Chapter 4

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Management Direction and Implementation

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Introduction

This chapter describes the process we used to formulate the management direction for Prime Hook NWR, including descriptions of the management actions and alternatives that were considered but not analyzed or chosen as the management direction for the refuge. We then present the chosen management direction for the refuge, including the goals, objectives, and strategies.

Developing the Management Direction

Relating Resources of Concern and Focal Species to Goals, Objectives, and Strategies

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. These identified resources and species were used to develop a set of refuge goals, objectives to achieve those goals, and a series of strategies to implement them.

Refuge 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.

Objectives are essentially incremental steps toward achieving a goal; they further define management targets in measurable terms. "Writing Refuge Management Goals and Objectives: A Handbook" (USFWS 2004a) recommends writing "SMART" objectives that possess five characteristics: (1) specific, (2) measurable, (3) achievable, (4) results-oriented, and (5) time-fixed. A rationale accompanies each objective to explain its context and why we think it is important. The objectives outlined in this chapter will guide the future development of refuge step-down plans, which we describe later in this chapter.

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 objectives. The list of strategies under each objective represents the potential suite of actions we may implement. We will evaluate most of them further as to how, when, and where we should implement them when we write our refuge step-down plans.

Environmental Baseline

It is important to understand that while the CCP 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 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.

Alternatives or Actions Considered but Eliminated

Management Alternatives Considered but not Chosen for Implementation

NEPA requires that a thorough analysis be made of a range of management alternatives, including a "no action" alternative that represents current refuge management. Both the draft and final CCP/EIS evaluated three alternatives (A, B, and C). We analyzed the socioeconomic, biological, physical, and cultural

consequences of implementing each alternative, and selected among these alternatives based on their greater or lesser ability to meet the purposes and needs described above. For the final CCP, we chose alternative B which focuses on focal species with proactive habitat management and expanded public use. Alternative B is presented in this chapter as the management direction that the refuge will implement over the next 15 years. Below are brief summaries of alternatives A and C.

Alternative A. Current Management (No Action)
This alternative primarily portrayed current management, representing the required "no action" alternative. It was used as the baseline for comparing the other two alternatives throughout the process of developing the CCP. Had this alternative been chosen, the habitat management program would have continued as it had prior to the development of the CCP, involving no active management of wetlands, no active forest management, and no agricultural management of upland fields. This means that natural ecological processes would have been allowed to proceed with no human intervention. While natural resource protection and conservation actions would have continued, generally speaking, the only habitat manipulation programs we would have conducted would have been the removal of invasive species and enhancement actions for federally listed endangered and threatened species.

We would have continued to offer hunting and fishing opportunities on refuge lands and respond to requests for interpretive and school programs. The refuge would have continued to provide 6 miles of walking trails, 7 miles of canoe trail, and associated viewing and photography infrastructures. Educational, interpretive, and community programs, such as the monthly lecture series and annual photography contest, would have also continued.

Alternative C. Historic Habitat Management
Alternative C habitat management emphasized a return to habitat management programs that were conducted on the refuge through most of its existence, but which were stopped 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 have conducted infrastructure and duneline enhancements to reestablish management of freshwater impoundments. Upland fields previously enrolled in the cooperative farming program would have once again been managed through farming practices with the cooperation of local farmers.

Under this alternative, public use would change slightly from current management. Hunting opportunities would have been expanded from current management but would have been less than those proposed under alternative B. Fishing, wildlife observation, and wildlife photography would not have changed much.

Under alternative C, we would have further enhanced local community outreach and partnerships, continued to support a Friends Group, and continued to provide valuable volunteer experiences. We would have also promoted 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.

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 management plan, 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 NWR'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. Approval to explore refuge boundary expansion comes from the Service's Director, and then expansion requires development of a land protection plan. 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 land protection plan 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 10,000 to 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 (5,000 to 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 were 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 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 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 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. 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. BIDEH 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 BIDEH 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 Refuge 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 percent 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 to 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 to 16 times per year. The non-consumptive users were more likely to be older (60s), retired, and female (54 percent). The consumptive users were more likely to be in their late 40s, employed, and male (97 percent).

The consumptive users overwhelmingly felt that opportunities for hunting should be increased. About 55 percent 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 percent), nature/wildlife viewing (64 percent), hiking/nature trails (56 percent), and special events, environmental education, and guided interpretive tours (collectively 68 percent) 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 percent favored reducing hunting. Only about 10 percent 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 CCPs, 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.

General Refuge Management

There are some actions we will take in managing Prime Hook NWR that are required by law or policy, or represent NEPA decisions that have recently undergone analysis, public review, agency review, and approval, and are binding. Others may be administrative actions that do not require public review, but we want to highlight them in this public document. They may also be actions crucial to achieving the refuge purposes, vision, and goals.

All of the following actions, which we discuss in more detail below, will be implemented:

- Using adaptive resource management.
- Managing invasive species.
- Monitoring and abating diseases affecting wildlife and forest health.
- Controlling nonnative and other pest animals.
- Conducting appropriate use and compatibility determinations.
- Providing opportunities for wildlife-dependent recreation.
- Protecting cultural resources.
- Conducting a refuge wilderness review.
- Providing refuge staffing and administration.
- Distributing refuge revenue sharing payments

Using Adaptive Resource Management

The 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 the management plan, 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 Department of the Interior 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 this 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 the management 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 BIDEH 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 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, 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 Department of the Interior regulations, and a pesticide use proposal 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 will continue to be monitored to track *Phragmites* control in relation to original 2002 treatment sites. 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 U.S.

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 nonnative; 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 this CCP. 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).

AI 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.

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.
- Follow protocols outlined in national, State, and refuge-specific disease prevention and control plans.

Controlling Nonnative 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, 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 will 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 nonnative 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 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 U.S. 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). Refuge staff or contractual employees will conduct removal immediately prior to or during the nesting season.

Conducting Appropriateness and Compatibility Determinations

Chapter 1 describes appropriate refuge uses policy and specific requirements necessary to prepare written compatibility determinations. Appendix E includes the approved, refuge-specific findings of appropriateness and compatibility determinations.

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 and the Refuge System mission.
- Refuge goals, objectives and management strategies.
- Fish, wildlife, plants, and their habitats.
- BIDEH 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.

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 5 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 have 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 in the future. 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 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 Service 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. 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.

Providing Opportunities for Wildlife-dependent Recreation

The 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, 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 USGS 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. In addition to published 50CFR regulations and State regulations, refuge-specific regulations also apply and are highlighted below in the following strategies.

Strategies Common to All Public Use Programs

- 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:
  - 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.

Protecting Cultural Resources

As outlined in chapter 3 under "Prehistoric and Historic Cultural and Environmental Setting and Human Land Use History," the Service has a regular process for ensuring protection of archaeological sites and historic structures from activities. The process includes review of projects by professional archaeologists in the Regional Office and consultation with the Delaware Department of Historical and Cultural Affairs (the Delaware State Historic Preservation Office, SHPO). Project leaders submit descriptions of their proposed projects, maps, and plans to the Regional Historic Preservation Officer (RHPO), who determines what is needed to identify archaeological sites in the project area and helps the refuge avoid sites when called for. Rarely, the Service will mitigate an unavoidable impact to a site, in consultation with the SHPO and interested parties. Any future ground disturbing activities would go through this process. Activities such as shoreline modification, commercial logging, and salt marsh restoration will require RHPO review and SHPO consultation under this process.

In addition, the Service protects sites from unauthorized excavation through the application of the Archaeological Resources Protection Act (ARPA). The Regional Director issues permits for any non-Service excavations on Service land. Unpermitted excavation would be the subject of law enforcement investigation by a team including an archaeologist. If possible, a case would be prosecuted.

From time to time, human remains are inadvertently discovered. This has never happened at Prime Hook, but increased erosion can be expected to reveal remains of European settlers as well as Native Americans in the future. The Service applies the Native American Graves Protection and Repatriation Act

if Native American remains are recovered. When it is possible to associate the remains with a Federally recognized tribe, they are repatriated to the tribe.

In order to strategically address the loss of archaeological sites and potential exposure of human remains at Prime Hook to erosion by sea level rise, the Service, in consultation with the SHPO, will prepare a cultural resource management plan for the refuge within five years, subject to the availability of funds. The plan will be consistent with resource management objectives in this CCP. The management plan will identify problems with specific sites, and specific protective measures such as survey, evaluation, excavation, stabilization, monitoring or other appropriate strategies that can alleviate or minimize impacts depending on the values of specific archaeological sites. The management plan will use existing sea level change information to schedule these management strategies for each site or area in a timely fashion. The plan will include a budget and provisions for evaluating the success of strategies implemented.

Conducting a Refuge Wilderness Review

The Service revised its Wilderness Stewardship Policy in November of 2008, to improve the 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 to help achieve the goals of the National Wilderness Preservation System 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.

Providing Refuge Staffing and Administration

Congress determines the annual budgets that our Washington headquarters and regional offices distribute to the field stations. The management activities 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 NWR Complex.

Permanent Staffing and Operational Budgets

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 to 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 this CCP. 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 this CCP, and within the guidelines of the new base budget approach, we will seek to fill our currently approved but vacant positions, which we believe are needed to accomplish our highest priority projects. This CCP 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. We also seek an increase in our maintenance staff since they provide invaluable support to all program areas.

Facility and Fleet Management

This CCP includes 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 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 thid CCP, once constructed, will be placed on the maintenance schedule. All facilities and equipment maintenance and upgrades will incorporate ecologically beneficial technologies, tools, materials, and practices.

Refuge Operating Hours
We will open the refuge for public use from one-half hour before sunrise to one-half hour after sunset, 7 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. We 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.

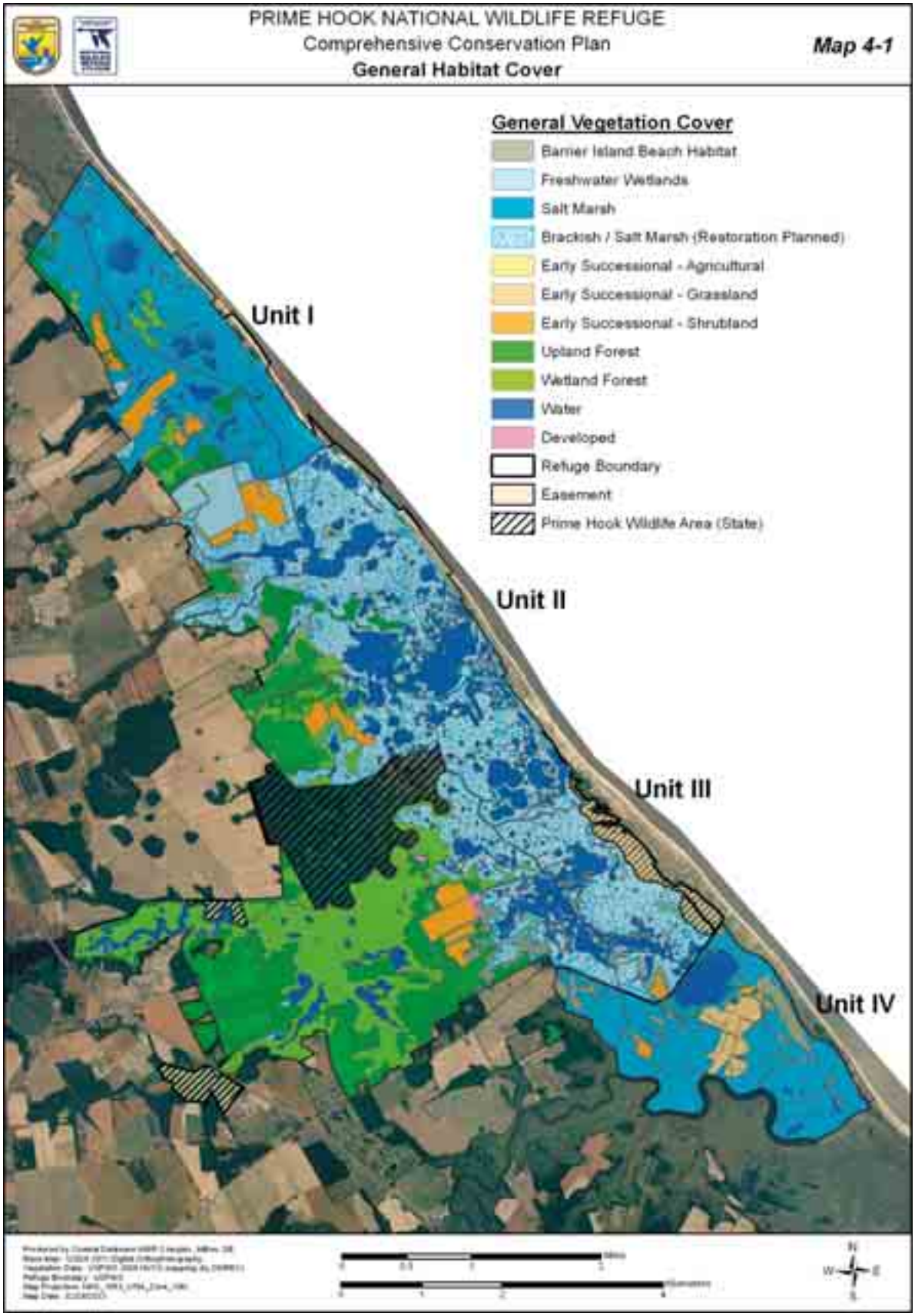
Management Goals, Objectives, and Strategies

The management direction presented here, in our professional judgement, will best achieve the refuge's purposes, vision, and goals, and the Refuge System mission and goals, as described in chapter 1. It includes the actions that best respond to public issues and opportunities identified during the planning process and public scoping meetings, and the actions that will contribute to conserving Federal trust resources of concern on the Delmarva Peninsula and in the Northeast region. Unless otherwise noted, all actions will be implemented by refuge staff.

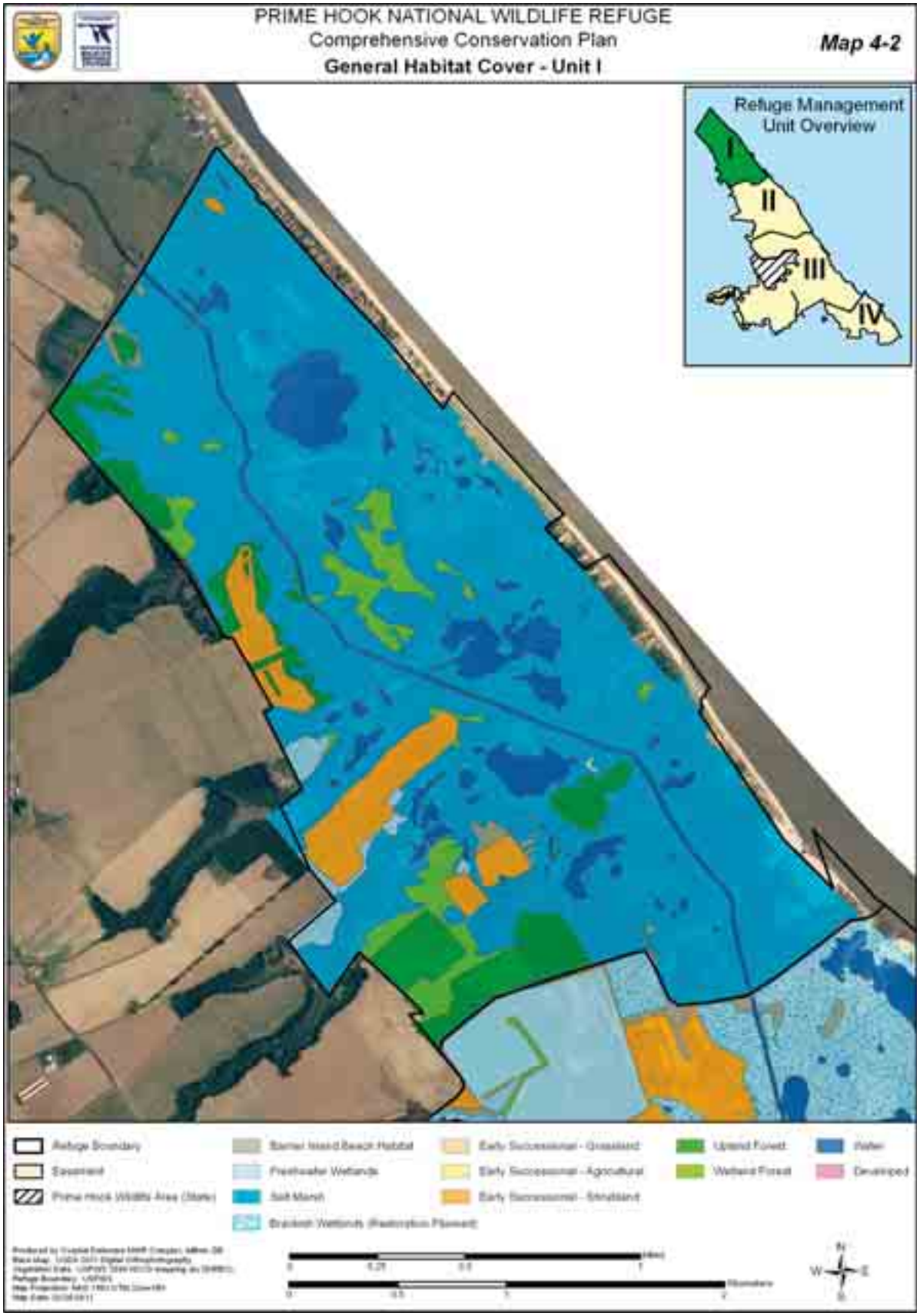
The biological and habitat goals, objectives, and management strategies are based on the following underlying hypotheses and assumptions that were used to decide the future management direction for the refuge, including the desired habitat conditions depicted in map 4-1 to map 4-5:

- Focal species management would be the best approach to conserve continental migratory bird populations, while maintaining, enhancing, and restoring BIDEH 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, BIDEH, and improves environmental health monitoring.

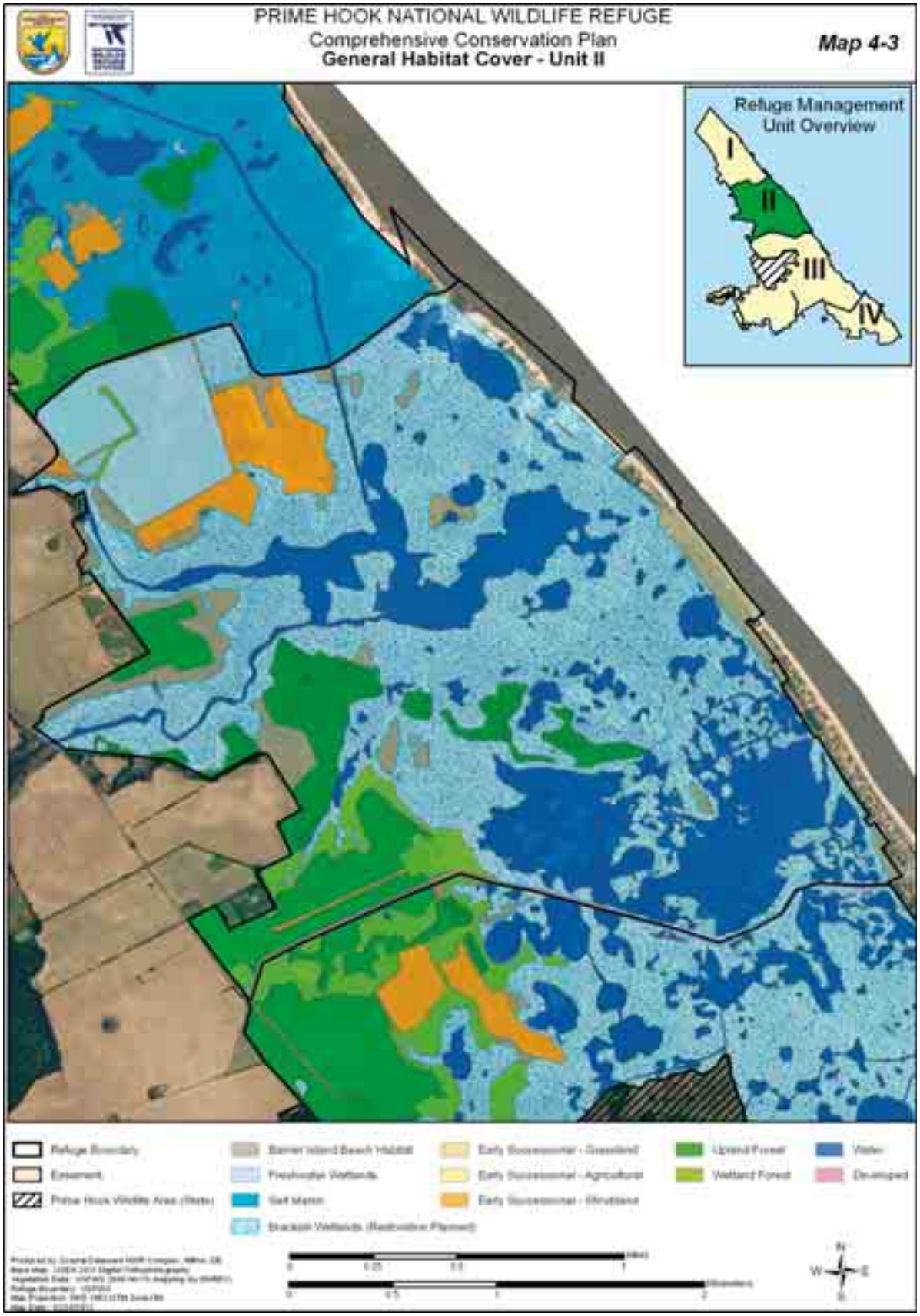
Map 4-1. General Habitat Cover



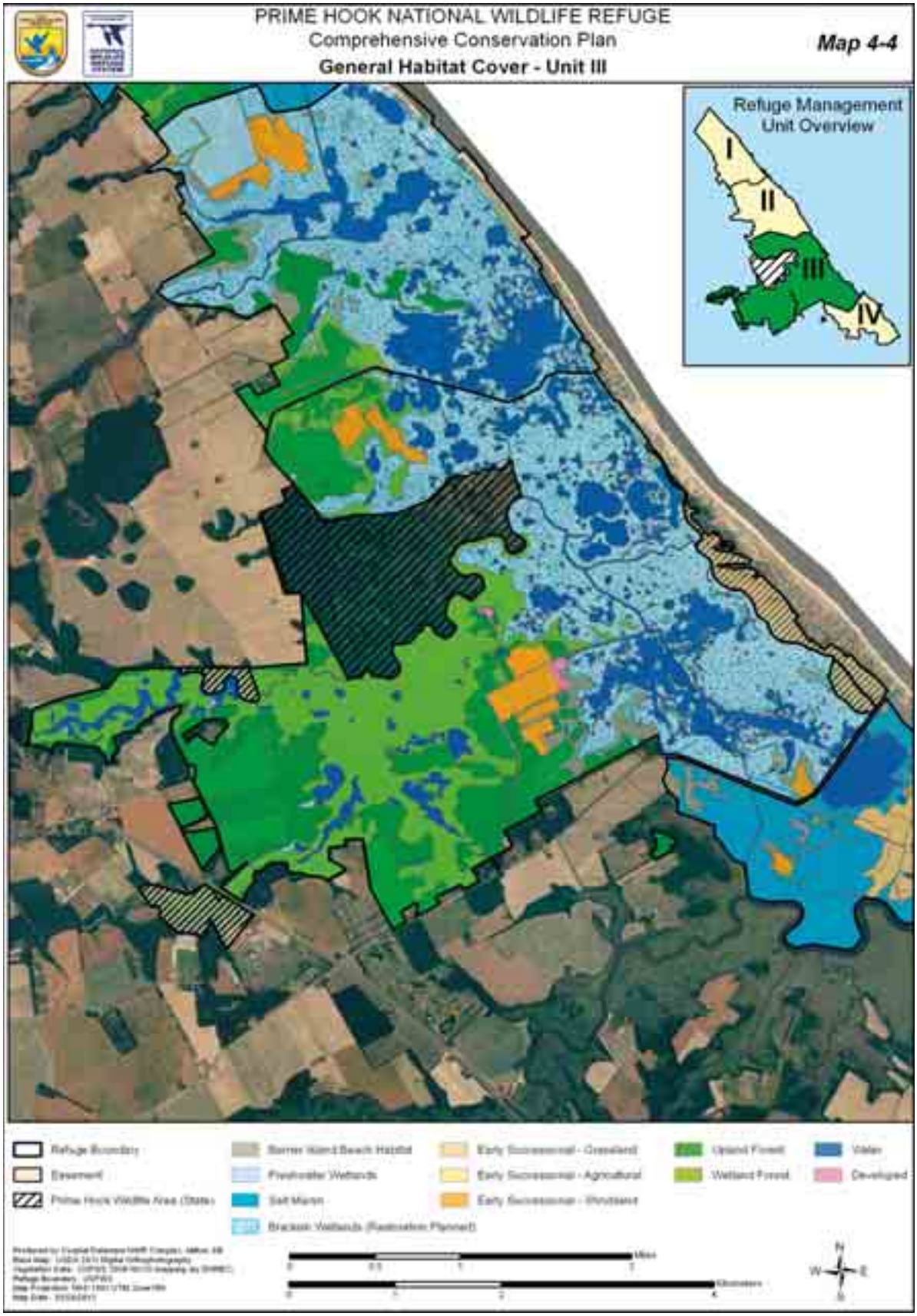
Map 4-2. General Habitat Cover in Unit I



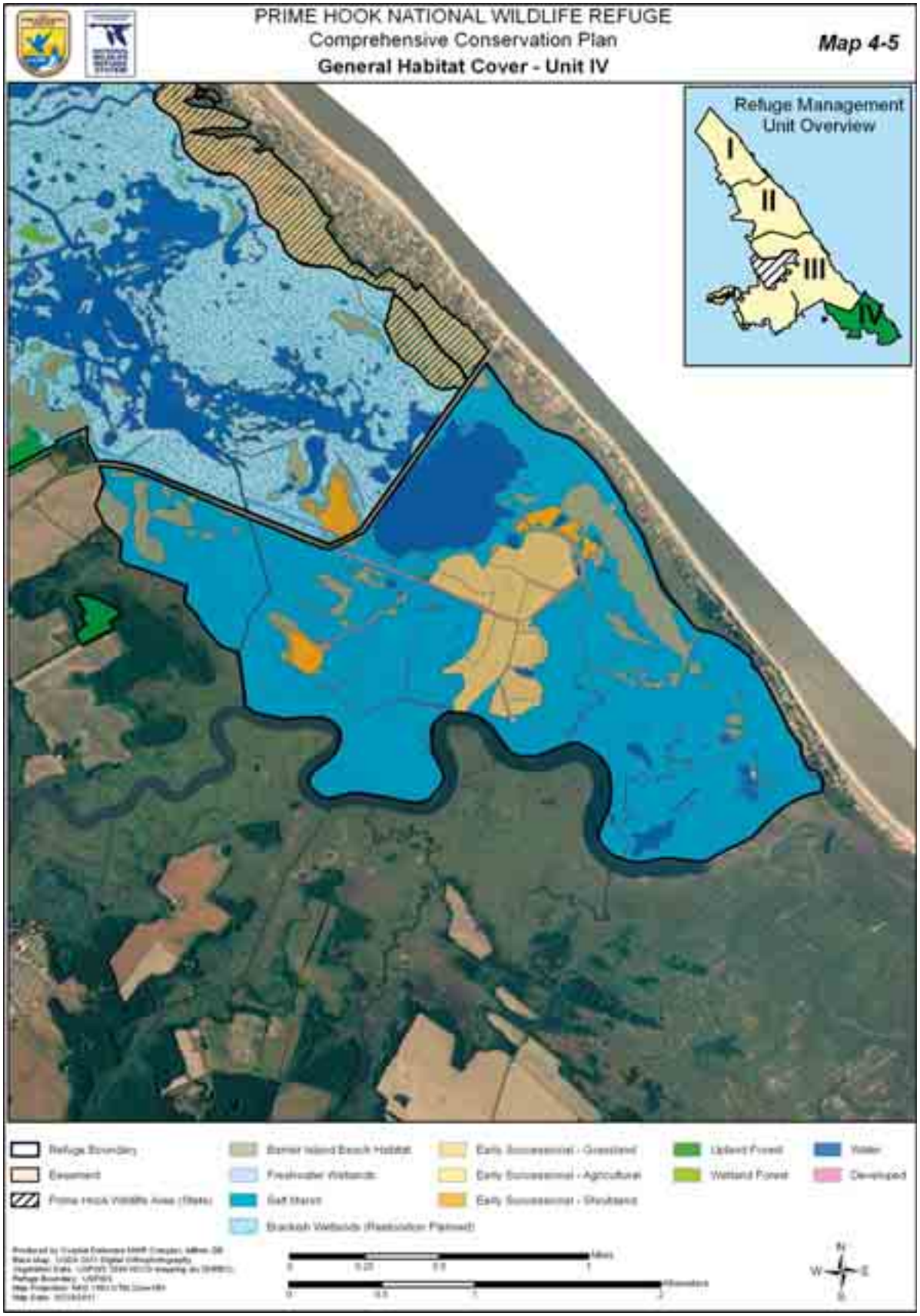
Map 4-3. General Habitat Cover in Unit II



Map 4-4. General Habitat Cover in Unit III



Map 4-5. General Habitat Cover in Unit IV



- Modify mosquito and integrated pest management 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 management direction incorporates the principles of SHC 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. The refuge will implement manipulative management tools and interventions that mimic natural processes to enhance habitat restoration where deemed most appropriate. At the same time, the refuge will strategically reduce the use of management actions that are contrary to the directions of the 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. We will use a combination of passive and active management approaches to foster or achieve more ecologically sustainable habitats than those that occur on the refuge at present.

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 plan outlines a proactive habitat management approach in response to these changing conditions.

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.

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.

For public use, we will expand existing opportunities for all six priority public uses, with additional emphasis on hunting and wildlife observation and photography. Map 4-6 depicts the proposed public use.

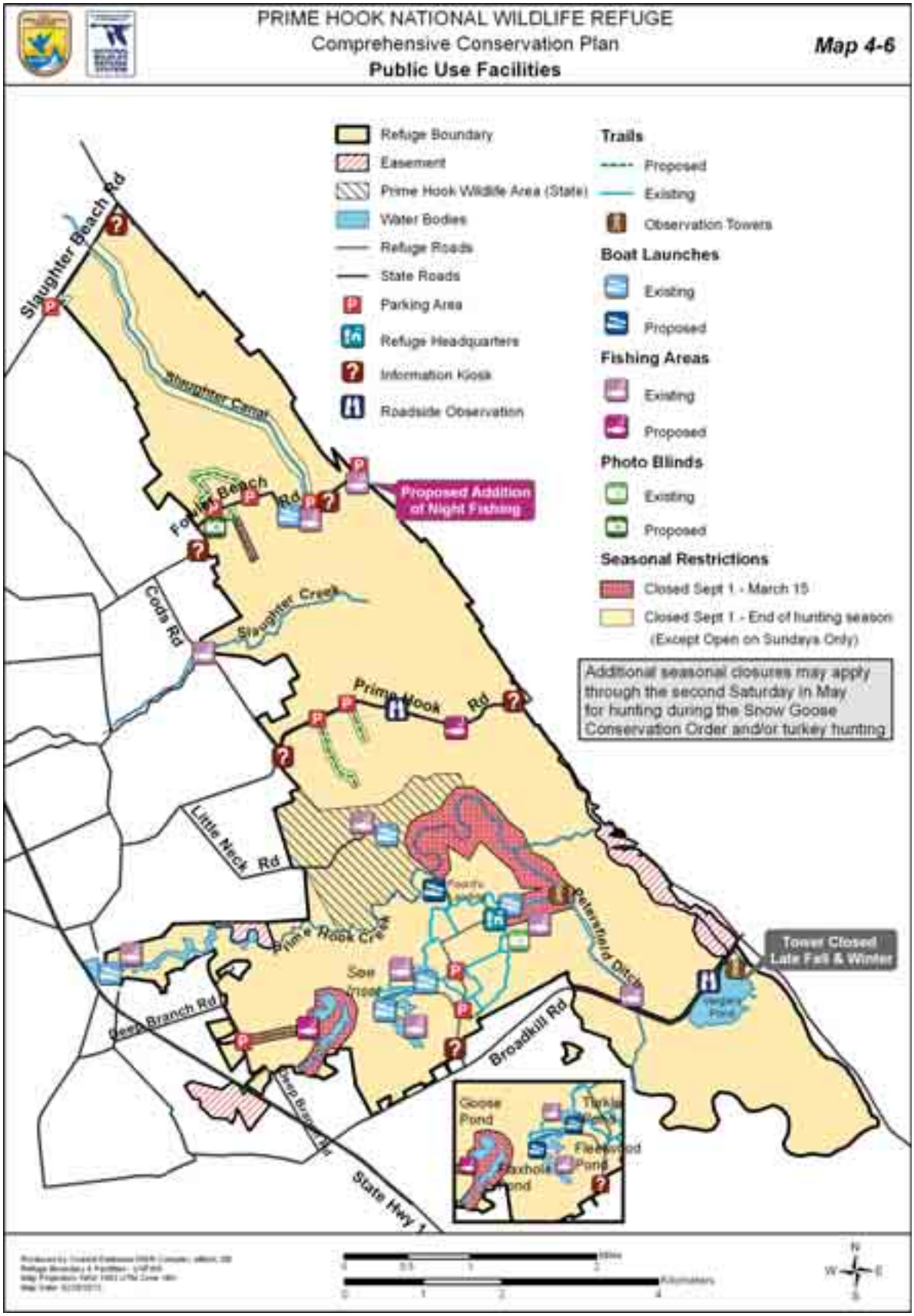
We will modify the hunting program for greater administrative efficiency and open additional areas of the refuge for the hunting program, with careful consideration of public safety and balancing this expanded use with other options for non-consumptive wildlife-dependent public uses.

We will expand some aspects of the hunting program to include additional days and acres throughout the hunting seasons established by the State. Deer hunting acreage will increase from 4,020 to 5,221 acres, waterfowl hunting from 1,722 to 3,432 acres (which meets the 40 percent "inviolate sanctuary" rule of the total 10,144 acres in the refuge), upland game and migratory bird (excluding waterfowl) hunting will remain at 1,995 acres, and turkey hunting will be added, from 0 to 3,729 acres.

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 5-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. 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, adjacent to the refuge, will continue to provide these opportunities.

Hunting 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

Map 4-6. Public Use Facilities



facilitate them when they are compatible and appropriate. In fact, we maintain or enhance opportunities for all six priority public uses. In other words, expansion of hunting opportunities at the refuge will not come at the expense of other priority public uses.

Opportunities for hunting and fishing will also be enhanced. 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 will be developed.

We will 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 will pursue establishing demonstration areas on the refuge to promote research, and developing applied management practices to benefit the species and habitats identified in this chapter.

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 will be based on available permanent funding sources, and will be considered in the context of regional and refuge priorities.

We will seek to expand the current office building to accommodate additional visitors for environmental education and interpretive programs. This office expansion will also provide needed space for storage of visitor services, supplies, and biological equipment. We will continue the use of travel trailers, which are used for interns, researchers, volunteers, and temporary employees.

Below we describe in detail the goals, objectives, and associated rationales and strategies that we will use to implement the 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 5-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 saltwater 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 1 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 will 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-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 Northeast Coastal and Barrier Network 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 will 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 Delaware Mosquito Control Section's surveillance program has detected and documented a mosquito-borne human health threat on or near the refuge (e.g., 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 PIF 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 PIF 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 sound science. This includes the Interim Guidance for Mosquito Management on National Wildlife Refuges (USFWS 2005) and other appropriate Service policy and 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 a documented human 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 will 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 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 a documented human health threat.

- Collaborate with State vector control personnel to develop specific action thresholds that will 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 NWR.

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 to 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 USGS-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
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 4-1).

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. DNHP 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 HMP (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
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 U.S. (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 and the Hadley Center for Climate Prediction and Research model. 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 will 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. DNHP 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 PIF 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, tables 3-6 and 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.