing their expenditures in the local economy and their total economic impact on Sussex County. Accounting for direct, indirect, and induced effects, all refuge activities would generate total economic impacts of $4.7 million in local output, 41 jobs, and $1.29 million in labor income. The hunting program costs $17,890 less and requires 54 fewer staff days than alternative A, with an estimated recovery of $3,832.	Economic impacts would be greater than alternative A and less than alternative B. We would also contribute negligibly to local agricultural sector with a co-op farming program of 600 acres. Numbers of visitors engaged in recreation would be slightly higher than alternative A and lower than alternative B with similar economic impacts on Sussex County. Accounting for direct, indirect, and induced effects, all refuge activities would generate total economic impacts of $4.03 million in local output, 34 jobs, and $1.1 million in labor income. The hunting program costs $1,315 less and requires 5 fewer staff days than alternative B, with an estimated recovery of $3,792.
	Regardless of which alternative we select, we would continue to pay refuge revenue sharing each year to Sussex County, and these contributions are relatively small to the county's budget. Regardless of the selected alternative, refuge management jobs, income, and expenditures would negligibly affect the local economy (less than 1 percent of total income and employment in Sussex County), but the expenditures of refuge visitors would continue to add some minor benefits for the local economy.		

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Cultural & Historical Resources	The refuge contains 14 prehistoric sites and 31 historic sites, which were identified in archaeological, historical, and geomorphological surveys conducted in 1982, 1984, and 2004. The likelihood is moderate to high that we may locate additional areas containing prehistoric or cultural resources.	We would continue to protect all refuge historic and pre-historic sites identified in alternative A and any future actions with the potential to impact cultural resources in moderate to high probability zones will be reviewed and assessed under all provisions of section 106 and Federal historic preservation act requirements (ARPA). This CCP document will be submitted and reviewed by State historic preservation officer for concurrence.	Beneficial impacts similar to alternative B.
	Some risk that refuge visitors may inadvertently or intentionally damage or disturb cultural and historic sites. Known sites would continue to be monitored and protected. Impacts to cultural and historic resources under alternative A have the potential to be less than under alternatives B and C because the passive habitat management approach in alternative A would involve less potential disturbance of culturally significant sites.	Similar to alternative A, but slightly more potential disturbance from habitat management activities, and we will also increase outreach and education to inform visitors and the general public about the refuge's cultural and historic resources.	Refuge management activities under alternative C have the potential to impact cultural resources by indirectly by exposing artifacts during actions such as cooperative farming, managing for early successional habitats, conducting reforestation projects, and prescribed burning
	Regardless of which alternative we select, we would protect known cultural or historic resources. We expect all the alternatives to have minimal adverse impacts on cultural and historic resources on the refuge. For compliance with section 106 of the National Historic Preservation Act, refuge staff will consult with the regional historic preservation officer during the planning stages of new actions. That office will consult as needed with the State historic preservation officer.		
Air Quality	Local long-term benefits in air filtration and carbon sequestration from protecting up to 10,000 acres within approved refuge boundary of wetland, upland, and open water habitats.	Negligible to long-term minor benefits for air filtering and carbon sequestration and slight increases due to proactive reforestation projects and wetland restoration projects. Increased energy-efficient practices with adoption of new practices (solar panel roof replacement for headquarters building, hybrid vehicle fleet)	Beneficial impacts similar to alternative B.
	Local negligible adverse effects from prescribed fire to control invasive plants, and negligible contribution to regional vehicle emissions by visitors.	Local negligible adverse effects from particulate emissions from prescribed fire, given increased grassland and shrubland maintenance and invasive plant control (200 to 1,000 acres/year). Small increase, but still insignificant vehicle emissions resulting from increased visitation.	Adverse impacts are similar to alternate A.
	None of our proposed refuge management activities should adversely affect regional air quality. None would violate EPA standards for criteria air pollutants and each would comply with the Clean Air Act. None would affect visibility due to emission-caused haze at the nearest class 1 airshed. Management actions and public uses at the refuge contribute a negligible increment to regional emissions.		

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Soils	Natural succession to native forested habitats versus proactive forested restoration will likely allow more time to restore and increase below ground biodiversity of soil organism that restore the health of soil resources. In the absence of active salt marsh restoration (dredge spoil) there may be slower or more limited return of vertical accretion than is likely under alternative B. Management actions would have a local long-term minor beneficial impact	Elimination of intensive agricultural practices on 600 acres will reduce soil erosion by wind and water in these areas and restore soil tilth. Restoration to native plant communities on prior farmed areas will rehabilitate damaged soils and restore natural functioning of beneficial soil bacteria and other soil organisms, re-establishing processes of decay and nutrient cycling that restores natural soil fertility levels and productivity of soils. Low intensity and regular prescribed fire in grasslands, shrublands, and understory burns to improve Delmarva fox squirrel forested habitats should improve soils by two ways: establishing native vegetation and by regularly returning nutrients to soils. Restoration of natural soil productivity will increase soil carbon stocks and capacity of soils for carbon sequestration. It is expected that restoring approximately 600 to 800 acres to forested habitats would increase carbon sequestration capacity of these soils within the next 100 year horizon. Salt marsh restoration will improve the quantity and quality of soils and sediment with impounded wetlands. In addition, restoration will reduce wave velocity and promote sediment deposition. Overwash and inlet formation, permitted to occur can contribute to the sediment budget of the wetlands. Management actions would result in local long-term minor to moderate beneficial impacts.	Taking 200 acres out of cropland production and restoring them to native vegetation significantly decreased soil erosion, improved soil conditions, and restored native soil biota with positive impacts for a large number of wildlife species. Periodic low intensity prescribed burning returns nutrients to soils. Use of glyphosate-tolerant corn and soybeans increase the success of conservation tillage, which can decrease soil erosion. The use of cover crops reduces soil erosion and increases soil fertility. Impacts from agricultural management actions can be mitigated with the use best management practices (cover crops and conservation tillage).

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Soils (cont.)	Lands abandoned from intensive agriculture with artificial depletion of nutrients can sometimes degrade ecosystem function, and facilitate the invasion of exotic soil species. Rapid saltwater intrusion could potentially cause subsidence through collapse of organic soils and conversion to open water. Even with greater sediment availability and tidal exchange, under some circumstances sediment-building process may not overcome the combination of sediment loss and relative sea level rise. There would be few ground disturbing activities and no active forest management to cause adverse soil effects. Best management practices in any refuge improvements would minimize short-term, localized soil impacts and eliminate potential cumulative effects. We would continue to prohibit recreational activities such as mountain biking, ATV's on pedestrian trails, or off-road vehicle travel that would damage soils on the refuge. Hiking trails, boat launch sites, wildlife observation areas, parking areas and other high-use areas would continue to be maintained well to keep soil effects to a minimum. Management action may result in local short-term and long-term moderate adverse impacts.	Impacts of forest management practices through clearing of vegetation and heavy equipment are expected to be negligible with the use of best management practices. The depth of subsidence is greatest marshes impounded form decades with large accumulation of freshwater peat of low bulk density. Rapid introduction of seawater can lead to peat collapse, which can lead to subsidence and may lead to open water environment. The discharge of dredge spoil may result in changes to physical, chemical, and biological characteristics of the substrate. Containment levees or berms may be needed to minimize the effects of dredge spoil as point and nonpoint source of pollution. In addition, timing and the construction of berms/levees may minimize wind and wave energy. Excessive elevation may impede channel formation and undesirable vegetation. Improper sediment grain size may have adverse impacts to piping plovers and/or horseshoe crabs. Minor impacts associated with the following new visitor services' improvements: new trails may require boardwalk pilings for trail access over wetlands or sensitive vegetation communities; expansion of facilities for education and visitor services programs is expected to cause negligible soil impacts. Increase visitation might result in increased trampling along trails, around visitor facilities, and waterfowl blind site areas. Management actions would result in local short-term minor adverse impacts.	Soil erosion may continue where conventional tillage practices increases soil erosion. Soil compaction is associated with field operations, which can increase surface run-off. The restricting tidal flow may have adverse impacts to sediment supply and sedimentation rates of the wetland system. Sedimentation rates are far below sea level rise rates. Impacts from public use would be similar to alternative A, except for deer and waterfowl hunting, which will have impacts greater than alternative A but less than alternative B. Farming and impoundment management will have short and long-term minor to moderate adverse impact to soils
	With all visitor services and recreational activities, habitat management activities and routine maintenance of all Service property and improvements, we will use best management practices in all refuge activities and actions that might affect refuge soils to ensure that we maintain soil productivity, and conserve and protect refuge soil resources.		

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Hydrology and Water Quality	Forested buffers will be created by relying on natural succession to create buffer zones. Continuing to discouraging interference with natural processes of inlet formation, sand migration, and overwash development in Unit I will have beneficial impacts for salt marsh habitats as renewable tidal flows and natural hydrologic patterns that create mini-inlets and expand overwash habitats will be allowed to evolve naturally. With control of pest plants, approved glyphosate herbicides are associated with less surface run-off than other common herbicides. Restore water circulation and access through the maintenance of refuge ditches to enhance water management capabilities. Management actions would have local short-term minor beneficial impacts.	Increasing forested buffers around refuge wetlands and watercourses will improve water quality and help mitigate pesticides and nitrogen run-off from off-refuge sources adjacent to refuge. Properly managed salt marsh restoration will permit natural tidal flows and natural hydrologic patterns that create mini-inlets. This will alleviate water quality problems encountered when sudden saltwater intrusion negatively influences the impoundment vegetation. Ditch maintenance will maintain and enhance water circulation and improve water quality. Proper hydrology must be attainable. Channels are needed to drain and successfully restore the marsh. Construction of tidal channels enhances tidal flooding, increases sedimentation rates, improves drainage, enhances vegetation colonization and species diversity. Vegetated marshes can reduce wave height by 63 percent within 7 meters. Reduced wave velocity may increase sediment deposition and decrease erosion. Restoration may result in decreased storm surges and waves. With the use of dredged material, the construction of berms or levees may protect restoration efforts from wave attack. The removal of Fowler Beach Road or increases in culvert size on other roads may improve tidal flushing and the overall hydrology. Management actions may have local short-term and long-term minor-to-moderate beneficial impacts.	Discouraging interference with natural processes of inlet formation, sand migration, and overwash development in Unit I will have beneficial impacts for salt marsh habitats as renewable tidal flows and natural hydrologic patterns that create mini-inlets and expand overwash habitats will be allowed to evolve naturally. Management actions may have local short-term minor beneficial impacts.

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Hydrology and Water Quality (cont.)	Adverse impacts to water quality are minimized with the use of buffer strips, using approved herbicides, and other best management practices. Increased frequency and duration of saltwater incursion into Unit II and ultimately into Unit III will have adverse effects on vegetation communities. These factors could result in a conversion of the wetland to largely open water, at least for the short term. Deeply subsided areas in high wave energy conditions may not vegetate after decades. An increase in tidal flooding frequency and range may create impacts for restored and existing marshes. If Spartina alterniflora does not establish an extensive root network in Spartina patens marsh areas before it is killed by salinity and flooding the marsh may collapse following mortality. Once the peat collapses, it would be unlikely that Spartina alterniflora would colonize. Negligible impacts may occur from anglers, hunters, or canoers/kayakers stirring up creek or pond bottom sediments or introducing pollutants into the waterways, but we do not expect even minor impacts that would cause long-term effects. Prohibition of gasoline motors in Turkle and Fleetwood Ponds minimizes impacts. Management actions may result in local short-term and long-term minor to moderate adverse impacts.	In salt marsh restoration the discharge of dredge material may lead to high BOD, which can reduce oxygen available to many organisms. An increase in nutrients may also lead to an increase in some species such algae. Dredged material may modify water circulation by obstructing flow, changing velocities, flow direction, and shoreline and substrate erosion rates. These impacts are minimized by confining material to decrease turbidity. Turbidity impacts are local and temporary. Indirect impacts include the possibility of algal blooms, increased dissolved oxygen, agrichemical may increase and decreased water temperatures. The maintenance exiting ditches or creation of new tidal channels to improve water circulation may increase turbidity and BOD locally. This is minimized with time of year restrictions. Hypersalinity is common problem in restoration sites. Proper hydrology is essential to promote rapid recovery and minimize adverse impacts. Catastrophic outcomes may occur once tidal flow is restored. A catastrophic blowout may result in open water with the absence of vegetation for prolonged periods, in the worst case, many decades to more than a century. This can be minimized through careful consideration of restoration design. Potential impacts from recreational users would also increase over alternative A, with expanded hunting, fishing, and wildlife observation opportunities. The use of manual propulsion or electric motors for fishing in the new areas of Goose and Flaxhole Ponds will minimize any effects on water quality. We plan to monitor those sites closely and address any elevated concerns. Management actions may result in local short-term minor adverse impacts.	The movement away from artificial dune restoration in Unit I increases the circulation of salt water into Unit I, which does have implications for Units II and III. Even if Unit II is managed as a freshwater impoundment, increased saltwater intrusion into Unit II will be likely, and will have adverse impacts on the maintenance of freshwater integrity in both Units II and III freshwater impoundments. The maintenance exiting ditches to improve water circulation may increase turbidity and BOD locally. This is minimized with time of year restrictions. Impacts from non-hunting public uses would be similar to alternative A. Impacts from hunting will be greater than alternative A, but less than alternative B. Management actions may result in long-term major impacts.
	None of our proposed refuge management activities would violate Federal or State standards for contributing pollutants to water sources; all three would comply with the Clean Water Act.		

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Vegetation	Allowing natural succession to occur in refuge uplands will take longer to achieve habitat management objectives and reduce quality of many forest stand conditions. Salt marsh restoration would have a moderate long-term beneficial impact marsh vegetation. Even though salt marshes are less diverse, they are most productive. Tidal flows established from inlets would continue to introduce new sediments that could aid in the natural return of the unit to salt marsh. Management actions would result in long-term moderate beneficial impacts.	Same as A, but with additional long-term benefits from protecting and pro-actively managing 10,144 acres within the approved Refuge boundary using forest management activities. These forest management actions would improve forest conditions of existing upland forest stands, create new forested acres and riparian buffers, and restore areas in non-native vegetation to native plant communities, thus reducing habitat fragmentation, promoting habitat connectivity, and increasing the refuge's carbon sequestration capacity. Increase acreage of upland forested habitat and early successional habitats. Restoration will promote habitat connectivity and reduce fragmentation. Various forest management techniques are aimed at stand improvement and will directly impact the composition of vegetation. These silvicultural treatments provide benefits regarding regeneration and stand replacement, species composition and diversity, forest health, and long-term sustainability of forest habitats. Prescribed burning can improve natural regeneration, especially oak species. Fire can also be used in hazard fuel reductions. Weed control would increase survivability, growth, and production of desired species. Only approved herbicides would be used. Salt marsh restoration would have a moderate-to-major long-term beneficial impact marsh vegetation. Even though salt marshes are less diverse, they are among the most productive. The placement of dredged material may provide a substrate for emergent vegetation allowing open water areas to function as marshes and reduce wave fetch. The salt marsh restoration efforts will focus on tidal range and sedimentary delivery rates to grow and expand salt marsh vegetation. Management actions would result in long-term moderate to major beneficial impacts.	Management of impounded wetlands would have moderate beneficial impact to freshwater vegetation. Water levels and timing of drawdowns determine composition and production of moist soil plants. Other factors influencing composition include soil types, temperatures salinities, and soil moisture. Management actions would result in short-term moderate beneficial impacts

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Vegetation (cont.)	Allowing deer hunting would ensure that deer overbrowsing does not result in extensive damage to vegetation. Vegetation trampling from hunting is negligible. Allowing natural conversion to occur instead of using proactive restoration may reduce quality of salt marsh conditions or result in more open water. Some portions may convert to open water due to subsidence, peat collapse, and low accretion rates, resulting in open water where there had previously been dense stands of freshwater wetland vegetation Direct loss of vegetated habitat would continue to occur as plants are physically removed by erosion from marine processes, increased water velocities, and increase herbivory pressures. Other visitor services programs would produce some effects on refuge vegetation. We would continue to maintain or improve infrastructure, such as roads and trails, which would involve the occasional trimming or felling of trees. Some trampling may result from visitors walking off-trail. Impacts would generally occur within areas already disturbed and confined to existing infrastructure footprints. We would continue to educate visitors about invasive plants to prevent the spread of seeds to new areas. Management actions would have short-term and long-term moderate-to-major adverse impacts.	Allowing deer hunting would ensure that deer overbrowsing does not result in extensive damage to vegetation. Vegetation trampling may increase, but will have minimal impacts from hunters in free roam hunting areas or areas adjacent to waterfowl blind sites. Direct impacts of management activities would be the temporary removal of vegetation through bush-hogging, mowing, burning, or applying herbicides. The impacts would be short term. Minor adverse impacts to upland forest communities may result if natural regeneration does not result in desirable species composition. Fire, as a management tool, will have negligible adverse impact on vegetation. Saltwater intrusion will significantly reduce the moist-soil (freshwater vegetation) acreage. In addition, forested wetlands may be adversely impacted. If raising marsh elevations are not successful, some additional portions of the unit may convert to open water due to subsidence, peat collapse, and low accretion rates, resulting in open water where there had previously been dense stands of freshwater wetland vegetation. Impacts from public use would increase from alternative A and are expected to be negligible. Minimal impacts are expected from the construction of new trails or expansion of existing facilities. New trails would be built on existing roads or presently maintained interior access routes to the extent possible. Management actions would result in negligible to minor short-term adverse impacts.	Hunting is expected to cause more impacts to vegetation than in alternative A, but less than alternative B. All other recreation is expected to cause adverse impacts similar to alternative A. Management actions would have local long-term minor-to-moderate adverse impact.

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Federal & State Endangered Species	Natural succession processes will take longer to achieve DFS habitat management objectives. Protection and maintenance actions conserve and enhance overwash inlet areas, mudflats sand flats and shorelines provide local short-term minor beneficial impacts. Management actions would result in short-term local minor beneficial impacts.	Afforestation will increase DFS habitat acres and enhance refuge population size to ensure long-term viability of DFS and refuge population. Forest management (TSI, silvicultural practices, and prescribed burning) will enhance the quality and quantity of the DFS habitat. Protection and maintenance actions conserve and enhance overwash inlet areas, mudflats sand flats and shorelines provide local short-term minor beneficial impacts. Seasonal closures of designated beach and overwash areas from March 1 through September 1. The deposition of dredged material on beaches can improve quality and availability of plover habitat, if it is clean sand of appropriate grain size. Management actions would result in short-term local minor beneficial impacts.	Seasonal closures of designated beach and overwash areas from March 1 through September 1. Management actions would result in local short-term minor to moderate adverse impacts.
	Management actions would have local short-term adverse impacts to endangered species but are minimized through seasonal closures and section 7 consultations. The continued loss of coastal wetlands would cause habitat loss and a decrease food supply for piping plovers. Management actions would result in local minor-to-moderate adverse impacts.	Impacts to endangered and sensitive plants and animals are expected to be greater than Alternative A, but are minimized through actions discussed in alternative A. Disturbance to endangered or sensitive plants and animals are minimized by following bald eagle management guidelines and completing section 7 consultations. Prohibiting dog walking minimizes or eliminates adverse impacts from dogs. If sediment quality standards and time in year restrictions are utilized, they can minimize any adverse impacts of the use of dredged material. Management actions would result in local short-term minor-to-moderate adverse impacts	Potential impacts from non-hunting public uses are similar to alternative A. Hunting is expected to cause more impacts to endangered species than in alternative A, but less than alternative B.

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Waterfowl	Passive conversion of freshwater impounded habitats to salt marsh will decrease the effective land-base of moist-soil seed yields and refugewide annual moist-soil production available for migrating and wintering waterfowl.	Impacts to waterfowl may increase overall from alternative A, with new waterfowl hunting areas in Unit I and Unit III. However, impacts are expected to be decreased by the designation of 3,185 acres of sanctuary areas with no disturbance from public use activities and by only hunting four days per week until 3pm in all hunt areas. Reducing the use of adulticides may have indirect beneficial impacts by providing a food resource. Eventual salt marsh restoration will reduce freshwater impounded habitats, which will decrease the effective land-base of moist-soil seed yields and refugewide annual moist-soil production available for migrating and wintering waterfowl. However, restored salt marsh will provide alternate waterfowl habitat in its place, especially for American black duck. The increased usage of sanctuaries will also benefit waterfowl. Management actions would result in local minor-to-moderate beneficial impacts.	Impacts from waterfowl hunting will be greater than in alternative A, but less than in alternative B. Impacts to waterfowl will be decreased by establishing waterfowl sanctuary areas and by only hunting three days per week until noon in all hunt areas. Maintaining the freshwater impoundment systems maximizes production of moist-soil plants on 4,200 acres for waterfowl foraging foods. The use of sanctuaries and moist-soil management coupled with water level management increases the carrying capacity of refuge wetland habitats to sustain high numbers of migrating and wintering waterfowl Browse and cover crops planted as part of the refuge's cooperative farming program provide a limited supplemental source of food for certain waterfowl species, primarily geese. The cooperative farming program involves the use, as approved, of glyphosate-tolerant corn and soybeans. This is considered more environmentally friendly than other herbicide technologies employed by farmers. Management actions would result in local short-term moderate beneficial impacts.
Shorebirds	There will be benefits from managing, enhancing and protecting barrier beach island and coastal salt marsh habitats, created through natural overwash processes, for piping plover and breeding American oystercatcher, least and common terns and migrating and wintering shorebird species. During the transitional phases to salt marsh may, for the short term increase, habitat availability for other breeding and migrating shorebirds. Management actions would result in local short-term and long-term minor-to-moderate adverse impacts.	Reducing the use of adulticides may have indirect beneficial impacts by providing a food resource. Proactive predator control would likely increase the productivity and numbers of State and federally endangered shorebird species that attempt to breed in available areas. Improved protection of beach habitats would also provide improved foraging and resting opportunities for spring and summer migrating shorebird species using these habitats. Through salt marsh restoration, there will be benefits from managing, enhancing and protecting barrier beach island and coastal salt marsh habitats, created through natural overwash processes, for piping plover and breeding American oystercatcher, least and common terns and migrating and wintering shorebird species. During the transitional phases to salt marsh may, for the short term increase, habitat availability for other breeding and migrating shorebirds. Management actions would result in local short-term and long-term minor-to-moderate beneficial impacts.	Moist-soil management assists with meeting the needs of shorebirds by providing protein rich foods during egg-laying, migration, and molt. Management actions would have local minor-to-moderate beneficial impacts Eliminating adulticides may have indirect beneficial impacts by providing a food resource. Same as alternative B.

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Shorebirds (cont.)	Use of mosquito adulticides and larvicides on barrier beach island habitats increases disturbance and potentially has indirect adverse impacts on shorebird condition and survival through direct impacts on invertebrate food resources during critical breeding and migration periods. No predator control and lack of proactive habitat protection on barrier beach island habitats during critical breeding and migrational shorebird periods in the spring, summer, and fall reduces availability of quality habitats for shorebird use. The absence of proactive restoration, such as is proposed in alternative B, may result in a higher ratio of open water in impounded wetland areas under alternative C. The potential for visitors to directly disrupt birds that are resting or foraging near water or disturb their nests can occur. Seasonal area closures, particularly along sensitive beach areas, and requiring dogs on leashes minimize disturbance. Management actions would result in local short-term and long-term minor adverse impacts.	Reducing the use of adulticides and other mosquito chemical use restrictions in freshwater wetland habitats and along beach strand habitats would reduce disturbance and mitigate adverse impacts on non-target insect food resources and aquatic food webs along barrier beach island and impoundment habitats. Restoration of salt marsh within refuge impounded wetlands, would likely increase open water habitats and decrease mudflat acreage relative to the freshwater impoundment management regime in alternative A, with minor local adverse impacts on shorebirds as mudflat habitats disappear. Impacts to shorebirds are expected to increase from alternative A, with an expansion of public use opportunities. Impacts are expected to be minimal. Seasonal closures in sensitive areas and eliminating dog walking on the refuge will minimize disturbance. Management actions would result in local short-term and long-term minor adverse impacts.	Hunting is expected to cause more impacts to shorebirds than in alternative A, but less than alternative B. All other recreation is expected to cause similar adverse impacts as in alternative A. Management actions would result in local long-term minor-to-moderate adverse impacts.
Landbirds	Improved forest interior conditions may develop passively over a long time, rather than as a result of active silvicultural management. To the extent there is an increase in salt marsh acreage through passive return of tidal flow in Unit II and eventual conversion of Unit III, would benefit salt marsh obligate passerines, such as seaside sparrows and salt marsh sharp-tailed sparrows, which are of tremendous conservation concern. Management actions would provide local short-term minor impacts.	In addition to alternative A, phasing out an additional 600 acres of farming acres has the continued and long-term beneficial impacts for area-sensitive landbirds. Benefits include greatly improved forest interior conditions for breeding forest landbirds through silvicultural management of refuge upland/wetland habitats. Adding more acres of grassland (~ 164) and early successional shrubland acreage (~ 234 acres) will benefit early successional-dependent landbird species. Proactive habitat management and restoration actions will increase landbird breeding potential and improve migrational and wintering foraging habitats with long term benefits of contributing to State and regional landbird population objectives. Direct beneficial impacts on targeted breeding landbirds, proactive habitat management of upland and wetland forests, maritime shrub, maritime forest, and early successional shrub and grassland habitats, and the maintenance and enhancement of biological integrity, diversity, and environmental health of salt marsh habitats, will also have direct beneficial impacts on other landbird species migrating to and wintering on the refuge. In addition, forested landbirds would also benefit by the expansion of the widths of forested riparian and wetland buffer zones and reap direct and long-term benefits from forest stand improvement on 775 acres.	Protection and conservation of existing 775 acres of mature mixed hardwood forested areas, 1,238 acres of forested wetland areas, and 2,200 acres of salt marsh habitats are beneficial to breeding, migrating, and wintering landbirds. However, fields managed through farming do not provide valuable landbird habitat. Protection and conservation of existing salt marsh are beneficial to sensitive salt marsh obligate passerines.

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Landbirds (cont.)		An increase in salt marsh acreage through restoration would benefit high priority tidal creek and salt marsh-dependent species, such as salt marsh sharp-tailed sparrows, seaside sparrows, and willet. Forest management actions to increase patch sizes with a greater diversity of species composition and structure of existing forest stands, reducing forest fragmentation by reforestation of certain areas, and improving forest health and biological integrity of existing forest stands will have beneficial long-term impacts on focal forest management bird species. The use of dredged material for active restoration would restore open water habitat to wetlands, providing a more diverse and stable habitat. Important stopover habitat would be created or restored for migratory birds. Management actions would result in local minor-to-moderate beneficial impacts.	

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Landbirds (cont.)	Possible loss of forested wetland acreage with increasing saltwater intrusion into forested wetland habitats in Unit III, and adverse impacts to wetland-dependent birding landbirds. Visitor activities and facility improvements have the potential to disturb birds. Off-trail visitor use has the greatest potential to impact nesting birds, but the extent of disturbance depends on vegetation density and visibility, and on species-specific responses to human presence. To minimize that impact, visitors are limited to trails. Maintenance or construction activities would displace birds temporarily, but we would avoid sensitive areas during the nesting season Upland bird hunting results in the direct removal of individuals, but annual seasons and harvest are set by the Delaware Division of Fish and Wildlife and would not jeopardize population viability. Hunting is negligible to non-hunted migratory birds because the hunting season does not coincide with the nesting season. Hunting, especially when dogs are present, results in the direct, short-term disturbance of resident upland birds and other wildlife. Management actions would provide local long-term minor-to-moderate impacts.	Temporary adverse impacts, particularly on migrating and wintering landbird species would result from setting back succession and maintaining grassland and shrubland habitats. Forest interior birds that require an open understory may be negatively impacted by selective harvesting practices. Efforts to reduce predation pressure on migratory birds of concern, especially to benefit species that nest on beaches and overwash habitats, would entail lethal removal of individual predatory birds from suitable nesting and brood rearing habitat. The restoration of tidal flow may initially increase the amount of surface water on a marsh and eliminate breeding habitat for birds that nest on or near the marsh surface. Indirect impacts from visitor activities would increase from those activities described under alternative A. Impacts will be minimized by requiring visitors to stay on designated new trails. Increased hunting opportunities, particularly with turkey hunting during April and May, will increase disturbance to nesting landbirds; however impacts are expected to be negligible due to the small number of permitted hunters (no more than five). Turkey hunting results in the direct removal of individuals, but annual seasons and harvest are set by the Delaware Division of Fish and Wildlife and would not jeopardize population viability. Refuge and State staff would assess turkey populations on the refuge to determine if a huntable population exists. Management actions would result in local short-term minor adverse impacts.	Loss of 600 acres of potential native forest or early successional habitats to cooperative farming that would be unavailable for focal breeding grassland, shrubland-dependent, or forest-interior dwelling landbird species and migrating and wintering landbirds. The use of these crops can affect landbirds indirectly by altering habitat and food sources, such as by reducing weed seed biomass or changing weed species composition. Potential impacts from non-hunting public uses are similar to alternative A. Hunting is expected to cause more impacts to landbirds than in alternative A, but less than alternative B. Management actions would provide local long-term minor-to-moderate adverse impacts.

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Secretive Marsh and Waterbirds	Increase in foraging areas with the increase in open water, although increased water depth may decrease food availability.	Breeding birds would be more severely impacted than migrating and wintering birds. Clapper rail and willets would benefit from salt marsh restoration. Reestablished tidal flow would provide food resources for waterbirds. Seasonal or area closures reduce disturbance. Management actions would result in long- term local minor beneficial impacts.	Using water level management techniques to create appropriate habitat structural conditions and enhance the annual production of invertebrates and fish, benefit focal breeding secretive marsh bird species. Quality foraging wetland habitats also benefit migrating and wintering secretive marsh and waterbird species. Management actions would result in short-term local minor beneficial impacts. Management actions would result in local minor beneficial impacts.
	The potential for anglers and wildlife observers to directly disrupt birds that are resting or foraging near water, disturb their nests, and leave debris that they can ingest or entangle themselves can occur. Seasonal or area closures minimize disturbance impacts. Management actions would have local minor-to-moderate adverse impacts.	Salt marsh restoration would adverse impact freshwater species such as bitterns and sora. Impacts for fishing, wildlife observation, and photography would increase from alternative A. Impacts are expected to be negligible. We would restrict access to designated areas, provide seasonal closures, and increase outreach and education. Management actions would result in short-term local adverse impacts.	Management actions would provide unfavorable habitat for salt marsh species such as clapper rail and willet. Potential impacts from non-hunting public uses are similar to alternative A. Impacts for fishing, wildlife observation/ photography would increase from alternative A. Impacts are expected to be negligible. We would restrict access to designated areas, provide seasonal closures, and increase outreach and education. Management actions may result in local long-term adverse impacts with the increase in open water.

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Fisheries	Loss of Unit II and Unit III freshwater habitats as they convert to salt marsh will increase refuge marine invertebrates needed to sustain more salt marsh fishery resources and decrease refuge freshwater fisheries resources. Management actions would result in local long-term minor-to-moderate beneficial impacts.	Same as alternative A, plus improve and expand water quality monitoring and habitat management actions to increase water circulation and water level management capability within freshwater impounded habitats. These actions improve foraging and breeding habitats for focal fish species that include river herring (alewife and blueback herring), elvers, and striped bass, and benefit other recreational fish species. Salt marshes provide critical nursery habitat for fish and shellfish. Increased tidal flushing into impounded areas may increase water-column aeration, reduce summertime oxygen stress, and promote survival of all aquatic animals including the migratory river herring. The return of tidal flow and creation of creeks during the restoration of salt marshes in the Delaware Bay provided an immediate, dramatic increase in fish species diversity and abundance, particularly by resident and transient young-of-year fish species that once again have access to the marsh area. The movement, habitat use, and diet composition of striped bass in restored salt marshes were similar to reference salt marshes, signifying the importance these restored sites in the management of commercially important large predators in the Delaware Bay. Changes in mosquito IPM practices and strategies, with reduction of adulticide use and prescribing additional thresholds for larvicide use, will improve the BIDEH of fisheries resources by providing additional protection to aquatic adult and larval insect species and other non-target invertebrates that are critical to maintaining healthy food webs for fish. Management actions would result in short-term minor-to-moderate beneficial impacts and long-term moderate local and regional beneficial impacts.	Continue refuge fisheries management by maintaining fish weir passages in Units II and III water control structures, which allow unimpeded passage of river herring and other anadromous fish species. Conduct area and seasonal closures and ditch cleaning in impoundments with direct benefits of improving oxygen content, water circulation, and water quality, as needed, to conserve priority fish resources of concern. Upstream freshwater systems provide spawning habitat for anadromous fish such as adult alosids (shad and river herring), for semi-anadromous fish such as white perch, and as nursery habitat for juvenile fish Management action would result in local long-term minor-to-moderate beneficial impacts.

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Fisheries (cont.)	Use of mosquito adulticides and larvicides has potentially adverse indirect impacts on fisheries resources because they are toxic to the aquatic invertebrates that sustain robust food webs. An open-water, shallow habitat (extension of the Delaware Bay), would have local long-term minor-to-moderate adverse impacts to the fisheries component of the BIDEH on the refuge. The inability of emergent wetland species to colonize due to lack of substrate and excessive water depths therefore, would not provide the necessary cover utilized by fisheries resources. Loss of freshwater marsh habitat would result in a decline in abundance of freshwater fish species. Adverse impacts of the refuge fishing program include deliberate introductions of non-native fish, and accidental introductions of invasive plants, pathogens, and exotic, invasive invertebrates. We will continue enforcement, outreach, and education to explain the impacts of those introductions. State regulations for fishing would be adhered to, which establish species and harvest limits to insure no cumulative impact on any fish populations. Management actions would result in local long-term minor adverse impacts.	Salt water intrusion into freshwater marshes may result in direct mortality or stress on freshwater fish species due to increased salinity. During the marsh restoration process, short-term minor adverse impacts may occur when a thin layer of silt is applied to the marsh surface, potentially causing an increase in the suspension of sediments and affecting the BOD on fisheries resources. Short-term minor to moderate direct adverse impacts to certain fish species may occur in restored marshes if these fish become restricted to areas of low dissolved oxygen and elevated temperatures. Fishing impacts will increase from those described under alternative A, and new opportunities in Goose and Flaxhole Ponds, night fishing at Fowler Beach, and fishing at the pulloffs along Prime Hook Beach Road would create the potential for those direct and indirect impacts to fisheries in the new areas. We will continue to work with DEDFW on outreach, education, and law enforcement. Requiring catch and release regulations and the mandatory use of barbless hooks in Turkle Pond, Fleetwood Pond, Goose Pond, Flaxhole Pond, and portions of Prime Hook Creek will decrease fish injury and mortality. Increased deer and waterfowl hunting will cause increased suspension of bottom sediments from boat motors. Management actions would result in short-term minor-to-moderate adverse impacts.	Diking and drainage of impounded freshwater marshes may degrade water quality, release acidity and metals, cause summertime oxygen depletions and fish kills, and thereby further reduced finfish populations Potential impacts from fishing are similar to alternative A. Hunting is expected to cause more impacts to fisheries than in alternative A, but less than alternative B. Management actions would result in a local long-term minor-to-moderate adverse impacts.
Mammals	Passive reforestation will increase DFS habitat and help sustain population viability for the long term. Increased forest cover also benefits bat species that gain increased roosting and brood rearing habitats. Along riparian buffer zones, increased forest cover benefits otter, mink, weasel, and beaver. Grassland and shrubland that develop naturally have direct benefits for many mammal species. Management actions would result in short-term and long-term minor-to-moderate direct beneficial impacts.	Same as alternative A, plus afforestation projects will increase DFS habitat and help sustain population viability for the long term. Increased forest cover also benefits bat species that gain increased roosting and brood rearing habitats. Along riparian buffer zones, increased forest cover benefits otter, mink, weasel, and beaver. Grassland and shrubland maintenance and enhancement has direct benefits for voles, moles, shrews, mice, rabbits, groundhogs, and deer. Carnivores and omnivores such as fox, skunk, mink, long-tailed weasel, coyote, opossum, and raccoon will thrive in ecotone areas between field and forest. Management actions would result in short-term and long-term minor-to-moderate direct beneficial impacts.	Continue strategies and management actions to conserve and maintain biological integrity, diversity, and environmental health of refuge habitats that have direct benefits for mammal population on the refuge. Controlling invasive and nuisance species, restoring native plant communities where appropriate, and improving habitat conditions for the endangered DFS, are conservation actions that have short-term, long-term and cumulative impacts benefiting mammalian populations on the refuge. Management actions would result in indirect long-term minor-to-moderate beneficial impacts.

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Mammals (cont.)	Deer or small game hunting results in the direct removal of individuals, but annual seasons and harvest are set by the Delaware Division of Fish and Wildlife and would not jeopardize population viability. Hunting benefits the health of the remaining individuals, and benefits species negatively affected by deer overbrowsing. Hunting for deer or small game, especially when dogs are present, results in direct, short-term disturbance of other resident mammals. The presence of humans will disturb most mammals, which typically results in a temporary displacement without long-term effects on individuals and populations. Management actions would contribute negligible short-term, site-specific, local, and regional, adverse impacts on hunted and non-hunted species.	Efforts to reduce predation pressure on migratory birds of concern, especially to benefit species that nest on beaches and overwash habitats would entail lethal removal of individual mammals from suitable nesting and brood rearing habitat. The removal of a few individual mammals from such localized areas would have a negligible adverse impact on the population as a whole. Maintenance activities such as brush-hogging and burning prescribed fires carry a direct risk to some individuals among small mammals, but the adverse impacts are short-term and negligible. Negligible to indirect adverse minor impacts are expected due to the removal of protective cover, which exposes small rodents and rabbits to predation or cold if in the winter. Indirect impacts from visitor activities would increase from those activities described under alternative A. Impacts would be minimized by requiring visitors to stay on designated new and existing trails. Direct hunting impacts would be similar to alternative A for small game; however, the deer harvest is expected in increase. Increased hunting opportunities, particularly with turkey hunting during April and May, will increase disturbance to mammals; however, impacts are expected to be minimal due to the small number of permitted turkey hunters (no more than five). Management actions in alternative B would result in negligible to short-term indirect minor adverse impacts.	Impacts to mammals from hunting will be similar to alternative B and impacts from other public use will be similar to alternative A.

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Amphibians and Reptiles	This alternative provides the habitat improvements beneficial for herpetiles, through passive conversion of upland fields to natural vegetation: Maintaining, enhancing, and restoring native forest cover Maintaining and protecting downed woody debris in forest floor Decreasing forest fragmentation and creating connecting corridors Enhancing connectivity between upland and wetland areas Restoring natural surface and ground water hydrology in prior converted wetlands	This alternative provides the most habitat improvements beneficial for herpetiles through active restoration: Maintaining, enhancing, and restoring native forest cover Maintaining and protecting downed woody debris in forest floor Decreasing forest fragmentation and creating connecting corridors Enhancing connectivity between upland and wetland areas Restoring natural surface and ground water hydrology in prior converted wetlands Reduced use of adulticides should provide direct benefits on wetlands and on reptiles and amphibians. The refuge will maintain connectivity between wetlands and upland forest habitats that serve as travel corridors for herpetiles. In impounded wetlands, newly restored brackish/saline wetland habitat will likely be colonized by the State-listed northern diamondback terrapin. Management actions would result in local, long-term minor-to-moderate beneficial impacts.	Protecting or improving conditions of existing mixed hardwood communities for DFS, wetland forest habitats, and freshwater marsh areas, also provides habitat for numerous amphibian and reptile species of interest. Shallow lotic areas and vernal pool habitats shaded by canopy trees are crucial breeding sites from February to late summer and for over-wintering amphibians. Maintenance of grassland and shrubland habitats provides direct benefits for reptiles and to a lesser extent for amphibians. Management of Unit II and Unit III wetlands as freshwater impoundments would have a moderate beneficial impact on a number of amphibian species that prefer freshwater wetlands. Management actions would result in short-term local minor-to-moderate beneficial impacts. Reduced use of adulticides should provide direct benefits on wetlands and on reptiles and amphibians.
	Use of mosquito adulticide and larvicides will have direct adverse impacts on aquatic and terrestrial invertebrates (including mosquitoes) and non-target insects, posing indirect adverse impacts for reptiles and amphibians. High salinities from saltwater intrusion render the wetlands inhabitable to most herpetiles. Visitor activities and improvements have the potential to disturb amphibians and reptiles. Roads and trails may create barriers or hazards to movement. Use of roads and trails by visitors may disturb species along those corridors. Those impacts are localized, concentrated in size and distribution, and relatively insignificant when considering the extent of all refuge land. Management actions would result in long-term local minor-to-moderate adverse impacts.	Salt marsh restoration may have minor-to-moderate adverse impacts on individual reptiles and amphibians (mortality) if they are not capable of emigrating upstream to areas with reduced salinities. Indirect impacts from visitor activities would increase from those activities described under alternative A. Impacts will be minimized by requiring visitors to stay on new and existing trails. Impacts from hunters are expected to be negligible because colder weather during the hunting season limits the activity of amphibians and reptiles. Management actions would result in local minor-to-moderate beneficial impacts.	Freshwater impoundments provide suitable habitat for many herpetiles, amphibians in particular. The refuge farming program may result in moderate local long-term adverse impacts. The use of such herbicides has been associated with adverse impacts on amphibians. Potential impacts to amphibians and reptiles from public uses will be greater than alternative A, but less than alternative B. Impacts are expected to be negligible.

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Invertebrates	In the absence of proactive restoration of salt marsh habitat, the benefits of salt marsh for certain invertebrates will not be realized as quickly or possibly to the same extent as under alternative B. Management actions will have moderate local, long-term beneficial impacts.	Increased restoration and maintenance of grassland, shrubland, and forested habitats will significantly increase refuge coverage of native plants for pollinating, herbivorous, and predatory invertebrates that provide ecological services and provide principle nutrition and food resources for migratory birds, fish, reptiles, amphibians, and mammalian species. An important direct benefit for refuge invertebrate populations is the removal of the cooperative farming program and conversion to native plant communities. Beach overwash processes would be permitted to occur unimpeded in alternative B, having a beneficial impact on invertebrates that utilize the intertidal area. Surf zones and tidal inlets are important nursery and foraging areas for fishes and waterbirds because of high densities of invertebrates. Restoration of salt marsh in impounded wetlands will benefit invertebrate species that favor salt marsh though the shift in invertebrate species composition may lag behind the shift in vegetation communities by a decade or more. Reduced use of adulticides, to support the limiting of direct mortality to refuge insect populations, will benefit pollinator insect species, rare insects, and other non-target invertebrates, thereby providing a larger, potentially more diverse food base for migrating and breeding shorebirds, landbirds, secret marsh birds, waterfowl and other wildlife. Management actions would, overall, result in moderate local, long-term beneficial impacts.	Continued water level management will maintain and enhance annual invertebrate production (especially benthic macroinvertebrates). Continued habitat management of native plant communities will benefit the invertebrates dependent on those communities. These benefits to invertebrates will benefit the migratory birds, fish, and other resident wildlife, which depend on invertebrate food resources. Management actions would result in local minor beneficial impacts.

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Invertebrates (cont.)	Use of mosquito adulticide and larvicides will have direct adverse impacts on aquatic and terrestrial invertebrates, including mosquitoes and non-target insects, posing potential long-term indirect adverse impacts to the ecological systems that support the refuge at lower trophic levels Management actions will result in minor local short-term adverse impacts.	Prescribed fire can have adverse impacts on invertebrates. The difference between causing beneficial or adverse impacts to invertebrates from mowing as a habitat management strategy is based on timing, scale, and techniques used. To minimize adverse impacts from mowing and allow sufficient space and time for pollinator populations to recover, mowing a mosaic of patches over several years is better than mowing all habitats at the same time, and no single areas should be mowed or burned more than once a year. It is expected that due to the sheer volume of invertebrates, populations adversely impacted by any shoreline or wetland sediment manipulation would recolonize and recover quickly. Reduced use of naled and continued use of Bti and methoprene on the refuge will result in the intended temporary reduction in adult and larval mosquito density, and a subsequent temporary local reduction in gross numbers of adult mosquitoes and potential shift in mosquito diversity. There may be a temporary adverse impact on both aquatic non-target invertebrate density and diversity, as well as adult non-target invertebrate density and diversity, e.g., chironomids, dragonflies. The Service recognizes that spray drift will likely enter the refuge from the three neighboring barrier island communities during mosquito control on those lands. Since the State employs best management practices, and follows the EPA approved label, the Service expects impacts to refuge resources to be negligible. Management actions would result in local short-term adverse impacts.	The State of No direct impacts of glyphosate resistance transgenes in plant material have been found on insects. Management actions would result local short-term and long-term minor-to-moderate adverse impacts. Delaware will still be permitted the limited use the larvicides Bti and methoprene, thus would still result in the adverse impacts to invertebrates.

Resources	Alternative A Current Management	Alternative B Service-Preferred Alternative	Alternative C Historic Management
Public Use and Access	We would continue to maintain the existing programs for all six priority public uses. Demand would continue to be satisfied for all but would be limited with interpretation and environmental education. No major conflicts among visitors engaged in respective wildlife dependent uses or programs. Implementing public access closures, for either wildlife protection (some seasonal/temporary) or to reduce user conflicts, would continue and may inconvenience some visitors Impacts and opportunities associated with hunting would not change.	There would be enhanced interpretation and environmental education opportunities and therefore impacts under alternative B with the proposed expansion of the existing visitor contact station and refuge office, which would help the refuge satisfy demand. Plans to open previously closed refuge units to certain activities, such as hunting and wildlife observation, will increase visitor use, as well as the opportunity to conduct outreach and raise appreciation of the refuge and Refuge System. Increased visitation coupled with expanded programs might increase likelihood of conflicts among visitors, especially if certain activities require closing off areas of the refuge to others. Increased outreach and enforcement presence over time would also reduce violations. Area closures to protect wildlife would continue to inconvenience some visitors. Expanded opportunities and new approaches to the hunting program (blind sites, preseason drawings, etc.) will provide diverse hunting experiences to a broader hunting public.	Impacts for environmental education and interpretation would be increased from alternative B. Fishing, wildlife observation, and photography opportunities are similar to alternative A. Hunting opportunities for deer and waterfowl are the same as alternative B, except the number of days are decreased. Turkey hunting is closed and upland game and webless migratory bird hunting are the same as under alternative A.
	Under all alternatives, we would continue to provide compatible wildlife-dependent activities that can be supported with respective staff and budget projections. We would maintain our infrastructure to support those activities and provide safe access. We would continue to conduct outreach to visitors and the local communities to instill an appreciation of the Refuge System and the refuge, its resources, and our priorities for management.		

Chapter 6

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Northern bobwhite

Consultation and Coordination with Others

- Introduction
- Public Involvement Summary
- Public and Partner Involvement
- List of Preparers

Introduction

Effective conservation usually begins with effective community involvement. To ensure that our future management of the Refuge considers the issues, concerns, and opportunities expressed by the public, we used a variety of public involvement techniques in our planning process. What follows is the chronology of public outreach activities we conducted while preparing the comprehensive conservation plan (CCP) and environmental impact statement (EIS) for Prime Hook National Wildlife Refuge (NWR).

Public Involvement Summary

We began the CCP process for Prime Hook NWR in 2005. We published our original Notice of Intent (NOI) in the *Federal Register* on October 17, 2005, stating we intended to prepare a CCP and environmental assessment for the refuge and announcing a public scoping period. During the scoping period, we solicited comments on the major issues that the public and others felt we would address in the CCP. We also held several public meetings during the scoping period.

Based on the extent of public comments received and subsequent developments since scoping, we determined that an EIS would be more appropriate than an EA. We felt that an EIS was necessary to ensure that a full and fair discussion of all significant environmental impacts occurs and to inform decision-makers and the public of the reasonable alternatives that would avoid or minimize adverse impacts and enhance the quality of the human environment. We published a second NOI in the *Federal Register* on May 9, 2011, announcing that we complete an EIS rather than EA. We also announced that we were accepting additional scoping comments through June 23, 2011.

We used the input we received during the scoping periods to prepare the draft CCP/EIS. On May 31, 2012, we published a notice of availability (NOA) in the *Federal Register*. The NOA announced the availability of the draft CCP/EIS for 60 days public review and comment. We published a second NOA on August 8, 2012 extending the public comment period through August 27, 2012. During the public comment period, we held six public meetings and one formal hearing, as well as three informal refuge open houses. During the draft CCP/EIS comment period, we received over 100 written comments and 19 oral comments. After compiling all of the responses we received, we wrote responses to all of the substantive comments. We include our responses to these comments as an appendix to this final CCP/EIS. Based on these comments, we made several modifications to alternative B in the final CCP/EIS.

For further information or questions please contact:

Thomas Bonetti, Planning Team Leader
U.S. Fish and Wildlife Service, Region 5
300 Westgate Center Drive
Hadley, 01035-9589 Email: *northeastplanning@fws.gov*

Public and Partner Involvement

Planning Updates, Surveys, and other Newsletters

September 2004–September 2005 Distributed 429 visitor surveys and 1,430 community surveys in cooperation with U.S. Geological Survey (USGS)

June 2005 Distributed newsletter announcing planning efforts for habitat management and hunting, and other issues including wood duck boxes

September 2005 Distributed a news release about migratory bird management at the refuge

December 2006 Distributed our “Conservation Planning Update” newsletter

August 2007 Distributed an updated “Conservation Planning Update” newsletter and completion of Final Report for Visitor and Community Survey Results for PHNWR by USGS

May 2011 Distributed a news release about completing an environmental impact statement instead of the originally anticipated environmental assessment

May 2012 Distributed a news release, *Federal Register* Notice, and newsletter announcing that the draft CCP/EIS was available for public review and comment. These also announced the length of the public comment period, where people could send written comments, and the dates and times of public meetings.

Public Scoping Meetings–Meeting Our Refuge Neighbors

July 13, 2005 (Town Meeting before public scoping meetings began)
Number of non-FWS attendants: 130
Location: Milton, DE

November 8, 2005 Number of non-FWS attendants: 110 (total for all 3 meetings)
Location: Milton, DE

November 9, 2005 Number of non-FWS attendants: 110 (total for all 3 meetings)
Location: Dover, DE

November 10, 2005 Number of non-FWS attendants: 110 (total for all 3 meetings)
Location: Lewes, DE

Public Meetings During the Draft CCP/EIS Public Comment Period

June 5, 2012 Public meeting focused on habitat management, Milford, DE

June 7, 2012 Public meeting focused on hunting, Milford, DE

June 9, 2012 Public meeting focused on habitat management, Milton, DE

June 12, 2012 Public meeting focused on hunting, Lewes, DE

June 14, 2012 Public meeting focused on wildlife observation, photography, fishing, environmental education, and interpretation, Milton, DE

Meetings with State Partners and Other Conservation Experts

June 19, 2012 Formal public hearing, Lewes, DE

July 19, 2012 Public meeting, Milford, DE

July 18-19, 2006

Outreach activity: Partners Workshop

Purpose: Develop a vision statement and goals for PHNWR

Number of non-FWS attendants: 14

Audience: Rob Gano, Delaware Division of Fish and Wildlife; Bill McAvoy, Delaware Natural Heritage Program; Glenn Garner, Friends of PHNWR; Otis Clifton, local landowner & farmer; Bill Fintel, local citizen & birder; Glen Wells, refuge cooperative farmer; David Weber, Sussex Bird Club; Joe Farrell, University of Delaware Sea Grant Program; Jim White, Delaware Nature Society; Nick DiPasquale & Mark Martel, Delaware Audubon Society; Jay Walls, Delaware Bassmasters; Jeff Gordon, Delmarva Ornithological Society; Jamie West, refuge hunter; Bill Jones, Jonathan Schafler, Annabella Larsen, George O'Shea, Tom Bonetti, Marci Caplis (moderator), Al Rizzo, USFWS

January 18, 2007

Outreach activity: Technical Workshop

Purpose: Share information and discuss the refuge's most important state and regional contributions to the conservation of federal trust resources within the framework provided by the refuge's establishment purposes, the National Wildlife Refuge System mission and its policies.

Number of non-FWS attendants: 10

Audience: Rob Gano & Bill Meredith, Delaware Division of Fish and Wildlife; Bill McAvoy, Delaware Natural Heritage Program; Joe Farrell, University of Delaware Sea Grant Program; Nick DiPasquale, Delaware Audubon Society/ Duffield Associates; Rachel Dawson, Ducks Unlimited; Jennifer Wheatley, Delaware Division of Soil and Water; Mark Nardi, US Geological Survey, MD-DE-DC; Mick McLaughlin, JCM Environmental Consultants; Cory Whaley, University of Delaware Cooperative Extension Service; Bill Jones, Jonathan Schafler, Annabella Larsen, George O'Shea, Tom Bonetti, Rick McCorkle, & Hal Laskowski, USFWS.

June 19-20, 2007

Outreach activity: Technical Workshop

Purpose: Identify priority resources of concern and develop draft biological objectives for PHNWR

Number of non-FWS attendants: 2

Audience: Rob Gano, Delaware Division of Fish and Wildlife; Robert Coxe, Delaware Natural Heritage Program; Bill Jones, Jonathan Schafler, Annabella Larsen, George O'Shea, Rick McCorkle, Hal Laskowski, Jan Taylor, Terry Villanueva, Ray Brown, Steve Funderburk, Greg Breese, Susan Guiteras, & Oscar Reed, USFWS.

May 7, 2008

Outreach activity: Planning meeting

Purpose: Review background hunting information and prepare hunting objectives and strategies

Number of non-FWS attendants: 3

Audience: Rob Gano, Ken Reynolds, & Pat Emory, Delaware Division of Fish and Wildlife; Bill Jones, Oscar Reed, Michael Stroeh, Tony Leger, Tom Bonetti, USFWS.

July 9, 2008

Outreach activity: Technical Workshop

Purpose: Develop draft public use objectives for PHNWR

Number of non-FWS attendants: 4

Audience: Rob Gano & Ken Reynolds (Wildlife), Craig Shirey (Fisheries), Delaware Division of Fish and Wildlife; Kendall Summers, Delaware Division of Parks & Recreation; Bill Jones, Annabella Larsen, George O'Shea, Susan Guiteras, Tom Bonetti, Julie Study, Tina Watson, Michael Dixon, Michael Stroeh, & Oscar Reed, USFWS.

April 22, 2010

Outreach activity: Planning meeting

Purpose: Review internal draft CCP document and alternatives with Delaware Division of Fish and Wildlife staff

Number of non-FWS attendants: 15

July 2012

Meeting with Senator Carper, his staff, and Tony Pratt from DNREC to provide an update on the CCP and discuss the draft CCP/EIS.

October 2012

Refuge tour and CCP update with Congressman Carney.

List of Preparers

Core Planning Team

Thomas Bonetti, Senior Refuge Planner and Planning Team Leader
Affiliation: USFWS Region 5 Regional Office

Education: B.S. Biology, M.S. Recreation Administration

Experience: USFWS, Region 5 Refuge Planner, 1998-present

U.S. Army Corps of Engineers, 1992-1998
California Department of Parks and Recreation, 1990-1992

Michael Stroeh, Project Leader
Affiliation: Coastal Delaware Refuge Complex, Bombay and Prime Hook NWRs (has since transferred to another refuge in Region 4)

Education: B.S. Wildlife Biology - University of Wisconsin - Stevens Point

Experience: Managed natural resources and public uses on national wildlife refuges for over 24 years.

Contribution: Participated completely in the planning and writing of CCP.

Oscar Reed, Jr., Deputy Refuge Manager
Affiliation: Coastal Delaware Refuge Complex; Bombay Hook NWR

Education: B.S. Biology

Experience: Natural resource and public use management for 19 years

Contribution: Assisted with CCP

Art Coppola, Refuge Manager
Affiliation: Prime Hook NWR

Education: B.S. in Natural Resources Management, University of Maryland–College Park, Humboldt State University, California

Experience: Refuge Management 3 years

Contribution: Assisted with CCP

Susan Guiteras, Wildlife Biologist
Affiliation: Coastal Delaware Refuge Complex
Bombay and Prime Hook NWRs
Education: B.S. Biology, M.S. Wildlife Ecology
Experience: Wildlife Biologist, USFWS, 13 years
Contribution: Participated in the writing of CCP, prepared maps.

Annabella Larsen, Wildlife Biologist
Affiliation: Coastal Delaware National Wildlife Refuge Complex;
Prime Hook NWR
Education: B.S. in Chemistry – Rutgers University 1982; B.S. in Biology – Salisbury State University 1986; B.S. Wildlife Management – Delaware State University – 1993.
Experience: Wildlife Biologist, USFWS, 19 years
Research Biologist – University of Salisbury, Maryland 1986-1988
Research Biologist – Wildlife International, Maryland 1988-1990
Engineering Technician – 1980-1982 Exxon Corporation
Contribution: Helped write all Chapters of CCP, HMP, some Compatibility Determinations

Daniel Stotts, Wildlife Biologist
Affiliation: Coastal Delaware Refuge Complex; Bombay and Prime Hook NWRs
Education: B.S. in Biology - University of Maryland - College Park
Experience: Wildlife Biologist, USFWS, 30 years
Contribution: Assisted with Chapters 2 & 4, HMP and Compatibility Determinations

Bill J. Jones, Visitor Services Manager
Affiliation: Coastal Delaware Refuge Complex; Prime Hook NWR
Education: B.S. & M.S. Fisheries Science and Management
Experience: Visitor Services Manager, USFWS, 12 years
Contribution: Visitor Services section of CCP and Compatibility Determinations. Prepared public outreach material including website updates, CCP newsletter articles, and database.

Assistance from other Service Personnel

Louise Kotarba
George O'Shea
Jennifer McAndrews
Dale Hudson
Mike Higgins
Al Rizzo
Tina Watson
Laura Mitchell
Kate McManus
Jonathan Schafler
Brian Braudis
Virginia Rettig
Brittany Benson
Meredith Bixby

Assistance from Federal, State, Local and other Partners

Delaware Bay Estuary Project
Delaware Division of Fish & Wildlife
Delaware Division of Soil & Water
Delaware Natural Heritage Program
Delaware Coastal Program
Delaware Division of Parks & Recreation
U.S. Geological Survey
Joyce Lindsay
Betty Kirk


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Snowy egret

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Horseshoe crab eggs

Glossary and Acronyms

Glossary

40% Migratory Bird Hunting Rule: "if a refuge, or portion thereof, has been designated, acquired, reserved, or set apart as an inviolate sanctuary, we may only allow hunting of migratory game birds on no more than 40 percent of that refuge, or portion, at any one time unless we find that taking of any such species in more than 40 percent of such area would be beneficial to the species (16 U.S.C. 668dd(d)(1)(A), National Wildlife Refuge System Administration Act; 16 U.S.C. 703-712, Migratory Bird Treaty Act; and 16 U.S.C. 715a-715r, Migratory Bird Conservation Act).

Abiotic: Not biotic; often referring to the nonliving components of the ecosystem such as water, rocks, and mineral soil.

Access: reasonable availability of and opportunity to participate in quality wildlife-dependent recreation.

Accessibility: the state or quality of being easily approached or entered, particularly as it relates to complying with the Americans with Disabilities Act.

Accessible facilities: structures accessible for most people with disabilities without assistance; facilities that meet UFAS standards; ADA-accessible

[E.g., parking lots, trails, pathways, ramps, picnic and camping areas, restrooms, boating facilities (docks, piers, gangways), fishing facilities, playgrounds, amphitheaters, exhibits, audiovisual programs, and wayside sites.]

Acetylcholinesterase: An enzyme that breaks down the neurotransmitter acetycholine to choline and acetate. Acetylcholinesterase is secreted by nerve cells at synapses and by muscle cells at neuromuscular junctions. Organophosphorus insecticides act as anti-acetyl cholinesterases by inhibiting the action of cholinesterase thereby causing neurological damage in organisms.

Actinorhizal plants: These plants have the ability to form nitrogen fixing nodules that confers a selective advantage in poor soils. Actinorhizal plants are characterized by their ability to form a symbiosis with the nitrogen fixing actinomycete *Frankia,* an association that leads to the formation of nitrogen-fixing root nodules. Most actinorhizal plant species are tree and scrub species that pioneer or colonize disturbed soils where available nitrogen is scarce. Several native shrubs and trees play this critical role in enriching the soil and enabling the establishment of other native plants in natural ecological succession. An example of an actinorhizal plant on the refuge is sweetgum.

Activity: What visitors do at a national wildlife refuge. The economic benefits to local communities of refuge visitation report (*Banking on Nature*) identifies visitor activities being grouped into hunting, fishing, and non-consumptive uses.

Adaption: adjustment to environmental conditions

Adaptive Management: The process of implementing policy decisions as scientifically driven management experiments that test predictions and assumptions in management plans, and using the resulting information to improve the plans.

Adventive: A species native to North America but not to Delaware that is now found growing in Delaware outside of its natural range. Adventive species are not considered to be part of Delaware's native flora and are treated as alien species in statistical summaries. These species are usually introduced by human-caused breakdowns of natural barriers to dispersal. In most cases, adventive species have not yet become widely or well established and may or may not be a threat to indigenous plant communities in Delaware. Adventive species also include plants that have been introduced, or intentionally planted in Delaware and are now escaping and surviving without cultivation.

Aestivation: Also known as "summer sleep" is a state of animal dormancy somewhat similar to hiberation. It takes place during times of extreme heat and dryness. Invertebrates (like crabs and especially many insect species) and vertebrate animals are known to enter this state to avoid damage from high temperatures and the risk of desiccation. Both terrestrial and aquatic animals undergo aestivation (from Latin aestas = summer).

Afforestation: is establishing a forest on land that is not a forest, or has not been a forest for a long time by planting trees or their seeds. The term reforestation refers to the reestablishment of the forest after its removal, or planting more trees in the same place after timber harvest.

Agricultural Land: Nonforested land (now or recently orchards, pastures, or crops)

Alternative: a set of objectives and strategies needed to achieve refuge goals and the desired future condition.

Amphipods: A group of nocturnal macroinvertebrates belonging to the order of Amphipoda and known as scuds, side-swimmers or freshwater shrimp. They range in size from 5-20 mm long and are restricted to cool, shallow water marshes and generally are found in permanent wetland habitats. They are important protein food sources for waterfowl.

Anadromous Fish: Fish that spend their adult lives in the sea but swim upriver to fresh water to breed (striped bass, American shad, river herring, and sturgeon).

Annual: a plant that flowers and dies within one year of germination

Appropriate Use: a proposed or existing use on a refuge that meets at least one of the following three conditions:

1. the use is a wildlife-dependent one;
2. the use contributes to fulfilling the refuge purpose(s), the System mission, or goals or objectives described in a refuge management plan approved after October 9, 1997, the date the National Wildlife Refuge System Improvement Act was signed into law; or
3. the use has been determined appropriate as specified in section 1.11 of that act.

Approved Acquisition Boundary: a project boundary that the Director of the U.S. Fish and Wildlife Service approves upon completion of the planning and environmental compliance process. An approved acquisition boundary only designates those lands which the Service has authority to acquire or manage through various agreements. The approval of an acquisition boundary does not grant the Service jurisdiction or control over lands within the boundary, and it does not make lands within the refuge boundary part of the National Wildlife Refuge System. Lands do not become part of the System until the Service buys them or they are placed under an agreement that provides for their management as part of the System.

Aquatic: growing in, living in, or dependent upon water.

Aquifer: An underground layer of permeable rock, sediment (usually sand or gravel), or soil that yields water. The pore spaces in aquifers are filled with water and are interconnected, so that the water flows through them. Aquifers can range from a few square kilometers to thousands of square kilometers in size.

Area of Emphasis: (AOE) priority pubic uses (hunting, fishing, environmental education, interpretation, wildlife observation, or photography) on a refuge that will be most effective in providing quality opportunities for visitors on that refuge. Every refuge has two AOE's, which were determined based on careful consideration of natural resources, existing staff, operational funds, and existing and potential facilities.

Area-sensitive Species: Species that require large areas of contiguous habitat.

Assemblage: In conservation biology, a predictable and particular collection of species within a biogeographic unit (ecoregion or specific habitat type).

ASMFC: Atlantic States Marine Fisheries Commission is a compact of the 15 Atlantic states created to "promote the better utilization of the fisheries, marine, shell and anadromous, of the Atlantic seaboard by the development of a joint program for the protection and conservation of such fisheries." The Commission conducts interstate fisheries management by coordinating the conservation and management efforts of 22 Atlantic coastal fish species and species groups—to maintain healthy, self-sustaining populations for all Atlantic coast fish species or successful restoration in progress by the year 2015.

Avian: of or having to do with birds

Avian Influenza: or "bird flu" is a disease caused by a virus that infects birds, including pets, domestic poultry, and wild birds.

Baiting: the direct or indirect placing, exposing, depositing, distributing, or scattering of salt, grain, or other feed that could lure or attract wildlife to, on, or over any areas where hunters are attempting to take them.

Basin: The land surrounding and draining into a water body (cf "watershed").

Benthos: Plants and animals that live on the bottom of aquatic environments.

BCC 2002 = Birds of Conservation Concern: A list develop in 2002 by the United States Fish and Wildlife Service to adhere to the mandate of the Fish and Wildlife Conservation Act, that instructs the Service to "identify species, subspecies, and populations of all migratory nongame bird that, without additional conservation actions are likely to become candidates for listing under the Endangered Species Act of 1973." The BCC 2002 list identifies both migratory and non-migratory bird species beyond those already designated as federally threatened or endangered, that represent the Services highest conservation priorities requiring proactive conservation action to survive.

Bioconcentration: A process resulting in concentration of persistent, fat-soluble compounds like PCBs, DDT, and methyl mercury in organisms at successively higher trophic levels of a food chain or web.

Biogeography: The scientific study of the geographic distributions of organisms.

Biological diversity or Biodiversity: The variety of life and its processes; it includes the variety of living organisms, the genetic differences among them, the communities and ecosystems in which they occur, and the ecological and evolutionary processes that keep them functioning in a healthy manner, yet ever changing and adapting. An ecosystem has greater biodiversity when it contains more species.

Biological Integrity: Biotic composition, structure, and functioning at genetic, organism, and community levels comparable with historic conditions, including the natural biological processes that genomes, organisms, and communities.

Biological Oxygen Demand (BOD): is a chemical procedure for determining how fast biological organisms use up oxygen in a body of water. It is used in water quality management and assessment, ecology and environmental science. BOD is not an accurate quantitative test, although it is often used as an indication of the quality of a water source. It is listed as a conventional pollutant in the U.S. Clean Water Act. BOD measures the rate of oxygen uptake by micro-organisms in a sample of water at a temperature of 20^{O} C and over an elapsed period of five days in the dark.

Typical BOD values: most pristine rivers will have a BOD below 1 mg/L. Moderately polluted waters will range from 2 to 8 mg/L, while municipal sewage that is treated in a three-stage process would have a BOD ~ 20 mg/L or less.

Biomass: The total mass or amount of living organisms in a particular area or volume

Biota: All of the organisms, including animals, plants, fungi, and micro-organisms, found in a given area.

Biotic Impoverishment: Loss of biota and biotic processes; virtually synonymous with the loss of biodiversity.

Blind Site: a designated area identified by a numbered marker where hunting is permitted; hunters can camouflage themselves in the area's natural vegetation, through the use of boat blinds, or construct temporarily construct ground blinds to reduce the chance of detection by sought after game.

Bog: A wetland type characerterized by saturated, acidic soil and peat accumulating due to poorly drained area rich in plant residues, usually surrounded by an area of open water, and having characteristic and diverse flora and fauna.

BP: **"Before the Present"** (Pre-contact eras are often given in either calendar years (B.C. and A.D.) or in years "before the present." BP is a notation developed as part of the radiocarbon-dating process and indicates a calibrated point measured from 1950. For example, 4950 BP is approximately the same as 3,000 B.C., while 200 BP is about the same as 1750 A.D. This approximation is necessary because there are correction factors used for BP dates, while there are none for calendar dates.

Brackish: Having a salinity between that of fresh and sea water (saltier than fresh, but not as salty as sea).

Breeding Habitat: Habitat used by migratory birds or other animals during the breeding season.

Buffer Zones: Land bordering and protecting critical habitats or water bodies by reducing runoff and non-point source pollution loading; areas created or sustained to lessen the negative effects of human disturbance on animals, plants, and their habitats. Buffers are usually areas of permanent vegetation adjacent to a wetland of waterway that help prevent sediments and contaminants from entering wetlands and waterways.

Bug: In lay terms the word bug refers to tiny creatures that crawl along, such as insects like spiders and millipedes. But for scientists the word has a much narrower meaning. In the strictest terms bugs are insects that have mouthparts adapted for piercing and sucking. The mouthparts of bugs are contained in a beak-shaped structure. So scientists would classify water boatmen, water striders or a cockroach as a bug but not a beetle. In fact scientists call lice and their relatives **true bugs** in the order HEMIPTERA to distinguish them from what everyone else calls bugs.

Bryophytes: A member of a large group of seedless green plants including the mosses, liverworts, and hornworts. Bryophytes lack the specialized tissue xylem and phloem that circulate water and dissolved nutrients in the vascular plants. Bryophytes generally live on land but are mostly found in moist environments as they have free-swimming sperm that require water for transport. In contrast, the gametophyte (haploid) generation of bryophytes constitutes the larger plant form, while the smaller sporophyte (diploid) generation grows on or within the gametophyte and depends upon it for nutrition.

Candidate Species: Species for which we have sufficient information on file about their biological vulnerability and threats to propose listing them.

Canopy: the layer of foliage formed by the crowns of trees in a stand. For stands with trees of different heights, foresters often distinguish among the upper, middle and lower canopy layers. These represent foliage on tall, medium, and short trees. The uppermost layers are called the overstory.

Carbon sequestration: is a geoengineering technique for the long-term storage of carbon or other forms of carbon, for the mitigation of global warming. Carbon dioxide is usually captured from the atmosphere through biological, chemical or physical processes. It has been proposed as a way to mitigate the accumulation of greenhouse gasses in the atmosphere released by burning fossil fuels. For example, reforestation of croplands has greater potential for carbon sequestration as carbon dioxide is transferred from the air and stored into the new biomass of trees for a longter period of time.

Catadromous fish: Fish that migrate downstream in the direction of the sea, usually to reproduce like the American eel.

C & D Canal: In 1824, the construction of the Chesapeake and Delaware Canal began. The new route shortened the distance between Philadelphia and Baltimore by 300 hundred miles. Completed in 1829, the Canal was 19 miles long (13.6 miles through Delaware), 10 feet deep by 36 feet wide.

Cenozoic: The geological era that began 65 million years ago and extends to the present. It followed the Mesozoic Era and is subdivided into the Tertiary and Quaternary periods. The Cenozoic is also known as the **Age of Mammals** as these animals evolved to become an abundant, diverse and dominant group. Birds and flowering plants also flourished.

CFR: Code of Federal Regulations.

Chronic Wasting Disease: a contagious neurological disease affecting deer, elk and moose. It causes a characteristic spongy degeneration of the brains of infected animals resulting in emaciation, abnormal behavior, loss of bodily functions and death.

Combined Sewer Overflow: A pipe that during storms, discharges untreated wastewater from a sewer system that carries both sanitary wastewater and stormwater. The overflow occurs because the system does not have the capacity to transport and treat the increased flow caused by stormwater runoff.

Community: All the organisms---plants, animals, and microbes---that live in a particular habitat and affect one another as part of the food web or through their various influences on the physical environment. Communities in nature are convenient groupings of different organisms regularly found in the same place at the same time.

Community Type: A particular assemblage of plants and animals, named for its dominant characteristic.

Compatible Determination: Means a written determination signed and dated by the Refuge Manager and Regional Chief, signifying that a proposed or existing use of a national wildlife refuge is a compatible use or is not a compatible use. The Director makes this delegation through the Regional Director.

Compatible Use: Means a proposed or existing wildlife-dependent use or any other use of a national wildlife refuge that, based on sound professional judgment, will not materially interfere with or detract from the fulfillment of the National Wildlife System mission or the purpose(s) of the national wildlife refuge.

Comprehensive Conservation Plan: Means a document that describes the desired future conditions of a refuge or planning unit and provides long-range guidance and management direction to achieve the purposes of the refuge; helps fulfill the mission of the Refuge System; maintains and, where appropriate restores the biological integrity, diversity and environmental health of each refuge and the Refuge System; helps achieve the goals of the National Wilderness Preservation System; and meets other mandates.

Conifer: Belonging to the phylum of seed-bearing plants (Coniferophyta) comprising of trees and shrubs that include pines, firs and spruces. Conifers have an extensive fossil record going back to the late Devonian (geological period in the Palaeozoic era dating 408 to 360 million years ago) and are typically evergreen trees inhabiting cool temperate regions with leaves reduced to needles or scales. The wood of conifers, is called **softwood** in contrast to the **hardwood** of angiosperm trees. In tradition systems of classification conifers were classified as the Gymnospermae, but now are divided into separate phyla: Coniferophyta (conifers), Cycadophyta (cycads), Ginkophyta (ginkgo), and Gnetophyta.

Conservation: Means management activities used to sustain and, where appropriate, restore and enhance, health populations of fish, wildlife, and plants utilizing, in accordance with applicable Federal and State laws, methods and procedures associated with modern scientific resource programs. Such methods and procedures include protection, research, census, law enforcement, habitat management, propagation, live trapping and transplantation, and regulated taking as per the provisions of the Endangered Species Act.

Conservation Agreements: written agreements among two or more parties for the purpose of ensuring the survival and welfare of unlisted species of fish and wildlife or their habitats or to achieve other specified conservation goals. Participants voluntarily commit to specific actions that will remove or reduce threats to those species.

Conservation Biology: The biological science that studies the dynamics of diversity, scarcity, and extinction. It is a modern applied science for maintaining the earth's biological diversity and is a cross-disciplinary field that applies the principles of ecology, biogeography, population genetics, economics, biology, sociology, and anthropology to the maintenance and restoration of biodiversity. Conservation biology is a "mission-oriented" science and its goal is to conserve natural systems and biological diversity.

Conservation Easement: A legal agreement between a landowner and a land trust (that is, a private, nonprofit conservation organization or government agency) that permanently limits the uses of a property to protect its conservation values.

Consultation: a type of stakeholder involvement in which decision makers ask stakeholders to comment on proposed decisions or actions.

Consumptive, wildlife-oriented recreation: hunting and fishing

Cookie Cutter: a floating machine designed to maintain and cut thick infestation of aquatic weeds and unconsolidated bottom material in marsh ditches by spreading the cut material out over the marsh. It will not cut through consolidated sediment, logs, or stumps.

Cool-Season Grass: introduced grass for crop and pastureland that grows in spring and fall and is dormant during hot summer months.

Cooperative agreement: a usually long-term habitat protection action, which can be modified by either party, in which no property rights are acquired. Lands under a cooperative agreement do no necessarily become part of the National Wildlife Refuge System

Corridor: A more or less continuous connection between adjacent and similar habitats; examples in a landscape context include hedgerows, streams, and irrigation ditches.

Critical Habitat: According to Federal Law, the ecosystem(s) upon which endangered and threatened species depend.

Cultigen: An organism, especially a cultivated plant, such as the banana, not known to have a wild or uncultivated counterpart.

Cultural Resource Inventory: a professional study to locate and evaluate evidence of cultural resources within a defined geographic area

[N.b. Various levels of inventories may include background literature searches, comprehensive field examinations to identify all exposed physical manifestations of cultural resources, or sample inventories for projecting site distribution and density over a larger area. Evaluating identified cultural resources to determine their eligibility for the National Register follows the criteria in 36 CFR 60.4 (cf. FWS Manual 614 FW 1.7).]

Cultural Resource Overview: a comprehensive document prepared for a field office that discusses, among other things, project prehistory and cultural history, the nature and extent of known cultural resources, previous research, management objectives, resource management conflicts or issues, and a general statement of how program objectives should be met and conflicts resolved

[An overview should reference or incorporate information from a field offices background or literature search described in section VIII of the Cultural Resource Management Handbook (FWS Manual 614 FW 1.7).]

Cumulative effects: The combined effects of all management and other human activities on a defined area of land, a body of water, or both.

Database: a collection of data arranged for ease and speed of analysis and retrieval, usually computerized

Dbh: (diameter at breast height) — the diameter of the stem of tree measure at breast height (usually 4.5 feet above the ground). The term is commonly used by foresters to describe tree size.

Deer Hunting Stand: a permanent, elevated structure used in hunting to reduce the chance of detection by deer.

Degradation: the loss of native species and processes due to human activities such that only certain components of the original biodiversity persist, often including significantly altered natural communities

Designated Wilderness Area: an area designated by Congress as part of the National Wilderness Preservation System [FWS Manual 610 FW 1.5]

Desired Future Condition: the qualities of an ecosystem or its components that an organization seeks to develop through its decisions and actions.

Diadromous Fishes: Fish species that use both marine and freshwater habitats during their life cycle. Species can be **anadromous**, living primarily at seas but migrating to freshwater habitats to spawn, or **catadromous**, living in freshwater creeks, ponds and rivers but migrating out to seas to spawn. The anadromous strategy is far more common and examples of refuge focal management species that are anadromous include alewives, blueback herring and striped bass; while the catadromous strategy is less common but exemplified by American eel.

Diapause: A period of insect inactivity and reduced physiological function induced by environmental factors; occurs often in larval,catepillar, or chrysalis stages.

Digitizing: the process of converting maps into geographically referenced electronic files for a geographic information system (GIS)

Dieldrin: A chlorinated hydrocarbon ($C_{12}H_8Cl_6O$), used as an insecticide and in mothproofing.

Disturbance: is a change in envriomental conditions, which interferes with the functioning of a biological system. It is reflected by any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment and biological environment. Disturbance at a variety of spatial and temporal scales is a nuatural, and even essential component of many communities and is a key concept used in restoration ecology.

Disturbance Cycles: Periodic recurrence of particular natural disturbances such as fire or flooding.

Diversity: Ecological measure of the number of species and their relative abundance (evenness) in a community; a low diversity refers to relatively fewer number of species or more even abundance.

Donation: a citizen or group may wish to give land or interests in land to the Service for the benefit of wildlife. Aside from the cost factor, these acquisitions are no different than any other means of land acquisition. Gifts and donations have the same planning requirements as purchases.

Drawdowns: the drainage (dewatering) of a wetland corresponding to regional growing season lengths. In the mid-Atlantic region the growing season ranges from 160 to 280 days in length. The period of time during which drawdowns occur helps determine soil moisture, vegetative response, and wetland productivity. Slower drawdowns (> 30 days) are more desirable for plant production, invertebrate response and wildlife use (See Moist Soil Management).

Duck Hunting Blind: a permanent blind camouflaged with switch grass used in hunting to reduce the chance of detection by waterfowl.

Duff: Decomposed ground forest litter or humus. The forest floor, also called duff, is one of the most distinctive features of a forest ecosystem. It consists of shed vegetative parts such as leaves, branches, bark, stems, etc., existing in various stages of decomposition above the soil surface. Composed not only of inorganic material, it also teems with a wide variety of faun and flora. It is one of the richest components of the forest ecosystem from the standpoint of biodiversity because of large numbers of decomposers and predators ion invertebrates, fungi, algae, bacteria and archaebacteria (single-celled microorganisms).

Easement: An agreement by which landowners give up or sell one of the rights on their property [landowners may donate rights-of-way across their properties to allow community members access to a river (cf. “conservation easement)].

Ecoregion: A territory defined by a combination of biological, social, and geographic criteria, rather than geopolitical considerations; generally, a system of related, interconnected ecosystems.

Ecosystem: A dynamic complex of plant, animal, fungal, and microorganism communities and their associated nonliving (abiotic) environment interacting as an ecological unit; two primary axioms defining ecosystem structure and function are (1) recycling of essential elements, including biomass in different trophic levels following characteristic spatial and temporal patterns in each ecosystem type; and (2) certain emergent properties of self-regulation and self sustaining elements.

Ecosystem Approach: A strategy or plan to manage ecosystems to provide for all associated organisms, as opposed to a strategy or plan for managing individual species, by considering environmental information based on boundaries of ecosystems like watersheds, rather than on geopolitical boundaries.

Ecosystem Dysfunction: Disruption of functioning of ecological processes in an ecosystem.

Ecosystem Management: Any land-management system that seeks to protect viable populations of all native species, perpetuate natural-disturbance regimes on a regional scale, adopt a planning timeline of centuries, and allow human use at levels that do not result in long-term ecological degradation.

Ecosystem Service: A benefit or service provided free by an ecosystem or by the natural environment, such as clean water, flood mitigation, or groundwater recharge.

Ecotone: A transitional zone between two (or more) ecological communities, as between a forest and wetland or river and its estuary. An ecotone has its own characteristics in addition to sharing certain features of the other communities; also known as edge-effect.

Ecotourism: Visits to an area that maintains and preserves natural resources as a basis for promoting its economic growth and development.

Edaphic: Of or relating to the soil, especially as it affects living organisms. In ecology, **edaphic** refers to plant communities that are distinguished by soil conditions rather than by the climate.

Emergent Wetland: wetlands dominated by erect, rooted, herbaceous plants

Endangered Species: a Federal- or State-listed protected species in danger of extinction throughout all or a significant portion of its range

Endemic: **(n)** A species or race native to a particular place and found only there.
(adj.) Restricted to a specified region or locality.

Environment: The sum total of all biological, chemical, and physical factors to which organisms are exposed. We usually think of the environment as everything that surrounds us: air, soils, ocean, bay, wetlands, grasslands, forests, creeks, streams, ponds, birds, animals, insects, plants, fish, reptiles, amphibians

Environmental Assessment: (EA) a public document that discusses the purpose and need for an action, its alternatives, and provides sufficient evidence and analysis of its impacts to determine whether to prepare an environmental impact statement or a finding of no significant impact [40 CFR 1508.9].

Environmental Education: curriculum-based education aimed at producing a citizenry that is knowledgeable about the biophysical environment and its associated problems, aware of how to help solve those problems, and motivated to work toward solving them

Environmental Health: Composition, structure, and functioning of soil, water, air, and other abiotic features comparable with historic conditions, including the natural biotic processes that shape the environment.

Environmental Impact Statement: (EIS) is a detailed, written analysis of the environmental impacts of a proposed action, adverse effects of the project that cannot be avoided, alternative courses of action, short-term uses of the environment versus the maintenance and enhancement of long-term productivity, and any irreversible commitment of resources.[40 CFR 1508.11].

Environmental Justice: refers to inequitable environmental burdens borne by groups such as racial minorities, women, residents of economically disadvantaged areas, or residents of developing nations. Environmental justice proponents generally view the environment as encompassing where we live, work, and play (sometimes "pray" and "learn" are also included) and seek to redress inequitable distributions of environmental burdens (pollution, industrial facilities, crime, etc.) and equitably distribute access to environmental goods such as nutritious food, clean air and water, parks, recreation, health care, education, transportation, etc.

EPT Index: A widely used measure of environmental condition. This simple index is calculated as the number of different kinds of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). The EPT Index is useful because most of the species in these three orders of aquatic insects are sensitive to pollution and environmental stress. Of the three sensitive orders, Ephemeroptera and Trichoptera larvae are most useful for biomonitoring pollution and serve as reliable indication that the aquatic environment is healthy.

Ericaceous: Pertaining to a heath, or vegetation characteristics of low fertility, acidic, poorly drained soils, dominated by small leaved shrubs or Ericaceae (heathers and heaths) and Myrtaceae (myrtles).

Estuary: A coastal water body, with tidal mixing, where fresh water from rivers mixes with salt water from the ocean.

Eutrophication: The process during which a water body becomes highly loaded with nutrients, (primarily nitrogen and phosphorous), often causing oxygen depletion from unconsumed algal production.

Exotic: Species that occur in a given place, area, or region as the result of direct or indirect, deliberate or accidental introduction of the species by humans.

Extant: Now living; not destroyed or lost; not extinct.

Extinction: the termination of existence of a lineage of organisms (e.g., a subspecies or

species.

Extirpation: Local extinction; a species or subspecies disappearing from a locality or region without becoming extinct throughout its range.

Fauna: all animal life associated with a given habitat, country, area, or period

Federal Lands Recreation Enhancement Act: (REA) this Act, Public Law 108-447 (118 Stat. 2809), allows the government to charge a fee for recreational use of public lands managed by the Bureau of Land Management (BLM), the Bureau of Reclamation (BOR), the Fish and Wildlife Service (FWS), the National Park Service (NPS) and the Forest Service (USFS). The recreation fee program is a program by which fees paid by visitors to certain federal recreation sites are retained by the collecting site and used to improve the quality of the visitor experiences at those sites.

Federal-listed species: a species listed either as endangered, threatened, or a species at risk (formerly, a “candidate species”) under the Endangered Species Act of 1973, as amended

Federal Trust Resource: A resource that the Government holds in trust for the people through law or administrative acts. Federal trust resources are nationally and internationally important, like endangered species, migratory birds and fish that regularly move across state lines. They also include cultural resources protected by Federal historic preservation laws, and nationally important or threatened habitats, like wetlands, navigable waters, and public lands like national wildlife refuges.

Federal Trust Species: All species where the Federal government has primary jurisdiction including federally endangered or threatened species, migratory birds, anadromous fish, and certain marine mammals.

Fee-Title Acquisition: The acquisition of most or all of the rights to a tract of land; a total transfer of property rights with the formal conveyance of a title. While a fee-title acquisition involves most rights to a property, certain rights may be reserved or not purchased, including water rights, mineral rights, or use reservation.

Final Demand: The total spending by final consumers on all goods. The amount reported in **Banking with Nature** as the change in spending by final consumers in a given region attributable to refuge visitation. Final demand includes spending by people who earn income from refuge visitors’ activities as well as spending by refuge visitors themselves.

Finding of No Significant Impact: (FONSI) supported by an environmental assessment, a document that briefly presents why a Federal action will have no significant effect on the human environment, and for which an environmental impact statement, therefore, will not be prepared. [40 CFR 1508.13]

Fire Regime: The distinctive frequency, intensity, and spatial distribution of natural fires within a given locality, habitat-type or ecoregion.

Fish Consumption Advisories: a public notice issued by the Delaware Department of Natural Resources and Environmental Control and the Delaware Department of Health and Social Service’s Division of Public Health about the presence of chemical toxins in the flesh of finfish and shellfish taken from Delaware waters and the associated health risk to anglers and their families who consume their catch.

Fish Weir:	A means of providing safe upstream and downstream passage for migrating fish around a barrier.
Floodplain:	Flat or nearly flat lands that may be submerged by floodwaters; a plain built up or in the process of being built up by stream or tidal deposition.
Flora:	In botany, flora of a given area refers to all the plant life occurring in a given place or time that is naturally occurring or indigenous (native) plants.
Friends Group:	Any formal organization whose mission is to support the goals and purpose of its associated refuge and the National Wildlife Refuge Association overall; "friends" organizations and cooperative and interpretive associations.
Flyway:	any one of several established migration routes of birds
Focal Species:	a species that is indicative of particular conditions in a system (ranging from natural to degraded) and used as a surrogate measure for other species of particular conditions. An element of biodiversity selected as a focus for conservation planning or action. The two principal types of targets in Conservancy planning projects are species and ecological communities.
Foraging:	searching for food.
Forbs:	Flowering plants (excluding grasses, sedges, and rushes) that do not have a woody stem and die back to the ground at the end of the growing season.
Forest Ecology:	Is the scientific study of the interrelated patterns, process, flora, fauna, and ecosystems of land dominated by trees. The management if forests is silviculture.
Forested Wetlands:	wetlands dominated by trees
Forest Association:	A woodland community described by a group of dominant tree species that also occurs with other tree species.
Founder Effects:	Nonselective changes in the genetic makeup of a colonizing population during its establishment by a few founding individuals.
Fragmentation:	The disruption of large and contiguous habitats into isolated and small patches. Fragmentation has two negative components for biota: the loss of total habitat area, and the creation of smaller, more isolated patches with no connectivity.
FY:	Fiscal Year is from October 1 to September 30.
Geographic Information System:	(GIS) a computerized system to compile, store, analyze and display geographically referenced information [E.g., GIS can overlay multiple sets of information on the distribution of a variety of biological and physical features.]
Grassland:	A habitat type with landscapes dominated by native grasses and forbs and with biodiversity characterized by species with wide distributions, and plant communities are easily maintained with periodic mowing or burning. In such systems larger vertebrates, birds, invertebrates, reptiles and amphibians make extensive use of these areas which are rare today on the landscape.
Groundwater:	water in the ground that is in the zone of saturation, from which wells and springs and groundwater runoff are supplied

Guild: A group of organisms, not taxonomically related, but are ecologically similar in characteristics such as food preferences, behavior, or microhabitat requirement, or similar in their ecological role or niche in general.

Habitat: The place or type of site where species and species assemblages are typically found and/or successfully reproduce.

[N.b. An organism's habitat must provide all of the basic requirements for life, and should be free of harmful contaminants.]

Habitat Fragmentation: the breaking up of a specific habitat into smaller, unconnected areas

[N.b. A habitat area that is too small may not provide enough space to maintain a breeding population of the species in question.]

Hardwood Species: Tree species characterized by broad, flat leaves, as distinguished from coniferous or needle-leaved trees. Oak, cherry, maple, and hickory are examples.

Harvest Information Program: (HIP) is a method by which your state wildlife agency and the U.S. Fish and Wildlife Service are developing more reliable estimates of the number of all migratory birds harvested throughout the country. These estimates give biologists the information they need to make sound decisions concerning hunting seasons, bag limits, and population management.

Hemi-marsh: Diverse stands of emergent vegetation intermixed with equal areas of open water. This creates edge within the marsh, providing attractive habitat for waterfowl.

Herptile (plural herptiles): This term is used to encompass both reptiles and amphibians, especially in situations where a member of either group of animals is meant without excluding the other. ***Etymology:*** From *herpetology (the branch of zoology that deals with the study of reptiles and amphibians,* by blending with *reptile.*

Historic Conditions: Composition, structure, and functioning of ecosystems resulting from natural processes that based on sound professional judgment, were present **before** substantial human related changes happened to the landscape. The historic conditions benchmark, for the purposes of restoring biological integrity, diversity and environmental health, is the post-Pleistocene, pre-European time period of 800 AD to 1800 that serves as the **"historic conditions"** benchmark containing a range of historic variability.

Historic Range of Variability : **(HRV)** is a description of the change over time and space in the ecological condition of potential natural vegetation types and the ecological processes that shape those types. Potential natural vegetation types represent native vegetation types and characteristics that would occur when natural disturbance regimes and biological processes occur without human intervention as a reference point to maintain and/or restore biological integrity, diversity, and environmental health.

Holocene: The most recent geological epoch of the Quaternary period, or the end of the Pleistocene up to the present. It follows the final glacial episode of the Pleistocene and is sometimes referred to as the **Postglacial** epoch. The Holocene is the most often used ecosystem reference point when considering historical conditions and ecology and its application to ecosystem restoration. The Holocene comprises the past 10,000 years of the earth's history, or the period following the last glaciation (**the Wisconsinan**) during which the surface of North American took its modern form. The Holocene climatic event marks the last synchronous global disturbance that affected every element of the environment from sea levels to soil-forming processes to the distribution of plants and animals, including humans. The Holocene is when several human cultures began to move away from foraging and harvester-based economies into agriculturally based economies. (Egan and Howell 2001 **in** ***The Historical Ecology Handbook: A Restorationist's Guide to Reference Ecosystems)***

Hundreds: **The Hundreds of Delaware:**
The term "Hundred" denotes a political sub-division. It is an archaic method of dividing an area into administrative unit. About 1682, each Delaware county was subdivided into "hundreds." It denoted an area in which 100 men resided who could be easily mustered for service to the king. The term therefore designated an area in which 10 families with 10 members resided. "Hundreds" continued to represent an assessment or tax district which became the basis of the electoral districts which were created in Delaware's 1897 constitution. Similar to a township which serves as a county's administrative district in other states, the "hundreds" designation is unique to Delaware.

Hydrology: The scientific study of terrestrial water, in particular inland water before its discharge into the oceans or evaporation into the atmosphere. It includes the study of the occurrence and movement of water and ice on or under the earth's surface and its reactions with the environment and biota. The science has many important applications in flood control, irrigation, domestic and industrial uses, hydroelectric power and natural resource management.

Hyper-eutrophic: A physical, chemical, and biological condition that results after a lake, an estuary, or slow-flowing watercourse receives excessive inputs of plant nutrients (mostly nitrates and phosphates) as a result of erosion and runoff from the surrounding land basin.

Hypogeous: Relating to the germination of a seed in which the cotyledons (embryonic leaves) remain below the surface of the ground.

Impact: (*Banking on Nature* definition): The new economic activity generated in a region as a refuge attracts non-residents to the area, This figure represents economic activity that would be lost if the refuge were not there.

Impoundment: An area of tidal marsh that has been cut off from tidal inundation through the construction of dikes, dams, or water control structures.

Indicator species: A species whose presence, absence, or relative well-being in a given environment is a sign of the overall health of its ecosystem. By monitoring the condition and behavior of an indicator species, scientists are likely to affect other species that are more difficult to study.

Indigenous: Native to a particular area.

Indigenous species: a species that, other than a result as an introduction, historically occurred or currently occurs in a particular ecosystem

Interagency Passport: The Recreation Enhancement Act (REA) established the "America the Beautiful – the National Parks and Federal Recreational Lands Pass" (Interagency Pass Program) to promote consistency among the participating federal agencies and to create a high-quality pass program that is supported by the public and partner organizations. The Interagency Pass Program provides four pass options for the public to use at Federal recreation sites where entrance or standard amenity fees are charged. The four passes that make up the program are:
Interagency Annual – Available to anyone 16 years and older at an annual cost of $80; Interagency Senior – Available to US residents and citizens 62 years old and older at a cost of $10 (lifetime); Interagency Access – free (lifetime) and available to US residents/citizens with a permanent disability; and Interagency Volunteer – Available to anyone who volunteers over 500 hours at one of the participating agencies.

Interjurisdictional Fish: Are those "…populations that two or more states, nations, or Native American tribal governments manage because of their geographic distribution or migratory patterns (710 FW 1.5 H). Examples include anadromous species of river herring, salmon and free-roaming species endemic to large river systems, such as sturgeon and paddlefish. [USWFS Director's Order No. 132, Section 6(C)]

Interpretation: The National Association of Interpreters defines "interpretation" as a communication process that forges emotional and intellectual connections between the interests of the audience and the inherent meanings in the resource.

Interpretive facilities: structures that structures that provide information about an event, place, or thing by a variety of means, including printed, audiovisual, or multimedia materials

[E.g., kiosks that offer printed materials and audiovisuals, signs, and trail heads.]

Interpretive Materials: any tool used to provide or clarify information, explain events or things, or increase awareness and understanding of the events or things

[E.g., printed materials like brochures, maps or curriculum materials; audio/visual materials like video and audio tapes, films, or slides; and, interactive multimedia materials, CD-ROM or other computer technology.]

Invasive Species: An alien species whose introduction causes or is likely to cause environmental harm or economic losses or harm human health. An invasive species is usually an aggressive plant or animal that colonizes a habitat and displaces native and beneficial species.

Invertebrate: Any animal lacking a backbone or bony segment that encloses the central nerve cord.

Inviolate Sanctuaries for Migratory Birds: A refuge, or portions thereof, acquired or established in one of the following ways:

1. With the approval of the Migratory Bird Conservation Commission (MBCC) for the purpose of an inviolate sanctuary, or for any other management purpose, for migratory birds; or
2. By an instrument or document that states that we are establishing the refuge as an inviolate sanctuary for migratory birds, or for any other management purpose, for migratory birds" under, or to fulfill the purpose of, the Migratory Bird Conservation Act.

Issue: any unsettled matter that requires a management decision

[E.g., a Service initiative, an opportunity, a management problem, a threat to the resources of the unit, a conflict in uses, a public concern, or the presence of an undesirable resource condition.]

[N.b. A CCP should document, describe, and analyze issues even if they cannot be resolved during the planning process (FWS Manual 602 FW 1.4).]

Keystone Species: A species that plays a pivotal role in an ecosystem and upon which a large part of the community depends. A keystone species presence within an ecosystem has a disproportionate effect on other organisms within the system. A keystone species is often a dominant predator whose removal allows a prey population to explode and often decrease overall diversity. Other kinds of keystone species such as beavers, that significantly alter the habitat around them, significantly affect large numbers of other organisms (flora and fauna).

Landform: The physical shape of the land reflecting geologic structure and geomorphological processes that have shaped the features of a given land surface.

Landscape: A heterogeneous land area composed of a cluster of interacting ecosystems repeated in similar form throughout; an ecological mosaic of specific ecosystems.

Landscape Management: Management of nature at a landscape scale that strives to maintain functions and processes that characterize landscape features.

Land Trusts: organizations dedicated to conserving land by purchase, donation, or conservation easement from landowners.

Lottery Hunt: opportunities to hunt (deer or waterfowl on Prime Hook NWR) in designated areas where permits for individual dates are randomly issued to participants through a drawing

Macroinvertebrates: Invertebrates large enough to be seen with the naked eye like most aquatic insects, snails, amphipods, and chironomids. These larger and more prominent invertebrates are extremely important as food resources for waterfowl and shorebirds and other water birds. Abundance and species composition of macroinvertebrates in freshwater streams and waterways is often measured as an indication of negative impacts and stream and watershed health.

Management: Manipulation of nature for a specific goal.

Marl: A crumbly mixture of clays, calcium and magnesium carbonates, and remnants of shells that forms in both freshwater and marine environments.

Mast: seeds and fruits produced by trees and shrubs that are eaten by wildlife.

Matrix: The most extensive and most connected habitat type in a landscape, which often plays the dominant role in landscape processes.

Memorandum of Understanding: (MOU) a document describing a bilateral or multilateral agreement between parties.

Mesic: Relating or adapted to a moderately moist habitat. Mesic soils are sandy-to-clay loams containing moisture-retentive organic matter. Maples, white ash and basswood are mesic plants.

Metapopulation: A set of partially isolated populations belonging to the same species. A metapopulation has several subpopulations linked together by immigration and emigration. The populations are able to exchange individuals and recolonize sites in which the species has recently become extinct. A metapopulation consists of "a population of populations."

Metapopulation dynamics. The processes of recolonization and extinction of subpopulations of a metapopulation. Although individual populations have finite life-spans, the metapopulation as a whole is often stable because immigrants from one population are likely to re-colonize habitat which has been left open by the extinction of another population.

Migratory Birds: birds that follow a seasonal movement from their breeding grounds to their wintering grounds. Waterfowl, shorebirds, raptors, and songbirds are all migratory birds.

Migratory Nongame Birds of Management Concern: Species of nongame birds that have undergone significant population declines; have small or restricted populations; or are dependent upon rare and vulnerable habitats. Non-game migratory birds protected by the Migratory Bird Treaty Act (MBTA), make up 88 to 96% of the bird species on the BCC 2002 lists.

Migration: regular extensive, seasonal movements of birds between their breeding regions and their wintering regions; to pass usually periodically from one region or climate to another for feeding or breeding.

Minimum viable population: The low end of the viable population range; the smallest isolated population having {x} percent chance of remaining extant for {y} years despite the foreseeable effects of demographic, environmental and genetic random variation and natural catastrophes.

Mitigation: Actions to compensate for the negative effects if a particular action or project.

Moist-Soil Management (MSM): Is a native wetland plant management system using water level manipulations to create wet/dry cycles in impounded marsh areas that support early successional herbaceous vegetation which produces large quantities of moist-soil annual seeds, tubers, and other plant parts as highly nutritious food sources for waterfowl and other wildlife. MSM uses the draw down of water levels to promote the germination of native plants on exposed mudflats from late winter, early spring and/or late summer months and subsequent re-flooding of the same areas during early fall waterfowl migration periods.

Monitoring: The process of collecting information to track changes of selected parameters over time.

Mosaic: an interconnected patchwork of distinct vegetation types.

Mudflats: unvegetated areas exposed after drawdown, low tide or natural seasonal drying of wetland areas. Waterfowl, shorebirds, and other birds can forage on invertebrates in these exposed areas.

Mycorrhizal: The symbiotic association of the mycelium of a fungus with the roots of plants, often trees. The fungus assists in the absorption of minerals and water from the soil and defends the roots from nematodes, while the plant roots provide carbohydrates to the fungus.

National Wildlife Refuge System Improvement Act of 1997:	(Improvement Act) Sets the mission and the administrative policy for all refuges in the National Wildlife Refuge System; defines a unifying mission for the Refuge System; establishes the legitimacy and appropriateness of the six priority public uses (hunting, fishing, wildlife observation, wildlife photography, environmental education, and interpretation); establishes a formal process for determining appropriateness and compatibility; establish the responsibilities of the Secretary of the Interior for managing and protecting the Refuge System; requires a comprehensive conservation plan for each refuge by the year 2012. This Act amended portions of the Refuge Recreation Act and National Wildlife Refuge System Administration Act of 1966.
National Environmental Policy Act:	(NEPA) requires all Federal agencies to examine the environmental impacts of their actions, incorporate environmental information, and use public participation in planning and implementing environmental actions.
National Wildlife Refuge Complex:	(Complex) an internal Service Administrative linking of refuge units closely related by their purposes, goals, ecosystem or geopolitical boundaries. In this case, referring to the Coastal Delaware National Wildlife Refuge Complex, which consists of Prime Hook NWR and Bombay Hook NWR.
National Wildlife Refuge System:	Means all lands, waters, and interests administrated by the U. S. Fish and Wildlife Service as wildlife refuges, wildlife ranges, wildlife management areas, waterfowl production areas, coordination areas, and other areas for the protection and conservation of fish and wildlife including those that are threatened with extinction as determined in writing by Presidential or Secretarial order. The determination by the Director may not be delegated.
National Wildlife Refuge System Mission:	Means to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans.
Native:	1. (n.) A species that has not been introduced from somewhere else by humans. 2. (adj.) not introduced by humans.
Native Plant:	a plant that has grown in the region since the last glaciation, and occurred before European settlement.
Natural Disturbance Events:	Recurring perturbations such as fires and floods that occur in ecosystems without human intervention.
Natural Range of Variation:	It is recognized that ecosystems are dynamic and complex but ecologists use this term to explain that what they measure or observe within an ecosystem is likely to change over space and time, but within a certain **range of variables** measured, the ecosystem remains basically recognizable. The natural range of variation refers to the changes within ecosystems that are operating without human influence. More recently ecological restorations use the term "historic range of variation" (HRV). HRV is a recognition that ecosystems have a range within which they are self-sustaining and beyond which they move into a state of disequilibrium. Because many of today's ecosystems are in an unsustainable state due to modern interventions into their historic processes, finding ways to look back at the factors that made them sustainable is a logical method to proceed in restoring degraded ecosystems.
Neartic:	Relating to the biogeographic subregion that includes Greenland, artic America, and parts of North America north of tropical Mexico.
Neotropical:	The new world tropical region from southern Mexico and the West Indies to South America.

Niche: Ecological role of a species in a community.

Non-ambulatory: not able to walk about

Non-consumptive, wildlife-oriented recreation: Wildlife observation and photography and environmental education and interpretation.

Nonforested Wetlands: wetlands dominated by shrubs or emergent vegetation

Non-native species: see "exotic species."

Non-point source pollution: A diffuse form of water quality degradation in which wastes are not released at one specific, identifiable point but from a number of points that are spread out and difficult to identify or control.

Nonpoint Source: A diffuse form of water quality degradation produced by erosion of land that causes sedimentation of streams, hyper-eutrophication from nutrients and pesticides used in agriculture and silvicultural practices, and by acid rain resulting from burning fuels that contain sulfur.

Nonvascular Plant: Any of various plants (mosses, liverworts and hornworts) that lack vascular tissue; a bryophyte for example.

Notice of Intent: (NOI) an announcement we publish in the Federal Register that we will prepare and review an environmental impact statement [40 CFR 1508.22]

Noxious Weed: A plant species designated by Federal or State law as generally possessing one or more of the following characteristics: aggressive or difficult to manage; parasitic; a carrier or host of serious insect or disease; or nonnative, new, or not common to the United States, according to the Federal Noxious Weed Act (PL 93-639), a noxious weed is one that causes disease or had adverse effects on man or the environment and, therefore, is detrimental to the agriculture and commerce of the United States and to the public health.

Objective: actions to be accomplished to achieve a desired outcome or goal. Objectives are more specific, and generally more measurable, than goals.

Obligate species: A species that must have access to a particular habitat type to persist.

Observation Platform: an elevated structure in a designated viewing area.

Other Recreational Use: a recreational use of the Refuge System that is not one of the six wildlife-dependent recreational uses and which may only be allowed if both appropriate and compatible.

Palustrine: One of three types of freshwater wetland systems, palustrine wetlands include marshes, bogs, swamps, and small shallow ponds.

Partners for Wildlife Program: a voluntary, cooperative habitat restoration program among the Service, other government agencies, public and private organizations, and private landowners to improve and protect fish and wildlife habitat on private land while leaving it in private ownership

Partnership: a contract or agreement among two or more individuals, groups of individuals, organizations, or agencies, in which each agrees to furnish a part of the capital or some service in kind (e.g., labor) for a mutually beneficial enterprise

Party (Hunt) Zone: a designated deer hunting area that allows two to ten hunters to free roam within the area and not be confined to a permanent deer hunting stand. There are four party hunt zones currently at PHNWR

Passive Management: protecting, monitoring key resources and conducting baseline inventories to improve our knowledge of the ecosystem

Patch: A highly localized unit of population and community.

Passerines: Songbirds.

Pathogens: Biological agents, such as bacteria and viruses, that cause sickness or disease. Common sources in the Delaware Estuary include wastewater treatment plants, combined sewage overflow, and nonpoint source runoff.

Palynology: The study of fossil pollen and spores (pollen analysis) and various other microfossils, such as coccoliths and dinoflagellates. Palynology is used in stratigraphy, palaeoclimatology, and archaeology. Pollen and spores are very resistant to decay and therefore their fossils are readily found in sediments and rocks. Spores and pollen are classified according to shape, form of aperture, and both internal and external details of the exine (outer coat). They are indicative of the nature of the dominant flora, and the climatic conditions of the period in which they lived.

Pedestrian Trails: areas designated for hiking use only and not opened to other modes of transportation such as biking.

Perennial: Lasting or active through the year or through many years; a plant species that has a life span of more than two years

Permanent Disability: a permanent physical, mental, or sensory impairment that substantially limits one or more major life activities, such as caring for oneself, performing manual tasks, walking, seeing, hearing, speaking, breathing, learning, and working. See 7 C.F.R. §15e.103; see also 29 U.S.C. § 705(20).

Pest: Any living organism (plant or animal) that occurs where it is not wanted or that causes damage to crops or humans or other animals.

Phenols: Any class of organic compounds that contain a hydroxyl group (OH) attached to an aromatic (benzene) ring. Phenols are used in industry to make plastics, detergents, pesticides and drugs. Phenols can be poisonous and carcinogenic to living organisms when found at elevated levels in the environment.

Phenology: The scientific study of cyclical biological events, such as flowering, breeding, and migration in relation to climatic conditions. Phenological records of the dates on which seasonal phenomena occur provide important information on how climatic change affects ecosystems over time.

Photography Blind: cf. Observation Platform

Phragmites australis: A common reed grass, generally considered a pest plant, because of its tendency to replace other valuable native vegetation by forming dense monotypic stands.

PhytoPlankton: Microscopic algae that are freely floating in aquatic environments and are important links to fish food chains.

Plant: As defined in the National Wildlife Refuge System Improvement Act (NWRSIA), means any member of the plant kingdom in a wild, unconfined state, including any plant community, seed, root, or other part of a plant.

Pleistocene: The span of geological time preceding the Recent epoch, during which continental glaciers advanced and retreated and the human species evolved. The epoch began about 2.5 million years ago and closed with the end of the Ice Age 10,000 years ago.

Point Source: A source of pollution that involves discharge of waste from an identifiable point, such as a smokestack or sewage-treatment outflow pipe.

Population: In biology, any group of organisms belonging to the same species occupying a particular space and time; it incorporates subject areas from ecology, genetics, evolution, demography, behavior, and biostatistics and deals with the fundamental issues of structure and dynamics of biological populations.

Population Monitoring: Assessing the characteristics of populations to ascertain their status and establish trends on their abundance, condition, distribution, and health.

Population Viability: Concept of a “viable” population number that represents a threshold for survival versus extinction.

Population Viability Analysis: (PVA) – Models and numerical estimation procedures to determine the minimum viable population size (MVP) or area (MVA). A PVA recognizes that extinction is subject to chance events and the likelihood of survival must be evaluated in consideration of a specified time frame to be used in conservation planning for endangered species. A population viability analysis can be effectively used in the recovery process of Endangered and Threatened species by supplying information that promotes proactive actions to enhance species recovery, improve our understanding of critical population processes and increase the predictive capabilities of future PVA models. (Bessinger & Westphal 1998)

Preferred Alternative: This is the alternative determined (by the decision maker) to best achieve the Refuge purpose, vision, and goals; contributes to the Refuge System mission, addresses the significant issues; and is consistent with principles of sound fish and wildlife management.

Prescribed Fire: the application of fire to wildland fuels, either by natural or intentional ignition to achieve identified land use objectives [FWS Manual 621 FW 1.7]

Prime Hook State Wildlife Management Area: Owned and managed by the Delaware Division of Fish and Wildlife, this 698-acre area borders the Prime Hook NWR on its northern, eastern, and southern boundaries

Priority Public Use: On national wildlife refuge lands, a compatible wildlife-dependent recreational use involving hunting, fishing, wildlife observation and photography, or environmental education and interpretation.

Private Land: land owned by a private individual or group or non-government organization

Proactive Management: Management of nature that seeks to avert a decline in habitat quality or quantity before an event is likely to occur.

Public: individuals, organizations, and non-government groups; officials of Federal, State, and local government agencies; Native American tribes, and foreign nations—includes anyone outside the core planning team, those who may or may not have indicated an interest in the issues, and those who do or do not realize that our decisions may affect them

Public Involvement: offering an opportunity to interested individuals and organizations whom our actions or policies may affect to become informed; soliciting their opinions. We thoroughly study public input, and give it thoughtful consideration in shaping decisions about managing refuges.

Public Land: land owned by the local, State, or Federal Government

Public Use: any use of the Refuge System by the public, including, but not limited to, wildlife-dependent recreation and other appropriate uses.

Purposes of a refuge: Means the purposes specified in or derived from the law, proclamation, executive order, agreement, public land order, or administrative memorandum establishing, authorizing or expanding a national wildlife refuge, unit or subunit.

Quality: defined by 11 criteria as it relates to wildlife-dependent recreation (605 FW 1-General Guidelines for Wildlife-Dependent Recreation) – 1) Promotes safety of participants, other visitors, and facilities; 2) Promotes compliance with applicable laws and regulations and responsible behavior; 3) Minimizes or eliminates conflict with fish and wildlife population or habitat goals or objectives in an approved plan; 4) Minimizes or eliminates conflicts with other compatible wildlife-dependent recreation; 5) Minimizes conflicts with neighboring landowners; 6) Promotes accessibility and availability to a broad spectrum of the American people; 7) Promotes resource stewardship and conservation; 8) Promotes public understanding and increases public appreciation of America's natural resources and our role in managing and conserving these resources; 9) Provides reliable/reasonable opportunities to experience wildlife; 10) Uses facilities that are accessible to people and blend into the natural setting; and 11) Uses visitor satisfaction to help define and evaluate programs.

Quaternary: The second period of the Cenozoic era, which began about 2 million years ago. It is subdivided into two epochs—the Pleistocene and Holocene. The beginning of the Quaternary is usually based on the onset of a worldwide cooling. During this period four principle glacial phases occurred in North America and Europe, in which ice advanced towards the equator, separated by interglacial periods marked by warmer climatic conditions. The last glacial ended about 10,000 years ago. Humans became the dominant terrestrial species during the Quaternary. Among the fauna adapted to the colder conditions of the Pleistocene were the mammoth and the woolly rhinoceros.

Ramsar Convention: A 1973 convention held in Ramsar, Iran which addressed the important of wetlands on an international scale. The main goals of the convention were 1.) "to stem the progressive encroachment of and the loss of wetlands now and in the future;" 2.) to promote habitats which are of international importance to waterfowl; 3.) to coordinate national policies with international action; and 4.) to encourage research and management.

Raptors: Birds of prey, such as bald eagles, osprey, northern harriers and peregrine falcons.

Rare Species: Species identified for special management emphasis because of their uncommon occurrence within a particular watershed or ecosystem.

Rare Community Types: Plant community types classified as rare by any State Natural Heritage Program; includes exemplary community types.

Recharge: Means water entering an underground aquifer through faults, fractures, or direct absorption.

Record of Decision: (ROD) is a concise public record of a decision by a Federal agency pursuant to NEPA which includes:
the decision; all the alternatives considered; the environmentally preferable alternative; a summary of monitoring and enforcement, where applicable for any mitigation; and, whether all practical means have been adopted to avoid or minimize environmental harm from the alternative selected (or if not, why not).

Recreation Fee Program: cf. Federal Lands Recreation Enhancement Act

Recreational Visitor Day: **(RVD)** A unit of measure equal to one person spending one full day (8 hours) recreating at a particular site. RVDs allow comparisons between visitors who stay for only short periods of time and those who stay longer.

Refuge Goals: "…descriptive, open-ended, and often broad statements of desired future conditions that convey a purpose but do not define measurable units." *(Writing Refuge Management Goals and Objectives: A Handbook)*

Refuge Purposes: "The terms 'purposes of the refuge' and 'purposes of each refuge' mean the purposes specified in or derived from the law, proclamation, executive order, agreement, public land order, donation document, or administrative memorandum establishing, authorizing, or expanding a refuge, refuge unit, or refuge subunit." (*National Wildlife Refuge System Improvement Act of 1997)*

Refuge Lands: Lands which the Service holds full interest in fee title or partial interest like an easement.

Refuge Management Activity: Means an activity conducted by the Service or a Service-authorized agent to fulfill one or more purposes of the national wildlife refuge, or the National Wildlife Refuge System mission. We do not require a compatibility determination for refuge management activities as defined by the term "refuge management activity" except for "**refuge management economic activities.**" Examples of refuge management activities that do not require a compatibility determination include prescribed burning, water level management, invasive species control; routine scientific monitoring studies, surveys, and censuses; historic preservation activities; law enforcement activities; and maintenance of existing refuge facilities, structures, and improvements. (CD Policy: 603 FW 2.10A)

Refuge Management Economic Activity: Means a refuge management activity on a national wildlife refuge which results in generation of a commodity which is or can be sold for income or revenue or traded for goods and services. Examples include farming, grazing, haying, and trapping.

Refuge Use: Any activity on a refuge, except administrative or law enforcement activity carried out by or under the direction of an authorized Service employee.

Refugium: Area that has escaped from major climatic changes that have occurred within the immediate region and that serves as a refuge for biota that was more widely distributed.

Regular Hunt: opportunities to hunt on Prime Hook NWR where a one-time annual permit is needed by participants to access designated areas on a first-come, free roam basis

Reintroduction: Placement of an individual, population, or species back into its historic habitat range after it has been extirpated from that habitat.

Resident/Non-Resident: Banking with Nature Definition: = People living more than 30 miles from the refuge are defined as non-residents.

Restoration: Management of a disturbed and/or degraded habitat that results in the recovery of its original features and native plant communities.

Restoration Ecology: Is the study of renewing degraded, damaged, or destroyed ecosystem function through active human intervention using biological principles and applications in population and community ecology aimed to restore and rehabilitate highly disturbed or degraded ecosystems to their more natural state. There is consensus in the scientific community that the current degradation and destruction of the earth's biota is taking place on a catastrophically short timescale leading to a current extinction rate 1,000 to 10,000 times the normal rate and that habitat loss is the leading cause of both species extinctions and ecosystem dysfunction. Two ways to reverse this trend is conservation of currently viable natural habitats and the restoration of degraded habitats.

Resources of Concern: All plant and/or animal species, species groups, or communities specifically identified in refuge purposes, system mission or international, national, regional and state plans or acts. For example, shorebirds have been identified a resource of concern at PHNWR as the refuge is a designated site in the Western Hemispheric Shorebird Reserve Network and it will focus on conserving priority shorebird species as identified in the United States Shorebird Conservation Plan, Partners in Flight Plan, the North American Waterfowl Management Plan, the North American Bird Conservation Initiative, the North American Waterbird Conservation Plan, the Delaware Wildlife Management Action Plan and Federal or state threatened and endangered species HMP Policy (620 FW 1.4G). The term **"resources of concern"** and **conservation targets** are used interchangeably in USFWS policy documents and other literature.

Right-of-Way: Covers uses that will encumber real property on refuges by granting a right to use and alter the landscape through construction of a facility such as a road, powerline, pipeline, or building (air navigation facility, radio tower, etc.). Generally, such uses are for a relatively long period of time; i.e., 10 years or longer. [340 FW 3]

Riparian: referring to the interface between freshwater habitats and the terrestrial landscape

Riparian Forested Land: forested along a stream or river

Riparian Habitat: Habitat along the banks of a stream or river [cf. note above]

Ruderal: Of a plant growing in disturbed soil, and so often in waste near human habitation

Runoff: water from rain, melted snow, or agricultural or landscape irrigation that flows over a land surface into a water body

Sanctuary: a place of refuge and protection

Scale: In ecology, referring to hierarchical units of measuring or modeling spatial processes, (like dispersal, niche divergence) or temporal processes (like succession, species guild formation); the magnitude of a region or process; refers to both spatial size like a small-scale patch or a large-scale landscape, and a temporal rate like rapid ecological succession or slow evolutionary speciation.

Scoping: the process of obtaining information from the public for input into the planning process

Seasonal Closures: areas and/or trails closed for the protection of wildlife based on their annual life cycles and habitat needs or due to conflicts with other uses. Closures are seasonal and are determined by Refuge staff.

Section 7: the section of the Endangered Species Act of 1973, as amended, outlines procedures for interagency cooperation to conserve federally listed species and designated critical habitats. Section 7(a)(1) requires Federal agencies to use their authorities to further the conservation of listed species. Section 7(a)(2) requires Federal agencies to consult with the Services to ensure that they are not undertaking, funding, permitting, or authorizing actions likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat. Other paragraphs of this section establish the requirement to conduct conferences on proposed species; allow applicants to initiate early consultation; require FWS and NMFS to prepare biological opinions and issue incidental take statements. Section 7 also establishes procedures for seeking exemptions from the requirements of section 7(a)(2) from the Endangered Species Committee. [ESA §7]

Section 7 Consultation: the various section 7 processes, including both consultation and conference if proposed species are involved. [50 CFR §402]

Service: cf. U.S. Fish and Wildlife Service

Shorebird: Any of a suborder (*Charadrii*) of birds, such as a plover or a snipe, that frequent the seashore or mud flat areas.

Shrublands: Habitats dominated by various species of shrubs, often with many grasses, forbs and some trees.

Significance: As it relates to the *Banking on Nature* Report, is the total economic activity in a region that is related to a refuge. Significance shows a refuge's role in the regional economy.

Slough: 1.) A depression or hollow, usually filled with deep mud or mire (wet, soggy, muddy ground); 2.) A stagnant swamp, marsh, bog or pond as part of a creek or backwater.

Smart Objectives: Specific, measurable, achievable, results-oriented and time-fixed (*Writing Refuge Management Goals and Objectives: A Handbook).*

Snag (Tree): A partially or fully dead tree that remains standing. Snags provide habitat for a variety of birds and other wildlife.

Sound Professional Judgment: A finding, determination, or decision that is consistent with principles of sound fish and wildlife management and administration, available science and resources, and adherence to the requirements of the Refuge Administration Act and other applicable laws.

Source Population: A population in a high-quality habitat where the birth rate greatly exceeds the death rate and the excess individuals emigrate.

Special Use Permit: (SUP) The issuance of a permit and collection of fees on lands of the National Wildlife Refuge System is authorized by the National Wildlife Refuge System Administration Act (16 U.S. C. 668dd-ee) as amended, and the Refuge Recreation Act (16 U.S. C. 460k-460k-4). A SUP is issued when the public is engaged in the following activities on a national wildlife refuge outside Alaska (Alaska refuges use a different form): agriculture, commercial activities, research/monitoring (does not include research/monitoring by refuge staff as part of normal duties), commercial filming, commercial visitor services, special events, and any other activity not mentioned above. At minimum, the refuge manager should complete an appropriate use decision or, preferably, a compatibility determination for the activity before issuing the Special Use Permit. The refuge manager determines fees according to existing policies and guidance.

Species:	the basic category of biological classification intended to designate a single kind of animal or plant. Any variation among the individuals may be regarded as not affecting the essential sameness which distinguishes them from all other organisms.
Species Assemblage:	The combination of certain species that occur together in a specific location with dependent interactions and certain community characteristics.
Species at Risk:	A species being considered for Federal listing as threatened or endangered, formerly, a "candidate species."
Species Diversity:	A measure of species richness and evenness is often used to quantify species diversity as a numerical comparison between communities. Species diversity increases as the number of species increases and as the number of individuals are more evenly distributed.
Species of Concern:	Species not federally listed as threatened or endangered, but about which we and/or our partners are concerned.
Species Richness:	The measure of species diversity calculated as the total number of species in a habitat or community whereas evenness is defined as the relative abundance of individuals among the recorded species.
Staging and Loafing:	Areas used by waterfowl to rest and increase fat and protein reserves in preparation for migration.
Stand:	an area of trees with a common set of conditions (e.g. based on age, density, species composition, or other features) that allow a single management treatment throughout
State Land:	State-owned public land
State-Listed Species:	cf. "Federal-listed species"
Step-Down Management Plan:	a plan for dealing with specific refuge management subjects, strategies, and schedules, e.g., cropland, wilderness, and fire [FWS Manual 602 FW 1.4]
Stochastic Processes:	Processes with a variable outcome that is random or uncertain. Stochastic processes increase in importance with decreasing or very small population size. Some examples are: **Genetic Uncertainty** ➔ random changes in genetic make-up due to founder effect, genetic drift, or inbreeding which affects fitness; **Environmental Uncertainty** ➔ represents unpredictable changes in factors such as weather, food supply, and populations of competitors, predators, and parasites; **Natural Catastrophes** ➔ represent floods, fires and droughts that occur at random intervals.
Stopover Habitat:	Habitat where birds rest and feed during migration
Strategy:	A specific action, tool, technique, or combination of actions, tools and techniques used to accomplish a refuge's stated objectives.
Stratigraphy:	The scientific study of rock strata, especially the distribution, deposition, correlation and age of sedimentary rocks. It is the branch of geology concerned with the origin, composition, sequence, and correlation of rock strata. It forms the basis of historical geology and has also found practical application in mineral exploration, especially that of petroleum.

Structural Diversity:	Diversity in a community that results from having many horizontal or vertical physical elements (like layers or tiers of a canopy, or varying heights and densities of forbs and grasses in an early successional "old field") An increase in laying, tiering, or plant heights and densities leads to an increase in structural diversity.
Structure:	The various horizontal and vertical physical elements of a vegetation community.
Succession:	The more or less predictable change in the composition of communities following a natural or human disturbance. It marks the regular patterns in how plants and other organisms take each other's place or how they "succeed" each other. First comes pioneer species---fast growing, fast-spreading plants adapted to harsher environmental conditions, like sweetgums pioneering poor soils with depleted fertility from intensive agricultural use. In time pioneers build up nitrogen in the soil and provide shade and wind protection for other species to colonize and eventually reverting to mixed hardwood or coniferous stand of trees. There are no absolute rules about succession. It can take a few years or centuries and has no fixed final state.
Successional Management:	Form of management, using habitat management techniques like controlled burning or water level control in marshes that manipulates the successional processes of a community to maintain early stages of plant communities to meet specific wildlife or habitat management objectives, or allowing native communities to revert to later successional stages of development at their own pace.
Successional Meadows:	A large treeless area that is dominated by grasses and small woody and non-woody plants.
Surface Water:	All waters whose surface is naturally exposed to the atmosphere, or wells or other collectors, directly influenced by surface water.
Sustainable Development:	The attempts to meet economic objectives in ways that do not degrade the underlying environmental support system. From a conservation biology perspective it implies that "human activities are conducted in a manner that respects the intrinsic value of the natural world, the role of the natural world in human well-being, and the needs for humans to live on the income from nature's capital rather than the capital itself."
Synergistic:	Producing or capable of producing synergy, or the interaction of two or more agents or forces so that their combined effect is greater than the sum of their individual effects.
Tax Ditch:	A tax ditch is a governmental subdivision in the state of Delaware. It is a watershed-based organization formed by a prescribed legal process in Superior Court. The organization is comprised by all landowners (called "taxables") of a particular watershed and was primarily devised to drain wetland areas for farming.
Terrestrial:	living on land
Territory:	an are over which an animal or group of animals establishes jurisdiction
Tertiary Period:	The first period of the Cenozoic Era, beginning with the end of the Mesozoic Era (Age of Reptiles) 63 to 65 million years ago and closing with the start of the Pleistocene epoch about 2.5 million years ago; succeeded by the Quaternary period (Pleistocene plus Recent epochs).
Threatened Species:	a Federal-listed, protected species that is likely to become an endangered species in all or a significant portion of its range

Tiering: Incorporating by reference the general discussions of broad topics in environmental impact statements into narrower statements of environmental analysis by focusing on specific issues.

Tilth: A measure of the health of soil. Good tilth is a term referring to soil that has the proper structure, and nutrients to grow healthy plants. Soil in good tilth is loamy, nutrient rich soil that can also be said to be friable because optimal soil conditions is represented by a mixture of sand, clay, and organic matter that prevents severe compaction.

Translocation: **(See Reintroduction) –** Management technique often used in mitigation for endangered species protection whereby an individual, population, or species is removed from its habitat to be established in another area of similar or identical habitat.

Tributary: A creek, stream or river that flows into a larger, creek or stream, feeding it water.

Trophic: The functional classification of organisms in an ecological community based on feeding relationships; the first level includes green plants; the second trophic level includes herbivores; and so on.

Trust Resource: cf. federal trust resource

Trust Species: cf. federal trust species

Turbidity: refers to the extent to which light penetrates a body of water. Turbid waters are those that do not generally support net growth of photosynthetic organisms

Umbrella Species: Species that require large areas to maintain viable populations and by which protection of their habitat may safeguard the habitat and populations of many other more restricted and less wide ranging species.

Understory: the lower layer of vegetation in a stand, which may include short trees, shrubs, and herbaceous plants

Unfragmented Habitat: Large, unbroken blocks of a particular type of habitat.

Upland: dry ground (i.e., other than wetlands).

Upwelling: A process whereby nutrient-rich waters from the ocean depths rise to the surface; it commonly occurs along the continental coastlines.

U.S. Fish and Wildlife Service: (Service, USFWS, FWS) the principal federal agency responsible for conserving, protecting, and enhancing fish and wildlife and their habitats for the continuing benefit of the American people. The Service manages the 93-million-acre National Wildlife Refuge System comprised of more than 530 national wildlife refuges and thousands of waterfowl production areas. It also operates 65 national fish hatcheries and 78 ecological service field stations, the agency enforces federal wildlife laws, manages migratory bird populations, restores national significant fisheries, conserves and restores wildlife habitat such as wetlands, administers the Endangered Species Act, and helps foreign governments with their conservation efforts. It also oversees the federal aid program that distributes millions of dollars in excise taxes on fishing and hunting equipment to state wildlife agencies.

U.S. Geological Survey: (USGS) a federal agency whose mission is to provide reliable scientific information to describe and understand the earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life.

Validation Monitoring: Scientific testing of the validity of the models and assumptions upon which a monitoring program is based.

Vascular: Any of various plants that have vascular tissues xylem and phloem. The vascular plants include all seed-bearing plants (gymnosperms and angiosperms) and the pteridophytes (includes ferns, lycophytes, and horsetails).

Vernal Pool: Depressions holding water for a temporary period in the spring, and in which various amphibians are highly dependent on for breeding (lays eggs); these depressions often harbor very unique flora and fauna.

Vision Statement: A concise statement of what a management unit could achieve in the next ten to fifteen years.

Visitors: A visitor is someone who comes to the refuge and participates in one or more of the activities available at the refuge.

Visitor Services: Any program provided by the U.S. Fish and Wildlife Service that is specifically or predominately designed for the participation or benefit of visitors.

Visitor Services Review: an evaluation of a refuge's visitor services program to support the CCP process. The review offers suggestions on addressing issues and opportunities, provides recommendations to assist the station in the development of the site's visitor services program, and provides the refuge staff with a fresh look at the refuge and the programs they manage everyday.

Visits (Visitation): A visit is not the same as a visitor. One visitor could be responsible for several visits on a refuge. For example, if a family of four went fishing in the morning and then hiked a nature trail in the afternoon, they would have contributed 8 activity visits but only 4 visitors.

Vulnerable species: Species that are sensitive to human activity because of their life history, appearance, reputation, edibility, location, or other factors.

Wading Birds: any of many long-legged birds that wade in water in search of food.

Watershed: A geographic area in which water, sediments, and dissolved materials drain to a common water body. A watershed includes both the land and the body of water into which the land drains.

Water Control Structure: A device installed to help control water levels and provide an appropriate outlet for discharging water, that can include stoplogs, flaplog, weirs, checkdams, and inline control structures.

Water Level Management: It is the active management of water elevation within a wetland to mimic natural seasonal hydrology patterns that are attractive to waterfowl and other wetland-dependent wildlife. These manipulations of water levels in the refuge's moist soil and impoundment management units are used to create a mudflat-type environment to attract shorebirds, to concentrate fish for wading birds to feed upon, to stimulate annual vegetation as a food source for waterfowl, and to reduce the number of plants that are low in nutrition for wildlife.

Water Quality Standards: State regulations which outline permissible levels of individual pollutants in specific bodies of water.

Warm-Season Grass: Native prairie grass that grows the most during summer, when cool-season grasses are dormant.

Waterfowl: a category of birds that includes ducks, geese, and swans.

Watershed: the geographic area within which water drains into a particular river, stream, or body of water; land and the body of water into which land drains

Well Protected: In CCP analysis, a rare species or community type is considered well protected if 75 percent or more of its occurrence sites are on dedicated open space or protected habitat.

Wetlands: lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. These areas are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted to life in saturated soil conditions. "Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water."—Cowardin et al 1979

Wet Meadows: Meadows located in moist, low-lying areas, often dominated by large colonies of native grasses, forbs and wildflowers. Often they are created by beaver dams or exposed pond bottoms. Saltmarsh meadows are subject to daily coastal tides.

Wilderness: cf. "designated wilderness area"

Wildfire: a free-burning fire requiring a suppression response; all fire other than prescribed fire that occurs on wildlands [FWS Manual 621 FW 1.7]

Wildland Fire: every wildland fire is either a wildfire or a prescribed fire [FWS Manual 621 FW 1.3]

Wildland Urban Interface: roughly defined as the zone where natural areas and development meet.

Wildlife: the terms "fish," "wildlife," and "fish and wildlife" mean any wild member of the animal kingdom, whether alive or dead, and regardless of whether it was bred, hatched, or born in cavity, including its parts, products, eggs, or offspring.

Wildlife-Dependent Recreational Use: a use of a national wildlife refuge involving hunting, fishing, wildlife observation and photography, or environmental education and interpretation (National Wildlife Refuge System Administration Act of 1966).

Wildlife Management: manipulating wildlife populations, either directly by regulating the numbers, ages, and sex ratios harvested, or indirectly by providing favorable habitat conditions and alleviating limiting factors

Wildlife-Oriented Recreation: recreational activities in which wildlife is the focus of the experience

["The terms 'wildlife-dependent recreation' and 'wildlife-dependent recreational use' mean a use of a refuge involving hunting, fishing, wildlife observation and photography, or environmental education and interpretation."—National Wildlife Refuge System Improvement Act of 1997]

Xeric: Characterized by, relating to, or requiring only a small amount of moisture

Acronyms

Acronym	Full Name
ACJV	Atlantic Coast Joint Venture
ADA	Americans with Disabilities Act
AHWP	Annual Habitat Work Plan
AOE	Area of Emphasis
APHIS	Animal and Plant Health Inspection Service
ASMFC	Atlantic States Marine Fisheries Commission
ATV	All-Terrain Vehicle
BBS	Breeding Bird Survey
BCR	Bird Conservation Region
BIDEH	Biological Integrity, Diversity, and Environmental Health
BMP	Best Management Practices
CBFO	Chesapeake Bay Field Office of the U.S. Fish & Wildlife Service
CCP	Comprehensive Conservation Plan
CDEDC	Central Delaware Economic Development Council
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CWD	Chronic Wasting Disease
DDA	Delaware Department of Agriculture
DDT	Dichloro-Diphenyl-Trichloroethane
DEDF&W	Delaware Division of Fish & Wildlife
DELDOT	Delaware Department of Transportation
DNHP	Delaware Natural Heritage Program
DNREC	Delaware Department of Natural Resources & Environmental Control
DU	Ducks Unlimited
EA	Environmental Assessment
EIS	Environmental Impact Statement
ELI	Environmental Law Institute
EPA	Environmental Protection Agency

Acronym	Full Name
ERDG	Ecological Research and Development Group
ESA	Endangered Species Act
FMO	Fire Management Officer
FMP	Fire Management Plan
FMU	Fire Management Unit
FOPH	Friends of Prime Hook National Wildlife Refuge
FY	Fiscal Year
GIS	Geographical Information Systems
GPS	Global Positioning System
GPRA	Government Performance and Results Act
HIP	Harvest Information System
HMP	Habitat Management Plan
IBA	Important Bird Area
ICS	Incident Command System
IMP	Habitat and Species Implementation and Monitoring Plan
IMPLAN	Impact Analysis for Planning
IPM	Integrated Pest Management
LPP	Land Protection Plan
LE	Law Enforcement
LMVJV	Lower Mississippi Valley Joint Venture Migratory Bird Science Team
MMS	Maintenance Management System
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MSL	Mean Sea Level
NABCI	North American Bird Conservation Initiative
NAWCP	North American Waterbird Conservation Plan
NAWMP	North American Waterfowl Management Plan and Joint Ventures
NCCEDC	New Castle County Economic Development Council

Acronym	Full Name
NEPA	National Environmental Policy Act
NFDRS	National Fire Danger Rating System
NFPORS	National Fire Plan Operating and Reporting System
NGO	Non-Governmental Organization
NHPA	National Historic Preservation Act
NRCS	Natural Resource Conservation Service
NVCS	National Vegetation Classification System
NWCG	National Wildfire Coordinating Group
NWR	National Wildlife Refuge
NWRA	National Wildlife Refuge Association
NWRIA	National Wildlife Refuge Improvement Act of 1997
NWRS	National Wildlife Refuge System
OMWM	Open Marsh Water Management
ORV	Off-Road Vehicle
PCBs	Polychlorinated Biphenyls
PHNWR	Prime Hook National Wildlife Refuge
PIF	Partners In Flight
PPE	Personal Protective Equipment
PSRAST	Physicians & Scientists for Responsible Application of Science & Technology
PWC	Personal Watercraft
REA	Federal Lands Recreation Enhancement Act
RFMC	Regional Fire Management Coordinator
RLGIS	Refuge Lands Geographical Information System
RM	Refuge Manual
RMAD	Refuge Management Action Database
ROD	Record of Decision
RONS	Refuge Operation Needs System
RRS	Refuge Revenue Sharing

Acronym	Full Name
SAMMS	Service Asset Maintenance Management System
SAV	Submerged Aquatic Vegetation
SCORP	Statewide Comprehensive Outdoor Recreation Plan
Service	United States Fish and Wildlife Service
SHPO	State Historic Preservation Office
SUP	Special Use Permit
TNC	The Nature Conservancy
TWS	The Wildlife Society
US SCP	U.S. Shorebird Conservation Plan
USDA	United States Department of Agriculture
USDOI	United States Department of Interior
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VSP	Visitor Services Professional
WAP	Wildlife Action Plan
WUI	Wildlife-urban interface
YCC	Youth Conservation Corps

Prime Hook National Wildlife Refuge
11978 Turkle Pond Road
Milton, DE 19968
Phone: 302/684 8419
http://www.fws.gov/northeast/primehook/

Federal Relay Service
for the deaf and hard-of-hearing
1 800/877 8339

U.S. Fish & Wildlife Service
http://www.fws.gov

For Refuge Information
1 800/344 WILD

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